

Predicted Metaverse Impacts on Architectural Heritage

Conservation & Building Reuse Sustainability

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Abstract

This article delves into the multifaceted effects of Metaverse technology on the conservation and repurposing of heritage sites. It seeks to answer pivotal questions: Can the creation of heritage zones in the Metaverse enhance or impede the sustainability of conservation efforts? Does Metaverse offer a conducive platform for documentation and experimentation, preserving the integrity of real-world sites? Through a meticulously crafted three-step methodology, the study explores the theoretical implications of Metaverse technology on heritage conservation, conducts a rigorous analytical assessment of its impact, and validates its findings via stakeholder surveys. By uncovering both positive and negative ramifications, the research not only illuminates the complexities but also proposes actionable guidelines for optimizing the integration of historical sites into virtual realms. This serves as an invaluable resource for stakeholders navigating the intricate intersection of cutting-edge technology and the preservation of cultural heritage, ensuring informed decision-making and sustainable conservation practices.

Keywords: *Heritage Conservation, Metaverse, Heritage Buildings Reuse, Virtual Reality*

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Introduction

Developments in computer science enrich human interaction, communication, and social transactions to enhance human life. During the COVID-19 pandemic, the need for remote communication emerged, especially in education, work, and social communication; the solution was in cyberspace. The term "metaverse," which appears for the first time in Neal Stephenson's 1992 science fiction book "Snow Crash," is interpreted as a virtual universe separate from the real one (Stephenson, 2000). After Mark Zuckerberg announced in October 2021 the use of metaverse technology in social media (Facebook) and changed the name of the company to Meta, huge investments were directed toward producing virtual elements such as avatars, homes, and virtual environments. Thus, heritage environments are nominated as one of the most critical targets for these investments, like the background of events in electronic games or as a destination for user visits.

The virtual world can be defined as a brand new digitally built environment, an extension of the real world that includes physical appearance, cultural and social interaction, aesthetics, and philosophical arguments (Moneta, 2020). The main goal of using Metaverse technology in social media is to create a virtual environment where a person can present himself to people in digital space, which means that he will be embodied inside the Internet rather than just looking at it. Metaverse technology has been used in architectural education by constructing heritage buildings to facilitate the knowledge and explanation of their components and their visit to virtual reality during the COVID-19 pandemic. Many applications use a three-dimensional model of many heritage sites, with the possibility of walking around (Purwantiasning & Kurniawan, 2020). Using it in electronic games and making it available in virtual reality (VR) will make their use on Facebook (a social media application) more widely accessible.

Multiple factors, including economic, social, and environmental ones, can have an impact on conservation and reuse processes in the long term. The use of new technologies, such as Metaverse technology, can have an impact on heritage conservation and heritage building reuse (Dao Thi, 2023). Because of these areas' sensitivity and historical value, these effects must be studied before using Metaverse technologies to minimize the adverse effects that can influence the social and cultural aspects of heritage areas (Saleh, 2021). The study of the anticipated impact of Metaverse technology on the long-term conservation and reuse of heritage buildings to avoid the negative influence of using architectural heritage areas in Metaverse applications.

Research Goals

The primary objective of the research is to investigate the predicted effects of creating heritage areas in Metaverse technology and various electronic fields or social media and to analyze these effects in order to identify their positive and negative impact to anticipate the impact of using this technology on heritage conservation and heritage buildings reuse processes.

Research Hypothesis

The research hypothesis is that expanding the creation of heritage areas in the Metaverse without control will harm the processes of heritage building conservation and reuse and that these controls are the only ones that can increase the likelihood of sustaining these processes.

Methodology

The research is divided into three stages. The first is a literature review that represents a study that depends on the theoretical method, which sets the concept of Metaverse technology and studies factors for sustaining heritage conservation. The second stage analyzes the strengths, weaknesses, opportunities, and threats affecting heritage conservation and sustainable building reuse. The last step depends on the practical approach to evaluating the analysis and presenting the predicted impact of using heritage areas in Metaverse applications.

