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Urban Heritage Resilience: An Integrated and Operationable Definition from the SHELTER and ARCH Projects

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Abstract: Resilience, initially a concept rooted in psychology, has traversed disciplinary boundaries, finding application in fields such as urban planning and development since the 2010s. Despite its broad application, most definitions remain too abstract to allow their practical integration into urban planning and development contexts. Addressing this challenge, the European research projects SHELTER and ARCH offer a practicable integration of resilience with planning and development practices surrounding urban heritage. Following a systemic approach to resilience, both projects integrate perspectives from urban development, climate change adaptation, disaster risk management, and heritage management, supported with tools and guidance to anchor resilience in existing practices. This paper presents the results from both projects, including similarities and differences.

Keywords: urban heritage; resilience; urban planning; climate change; urban development; sustainable urban development

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1. Introduction

Urban heritage is a system of tangible and intangible heritage, including dimensions of use and functions as well as communities and users. The ultimate purpose of urban heritage is to increase the quality of life of these communities and users [1]. This necessitates management approaches that integrate principles of sustainability and resilience. Sustainable practices, such as the preservation and adaptive reuse of historic structures, not only conserve resources but also diminish the environmental impact linked with new construction, contributing to a more sustainable urban environment. Additionally, embracing resilience in the management of urban heritage acknowledges the dynamic nature of communities and equips them to effectively confront and recover from challenges. Intangible aspects like cultural traditions and social bonds play a pivotal role in fostering resilience, fortifying the community's ability to withstand adversities [2].

While the concepts of sustainability and resilience have seen increased use in high-level strategies (see, e.g., ref. [3]) at international (e.g., refs. [4–6]), national (e.g., German Resilience Strategy [7]), and local levels (e.g., Rockefeller 100 resilient cities program [8], UN Making Cities Resilient Campaign [9]), the concept of urban resilience remains too abstract and lacks sufficient detail to be implemented on the operational level, hampering the development of tailored actions that go beyond abstract strategic goals. To make the concept of urban resilience more operationalizable in our cities, we need to better connect it to practices of urban planning and management while keeping a sufficient degree of universality to ensure replicability.

To implement such a necessary cross-sectorial concept of urban resilience, a common understanding of it is needed. From the range of different definitions that coexist, Meerow et al. provide a suitable starting point for further elaboration: "Urban resilience

refers to the ability of an urban system-and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales-to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity" [10].

The research question of this paper is as follows: How can a concept for urban resilience be described that is operationalizable and applicable in urban planning and at the same time reflects the various roles of urban heritage related to resilience? The paper aims to propose the frameworks developed in the European research projects SHELTER and ARCH as a concept with a medium level of detail and enough universality that can be communicated to the wide range of stakeholders that are part of the urban governance systems. These frameworks have been co-developed and tested together with municipalities and cultural landscapes from Europe as well as Turkey and have subsequently been adapted into a CEN Workshop Agreement by 22 European organizations.

2. Materials and Methods

2.1. Systemic Approach to Resilience for Urban Planning and Urban Heritage Management

A systemic approach is based on the understanding of the real world being organized in systems. Instead of focusing on singular entities, a systemic approach considers the dynamic, complex, and non-linear connections and interdependencies between the different elements of the system, implementing a far more complex but at the same time more realistic view of phenomena [2]. The governance in these complex systems must be multidisciplinary and different from more traditional unidisciplinary problem-solving approaches [11], e.g., via more adaptive approaches embracing uncertainty [12].

Other theoretical approaches to urban heritage are object-based (what LJ Smith (2006) has labeled the authorized heritage discourse [13]), which are more rooted in linear thinking and disciplinary approaches that focus on building materials and fabric. These approaches often do not sufficiently address the urban heritage context in terms of its social, economic, and other dimensions. In contrast, the systems approach acknowledges context, change, and the connection and influences between different parts of the system.

The term resilience can be traced back to the 15th century as a juridical term for the restoration of the original legal situation. It was not until the 19th century that it related to the physical qualities of the material to withstand something (psychology integrated the term only in the first decades of the 20th century and connected it with emotional/psychological stability, which was also linked to the concept of homeostasis) [14,15]. One milestone in the rise in the popularity of the term was a study that explored children from difficult families where the ability to deal with and overcome obstacles was described as resilience [16]. The systemic nature of resilience makes the concept highly transferable. In the second half of the 20th century, the term resilience was transferred to other disciplines such as biology [17]. Since then, resilience has been examined in family systems [18], food systems [19], education systems [20], soil systems [21], communities [22], and cities [23] (or even at a global scale, taking mankind into account [24]). Recent publications [25–27] have already linked cultural heritage with resilience and sustainability, mostly with a focus on disaster risk management. In this paper, we start with the core concept of resilience and explore definitions that can be used in specific heritage-related urban planning challenges as well as conservation scenarios.

There are different views of resilience as a vision from a systemic evolution lens and self-organization [28]. The work of Folke (2006) describes the evolution of the resilience concept from a linear engineering perspective, where the objective is to return to the initial hypothetical status, to a much broader, humanistic, and comprehensive one where the objective is the adaptation and transformation of socio-ecological systems to a more sustainable status [29].

The understanding of urban environments as socio-ecological systems (process-dependent, multidimensional, multiagent, multiscalar, and with self-organizing capabilities) has deep implications for their resilience enhancement, as it requires a change from

mechanistic and linear views to a more systemic vision of their resilience. The assessment of the resilience of urban environments must be conducted within the larger socio-ecological system, though the size of the systems and subsystems (defined by their borders, where it usually becomes interesting) can vary. This vision must jointly address specified and generalized resilience to not lose resilience in parts of the system or its subsystems [30]. Specified resilience is the ability of a socio-ecological system to address specific hazards or hazard combinations impacting specific components, usually addressed via technological–structural solutions. In this more short-term, system-intrinsic, and hazard-specific context, risk and vulnerability assessments can use direct quantitative and spatial approaches for prioritization and identification of specific "hot spots", making them especially beneficial for the protection of urban heritage (conservation-friendly resilience). Generalized resilience is the long-term, transformative ability to address all kinds of shocks and disturbances (including unknown ones) [31], usually also integrating "soft" social–cultural solutions. General resilience is a blurrier concept, dependent on the vulnerability of the system but also related to the development of adaptive, learning, and self-organization capabilities. As such, its quantitative assessment and operationalization is more difficult. But it can also act as a transdisciplinary bridge [10] that can unify the fields of disaster risk management, climate change adaptation, and sustainable urban development [32,33]. It can be suitable for a heritage-led resilience enhancement assessment (see, e.g., the ARCH Resilience Assessment Dashboard [34,35]), because of its focus on the transformation processes (how societies cope with uncertainty, adapt to new situations, and transform to new environmental, social, and economic conditions to make the new system more sustainable while retaining their identity). Addressing both concepts is important since practitioners tend to focus only on specified resilience, narrowing options for dealing with new hazards and shocks [10].

