Building the Future While Preserving the Past: Digital Tools and Community Engagement to "Re-Generate" Historic Buildings in Post-Disaster Scenarios

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Abstract. Cultural heritage has always been recognized as a fil rouge that links the past, present, and future. Today more than ever, its existence is threatened by natural disasters, conflicts, and vandalism that have a serious impact on the entire urban fabric. Digital technology and community engagement can contribute to its safeguarding as well as to "re-generating" urban spaces and giving life back to the cultural identity that may have been lost due to disaster or war. In this perspective, rebuilding the urban spaces after a traumatic event represents a key strategy for resilience, providing cities and communities the opportunity to reinvent themselves. To this end, the paper intends to show that adaptive reuse of built heritage, when properly supported by digital technologies and collaborative and co-design multidisciplinary participatory processes, can be an effective strategy for renewing and thus preserving memories of built heritage damaged by disasters or armed conflict. The analysis of best practices for adapting historic buildings, especially those repurposed after wartime damage, clearly supports this point.

Keywords: Adaptive reuse · built heritage · community engagement · digital technologies · co-design

1 Introduction

1.1 Adaptive Reuse of Historic Buildings

Historic urban areas "are among the most abundant and diverse manifestations of our common cultural heritage, shaped by generations and constituting a key testimony to humankind's endeavors and aspirations through space and time" [1]. In recent decades, wars, natural and human-made disasters, and economic crises have severely impacted cities and people, with consequences on the global economy.

Places, buildings, and cultural heritage (CH) are expressions of the identity, traditions, and values of the communities, becoming a reference point for residents. For this reason, recovering, restoring, reconstructing, and adapting buildings is essential to give life back to the cultural identity that may have been lost due to disaster or war. Rebuilding

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the urban fabric after a traumatic event represents a key strategy for resilience, providing cities and communities the opportunity to reinvent themselves [2].

The adaptive reuse of historic buildings can be a successful strategy for reconstructing damaged buildings in armed conflicts or in post disaster scenarios. This approach not only contributes to preserving the original worth of the built heritage but also allows it to serve new functions while complying with sustainable development principles.

Adaptive reuse of historic buildings has less impact on the environment than new construction; it is an effective strategy for preserving its intrinsic and historical value for both current and future generations [3].

Applying the concept of adaptive reuse to existing built heritage requires not only structural and physical modifications but also changes in the use and functions of the spaces. This approach allows for the enhancement of places while preserving cultural heritage, all while considering social aspects (citizen involvement), environmental aspects (energy efficiency, waste reduction, etc.), and economic aspects (cost savings and profitability) [4–6].

In general, adaptive reuse allows for the transformation of a building to adapt it for a different use, aiming for new functionality and efficiency. In the case of historic buildings, this process should take into account their historical and cultural characteristics. Thanks to adaptive reuse, it is possible to extend the life of a building by integrating efficient systems into the existing structure that enhance its resilience and sustainability [7, 8].

Therefore, it is essential to develop integrated strategies that consider both the sustainability and cultural value of built heritage, particularly in the context of historic buildings, to guarantee their preservation and effective reuse. To ensure that recovery or regeneration interventions are effective, it is necessary to conduct a comprehensive analysis of the building, taking into account its performance, to implement ad hoc solutions. Additionally, the use of life cycle analysis (LCA) allows for the preliminary assessment of the potential impact that a project may have, not just on the building itself, but also on the surrounding community and the environment [9].

Adaptive reuse, particularly in post-disaster or post-war scenarios, offers a concrete solution for protecting and recovering the remaining heritage. This approach not only helps to preserve the memories of places and people, but it also supports the regeneration of urban areas, making cities smarter, more functional, and responsive to the needs of local communities. As a result, it is important to combine digital technologies with participatory processes, considered essential elements for implementing an adaptive reuse project that is effective and efficient.

Fostering collaboration across institutions, communities, and industry stakeholders using digital technology may be helpful in the formulation of strategies for addressing and mitigating any potential challenges. Additionally, the development of a strong and cohesive network committed to the protection and enhancement of cultural heritage, also including adaptive reuse, can facilitate the sharing of information, skills, and resources among all parties involved in the decision-making process [10].

1.2 Digital Tools for Adaptive Reuse

Digital technologies offer a significant contribution in terms of emergency prevention and management thanks to the definition of approaches focused on collecting and sharing real-time data. This enhances the monitoring and prevention of disasters [11].