The research methodology is divided into three approaches; the first depends on the theoretical background and contextual approach. Studying the Metaverse concept and its applications in architecture and heritage conservation, such as virtual reality (VR) and augmented reality (AR). Examining the factors that affect the sustainability of the heritage conservation process and the relation between them and Metaverse technology and applications. The second approach depends on an analytical approach that analyzes the influence of Metaverse technology (VR) and (AR) on heritage conservation sustainability factors. The analytical side studies the analysis to predict the effects of Metaverse technology on architectural heritage sites. The last applied approach evaluates the research proposal through the evaluation elements inferred from the analysis. The analysis will be examined through an investigation directed at a group of stakeholders related to architectural heritage sites and the conservation process to evaluate this analysis and predict the impact of using architectural heritage areas in Metaverse applications to reach the results and recommendations, as shown in Figure 1.

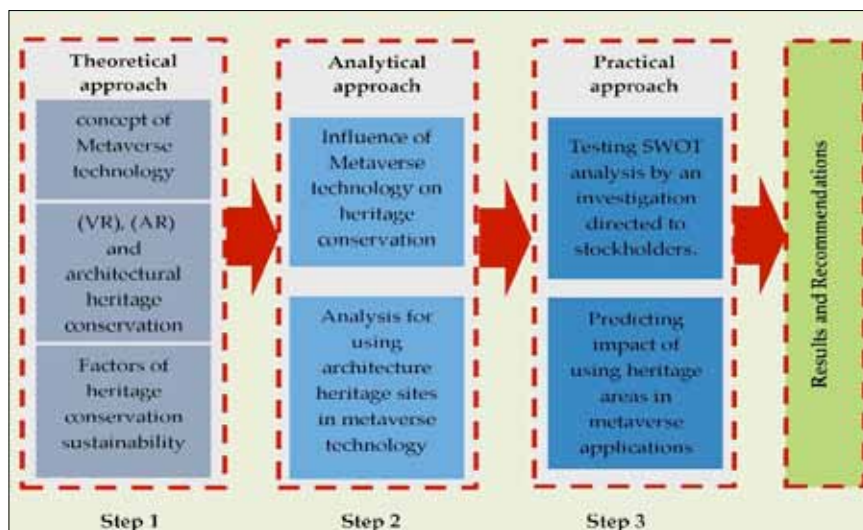


Figure 1. The research methodology.

Theoretical Background and Contextual Approach: Metaverse Technology and Historical Conservation Sustainability

Metaverse is the next version of the Internet, which includes virtual worlds where users can create 3D environments and objects and move through them with their avatars (Binson, 2021; Moneta, 2020). Metaverse can be considered a blending of virtual, physical, and digital environments facilitated by the convergence of Internet and web technology and

extended reality. From the previous definitions of Metaverse technology, we find that building heritage areas and environments can represent an essential part of the experience of visiting and residing in these areas, which can attract many users of these technologies. Metaverse technology has already been used in architectural education to build historical and heritage areas and present to students materials related to the study of the history of architecture, especially during the period of the COVID-19 pandemic (Gaffar, 2021).

Users can now build their own shapes and 3D environments and live in a virtual world. The emerging platforms that use virtual environments enrich the experience that emulates virtual space for social and online meetings. However, to get to the virtual world, we have to pass the digitalized real-world phase (digital twins) and the merged and perpetual world phase to reach the virtual world (digital natives), as shown in Figure 2.

As Metaverse building blocks, virtual reality (VR) and augmented reality (AR) help transform the physical world into a virtual one. Currently employed in digitizing the physical world (digital twins), these applications aid architectural education during the COVID-19 pandemic.

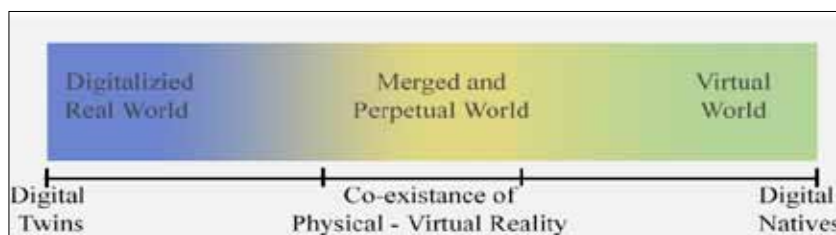


Figure 2. The transformation phases from digital twins to reach the digital natives, Source: Modified by the author from: Lee, Lik-Hang et al., 2021.