2.2. Sustainability vs. Resilience

Closely related to the concept of resilience is the concept of sustainability. Sustainability emphasizes the responsible use of resources and the creation of systems that endure over time, fostering a balance between present needs and the preservation of resources for future generations [36]. The relationship between sustainability and resilience lies in their shared goal of creating robust and enduring systems. Key differences between the concepts of sustainability and resilience can be seen in Table 1 [17].

Table 1. Comparison between sustainability and resilience ([17], p. 10.1).

Concept	Sustainability	Resilience
Background	Forest management. Example: 18th-century Germany.	Psychological resilience: the ability to bounce back from a stressful or adverse situation. Theoretical basis developed in the United States in the 1950s.
Objective	To maintain the overall natural resource base.	To make systems flexible enough to deal with changes without changing their principal character.
Definition	Premise: everything that we need for our survival and well-being depends, either directly or indirectly, on the natural environment. Process: to create and maintain the conditions under which humans and nature can exist in productive harmony, thereby enabling the fulfillment of the environmental, social, and economic requirements of present and future generations.	The ability of a system to respond flexibly to situational changes and negative factors without changing the essential state.
Type	Primarily linear	Dynamic system
Trend	To enable economic development without damaging the natural resource base.	To stimulate flexibility, adaptability, and risk-preparedness to deal with sudden or long-term changes.
Complexity	Fair	High
Level of integration	Semi-integrated	Integrated
Parameters involved	Limited number	High number
Implementation	Management and development plans, management mechanisms, etc.	New governance models. Change in attitude and values. Empowering communities. Prioritization of cross-cutting topics, initiatives, and developments

Despite their conceptual differences, sustainability and resilience represent complementary aspects of a holistic approach to address the complex challenges in socio-ecological–technical systems [37]. A sustainable system, by its nature, tends to be more resilient because it is designed to withstand changes, shocks, and uncertainties without compromising its long-term viability. Conversely, resilient systems often incorporate sustainable practices to ensure their adaptability and persistence over time. Together, sustainability and resilience form a synergistic framework that promotes not only the responsible use of resources but also the ability of systems to withstand, recover, and thrive in the face of challenges, thereby contributing to the overall well-being of communities and the planet.

2.3. Understanding Cultural Heritage for the Operationalization of Urban Resilience

Similarly to the concept of resilience, the evolution of the concept of cultural heritage and its management has deep implications for the operationalization of urban resilience. What we understand today as cultural heritage and how we use and connect it on a theoretical and practical level have significantly changed during the last few decades. Evolved from a focus on single buildings and built heritage, today, what we understand as cultural heritage has become different: "(...) 'heritage' (is seen) as a social and political construct encompassing all those places, artefacts and cultural expressions inherited from the past which, because they are seen to reflect and validate our identity as nations, communities, families and even individuals, are worthy of some form of respect and protection" [38].

With the professionalization of the heritage sector in the 20th century and the growing number of heritage assets (with new categories of cultural heritage), the concept and understanding of cultural heritage have changed significantly, acknowledging its complexity. There has been a shift from the traditional sectorial or one-dimensional approach to a new transversal, multidimensional, community-oriented, dynamic, and systemic approach that aligns different policy areas and resources [39].

This evolution in the understanding of cultural heritage has forced the evolution of the conservation of built heritage, together with the heritage sector: from protecting individual monuments to addressing complex historic environments, and from the interest in tangible heritage (with the minimum intervention as an objective) to conservation based on active participation (with priority to people's well-being) [40]. Therefore, nowadays, three different paradigms coexist in parallel with different but compatible focal points: preservation with a focus on authenticity, conservation centered on adaptive reuse, and heritage management with a focus on the meanings and experience (Ashworth, 2011). Janssen et al. also identified three different approaches that have emerged: conservation as a sector (silo-thinking where built heritage issues are different from spatial development), conservation as a factor (built heritage is considered as a resource), and conservation as a vector (built heritage is the starting point for sustainable spatial development). Although they have evolved separately, they are all equally relevant today [2,41]. As a result, the preservation of buildings and monuments can no longer be separated from their use and urban context [42], and a holistic and systemic understanding is required [1].

Parallel to this process, the role of local communities and practices like participation becomes more relevant [43]. A milestone was the adoption of the Framework Convention on the Value of Cultural Heritage for Society as it articulated a sea of change in perceptions and reframed the role of local communities and use values in heritage. The convention states that the objective of the conservation of cultural heritage is the "human development and quality of life" so there is "the need to put people and human values at the centre of an enlarged and cross-disciplinary concept of cultural heritage" ("Faro Convention" [44]).

This contemporary understanding of cultural heritage is comparable to the systemic approach and the theoretical concept of resilience [1,45,46]. Therefore, within this new paradigm, the operationalization of resilience in cultural heritage environments cannot be linear but a dynamic and iterative process influenced by forces across spatial and temporal scales where sustainable management of change is required, and the ordinary dynamics of historic environments must be combined with exceptional changes due to extreme events.

This systemic understanding of cultural heritage is consequently demanding planning and development concepts that are fully operationalizable within these systems and are not solely focused on material aspects of the conservation of built heritage.