Digital tools can be extremely useful even during the re-generation phase, which is a very important time to influence the sustainability of the built environment and its capacity to withstand future potential emergencies, resulting in renewed and improved well-being for the community. Among the digital technologies employed in the rebuilding process, those associated with Industry 4.0 play a significant role. These technologies, when combined with remote sensing, 3D modeling, and other tools, facilitate the development of efficient and successful solutions. In addition, digital technologies stimulate inclusive and collaborative practices that encourage and foster knowledge and information sharing across all levels. In this perspective, the idea of adaptive reuse of built heritage presents a valuable opportunity for creating more sustainable, resilient, and inclusive urban spaces. Indeed, by adopting approaches that also focus on human beings, it is possible to reconnect the built environment with the communities it belongs to.

The construction industry has significantly benefitted from digital transformation, although this transition is not yet fully achieved, mainly due to the fragmented nature of this sector. However, the adoption of digital technologies has significantly improved the sector's productivity and competitiveness, as it directly influences every stage of a project's life cycle. In addition, by transforming the concept of collaboration and co-design, digital technologies pave the way to improve sustainability. The application of these concepts to the built environment through the recovery, regeneration, reuse, and restoration of buildings aims to enhance the quality of places and the well-being of citizens while also promoting environmental, economic, and social sustainability.

Digital transformation can act as a roadmap in regeneration projects, fostering a collaborative relation among the different participants (citizens, institutions, sector stakeholders) suitable for identifying the most appropriate solutions.

1.3 Community Engagement

Cultural heritage is a fil rouge that links past, present, and future. So, it is central to safeguard, recover, and reuse it to preserve all those tangible and intangible values to pass on to future generations [5, 10]. The conservation and regeneration of historic buildings positively influence the urban landscape, as it allows for the new life of both the buildings and the surrounding environment [12]. The regeneration of the built heritage, in fact, should have a significant impact on the environment and society [6, 13]. Recognizing the interconnection between cultural heritage and community, it is essential to consider the community as a key player in the decision-making process for its protection, enhancement, and regeneration [14]. The Leeuwarden Declaration and the Faro Convention provide recognition in this sense. The latter not only emphasizes the importance of protecting cultural heritage, defined as a "group of resources inherited from the past which people identify, independently of ownership, as a reflection and expression of their constantly evolving values, beliefs, knowledge, and traditions", but

also links it to the community, referred to as the "heritage community", with the goal of encouraging active engagement from society in its management [15].

The decision-making process allows for a holistic approach to various aspects related to the adaptive reuse of the built environment, ranging from the intrinsic value of the asset to its structural features, the surrounding context, and the needs of the community. The involvement of civil society and stakeholders thus becomes an important asset in project design, as it broadens the focus beyond purely technical issues [16]. Thanks to a collaborative process that fosters co-evaluation and cooperation and brings together the perspectives of industry experts and citizens, who, despite their differing experiences and skills, are both essential in identifying solutions suitable for the urban fabric [17].

1.4 Partnership Models for Built Heritage Management and Sustainability

The recovery of built heritage in a post-war or disaster scenario takes on significant importance from a cultural, environmental, and especially social perspective, as it symbolizes the identity of a community and a new opportunity for economic revival. Addressing the challenges of recovering built heritage requires adequate resources; moreover, for this to be effective, it is necessary to consider an additional aspect concerning its long-term economic sustainability and, consequently, the adoption of an appropriate management and financing model.

In this perspective, traditional financing models, mostly the exclusive prerogative of the state and public entities, may be inadequate and ineffective. It is necessary to resort to management models that involve multiple actors, as economic sustainability must cover the entire life cycle of the building from the recovery phase to management to the adaptive reuse of the asset.

Among the alternative models of management and financial sustainability to traditional ones are Public-Private Partnerships (P3), Public–Private–People Partnership (P4), and Public Private People Policy Partnerships (P5) [18–20].

P3s involve a collaboration between public and private entities, primarily aimed at providing funding for the construction, renovation, management, and maintenance of infrastructure or the provision of services. They allow access to private capital, generating revenue without burdening the public budget [18].

In P4s, the community is an active part of the partnership. This allows for greater community involvement in the recovery and long-term management of the asset [19].

P5s are characterized by the inclusion of the local political component [20].