Digital Technology in Heritage Conservation

Digital technology makes remote cultures and locations more accessible than ever before. At the level of heritage conservation, digital technology provides images with a high resolution. These 3D models can be utilized in heritage documentation, and digital heritage applications can encourage users to value and appreciate their heritage. It will produce citizens who will aid in heritage preservation and prevent its destruction (Economou, 2016).

Heritage Conservation and Digital Twins

Heritage Conservation and Digital Twins

The idea of digital twins can be divided into two sub-systems: the virtual system holds all the data related to the physical system and the physical system itself. As a result of this connection, data and information flow between the two systems from real space to virtual space, which means there is mirroring or twinning between what existed in real and what existed in virtual (Grieves, 2016), so digital twins can be used in research, education, and heritage conservation.

According to the digital twin's concept, the physical conservation and reuse project data can be used to create a virtual perception that will help create accurate documentation for heritage sites and buildings. The digital twin's concept can help in project evaluation after

implementation, which is more suitable for sensitive heritage buildings and more sustainable because, in this situation, we can decrease the dangers caused by heritage building reuse. Digital twins can make very accurate replicas of heritage monuments that are used in research, education, and heritage conservation.

Virtual and Augmented Reality as Heritage Conservation Digital Applications

Virtual reality (VR) is a computer-generated environment that simulates a physical presence in real or imaginary worlds (Munoz et al., 2014) and closely resembles the reality of the person using it (Shakeri & Ornek, 2022). In heritage conservation, VR technology can create heritage sites to help better understand and identify the main issues of conservation and building reuse. Besides, VR is a tool to help users, stockholders, and decision-makers make suitable decisions for conservation and building reuse.

Virtual reality (VR) applications helped build many heritage sites for educational purposes, which helped in distance learning processes. This technology can help understand and assimilate the fine details in these sites, as well as the traditional building methods and technology used in construction (Gaafar, 2021), as shown in Figure 3.

Augmented reality (AR) can be summarized by adding tools to (VR) to make the scene more real, such as furniture, lights, or new construction elements that overlap the virtual and real worlds. Augmented reality differs from virtual reality in that it can present an image of the building after the conservation and reuse operations, with the addition of all the new elements that help evaluate the reuse operations and their suitability for the building, and it enabled making (VBIM). So, we can say that AR permits users to see the real world and not the virtual environment produced by VR (Aziz & Siang, 2014).



Figure 3. Left, Real Pharaonic Tomb. Right, Model for the Same Tomb Created by VR for Educational Purposes, Source: (Gaafar, 2021).

Social Media Metaverse and Heritage Conservation

The social media Metaverse is just in the development phase, and massive investments have been spent emphasizing the Metaverse applications. Video games and positioning applications represent the most important applications that deal with communication, which can be used in the following:

- Games: gaming is anticipated to be an essential application for Metaverse technology due to its immersive nature. Many cities and heritage buildings appeared as back-grounds for video games, and these buildings contained many details that could be used in documenting these buildings or the periods that they could express, as shown in Figure 4. Zuckerberg explained how the Metaverse would provide gamers with a platform that would increase their gaming experiences and allow more games to be included (Allam et al., 2022).



Figure 4. Left, A model of games used historical buildings as a background. Right, A model of the games used historical buildings as a background, Source: <https://www.ubisoft.com/en-gb/game/assassins-creed/odyssey>.

- GIS applications: many users use GPS applications to interact with traffic and directions, and the most important of these applications is one that contains three-dimensional models of many heritage and historical sites (Figure 5). The user can roam around heritage areas, which can be the basis for Metaverse applications that can use these technologies to navigate heritage areas.



Figure 5. Two different scenes for Piazza San Marco from the Google Earth application, Source: produced by Google Earth image date 9/23/2023, 45o26'01.88" N, 12o20'17.6" E eye alt 30ft.

