

A risk-reduction framework for urban cultural heritage: a comparative study on Italian historic centres

A DRP
framework for
urban cultural
heritage

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Abstract

Purpose – The purpose of this paper is to present and validate a large-scale methodology for risk assessment and management in cultural heritage sites, taking into account their specific tangible or intangible values. Emphasis is given to historic centres that are key resources in building resilience to disasters but are also highly vulnerable due to several factors, such as the characteristics of the built environment, the community and social life, the lack of risk awareness and maintenance and finally the poor regulatory framework for their management and valorisation.

Design/methodology/approach – The multi-step procedure starts from the assessment of the attributes of cultural heritage in order to identify priorities and address the analysis. Then, it evaluates the primary and secondary hazards in the area, the vulnerabilities and threats of the site and the impacts of the chain of events. Finally, it allows for calibrating a site-specific set of mitigation, preparedness, response and recovery measures.

Findings – The application to two case studies in the Italian peninsula, the historic centres of San Gimignano and Reggio Calabria, allows for identifying research gaps and practical opportunities towards the adoption of common guidelines for the selection of safety measures.

Originality/value – By providing a qualitative assessment of risks, the research points out the potentialities of the methodology in the disaster risk management of cultural heritage due to its capacity to be comprehensive and inclusive towards disciplines and professionals.

Keywords Cultural heritage, Disaster risk reduction, Resilience, Vulnerability, Historic urban landscape, World heritage, Management, Disasters

Paper type Research paper

1. Introduction

Italy is a country that preserves a century-old artistic and historical tradition, which is also recognised by the great number of assets listed as national heritage or world heritage sites (WHSS). The last decades have been characterised by a growing awareness of the necessity to

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safeguard and promote cultural heritage (CH), both tangible and intangible, located in hazard-prone areas (Paolini *et al.*, 2012; UNISDR, 2015; ICCROM, 2010, 2016; Stanton-Geddes and Soz, 2017). Emblematic examples of hazards impacting Italian WHSs are the flood in Florence (1966), the seasonal water level rising in Venice and the erosion of the Palatine Hill in Rome caused by heavy rainfalls (De Paoli *et al.*, 2020).

The occurrence of disasters and the subsequent damage to CH highlight that further work is still necessary to achieve the “preventive conservation” theorised by Brandi (1977) and later elaborated by Giovanni Urbani as “programmed conservation” (MiBACT and ICR, 1976). Key moments for the development of preventive conservation in Italy have been the Franceschini Commission (1964) and the *pilot plan for the programmed conservation of cultural heritage in Umbria* (1976). The first one extended the legislative notion of CH to a wider range of cultural assets and positively revised the funding mechanisms for heritage protection (Pallottino, 1987). Instead, the second aimed at understanding and managing risk of movable and immovable CH in a pilot area, thus assessing the vulnerabilities and exposure to several deterioration factors. As discussed by Lambert (2010), the proposal failed in the implementation phase due to political and administrative issues. However, an important step towards attaining programmed conservation is the “Risk Map of CH”, which was developed by the Central Institute for Restoration (ICR) during the 1990s (Baldi *et al.*, 1987). Today, the Risk Map has been adopted by “Vincoli in Rete” that is a geographical information system (GIS) containing information on the distribution of Italian CH, their state of conservation and potential indicator-based risk. Unfortunately, the system appears to be weak if proper planning is missing, and the main drawbacks are primarily linked to: (1) the punctual analysis of the individual CH units; (2) the limited range of risk-related indicators that provide an uncertain estimation and (3) the lack of attention to historical urban landscapes, such as historic centres, whose large-scale protection requires to include diverse source of data (e.g. urban planning) and cooperating with local and regional authorities. As such, the automaticity of risk calculation, however sophisticated it may be, cannot replace a conscious planning, the outcome of which is the result of a discriminating evaluation on data.