The choice of one partnership model over another for the recovery and enhancement of built heritage cannot disregard the analysis of various aspects, including the political context in which the asset is located, the nature of the asset, the interest of the local community in relation to it, and the objectives that are intended to be pursued.

1.5 Paper Objectives

Based on previous studies [10], this paper aims to explore how digital technologies, community involvement, supported by appropriate management and sustainability models, can contribute to "re-generating" urban spaces in the aftermath of war or disasters,

through the implementation of specific projects, where the goal is to protect the built heritage and reduce environmental impacts by using co-design approaches to develop more resilient and aware urban spaces and communities.

This document aims to show that adaptive reuse of built heritage, when properly supported by digital technologies and participatory processes, can be an effective strategy for renewing and thus preserving memories of built heritage damaged by disasters or armed conflict.

The analysis of best practices for adapting historic buildings, especially those damaged by war, clearly supports this point.

After analyzing the background of the paper (Sect. 1), the methodology is presented (Sect. 2), best practices of adaptive reuse of the built heritage severely damaged during armed conflict are analyzed (Sect. 3). Finally, the results and discussion are presented (Sect. 4), followed by the conclusions and prospects for future research (Sect. 5).

2 Methodology

The objective of this paper is to analyze the importance of adaptive reuse of the built heritage with a focus on key aspects characterizing this type of intervention: the role of digital technologies, the role of communities, and the importance of identifying an appropriate management model in the co-design process.

The research methodology consists of two steps. The first phase, theoretical analysis, involves a literature review. The documents were searched on Scopus using the following keywords: “adaptive reuse” AND “built heritage” OR “built environment”. This has made it possible to identify the most relevant papers that have current evidence of adaptive reuse practices in the built environment. Additional supporting documentation, useful for an interdisciplinary analysis, has been collected from other libraries and online databases.

The second phase included the analysis of seven case studies that were considered to be particularly emblematic. These have been selected taking into account some particular aspects, such as the diversity of geographical and cultural contexts, the relevance to the theme, and the approach adopted in the recovery and reuse phase.

The selection of case studies aimed to highlight how in geographically and culturally distant areas the approach and motivations adopted in the recovery and reconstruction phase are very similar to each other and the relevance that the recovery of a given place has on the life of the communities.

For the analysis of these cases, other libraries and online databases were consulted.

The results of these two steps are presented in the following Sect. 3.

3 Best Practices of Adaptive Reuse of Built Heritage

Interventions aimed at the adaptive reuse of the built heritage are important because they allow for the prolongation of the life of buildings, regenerating spaces, and making them accessible and usable for future generations as well. Moreover, this approach additionally has the potential to generate new economic profits [21].

These interventions can include a variety of approaches, from conservation efforts to redevelopment projects, and may focus on specific elements of a building or encompass an entire site [22, 23].

Renovating, regenerating, and adapting the built heritage requires interdisciplinary skills to minimize the impact of interventions on it and ensure the safeguarding of its historical value, taking into account the context.

Protecting the built heritage and considering it a community asset can foster community well-being. Cultural heritage is fundamental because it stimulates both urban and rural regeneration, represents the identity and values of a community, and testifies to resilience against climate change, wars, and man-made damage.

Worldwide, the number of the built heritage abandoned due to obsolescence or as a result of disasters, conflict, climatic, social, and economic events is constantly increasing. To intervene and recover this vast building stock, it is necessary to develop approaches that contribute to improving the energy, technological, and structural performance of buildings, enhancing the remaining internal resources to mitigate the environmental, economic, and social impact of the interventions [21, 24].

Although the benefits of adaptive reuse of the built environment have been recognized, challenges persist in its successful implementation, largely due to the current planning and construction regulations. This situation also affects the relationship among stakeholders, institutions, and civil society, contradicting the principles stated in the Leeuwarden Declaration [25].

The choice of a new use in the adaptive reuse of the built environment requires a holistic approach, involving all actors: citizens, institutions, and stakeholders. This evaluation must take into account various factors such as, for example, the building structure and historical value, the needs expressed by the local community in order to ensure the good's adequate integration into the urban context, the possibility of attracting capital that can ensure its management over time, as well as the choice of materials [26].