Sustainability Factors of Architectural Heritage Conservation and Building Reuse

Sustainable development depends mainly on the interaction of three primary factors: the economy, the environment, and the local community (Figure 6). Therefore, developing the three axes together is necessary when investing in the heritage environment (Purwantiasning, 2021). Environmental development aims to create urban aspects and services, which is one of the main elements.

The expected effects of using Metaverse technologies, especially at the level of social media, can affect the sustainability of the preservation and reuse of heritage buildings on all sustainability factors, which can be summarized in the following:

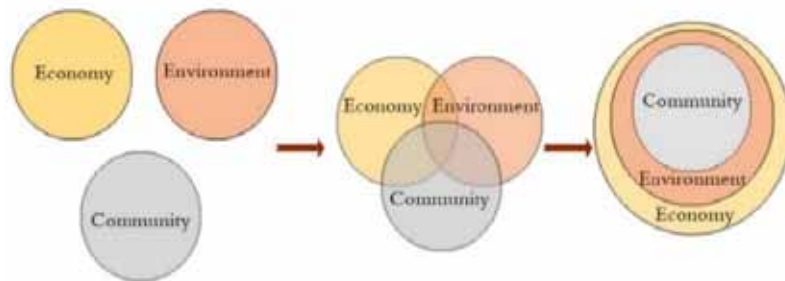


Figure 6. Factors of architectural heritage conservation sustainability, Source: The authors.

Predict the Influence of Metaverse on the Architectural Heritage Site Economy

The economies of heritage areas depend on traditional industries or investment in the employment of heritage buildings, in addition to tourism (Elbelkasy & Mustafa, 2022), which constitutes one of the most important economic resources for these areas. Interaction and visiting heritage areas through Metaverse applications can affect the number of tourists coming to these areas, which may affect the economies of these areas.

Predict the Influence of Metaverse on the Architectural Heritage Site Environment

Developing and developing heritage environments depend on a plan to preserve these areas, which government agencies, civil society organizations, and loans or grants from international bodies interested in heritage mainly fund. The operations of reused heritage buildings can be done by individual investors or for-profit entities. NGO aims to develop the local community economically (Rashed & Al-attar, 2005). The economic returns used in maintenance and development must be increased to ensure the sustainability of heritage environment development. The economic returns could be affected due to the use of Metaverse techniques if the financial returns necessary to sustain the preservation and development of heritage environments are not considered.

Predict the Influence of Metaverse on the Architectural Heritage Site Community

Development of the local community is considered one of the purposes of heritage conservation, which can be achieved by increasing financial returns from local handicrafts that characterize the heritage areas. Increase income through tourism returns, which can be affected due to the use of Metaverse technologies, which will reduce these returns. In the re-settlement of heritage areas with the new community with a higher social and economic level, financial returns will not be required for maintenance operations, which will be provided by re-settlement operations (Elbelkasy 2022).

Using Metaverse Technology in Architectural Heritage Buildings Reuse

Reusing heritage buildings is one of the most important guarantees for the sustainability of the conservation of these buildings and the development of the entire heritage area. The process of selecting the new function of the building goes through a set of phases, as follows (FatemeH Hedieh Arfa, 2022):

- Definition of design strategies
- Definition of adaptive reuse potential
- Definition of the appropriate function
- Evaluate the building
- Final decision making
- The decision of functional changes
- Public participation

The new function of the heritage building has to suit the following (Mahmoud 2015):

- Building nature.
- The structural condition of the building.
- Space potential of the building.
- The local community of the heritage area.

Metaverse techniques help model alternatives for the reuse of heritage buildings, which allows the evaluation of various alternatives before implementation processes and ensures the interaction of the local community with the optimal option for reuse. Augmented reality techniques can also be used to study the movement in architectural space and furniture potentials, which helps decision-makers explore all alternatives. It is also possible to study the economic returns resulting from the various options and use them to reduce the risks of investment operations, select a suitable proposed process to bridge gaps between public and private finance and develop collaborative initiatives (Burnham, 2022).