In spite of these efforts, the effects of the latest economic crisis and the consequent lack of funds affected the construction sector and significantly contributed to neglecting the conservation and maintenance of CH (ICOMOS, 2005; EP, 2007). This is even more relevant in historic centres where the great vulnerability and exposure to natural and human-induced hazards is causing their isolation and, often, their decline. In these areas, physical vulnerabilities are sided by socio-economic and socio-cultural vulnerabilities. The first ones are commonly related the lack of hazard-resistant design and the aging of buildings, while the others depend on the economy and the unique significance of the place to local people. In fact, most of the historic centres are under heritage protection law in Italy on account of their landscape value, intended as their capacity to witness territorial adaptation of human habitats and to host traditional activities (MiBACT, 2004). Therefore, it is necessary to adopt of a wider perspective and consider the great tangible and intangible losses caused by hazards affecting a greater number of historical settlements. In this regard, the 2009 and the 2016 earthquakes in Central Italy damaged and destroyed several urban centres, such as L’Aquila, Amatrice, Arquata del Tronto and Visso (Fragomeli *et al.*, 2018). Their recovery is still challenging due to the loss of social cohesion, cultural assets and urban fabric.

The need to adopt a holistic approach in territorial planning has been a crucial topic for environmental researchers ever since the publication of the pioneering studies of McHarg (1969). The author suggested to design with, rather than against, nature in order to produce compatible transformations with little negative impact. Conversely, urbanisation took place without considering the environmental features of the territory, such as landscape values or hazard factors (seismic zones, areas in hydrogeological instability), hence inducing or increasing risks. A critical reflection on the topic began in the 1980s, after the Irpinia

earthquake, when researchers introduced the concept of “urban vulnerability” and stressed the need for integrating land-use compatibility and risk reduction strategies in the ordinary spatial planning. Damage occurred to the whole historical urban landscape in historic centres, not only in single monumental buildings, collections and artworks. Starting from this awareness, the Minimum Urban Structure (SUM) has been proposed and adopted (Calabria Reg. Law n. 19/2002; Umbria Reg. Law n. 11/2005) with the objective to ensure the safety and recovery of the urban system (Fabietti, 1999). It is a methodological tool that analyses the vulnerability of a number of sub-systems corresponding to the main urban functions, such as the historical memory and identity, economic and productive and emergency systems. Although the SUM has the merit of having integrated the recovery of different sub-systems into a single methodology, it does not account for the stakeholders involved in the process and their management. Moreover, it does not provide suggestions on how to perform the vulnerability assessments, which is indeed a central problem when dealing with tangible and intangible CH.

In the last decades, the difficult post-earthquake reconstructions in Central Italy fostered the development of a national programmatic framework aimed at reducing the disaster risk on CH through a legislative approach. Although useful, regulations have often generated operational confusion and resulted in excessive bureaucratization overtime (Di Giovanni, 2016). Furthermore, the lack of a shared linguistic and procedural code among disciplines hindered the implementation of non-sectoral, effective intervention tools like risk management plans and projects. Efforts implemented by the Ministry for Cultural Heritage have seen the development of regional databases based on national guidelines, such as the Information System for Seismic Risk Assessment (SIVARS). The procedure allows for estimating the physical vulnerability of monumental buildings by means of three assessment levels, ranging from simplified to detailed investigations (PCM, 2011). The first-level approach (LV1) is based on simplified mechanical models for a qualitative investigation; the second one (LV2) consists in the evaluation of local collapse mechanisms by a kinematic analysis and the third one (LV3) encompasses global analyses of the whole building based on structural models. First-level approaches are suitable for territorial evaluations, but their implementation is difficult for historic centres. In fact, the high numbers of units and the presence of complex aggregates is critical due to the non-uniform and non-detailed knowledge of buildings. The need to improve the culture of prevention throughout the country in a structural way – and not only intervene in the emergency phase – has encouraged the foundation of the Casa Italia Department in April 2017. Among its activities, the Department promoted the creation of a large-scale institutional database to monitor the quality of the natural and built environment. A key output of the project is the Risk Map of Italian Municipalities (www.istat.it/it/mappa-rischi) that provides maps, data and indicators for the capillary identification of different risks at a territorial level (PCM and SMCI, 2017). Hence, the repository is useful to collect initial large-scale data, but it is not specifically targeted on CH assets. Despite the large number of actions promoted in the past years, only a limited number of research initiatives regarding historic centres have attempted to combine risk analysis, risk management, heritage studies and urban planning (Giuliani *et al.*, 2020; Cutini *et al.*, 2019; De Paoli, 2010).