2.4. Urban Heritage as a Resource: Operationalisation of Heritage-Led Urban Resilience

Urban heritage in the past has often been seen as an obstacle to resilience [15]. The interpretation of the role of cultural heritage in urban resilience as values that must be protected could be understood as an artificial limitation rooted in linear thinking approaches. The development of a more contemporary understanding of the role of cultural heritage allows the understanding of heritage as a resource for resilience, through a more comprehensive interpretation of their values, which considers not only traditional intrinsic or art-historical values but also community-based or use values [1,47]. Moreover, the contribution of cultural heritage to resilience must be considered as part of the intrinsic values of the assets regardless of their official status [17]. This contribution can be understood along four different axes: through design and construction; the use of appropriate materials; adaptive use; and factors in urban planning [15]. At the same time, urban heritage must be understood as a subsystem of the larger urban environment, including local communities, as well as functions and use [48], much more than a simple collection of (listed) built heritage. By acknowledging it as a system that includes users, uses, functions, etc., it is following a systemic understanding that is also present in the concept of resilience.

Historic environments are singular from a vulnerability and resilience perspective. They have inherent resilience characteristics that have been tested for centuries, which can trigger a cultural and natural heritage-led resilience enhancement, but also specific characteristics that make them more vulnerable to hazards and disruptions, which make conservation-friendly resilience necessary.

The following table summarizes some of the resilience characteristics gathered from the literature and their implications for heritage-led resilience in urban heritage (Table 2):

Table 2. Summary of characteristics describing the notion of resilience and their implications for SHELTER.

Characteristics of the Notion of Resilience	Literature	Heritage-Led Resilience
Robustness Strength	[29,49–52]	The survival of historic cities until modern times shows the capacity of these environments to recover from past disasters. The social memory and local knowledge resulting from this history have to be gathered and operationalized.
Flexibility Adaptability Adaptive capacity Learning capacity Autonomy Room for autonomous change Reflexivity	[3,15,29,49–54]	Historic environments are the results of evolution processes to adapt to the requirements of each epoch. The strategies to improve resilience must include and respect the result of these processes (local techniques, selection of materials and construction cultures) but they also need to learn from the flexibility and adaptability of changing conditions that create these results.
Living with uncertainty Social memory	[55–57]	Generalized resilience requires learning to live with uncertainty ("expecting the unexpected") and building a memory of past events to build the capability to learn from crises and disasters. Long-enduring urban environments have developed adaptations to deal with these disturbances, using social memory as a key part of the system's resilience.
Self-organization	[55,56,58]	During a significant part of their story, historic cities have been an example of urban self-organization. Like nature's cycles involving renewal and reorganization, the resilience of a system is closely related to this capacity for self-organization.
Diversity Variety Inclusive Fair governance Collaboration Social capital	[51–55,59]	In ecological systems, diversity provides the conditions for new opportunities in the renewal cycle so the diversity of stakeholders' partnerships and arrangements already created around heritage conservation can be used to bring a diversity of views and considerations into the discussion, expanding the role of information, education, and dialogue.

Table 2. *Cont.*

Characteristics of the Notion of Resilience	Literature	Heritage-Led Resilience
Cross-scale dynamic	[29,57]	Responses to challenges such as climate change and disasters require building cross-scale management capabilities, like the ones necessary for urban conservation.
Resourceful Efficiency	[15,51–54]	Historic areas have shown effective ways to construct and design functional urban environments with local and durable materials. New resilience strategies should manage the changing process to keep this identity, considering issues such as maintenance, life cycle, durability and compatibility of the materials, local construction techniques, etc., considering the singularity of cultural heritage's physical vulnerability framed in a broader concept of multidimensional resilience.
Intersectorality Integrated	[15,52]	Urban conservation policies and strategies always require integrated visions to include all the necessary competencies. The improvement of resilience in historic areas is going to need to continue with this tradition and include new departments and sectors in the decision-making.
Innovation Combining different kinds of knowledge for learning Interdependence	[51,55,59]	The cultural heritage field has always needed a combination of different kinds of knowledge. The focus on the complementarity of this knowledge can help increase the capacity to learn. Climate change and urban conservation can be used as an example to illustrate the potential contributions of local and traditional knowledge.

The operationalization of the urban resilience concept to close the gap between theory and practice has been one of the main objectives in the resilience literature of the last few years. Specifically, the resilience phenomenon in historic environments was until recently not effectively approached or even theoretically supported [60]. Resilience is a multi-faceted aspect, so a framework for its operationalization should address all the different dimensions of an urban system [28]. The first step to building a framework to make the concept of resilience operative for urban heritage is to identify the different layers to be considered. Parson et al. (2016) identified the following dimensions for urban resilience: social character, economic capital, infrastructure and planning, emergency services, community capital, information and engagement, governance, policy and leadership, and social and community engagement [50,55]. For historic environments in particular, these dimensions can be grouped as follows:

- Historic building environment resilience: How the historic building environment addresses disruption, affordable comfort, structural security through traditional techniques, vernacular architecture, and built/unbuilt environment relationships, and its relevance as a container and management unit for other cultural heritage scales (as movable cultural heritage).
- Cultural resilience: How historic areas address social inclusion and support social and technical innovation through cultural identity, local knowledge, intangible cultural heritage, and openness to exploring novel pathways.
- Social resilience: How individuals' physical and psychological well-being are addressed within the historic area; strong and healthy personal relationships, connection to culture and nature, and learning and sharing of new skills are enabled.
- Governance and institutional resilience: How links and partnerships are created and managed with support networks and across sectors (including public sector/government, research, and business).
- Economic resilience: How well the local and regional economic sectors can make use of competitive advantages as well as their ability to innovate, experiment, and restructure [61].
- Environmental resilience: How historic areas traditionally enhance biodiversity, cut carbon dependence, and create meaningful locally based livelihoods.

Table 3 shows the detailed link that the authors made between these themes of resilience and how they are related to the identified resilience dimensions:

Table 3. Themes of resilience and their relationships with natural hazard resilience according to [55]. HBR = historic building environment resilience; CR = cultural resilience; SR = social resilience; GIR = governance and institutional resilience; ER = economic resilience; ENR = environmental resilience); Green highlights = theme is connected to resilience dimension.