Analytical Approach: Analysis of Using Architectural Heritage in Metaverse Applications

A structured methodology combining literature review-based analysis and stakeholder questionnaires was employed to comprehensively assess the potential impacts of integrating Metaverse technology into architectural heritage contexts. This methodological approach aimed to provide a nuanced understanding of the environmental, economic, and community dimensions influenced by utilizing Metaverse applications such as virtual reality (VR), augmented reality (AR), games, and social media in heritage areas.

The initial phase of the methodology involved an exhaustive review of existing literature on integrating Metaverse technology in architectural heritage settings. This literature encompassed scholarly articles, research papers, reports, and case studies that examined the positive and negative aspects of employing Metaverse applications in heritage conservation and development. This review process synthesized vital themes, trends, and findings to establish a foundational understanding of the potential implications of Metaverse technology on architectural heritage. Particular emphasis was placed on identifying environmental, economic, and community impacts, thus laying the groundwork for subsequent analysis.

Following the literature review, a stakeholder questionnaire was designed to validate and augment the insights gleaned from the literature. Stakeholders representing diverse interests in architectural heritage—including conservationists, community members, tourism authorities, planners, developers, and technology experts—participated in this study phase. The questionnaire, structured to address specific aspects of environmental, economic, and community dimensions, solicited stakeholders' insights, opinions, and perspectives regarding the potential impacts of Metaverse technology on architectural heritage environments.

The collected data underwent both quantitative and qualitative analysis to discern common themes, disparate viewpoints, and areas of consensus or contention among stakeholders.

Drawing upon the literature review and stakeholder questionnaire findings, an analytical framework was developed to examine the impacts of Metaverse technology on architectural heritage systematically. This framework, organized around the three elements of sustainability—environmental, economic, and community—categorized and analyzed the positive and negative implications of Metaverse applications. At each level of analysis, considerations were made for the effects on heritage conservation processes, economic viability, and social cohesion within local communities. By integrating insights from both the literature and stakeholder perspectives, this methodology facilitated a holistic understanding of the multifaceted impacts of Metaverse technology on architectural heritage.

Analysis According to Environmental Level

The following points include the analysis of the environmental impacts of using heritage areas in Metaverse applications (VR, AR, games, and social media).

Positive impact.

1. Using Metaverse technology to visit heritage areas will reduce the number of visitors to heritage sites, reducing pollution from vehicles and waste.
2. VR and AR can be used to create a virtual building information model (VBIM) for heritage area projects, which helps assess needs and select the best proposals.
3. Metaverse technology allows the evaluation and study of place-making in heritage areas' urban spaces and presents different scenarios for the region's multiple characters and periods.
4. AR and VR technologies help local communities interact with proposed place-making projects in the heritage environment's urban spaces, evaluate them, and participate in their implementation.

Negative Impact

1. The use of (AR) in the urban spaces of the heritage environment in a way that does not suit the traditions, values, or culture of the local community will affect the heritage value.
2. Heritage area local environment plans were created to serve visitors and the local community. Using Metaverse technology will affect these plans and change the heritage environment by reducing visitors.
3. One of the expected risks is that there will be a disconnect between reality and virtual reality, contributing to the deterioration of the heritage environment.

Analysis According to Economic Level

The following points include the analysis of the economic impacts of using heritage areas in Metaverse applications (VR, AR, games, and social media).

Positive Impact

1. Using Metaverse technology in heritage areas will increase investment fields and facilitate the assessment of these investment projects.
2. Building a virtual model for investment projects in heritage areas ensures local community participation, which is essential to their sustainability (Elbelkasy, 2017).

3. Metaverse applications help select the best economic evaluation method for heritage investment projects.
4. Expect huge returns from Metaverse applications that use heritage areas and Civilization Rights to develop heritage. Civilization rights require those who profit from world heritage to develop heritage environments that benefit and develop local communities (Rashed, 2020).

Negative Impact

1. The use of architectural heritage areas in Metaverse applications will reduce visitor numbers, which will affect heritage economies by lowering the returns of investment projects that depend on visitors.
2. The economies of heritage areas depend on marketing the handicrafts that characterize these areas, which could be affected by the use of Metaverse technology and reduce visitor returns.
3. Reducing the economic returns to heritage areas is one of the most critical factors threatening the sustainability of the conservation of these areas.
4. Using Metaverse technology and reducing the number of visitors in heritage areas reduces the economic returns of handicrafts, which threatens their extinction.