3.1 Case Studies

The following Table 1, resulting from phase two explain in Sect. 2, presents some case studies that cover different geographical and cultural backgrounds. They are united by the brutality of the military actions that involved them and that led to significant loss of human lives and the destruction of a heritage of inestimable artistic, architectural, and cultural value. In these contexts, cultural heritage has been considered a true war target since it embodies a cultural identity that the belligerents believe must be obliterated. Despite the severe wounds suffered, local communities' will and determination, supported by international, local, and private financial contributions, the use of digital technologies, and the involvement of local and international stakeholders have enabled not only the reconstruction of what was severely damaged or destroyed but also the revitalization of emblematic places that are significant for local communities as well as for the entire international community.

Table 1. Case studies. Sarajevo, Bosnia and Herzegovina

Case Studies Sarajevo, Bosnia and Herzegovina	
Background	Sarajevo experienced significant destruction to its cultural heritage during the war (1992–1995). The National Library (**Vijećnica**) and other historic buildings and monuments were destroyed or severely damaged [27, 28]
Community engagement	The reconstruction of the library started in the aftermath of war. The collaboration among international organizations and the local community was strong. Citizens were part of the entire process and did not hesitate to express their disappointment regarding the decision to transform the public library into a city hall [28–30]
Digital technologies	Digital technologies have been particularly important for both preservation and representation itself; among them, 3D models and virtual reality (VR) were used to generate digital replicas of the building [31, 32]
Impact	Thanks to the collaboration between the local and international communities, international and local funding, and the use of digital technologies, it was possible to rebuild a place symbolizing history, culture, and resilience
Pristina, Kosovo	
Background	The Kosovo War (1998–1999) left deep wounds on the city and its infrastructure, especially on the National Library "Pjetër Bogdani" of Pristina. During the conflict, the National Library interior was heavily damaged and suffered extensive loss and destruction of documents [33–35]
Community engagement	The recovery of the National Library has been an ongoing process for several years since the end of the war. The local community, along with support from international organizations and experts, committed to the process of restoring the library [33, 36]
Digital technologies	Thanks to digital technologies, it has been possible to digitize the documents stored within the library, ensuring the protection of cultural and intellectual heritage, and to design restoration interventions for the building while respecting its original structures and simultaneously optimizing energy efficiency and safety [35, 37, 38]
Impact	This process was supported by several funding sources. The collaboration between international and local actors allowed for giving new life to the library. Thanks to these synergies and the application of digital technologies, new functionalities have been integrated, while preserving the building's historical worth, making it more sustainable and resilient
Aleppo, Syria	
Background	The historic center of Aleppo has been subjected to systematic destruction aimed at erasing its identity and cultural value during the conflict (2012–2016). Many historic buildings, symbolic sites, and traditional markets have been destroyed or irreparably damaged [39, 40]
Community engagement	Despite the commitment of the local and international community, considering the extent of the devastation, the recovery process in Aleppo is long and complex. Local community groups, supported by the international community and stakeholders, were actively involved in the city's recovery process and had a key role in defining solutions for cultural heritage restoration [39, 40]
Digital technologies	Digital technologies, such as photogrammetry and 3D models were used to map damaged areas and digitally preserve the city's memory, while GIS technologies have been employed to collect data on building conditions and plan targeted and sustainable interventions. Furthermore, digital twins of the damaged buildings and historical sites have been developed, making it possible to virtually reconstruct the city and assess the best recovery options [41–43]
Impact	Although Aleppo is still in the process of recovering, it is nonetheless a clear example of how community engagement, the application of digital technology, and adequate international and local funding can contribute to protecting and enhancing cultural heritage in post-war scenarios

(*continued*)

Table 1. (*continued*)