Theme Definition		Description of Theme	Relationship to Resilience	Urban Heritage Resilience Dimensions					
				HBR	CR	SR	GIR	ECR	ENR
Social character	The social characteristics of the community.	Represents the social and demographic factors that influence the ability to prepare for and recover from a natural hazard event.	Gender, age, disability, health, household size and structure, language, literacy, education, and employment influence abilities to build disaster resilience [62,63].						
Social and community engagement	The capacity within communities to learn, adapt, and transform.	Represents the social enablers within communities for engagement, learning, adaptation, and transformation.	Cooperation and trust are essential to building disaster resilience and arise partly through social mechanisms including social capital [56,64].						
			Behavioral change has a social and cultural context [65,66].						
Community capital	The cohesion and connectedness of the community.	Represents the features of a community that facilitate coordination and cooperation for mutual benefit.	Social networks assist community recovery following disaster [67].						
			Bonding, bridging, and linking social capital can enhance solutions to collective action problems that arise following natural disasters [68].						
Economic capital	The economic characteristics of the community.	Represents the economic factors that influence the ability to prepare for and recover from a natural hazard event.	Access to economic capital may be a barrier to resilience [69].						
			Economic capital often supports healthy social capital [63].						
Infrastructure and planning	The presence of legislation, plans, structures, or codes to protect infrastructure and ensure service availability.	Represents preparation for natural hazard events using strategies of mitigation, planning, or risk management.	Considered siting and planning of infrastructure is an important element of hazard mitigation. Multiple levels of government are involved in the planning process [70,71].						
			Planners can be agents of change in building disaster resilience [72].						
Emergency services	The presence of emergency services and disaster response plans.	Represents the potential to respond to a natural hazard event.	Emergency response capabilities and systems support resilience through the prevention, preparedness, response, and recovery cycle [73].						
Information and engagement	Availability and accessibility of natural hazard information and community engagement to encourage risk awareness.	Represents the relationship between communities and information, the uptake of information about risks, and the knowledge required for preparation and self-reliance.	Emergency management community engagement comprises different approaches including information, participation, consultation, collaboration, and empowerment.						
			Community engagement is a vehicle of public participation in decision-making about natural hazards [74].						

Table 3. *Cont.*

Theme Definition		Description of Theme	Relationship to Resilience	Urban Heritage Resilience Dimensions					
				HBR	CR	SR	GIR	ECR	ENR
Governance, policy and leadership	The capacity within government agencies to learn, adapt, and transform.	Represents the flexibility within organizations to adaptively learn, review, and adjust policies and procedures, or to transform organizational practices.	Effective response to natural hazard events can be facilitated by long-term design efforts in public leadership [75,76].				■		
			Transformative adaptation requires altering fundamental value systems and regulatory or bureaucratic regimes associated with natural hazard management [77].				■		■
			Collaborative learning facilitates innovation and opportunity for feedback and iterative management [54,78].			■			

A heritage-centered resilience vision should aim to be community-based, culture-driven, socially just, and economically viable while integrating local and traditional knowledge as well as local ecosystems and resources. Such a vision should reuse and adapt approaches from already more developed fields whenever possible, only developing new heritage-specific approaches when the singularity of urban heritage makes this mandatory. The following table shows the identified dimensions of resilience, suggestions for their operationalization from SHELTER and ARCH, and singularity in the cultural heritage of the dimension (Table 4):

Table 4. Dimensions and SHELTER approach.

Dimension	Suggestions for Operationalization	Singularity
Historic building environment resilience	Including the physical vulnerability of the historic built environment as a nested concept for general resilience, vernacular architecture as a catalyst of heritage-led resilience by capitalizing on its intrinsic characteristics, and considering the singularities of the built environment for conservation-friendly planning.	Very High
Cultural resilience	Considering tangible and intangible cultural heritage as key drivers in urban heritage resilience, fostering identity and sense of place, stimulating social cohesion through cultural activities and traditions, and safeguarding traditional knowledge and practices. Cultural diversity has the capacity to increase the resilience of social systems, since it is the result of centuries of slow adaptation to the hazards that affect local environments.	Very High
Social resilience	Considering social memory as a key part of historic area resilience. Vulnerable groups (elderly, migrants, children, disabled) are specifically considered and the gender perspective is transversal.	High
Governance and institutional resilience	Adoption of adaptive governance approaches that include cross-departmental, cross-sectoral, and cross-scale collaboration, increased community participation, and collaboration with relevant external actors (e.g., NGOs) and special interest groups.	High
Economic resilience	Foster the innovation and competitive advantage of the local and regional economic sectors while making use of local materials and practices, valorizing local knowledge of craftsmen and artisans, and incentivizing solutions from the local cultural sector.	Medium
Environmental resilience	Proposing circular approaches that reuse local materials and renewable resources and take advantage of the historic adaptation to local climate and circumstances.	Medium

2.5. Requirements for a Framework to Operationalize Urban Heritage Resilience

Based on the above analyses and comparisons, any framework aimed at operationalizing urban heritage resilience needs to take the multidimensionality of resilience and the social–ecological–technical system nature of urban heritage into account. Such a framework would also need to consider the long-term adaptive and transformative characteristics of a resilient system as well as the need to maintain and return to a functional state in the short term. The adaptive cycle [29,79,80] provides the ideal base for such a framework as it focuses on the dynamics of systems that do not have an equilibrium state, but repeatedly pass through four phases: growth and exploitation; conservation; collapse or release; and renewal and reorganization. Here, the shifts between phases can be the result of gradual changes or shocks. Urban heritage resilience then describes how an urban heritage system reacts to these changes and shocks as well as its long-term development path. It can be expressed in terms of a system's robustness and rate of recovery [81]. A system's robustness is determined according to its ability to absorb disturbances before losing its identity. At the same time, its rate of recovery can be expressed as the flexibility and the time needed to rearrange itself into a new stable state after a disturbance occurs (see Figure 1).