Analysis According to the Community Level

The following points include the analysis of the social impacts of using heritage areas in Metaverse applications (VR, AR, games, and social media).

Positive Impact

1. AR technology can revive the ancient cultures, customs, and traditions of heritage areas, allowing researchers to study their development and predict their future effects on the heritage environment.
2. (VR) and (AR) technologies allow an integrated visualization of conservation projects, which ensures more significant interaction from the local community because it can coexist with the project and learn about its various dimensions, ensuring achieving sustainability.
3. Metaverse technology can visualize heritage conservation projects and their effects on the local community. Their knowledge and evaluation of proposed projects promote community interaction.

Negative Impact

1. The use of Metaverse technology and the lack of returns from tourism projects in heritage areas can lead to unexpected changes in the nature and composition of the community, which affect conservation processes.
2. It is using Metaverse technology for heritage areas and reusing them in a way that is not commensurate with the values and culture of the local community.
3. The use of Metaverse technology and the lack of return from tourism projects affects handicrafts and their return and thus may lead to their extinction due to the local community's tendency to use other sources of income.

Evaluation of the Analysis

The analysis was evaluated by a questionnaire directed to the specialists and academics in conservation (architects – archeologists) and tourism, as in Figure (7).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Tourism worker	6	11.1	11.1	11.1
	Archaeologists	6	11.1	11.1	22.2
	Architect	27	50.0	50.0	72.2
	Academic	15	27.8	27.8	100.0
	Total	54	100.0	100.0	

Figure 7. Table of the numbers, percentages and distribution of the participants.

The questionnaire was divided into three parts as the follows:

- Part one: testing the environmental aspects, such as the influence of the number of visitors to the heritage area on the pollution, infrastructure, placemaking, and urban spaces in heritage areas; the results of testing this aspect are shown in figure's 8 table below..
- Part two: testing the economic aspects of decreased visitors' influence on financial returns, returns from handicrafts, and profits from reuse projects. The results of testing this aspect are shown in figure's 8 table.
- Part three: testing the social aspect as the influence of decreased economic returns on the local community, community public participation, community changes, and impact on traditions and customs of the local community; the result of testing this aspect is shown below..

Part	Testing field	Testing result	
		Mean value	Significance values
Environmental aspects	Decrease pollution according to decrease visitors' number.	2.3333	.050
	Using VR as a tool to evaluate infrastructure projects	1.7222	.208
	Using VR as a tool to evaluate space-making projects	1.5556	.234
	Decrease visitors due to using Metaverse will waste money spent on infrastructure projects	2.9444	.753
	Using Metaverse application ensures local community public participation in evaluating environmental projects	2.0000	.005
	Using Metaverse application will decrease waste financing money spent on environmental development projects	2.4444	.036
Economic aspects	Using Metaverse application will increase investment in heritage areas.	2.0000	.000
	Using Metaverse application will provide investment evaluating model	2.0000	.442
	Using Metaverse application can decrease investment returns.	2.4444	.292
	Using Metaverse application can decrease economic returns from handicrafts.	2.1111	.137
	Economic returns from Metaverse application, which uses heritage areas, can be used to develop these areas	1.7222	.000
	Decreased returns from handicrafts due to using Metaverse applications will threaten the future of these handicrafts.	2.0556	.454

Figure 8. Table of results from testing analysis. Continued next page.

Part	Testing field	Testing result	
		Mean value	Significance values
Social aspects	Using Metaverse application can help revive old traditions.	2.2778	.038
	Using Metaverse application will lead the community to public participation in conservation projects.	2.1667	.016
	Decreased returns due to using Metaverse applications will help to change the community of heritage areas.	2.2222	.092
	Using Metaverse applications will help study and predict change in the community of heritage areas.	2.5556	.001
	Using Metaverse applications can be harmful if they are used in a way not appropriate to the community.	2.3889	.000
	Using Metaverse applications can help lose handicrafts.	2.3889	0.000

Figure 8 cont. Table of results from testing analysis.