Case Studies Sarajevo, Bosnia and Herzegovina	
Homs, Syria	
Background	Homs is an important Syrian cultural center devastated by the civil war (2011–2014), which destroyed historic buildings, symbolic monuments, urban infrastructure, and service facilities. The extent of the damage caused by the conflict is enormous [44]
Community engagement	The recovery of the city, which began at the end of the conflict, has been slow and has had to adapt to the precarious situation in the country; however, NGOs and international organizations have been working with the local community to help rebuild the city. The participatory process involving citizens has represented a way to strengthen social cohesion and stimulate the community's sense of belonging [44, 45]
Digital technologies	Digital technologies have been a valuable tool for post-war reconstruction. Homs has benefited from the use of 3D models to analyze the degradation of buildings and simulate various restoration scenarios. Drones were employed to collect high-resolution images of the damaged buildings and to reconstruct digital models. Furthermore, a GIS system was developed to map the damage and plan the reconstruction efficiently [46, 47]
Impact	The initiatives and projects launched for the recovery of the city, funded by various national and international sources, have had a significant impact on the life of the community. Citizens' involvement and the use of digital technologies have made the process of reconstructing the city and restoring Homs as a cultural center and symbol of resilience after the conflict
Mosul, Iraq	
Background	Mosul, one of the oldest cities in Iraq, was the target of systematic and deliberate destruction of its cultural heritage by terrorist groups (2014–2017), becoming a symbol of devastation and destruction of Iraq's heritage [48]
Community engagement	The local community, supported by international stakeholders and both governmental and non-governmental organizations, has played an active and decisive role in all phases of Mosul's reconstruction. The projects and activities launched were numerous [48–51]
Digital technologies	Digital technologies, crucial in the reconstruction process, contributed to the documentation and preservation of the local cultural heritage. GIS, 3D digital models generated through photogrammetry, were used to map the entire site and create a detailed digital representation of the city and its heritage [52]
Impact	The participatory process was fundamental in restoring the cultural identity of the city the recovery and reconstruction of Mosul was made possible thanks to the substantial funds received from local and international sources. The combination of digitization and community participation has enabled the recovery of one of Iraq's most precious historical assets as well as to address the physical, psychological and social damage of the conflict
Kabul, Afghanistan	
Background	The National Museum of Kabul, which once housed one of the most significant archives of afghan cultural heritage, suffered severe damage during decades of conflicts (1990s) [53]
Community engagement	The recovery process of the National Museum has been marked by a series of initiatives and projects launched over the years that have highlighted the commitment and interest of both the local community and the entire international community, which have spared no effort in supporting activities for the recovery and restoration of the museum [53]
Digital technologies	Digital technologies have been widely used both to preserve collections and to make them accessible. Thanks to 3D photogrammetry, digital copies of the artifacts have been created, allowing restoration in case of future damage, while digitization has contributed to virtually preserving the heritage, creating a globally accessible digital archive, which is also useful for research [54]

(*continued*)

Table 1. (*continued*)

Case Studies Sarajevo, Bosnia and Herzegovina	
Impact	Digital technologies, the commitment of the community and the financial support received to fund restoration activities have allowed for the reconstruction of an important physical space for the city, while strengthened the sense of national identity that also comes from cultural heritage
Beirut, Lebanon	
Background	Beit Beirut (Yellow House) is a historic building located in the Sodeco neighborhood of Beirut. A strategic point during the Lebanese Civil War (1975–1990), it suffered severe damage due to its location along the Green Line that separated the Christian and the Muslim areas [48]
Community engagement	The restoration project, started in the following years, involved architects, historians, and the local community. These groups worked collaboratively to provide a genuine representation of the city's collective memory, defining innovative interventions that preserved the ancient forms while highlighting the wounds suffered during the conflict [48, 55]
Digital technologies	Digital tools adopted have played an important role in documenting the recovery process of the building and in its presentation, increasing visitor engagement and fostering a deeper understanding of Beirut's history [56]
Impact	The recovery of Beit Beirut, a symbol of resilience, made possible by local and international funding, has had a significant impact on the community. Digital technologies have represented an additional tool through which to engage the community, especially the younger generations, and reach a wider audience

4 Results and Discussion

Even though disasters are usually associated with armed conflicts or catastrophes that involve the need to rebuild cities or certain areas particularly affected by these events, radical economic, political, and social changes can also have similar effects and require a profound revision and regeneration of the territory.

The technology-community combination for the implementation of activities aimed at the adaptive reuse of the built heritage fosters a strong bond between the community and the places and, on the other hand, to assess and adopt the best solutions based on the community's needs in order to create an urban fabric more functional and smarter [2]. Thanks to technology, it is indeed possible to establish a digital connection between communities and the built environment.

The participation of the local community in the decision-making process is fundamental for preserving and improving the built heritage. So, it is important to carry out a stakeholder analysis to identify all those who will be actively involved in the project, as well as to define their level of involvement in the process.

Additionally, digital technologies play an important role as they facilitate interaction among all parties involved and help digitize heritage, making it accessible to a broader audience [3, 12, 57].

Digital tools may also be employed to mitigate the social repercussions of a disaster. They are very useful not only during the risk prevention and management phase but also in supporting the psychological and emotional aspects of the community following the loss of the built environment, contributing significantly to the recovery operations of the impacted areas [11].