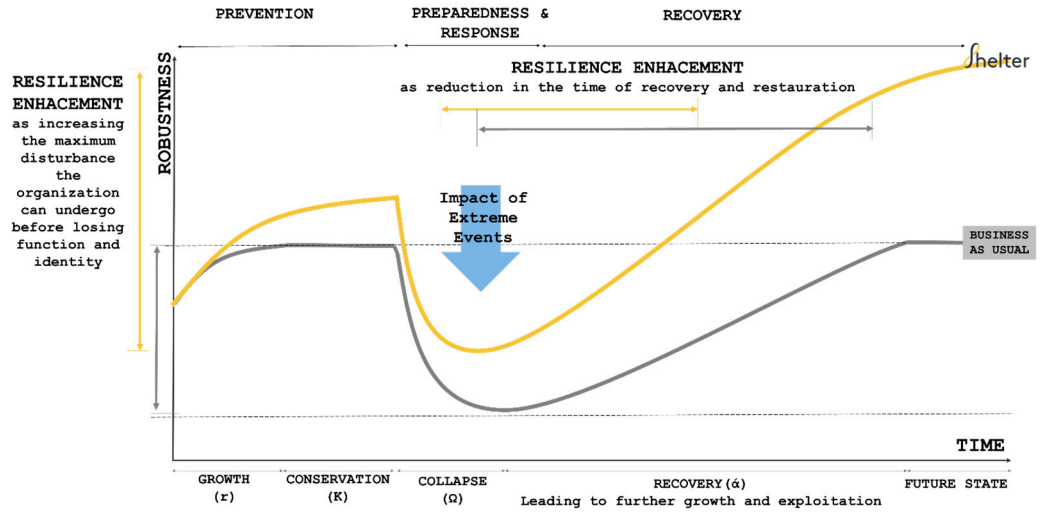

Figure 1. Enhancement of resilience as improvement of HA's robustness and rapidity (adapted from [81]).

It follows that a framework for urban heritage resilience needs to increase the robustness of the urban heritage system as well as reduce the time this system needs to recover and be restored, both under slow-onset stresses and sudden-onset disasters. Thus, it becomes evident that an urban heritage framework should combine an adaptation/prevention/preparedness cycle (as in climate change adaptation) and a response/recovery cycle (as in disaster risk management). To make such a framework operational, it requires the integration of suitable methods, tools, and strategies that positively impact urban heritage resilience in different phases of the cycles and consistently consider the different resilience dimensions.

3. Results

3.1. Urban Heritage Resilience in SHELTER and ARCH

Resilience in historic environments within SHELTER and ARCH has been defined in Table 5.

Table 5. Resilience definitions from SHELTER and ARCH.

Resilience in SHELTER	Resilience in ARCH
"[T]he ability of a historic urban or territorial system-and all its social, cultural, economic, environmental dimensions across temporal and spatial scales to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and use it for a systemic transformation to still retain essentially the same function, structure and feedbacks, and therefore identity, that is, the capacity to adapt in order to maintain the same identity"	"The sustained ability of a historic area as a social-ecological system (including its social, cultural, political, economic, natural, and environmental dimensions) to cope with hazardous events by responding and adapting in socially just ways that maintain the historic area's functions and heritage significance (including identity, integrity, and authenticity)."

Both definitions are complementary and acknowledge the multidimensional and cross-scalar nature of resilience in historic environments. These environments are seen as socio-ecological systems, requiring heritage-led resilience that leverages their inherent traits like self-learning, circular economy, and sustainability. Conservation-friendly resilience is essential to balance cultural identity preservation with adaptation to new needs. Responses must be socially just, addressing community vulnerabilities and power imbalances without worsening inequalities. Finally, resilience planning must consider different temporal and spatial scales.

3.2. The SHELTER and ARCH Frameworks

Both the SHELTER framework (Figure 2) and ARCH framework (Figure 3) provide integrated and operational approaches for urban heritage resilience. They are innovative in that both integrate the disaster risk management (prevention, preparedness, response and recovery) and climate change adaptation planning processes in complementary and mutually strengthening circular processes, answering calls for more harmonization between CCA and DRM at the policy level (see, e.g., refs. [5,82,83]). Their accompanying guidance and step-by-step instructions focus specifically on urban heritage and local knowledge as a valuable resource for resilience, e.g., to ensure a sense of place and foster societal resilience for the local community during and after a disaster, but also more practical solutions like the use of heritage buildings as cooling places during heatwaves. Together with accompanying tools, methods, and indicators (see below), this provides an innovative, comprehensive toolbox that can be adapted to local needs. SHELTER adopts the adaptive cycle approach to combine disaster risk management and climate change adaptation. It also links its framework with thematic areas relevant to urban resilience planning: existing data and knowledge, assessment and monitoring, tools, solutions, planning, and policies. The SHELTER framework is based on a matrix acting as a canvas that is the result of the intersection between the four phases of disaster risk management and the tools and mechanisms that support resilience building in historic environments. ARCH on the other hand is based on the cyclical structure of the DRM framework by Jigyasu, King, and Wijesuriya [84] and the climate change adaptation cycle of the Urban Adaptation Support Tool [85]. It consists of ten cyclical steps spread across three phases: 'pre-disaster', 'during', and 'post-disaster'. In addition, the ARCH framework acknowledges that the results of some steps might need to be revised in case of the occurrence of a disaster to facilitate the recovery process, i.e., ARCH integrates the adaptive cycle approach in a more indirect way than SHELTER.

The two frameworks advocate for conducting vulnerability and risk assessments both for slow-onset climatic risks as well as sudden-onset risks from, e.g., natural disasters. Based on these analyses, CCA measures, risk prevention and mitigation measures, and emergency response measures should be identified, assessed, selected, and implemented. Both frameworks also advocate for the establishment of a monitoring, evaluation, and learning framework, not just monitoring the implementation effort but also the progress of the combined DRM/CCA process, enabling a feedback loop of learning processes that allows us to adjust goals and processes. Lastly, both frameworks suggest a revision of the

results from the normal operating phase as part of the recovery after a disaster to account for the need to adjust information and actions identified under normal conditions with the post-disaster situation.