Predicting the Impacts of Using Metaverse Technology on Architectural Heritage Conservation Sustainability

According to the previous analysis, we can predict the influence of using Metaverse technology and applications on heritage conservation sustainability factors (environment, economic, and community) as shown in Figure 9's table.

	VR	AR	S. M. Metaverse app.	Games	G.I.S. app.
Environment	Infrastructure	Providing VR and AR scenarios for architectural heritage area infrastructure, helping evaluate the recent projects that decrease negative impacts.			Providing a database for infrastructure, helping detect futuristic needs
	Place Making	Providing VR and AR placemaking scenarios for architectural heritage areas. Increase the community interaction.	Testing different scenarios for place-making will decrease the negative impacts.		
	Pollution	Decrease pollution rates according to using metaverse application due to decreasing visitor numbers.			
Economic	Investment returns	Providing VR and AR scenarios for investment projects decreases investment risks and helps choose suitable economic evaluation methods.	Used returns from the Metaverse, social media, games, and the GIS app. in development projects in heritage areas as any investment project.		
	Returns from handicrafts	providing VR and AR models for explaining the process of making handicraft products will preserve it.	It can be used to mark heritage area products to increase economic returns.	Using the process of making handicrafts in games will preserve it.	Making a database of handicrafts will improve and develop it.
	Returns from using heritage areas in metaverse applications	Using the heritage areas in prof-making activities must direct part of the profits towards developing the heritage areas that will increase the economic returns.			

Figure 9. Impacts of using Metaverse technology on heritage conservation sustainability matrix. Continued next page.

	VR	AR	S. M. Metaverse app.	Games	G.I.S. app.
Community	Customs and traditions	Using AR in the documentation will help preserve old traditions	Revive old traditions and discuss the development of customs and traditions.		Making a database for traditions and customs
	Public participation	Using VR and AR in conservation projects will encourage the community to participate.	Make a discussion about the conservation projects.		Documented conservation projects.
	Community change	Study changes in the community according to the use of metaverse technology and applications.			
	Community and handicrafts	Supporting handicrafts by marketing them and allocating part of the proceeds from using heritage areas for developing handicrafts.			

Figure 9 cont.. Impacts of using Metaverse technology on heritage conservation sustainability matrix.

Discussion

Urban heritage is a cornerstone of cultural identity, embodying social, artistic, and historical values crucial for societal cohesion and preservation of identity. Preserving and conserving these areas are paramount to safeguarding cultural legacies for future generations (Ladiana & Sivo, 2019). However, it is imperative to ensure that conservation and reuse efforts do not inadvertently disrupt the delicate balance of local communities and economies, thereby threatening the sustainability of these operations.

Strengths: The utilization of heritage areas in Metaverse technology presents many opportunities due to the capabilities offered by digital twin technologies. Virtual reality (VR) and augmented reality (AR) applications offer immersive experiences that can aid in the development and evaluation of multiple scenarios for conservation, reuse, and placemaking projects (Economou, 2016). By virtually simulating proposed projects, stakeholders can assess their viability and suitability for the region and local community, thus enhancing decision-making processes.

Moreover, VR and AR technologies are powerful tools for engaging local communities in conservation and reuse projects. By providing interactive experiences, these technologies enable stakeholders to experience and evaluate proposed projects before implementation, fostering greater community involvement and ownership. This participatory approach is crucial for ensuring that projects align with the wishes and needs of the local community, ultimately enhancing their sustainability standards.

Weaknesses: It is essential to acknowledge and address potential challenges associated with integrating Metaverse technology into urban heritage conservation. Sonia Billore underscores the critical role of the local community in conservation efforts, highlighting the potential risks of unplanned demographic shifts and economic changes (Billore, 2021). The reduction in visitor numbers resulting from adopting Metaverse techniques could negatively impact heritage economies reliant on tourism revenue, potentially leading to the decline of traditional handicrafts and cultural practices.