Urbanization presents significant challenges in managing natural or man-made disasters, given the speed at which cities develop and grow. Planning smart and resilient urban

actions and environments is important to protect citizens, infrastructure, and cultural heritage.

Urban design and regeneration can involve bottom-up approaches because the aim of this type of design is strongly focused on the needs of users. Therefore, community involvement in a co-design process can contribute to the creation of more sustainable environments from an environmental, social, and economic perspective. The heterogeneity of the subjects involved in the co-creative process can therefore be a strength because it offers more perspectives and viewpoints, but at the same time, it can represent a weakness precisely related to this aspect. For this reason, communication and the tools used to convey information become the key to a shared language.

Furthermore, the choice of a partnership model, such as the P4 type (Public–Private–People Partnership), can ensure authentic and meaningful involvement of the local community, capable of achieving sustainable results and promoting social inclusion and a deeper bond between the community and cultural heritage [18–20].

In resilient cities, in addition to risk assessment, community involvement is also of particular importance, along with the use of digital technologies. The latter provide significant support in the process; on one hand, they facilitate communication, and on the other hand, they are capable of generating, collecting, and analyzing real-time data that can be shared among all the parties involved, improving predictive analysis and reducing response time in the event of a disaster and in post-disaster reconstruction. The involvement of the community and its participation in the co-creative and decision-making process of places and spaces, along with a co-evolutionary approach, enhances resilience even in the absence of catastrophic and/or alarming situations. Organizing the active participation of the community and its autonomy and resilience, along with access to data, information, and resources, ensures the social sustainability of citizens and a better response to local needs.

In this perspective, bottom-up urban planning is to be preferred over traditional top-down planning. This is valid both in the context of the adaptive reuse of a built asset and for the protection of cultural heritage in a situation of armed conflict or in post-disaster scenarios [10].

Cultural heritage defines a society's roots, values, historical memory, traditions, and identity. If not adequately preserved, regenerated, and adapted, time, conflicts, vandalism, and climate change have the potential to damage or wear down this heritage. Fortunately, it is now possible to safeguard the ongoing preservation of built heritage, as local and international communities have the appropriate resources to address these challenges.

Most of the studies examined emphasize the critical importance of two key factors that influence the success of built heritage preservation and reuse interventions: the role of digital technologies in the construction sector as tools for the protection and enhancement of cultural heritage, as well as tools capable of connecting all of the players in the process, and the importance of involving civil society in the decision-making processes.

Digital technologies thanks to an in-depth life cycle analysis improve decision-making processes, encourage collaboration among project stakeholders by facilitating the sharing of information and data, and support the design of effective solutions

and services. Digital technologies are considered essential for the planning, development, and redefinition of processes through a co-creative and collaborative approach among citizens, institutions, and stakeholders in order to address the transition towards sustainability and digitalization of urban spaces.

Although digital technologies are crucial for development and social inclusion, disparities in the presence and access to digital infrastructures and adequate training that can bridge the digital divide and provide all the necessary tools to achieve an adequate level of digital literacy still persist today, especially in the developing countries and in contexts affected by armed conflicts and disasters. This gap consequently deprives millions of people of the opportunity to actively participate in social life, with a negative impact that also reflects on education, healthcare, and the economy [59–61].

The aspect related to the involvement of civil society also highlights the close connection between cultural heritage and communities and the importance of sharing and participation in the decision-making process regarding the protection and/or reuse of built heritage, as defined in the Leeuwarden Declaration and the Faro Convention, so that interventions can have a positive impact from environmental, social, and economic perspectives.

To ensure the long-term success of recovery and adaptive reuse projects of built heritage, it is essential to establish a participatory governance model that should facilitate ongoing management and maintenance of the recovered asset while assessing the social, economic, and environmental impact connected to the recovery and reuse project over the short, medium, and long term. By adopting a partnership model supporting a bottom-up approach, it is possible to stimulate and improve citizen participation in social innovation processes, with the aim of finding solutions that are sustainable from environmental, economic, and social perspectives. This approach allows for addressing significant challenges by identifying potential gaps and needs already in the early stages of the co-design process in order to develop tailored strategies and interventions that meet the needs of local communities and to start the process of renewal.