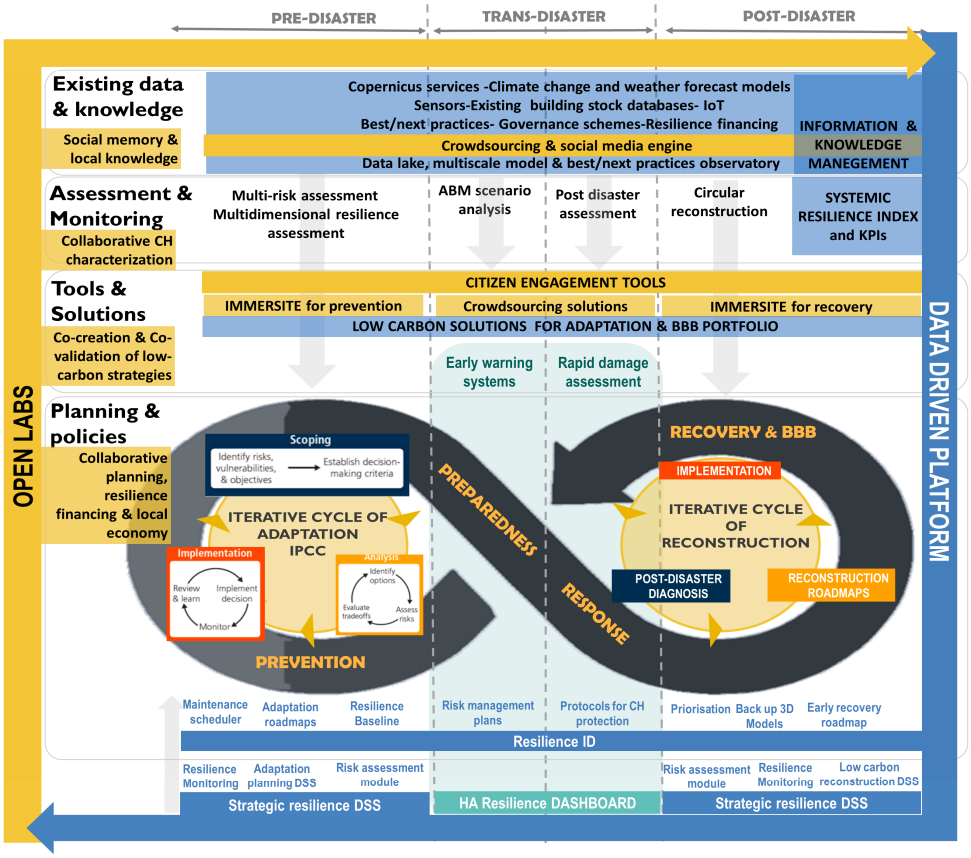

Figure 2. SHELTER operational knowledge framework.



Figure 3. ARCH resilience framework.

The SHELTER and ARCH frameworks were developed in an intensive co-creation process with municipalities and cultural landscapes. These processes started with a top-down literature review of existing frameworks, while in parallel, requirements from end users were collected in a bottom-up approach. Based on findings from both processes, prototypes of the frameworks were discussed with municipal stakeholders directly involved in the two projects. For ARCH, these included Bratislava, Slovakia; Camerino, Italy; Hamburg, Germany; and Valencia, Spain. For SHELTER, these included Dordrecht in the Netherlands, Seferihisar in Turkey, Serra do Xurés Natural Park in Spain, Ravenna in Italy, and the Sava River Basin. The process with local stakeholders from these areas included, e.g., discussions with municipal disaster risk management departments, heritage preservation departments, and urban planning departments. Feedback from these discussions was used to further refine the frameworks. Afterwards, the two frameworks were employed as the basis for the development of methods, tools, and indicators within the projects (see below), which were applied to differing degrees by the end users involved in both projects. For example, the municipality of Camerino conducted detailed risk assessments for their historic old town, based on risk indicators identified with the ARCH framework, to inform the reconstruction plan of the old town. In the SHELTER project, all the generated tools from the framework were co-created with the five case studies. Some of these tools, like the Resilience Dashboard, the Decision Support System, and the crowdsourcing solutions, were implemented in all of them to validate their replicability. Others were developed specifically through a co-creation process with some of the cases, such as IMMERSITE for the city of Dordrecht or the rapid damage assessment through satellite for the Sava River Basin and Serra do Xurés Natural Park.

In addition, the two frameworks provided the basis for a combined CEN Workshop Agreement (CWA) [86] under the participation of project partners and external participants. For each step, the CWA proposes requirements that decision-makers have to fulfill, recommendations that could be performed, indicators to measure progress in building resilience and supporting guidelines, tools, and standards that help to progress within each resilience-building step.

With their focus on a holistic process, SHELTER and ARCH integrate the notion of generalized resilience ("all-hazards approach") with specific resilience (assessing and addressing risks of specific hazards). More specifically, both frameworks advocate for the following:

- Proper data acquisition and management, system analysis, and scenario definition, including the identification and integration of multiple data sources (satellite, sensors, crowdsourcing, predictive models, statistic models) and existing knowledge (including local social memory regarding past events, best practices, and results) as the basis for any resilience-building process.
- Risk and resilience assessments that include direct and indirect impacts of events on cultural assets (i.e., from physical damage and degradation of sites to socio-cultural, environmental, and socio-economic dimensions) and consider sensitiveness, adaptive capacity, and exposure to a specific hazard or to a combination of multiple hazards.
- Identification and assessment of risk prevention, mitigation, climate change adaptation, and emergency response measures that take the need for urban heritage into account and allow for adaptive policy-making.
- Decision-making based on adaptation pathways that can include conservation-friendly multifunctional solutions such as the implementation of NBS and local solutions.
- Monitoring and learning processes, covering technical early warning systems as well as regular re-assessments and adaptation of plans, if necessary.

Across all these steps, SHELTER and ARCH require the implementation of community-based and heritage-led approaches that facilitate the effective collaboration of local, regional, national, and international stakeholders and increase the capacity of local communities to prepare for and react to a disaster. This includes suitable documentation strategies that allow relevant information, e.g., on pre-planned early recovery roadmaps in trans-disaster

and post-disaster phases, and codified social memory, i.e., local experience in dealing with past disasters, to be made available to a broad range of stakeholders. This also includes supporting stakeholders in being prepared for the challenges of climate change and natural hazards by collecting and exchanging best practices, lessons learned, and next practices in the field of urban heritage, increasing awareness and understanding of response options and interdependencies in a peer learning environment.