Opportunities: Public participation emerges as a vital aspect of successful conservation projects, with Metaverse applications offering a platform for stakeholders to envision and evaluate future projects (Duan et al., 2021). By showcasing proposed initiatives and soliciting community feedback, these technologies foster greater transparency and inclusivity in decision-making processes, ultimately enhancing project outcomes.

Furthermore, Anna Fischer's perspective on the purpose of virtual spaces underscores the potential for Metaverse technology to facilitate cost-effective prototyping and environmental impact assessments (Fischer, 2022). VR and AR technologies enable the creation of multiple conservation and reuse scenarios, minimizing project impacts and ensuring their long-term success. Additionally, augmented reality has the potential to revive ancient customs and traditions, enriching visitor experiences and promoting cultural heritage preservation.

Threats: Integrating Metaverse technology in urban heritage conservation holds immense potential for enhancing stakeholder engagement, project transparency, and environmental sustainability. However, careful consideration must be given to these technologies' socio-economic impacts and cultural implications. By fostering community participation, promoting financial sustainability, and leveraging innovative technologies, stakeholders can ensure the practical preservation and promotion of urban heritage for future generations.

Results and Recommendations

The research findings underscore several critical points regarding the integration of Metaverse technology in urban heritage conservation efforts, leading to the following conclusions and recommendations:

The local community emerges as a pivotal factor in ensuring the success and sustainability of conservation and reuse projects. Leveraging Virtual Reality (VR) and Augmented Reality (AR) applications to create diverse scenarios can enhance community understanding of project objectives and raise awareness among local stakeholders.

While Metaverse technology offers innovative solutions for heritage conservation, its adoption may decrease visitors, resulting in reduced tourism income and potential harm to the sustainability of heritage conservation efforts.

Revising ancient customs and traditions in heritage areas through VR and AR technologies enriches visitor experiences and facilitates the creation of multiple reuse scenarios, particularly for buildings inaccessible due to construction conditions or sensitivity.

Ensuring the sustainable conservation of heritage areas requires providing adequate economic returns. Stakeholders benefiting from heritage must contribute to the development of these areas, irrespective of the potential impact of Metaverse technology on visitor numbers and tourism income.

While Metaverse technologies offer numerous positive aspects, such as supporting community participation and facilitating scenario development, they pose challenges, including potential decreases in visitor numbers and adverse effects on societal structures and handicrafts in heritage areas.

The impact of using architectural heritage areas in Metaverse applications can be bifurcated into preparatory activities for conservation and reuse projects and leveraging heritage environments to attract the public.

Recommendations:

- Encourage designers to utilize Metaverse technology in documenting, preserving, and reusing heritage buildings, facilitating the creation of diverse restoration materials and reuse scenarios.
- Raise awareness among local communities about heritage conservation projects by providing VR and AR models showcasing conservation and reuse projects.
- Evaluate the environmental and social impacts of implemented conservation and reuse projects using Metaverse technology and gather community feedback to select suitable scenarios.
- Develop laws and regulations to ensure that the use of architectural heritage in Metaverse technology aligns with the customs and traditions of local communities.
- Integrate local community awareness into conservation and reuse projects by presenting proposed scenarios through Metaverse techniques, enhancing stakeholders' understanding and engagement.
- Mitigate the adverse effects of using heritage areas in Metaverse technologies, particularly in electronic games and social media Metaverse applications.

Conclusion

The research discussed the research hypothesis by dealing with Metaverse applications as one type that could cause the non-sustainability of conservation and reuse of heritage buildings—still, the analytical study of the research and the proposed framework divided these applications into two types. The first is helpful for conservation projects through virtual reality and augmented reality techniques in developing scenarios. Conservation operations can be evaluated. An integrated vision of these projects can be achieved if the local community can participate in evaluating these proposals, which helps sustain conservation operations. The second type uses heritage as a commodity through which material gains can be achieved, and this type can affect the sustainability of preservation operations. Still, it can be used to serve the preservation process of established rules, laws, and legislation that give rights to exploit these areas for material gains. It has already been stated that the research hypothesis cannot be achieved. Still, it is partially achieved if we do not set regulations for using urban heritage in a way that achieves economic returns for its beneficiaries.

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