Effective risk planning that incorporates digital tools and engages the community can significantly reduce the harmful impacts of a disaster on both lives and infrastructure. Involving the community at every stage of the disaster management process promotes resilience and accountability.

The integration of digital technologies, regulatory tools, and optimized participatory processes represents the ideal solution for creating virtuous pathways. In this way, the continuous exchange of information, data, cross-disciplinary skills, and resources can concretely contribute to addressing challenges.

The originality of the study lies in the interdisciplinary approach adopted, which has made it possible to analyze and relate various aspects relating to the protection of cultural heritage, especially in a post-war scenario, in order to make more evident the dynamics that drive a process of recovery and reuse of built heritage functional to the acquisition of knowledge useful for implementing adaptive reuse projects sustainable over time because effectively able to take into account the identity, the history, and the values of the places and peoples who live there.

The advancements that this study is bringing to the research field are mostly related to understanding, through the analysis of best practices, how adaptive reuse of built

heritage, when properly supported by digital technologies, can be an effective strategy for renewing and thus preserving the intrinsic value of built heritage damaged by disasters or armed conflict. The role of technological innovations alone is not sufficient to ensure the preservation of cultural heritage. Innovations are necessary; however, it is essential to operationally connect them (AI, ICT, nanotechnologies, etc.) with the humanities/social sciences.

Furthermore, participatory processes can play a fundamental role in preserving, over time, the memory of cultural heritage afflicted by conflicts or disasters. Actively involving local communities in the conservation and enhancement of symbolic places, thus allowing future generations to inherit not only the tangible history but also the emotional and identity significance of these assets that would otherwise risk being forgotten.

5 Conclusions

The adaptive reuse of built heritage is a key element, fostering radical innovation in various locations, also thanks to the use of digital technologies, with significant repercussions from an environmental, social, and economic perspective. This approach, in fact, allows for the protection of the environment by reducing natural resource consumption and waste production, enhancing existing community assets, and engaging the local population in a process of co-design, sustainability, and resilience, ultimately leading to cost savings.

Research has highlighted the importance of community and digital technologies in the implementation of this process, regardless of the specific context or asset addressed.

The case studies analyzed clearly show that, even in times of armed conflict and disasters, community participation and digital technologies are key tools for the restoration and adaptive reuse of historic buildings. Their combination, in fact, simplifies buildings restoration as well as contributes to restore historical memory and social cohesion in local communities, so contributing to overcoming the wounds left by conflicts.

Through adaptive reuse, it is possible to recover and pass on values and traditions, as well as the identity of the community to which the heritage belongs, to future generations. This strengthens the connection between the heritage and its citizens, fostering intelligent, aware, and resilient cities and societies that can effectively address and mitigate the impacts of potential disasters or conflicts.

Digital technologies not only facilitate the adaptive reuse of cultural heritage but also serve as essential tools for its protection, enhancement, and regeneration. With these digital tools, it becomes possible to collect, manage, and share data and information in real-time, offering all parties a comprehensive view of the entire process. Digitalization can also contribute to creating a virtual archive of cultural heritage and making it accessible to institutions, professionals, and the community. This accessibility is important for responding to catastrophic events or armed conflicts, and it also aids in evaluating how built heritage has evolved over the years, particularly in terms of adaptive reuse or energy retrofitting.

The community is another pillar of this process. A bottom-up approach enables the development of projects and interventions that respond to the real needs of citizens and are effectively integrated into the urban fabric. Furthermore, it fosters the creation

of synergies and enhances awareness, contributing to building an active and resilient community.

Due to the heterogeneity of the built heritage worldwide and the unique characteristics of its locations, it is not possible to define a standardized approach that can be replicated in every context, as well as it is not possible to identify a partnership model that is replicable in every context, but to identify, from time to time, one that, after careful planning, is able to ensure effective, sustainable, and long-term management of the built heritage. Therefore, future research and studies should focus on the interconnection between adaptive reuse, digital tools, and community active participation in the decision-making process in order to define new strategies and methodologies for making urban areas more resilient and citizen-friendly.

The next step of this research will consist of identifying calls and projects, both national and international, focused on the adaptive reuse of built heritage, to implement an innovative and participatory ecosystem that, through collaborative, co-creative, and multidisciplinary approaches, can foster the creation of a transnational network for sharing experiences and best practices. This ecosystem should encourage and promote innovation and social and digital inclusion, contributing to overcoming the digital divide and implementing sustainable interventions.

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