3.3. Further Operationalizing Urban Heritage Resilience Through Dedicated Tools

To further translate the operational aspect of the SHELTER and ARCH frameworks into actionable and context-specific strategies for urban heritage resilience, it is necessary to develop dedicated tools and methods for each step of the resilience-building process. These tools and methods need to facilitate the collection, analysis, and dissemination of relevant information and knowledge, the assessment of risks and resilience, and the strategic decision-making of stakeholders to allow a sensible operationalization of the all-hazards approach, i.e., prioritizing those risks of highest relevance for the local context. This should also include simplified guidelines and step-by-step guides for the operational level, including easy-to-use instructions for use during high-stress situations in the emergency phase. Both SHELTER and ARCH provided such tools and methods, the main components of which are the following:

3.3.1. Information and Knowledge Management

The models and data needed to make informed decisions around urban heritage resilience are not always readily available in a format that is usable for decision-makers. Data lakes and information management systems like the SHELTER Data Lake and the ARCH Historic Area Information System/Threats and Hazard Information System provide the basis to combine heterogeneous data (satellite imagery, sensor data, geo-environmental and social big data, existing building and disaster databases, and crowdsourcing). These systems require a multiscale data model to structure all information available at the local, regional, national, and European levels, ideally compliant with existing data models (e.g., INSPIRE). These information management systems for the state of the urban area and the hazards potentially affecting these areas need to be supplemented by databases that provide structured information on potential resilience-enhancing measures, including local and traditional knowledge from the communities, assessed for their cost-effectiveness, their potential effects on the heritage values, and co-benefits for climate change mitigation and sustainable development. Such databases are provided by the SHELTER portfolio and the ARCH Resilience Measures Inventory.

These information and knowledge management methods and tools provide the basis for all steps and phases (prevention, preparedness, response, and recovery) of resilience building.

3.3.2. Risk and Resilience Assessment

Improving the resilience of urban areas requires the assessment of specific (risk) and generalized resilience on multiple levels—from the building/structure level to the city/region level. Risk assessments need to be able to consider multiple, potentially compounding hazards, and support not only quantitative assessment (e.g., based on damage functions) but also expert-knowledge-based assessments, where quantifiable data are not available—which is often the case for cultural heritage, where the intrinsic value ascribed to the heritage by the local community needs to be captured. Resilience assessments on the other hand need to cover a multitude of topics, from organizational/governance aspects to financial capacities, training and education capacities, and heritage management perspectives. This requires an iterative, multi-stakeholder assessment approach that allows the incremental analysis of different aspects of resilience maturity as new knowledge becomes available. Both SHELTER and ARCH provide different but complementary approaches to these problems. In the SHELTER project, natural hazards and climate change

impacts concerning cultural heritage typologies were characterized using case study information. From this characterization, an indicator-based method was developed to establish a holistic assessment of social, economic, and environmental aspects through the hazard, exposure, and vulnerability-related indicators. This selection was performed by evaluating the alternative approaches of quantitative risk assessment, event-tree analysis, risk matrix approaches, and indicator-based approaches and prioritizing their holistic nature. This spatially explicit, multi-hazard, and cross-scale resilience assessment and monitoring system was implemented in the Decision Support System. ARCH, on the other hand, followed a semi-quantitative, indicator-based risk assessment approach, based on impact chains [87]—cause–effect models that describe the relationship between different hazards, the elements exposed to these hazards, their sensitivities and capacities, and how these lead to (cascading) impacts and subsequently to risk. These models are usually created in multi-stakeholder workshops, making use of the local expert knowledge, and are then quantified using indicator data provided by the information management systems. In the SHELTER project, the resilience assessment was addressed through the development of the Historic Area's Resilience Index, an easy-to-use tool for self-assessment. This methodology was based on indicators previously developed in the project, which were selected and prioritized by the case studies. These indicators were transformed into qualitative measures focused on assessing current capacities to identify strengths and weaknesses, thereby better focusing future improvement strategies. Since the indicators were not hazard-dependent, they were sometimes merged and generalized to be applicable to a broader range of historic areas with different characteristics, scales, and hazards. As a result, 44 qualitative indicators were proposed: 33 applicable to both cultural and natural heritage, 3 specifically addressing cultural heritage, and 8 specifically addressing natural heritage. The Resilience Index was included in the Resilience Dashboard, where end users can perform an assessment through a questionnaire, with results displayed in the form of graphs.

In ARCH, a scorecard approach was employed for resilience assessments, i.e., a structured online questionnaire for multi-stakeholder self-assessments. The core of the ARCH Resilience Assessment Dashboard (RAD) is 221 questions, categorized into ten overarching essentials—an adapted version of the Ten Essentials for Making Cities Resilient [9]—three disaster risk management phases, four topics (disaster risk management, climate change adaptation, heritage management, social justice), and six resilience dimensions (built environment, natural environment, economy, policy, society, and culture). Each question is answered on a 6-point Likert scale and supported by explanatory information, including potential stakeholders who have the information needed to answer the question. The RAD provides users with a score, which indicates their performance in the different aspects relevant to building resilience. By analyzing the results, users can identify weak points in the resilience of the historic area. Based on these results, users can formulate a list of actions for increasing resilience.

Based on the results from the risk and resilience assessments, resilience-enhancing measures need to be identified and collated into implementable action plans.

3.3.3. Strategic Decision Support

Once risk and resilience weak spots have been identified, suitable measures to address these weak spots need to be selected (e.g., from the SHELTER portfolio or the ARCH Resilience Measures Inventory). These measures need to be bundled together in a way that allows effective and efficient implementation and then be sequenced over time to allow for adaptive planning. SHELTER supports this by providing a strategic and spatially explicit decision-making tool (the SHELTER DSS [88]). The DSS combines the following:

- A multi-risk assessment module for diagnosis and prioritization (identifying "hot spots") based on the multiscale data model and the data lake.
- A DSS for planning adaptation and building back better that combines the information from the multi-risk module and the solution portfolio.

ARCH supports this process via the Resilience Pathway Visualisation Tool (RPVT), a web-based tool that allows users to visually construct implementation pathways for resilience measures, i.e., which resilience measures must be implemented in which sequence to raise the resilience to a certain level until a certain time. It also allows users to assess and compare alternative resilience pathways.

3.4. Changing Roles of Urban Cultural Heritage Throughout the Four Different Phases

On a global scale, cultural heritage is increasingly frequently affected by disasters (e.g., flooding, earthquakes, fire), and crises ranging from short to long term. Climate change is the most pressing and urgent crisis, but there are also economic crises or health crises [89–92]. The aims to respond to these crises vary according to their specific scope and nature. As we have already seen, the SHELTER and ARCH concepts of resilience are structured in four phases: prevention, preparedness, recovery and building back better. In each of the phases, different entities and processes are relevant to enhance resilience. The diversification of resilience into these four different phases considers the different contexts and different needs in each resilience phase, which can help to enhance the understanding of which expertise, decisions, skills, resources, etc., are relevant in each phase (and are not the same in each phase). Building on these four, the objectives and potential roles of cultural heritage have also been diversified (Table 6).

Table 6. Potential roles of cultural heritage in the SHELTER concept of resilience. Based on [91,92] and own considerations [2].

SHELTER Concept Phase of Resilience	Potential Objectives	Potential Role of Cultural Heritage
Prevention	Avoid disaster and crisis	Context/element of the scoping
Preparedness	Enhance preparation for potential disaster and crisis	Asset to be protected
Response	Emergency reactions	Resource
Recovery and BBB	Increase the quality of life for local communities	Resource

Table 6 shows the role of cultural heritage in the four resilience phases based on the SHELTER concept of resilience. This more refined understanding expands the often-used narrative that cultural heritage is only made of objects (mainly buildings) that are to be protected. Understanding the different resilience phases opens the door to new roles of cultural heritage. One role is a resource for resilience [15,93]; another one is often a major part of the context in which disasters and crises are happening. The role of context needs to be explored in more detail, but there are obvious relations like restrictions and limitations on the use of big emergency vehicles due to small/steep historic urban street patterns, for example, or limitations on the use of specific emergency technologies such as chemical fire extinguishers because cultural heritage could be harmed even if it is not affected by a fire in the first place. These described changing roles of cultural heritage well reflect the underlying systemic logic that is apparent in the SHELTER and ARCH concepts of resilience and in a contemporary understanding of cultural heritage [48,91,92].

4. Conclusions

Operationalizing urban heritage resilience necessitates an acceptance of a certain "fluidity", often seen in system-based approaches. These approaches do not have fixed and rigid boundaries but instead rely on perspective, timing, and context. Within these frameworks, urban heritage must assume different roles, ranging from an asset needing protection to a valuable resource for supporting resilience. This includes that the heritage sector needs to better comprehend and define its role concerning urban resilience and disaster risk management. While it is evident that disasters and transformations related

to urban heritage are becoming more frequent [2], awareness and understanding of the associated risks, processes, and responsibilities among site managers and heritage officers remain quite limited. Additionally, the variety of roles that cultural heritage can play in urban resilience—such as being a resource for adaptation or providing a sense of home and well-being by serving as a stable context during times of change and disaster—are often overlooked.

Frameworks aimed at improving the operationalization of urban heritage resilience need to acknowledge this contextual flexibility, treating urban heritage both as a resource and an asset to protect. Furthermore, these frameworks should allow practitioners a degree of freedom to tailor solutions to local contexts using system-based approaches. In this sense, urban heritage resilience can only be understood as a framework that builds on a general approach. To put it into practice, it needs to be adjusted, 'filled', and tailored to any specific context considering that every urban heritage is unique and intricately linked to 'other' parts of a heritage system like people, values, processes, resources, hazards, etc. This needs to include fostering community engagement and incorporating local knowledge as vital components. By involving local communities in the resilience planning process, practitioners can ensure that the measures implemented are culturally sensitive, socially inclusive, and widely supported. This participatory approach helps to build trust and cooperation, which are essential for effective resilience building.

However, this leads to increased complexity due to higher abstraction levels compared to systems with clearly defined borders, where solutions are straightforward. This complexity was evident in initial feedback on the SHELTER framework, which, in its published form, appeared intricate and challenging to communicate to decision-makers and urban practitioners. Despite this, once understood, especially its structure with four distinct phases, the framework has proven effective in practical urban planning and management scenarios [2]. The SHELTER and ARCH frameworks presented in this publication should not be understood as a regulation or blueprint but rather as ideas for a structured process which needs to be tailored to any specific case.

Given the flexibility required, the selection of methods and tools must be diverse to suit varying local contexts. As a result, practitioners must navigate a complex landscape of methods and strategies, each tailored to address specific aspects of resilience, further complicating the implementation process. Nevertheless, this should not lead to incompatibility among tools. Thus, there is a need for better harmonization of foundational elements (e.g., data, information, interfaces, methods) so that different tools can operate on the same foundational data depending on local circumstances and perspectives. These tools and methods need to be gathered, explained, and provided in a way that allows easier application by urban practitioners. This should include training, education, and capacity building to develop necessary skills and knowledge, clearly defining the roles of key players and stakeholders, and adjusting governance schemes accordingly.

The ARCH and SHELTER frameworks represent progress in this area but have been limited to real-world applications within European research projects. Despite their use in nine diverse pilot sites—each differing in size, hazards, heritage assets, and governance methods—these frameworks and their lessons now need broader application. They should be adapted as needed and consistently implemented across different local settings to become fully operational. This includes an exploration of how these frameworks could be adapted to urban heritage contexts outside of Europe, which can present different challenges of governance, hazards, and socio-cultural settings. Via collaboration with ICCROM, ICOMOS, and UNESCO, such an exploration would be possible. A first step in this direction has been taken through the participation of both projects in a scoping study conducted by UNESCO, ICCROM, ICOMOS, and IUCN aimed at developing a joint toolkit on climate action for World Heritage.

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