Given this heterogeneous framework, this paper suggests a trans-disciplinary methodology capable to tackle the issue of preserving Italian historic centres and to foster their disaster risk management (DRM) and reduction (DRR). The concept stems from the proposals for the management of CH at risk developed by researchers and international bodies, such as UNESCO, ICCROM, ICOM and ICOMOS/ ICORP (Paolini *et al.*, 2012; Jigyasu and Vanicka, 2013). Emphasis is given not only to the material integrity of each heritage, but most of all to the preservation of its significance for the community. This aspect is embodied by the notion of “value” which is central in this work. In fact, the necessity to limit the loss of value determines a values-centred DRM of heritage assets that is linked to conservation

decision-making providing criteria for risk prioritization. The methodology has been applied to two sample historic centres in Italy, Reggio Calabria (Calabria) and San Gimignano (Tuscany).

2. Methodology

According to literature, the DRM is a cyclical process consisting of three phases: before, during and after a disaster (Alexander, 2002), corresponding to prevention, emergency and recovery procedures, respectively. When dealing with CH, prevention activities are the most important since they allow for limiting or avoiding the loss of integrity and authenticity (UNESCO, 2008). In the pre-disaster phase, the main actions concern the evaluation of risk in the site, the identification of a set of strategical measures and multi-level policies for risk mitigation and the improvement of preparedness of both communities and public services (Stanton-Geddes *et al.*, 2017; Jha *et al.*, 2013).

An integrated approach to disaster risk management of CH considers the possibilities of multiple hazards occurring in parallel or as result of interactions between various natural and human-induced events (Kappes *et al.*, 2012; Alexander, 2001). With reference to the built environment, risk is commonly evaluated as a mathematical probability that is a function of three main factors: hazard, vulnerability and exposure (Alexander, 2001; Covello and Mumpower, 1985; Di Miceli *et al.*, 2017). The complexity of a disaster situation is influenced by the combination of those three measures: hazards on the site can be either natural or human-induced; vulnerabilities are associated to the susceptibility to damaging and are categorised in physical, functional, socio-economic and political (Michalski and Pedersoli, 2016); exposure refers to all the human and material elements present in hazard zones that are thereby subject to potential losses. Literature on CH mainly refers to physical vulnerabilities that measure the liability to damage of buildings and infrastructures at different scales (national, territorial, urban, building) (Calvi *et al.*, 2006; Giuliani *et al.*, 2020). However, greater attention should also be given to the evaluation of socio-cultural values of CH, both tangible and intangible (EC, 2018), whose importance is fundamental for planning any intervention that fosters its capacity and resilience.

In this study, the assessment of risk is based on a qualitative procedure that allow for conducting a rapid characterisation and focusing on the management of the CH site (Michalski and Pedersoli, 2016). By including expert-based evaluations, it is possible to encourage the cooperation between risk analysts and heritage conservation practitioners. Furthermore, the quantification of losses or potential damage is commonly affected by uncertainties that may hinder the effective implementation of DRR actions (Alexander, 2001). In detail, the methodological approach for the resilience-oriented management of the two historic centres comprises the following steps (Figure 1):

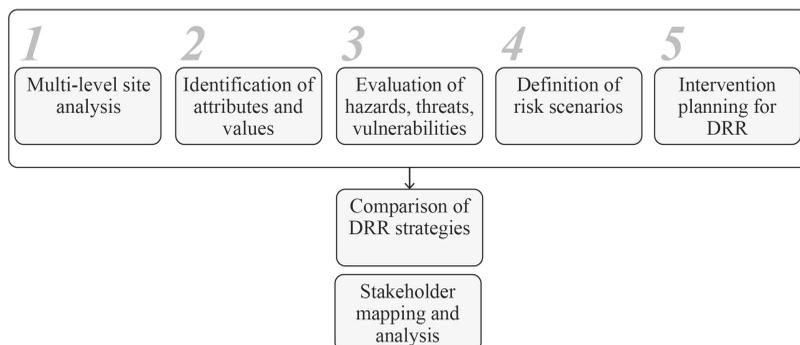


Figure 1. Methodological steps for the analysis and management of risks in CH sites

- (1) Multi-level CH site analysis;
- (2) Value assessment and identification of the specific attributes of CH;
- (3) Identification of hazards, vulnerabilities and impacts with reference to the set of exposed attributes;
- (4) Definition of a reference multi-hazard risk scenario;
- (5) Intervention planning for DRR and monitoring at all stages.

The first step of the methodology consists of a context analysis to characterize the site at the territorial and urban scales. The basic information that should be collected can be summarized in: (1) location and identification; (2) context analysis including topography, accessibility, services; (3) physical characteristics of the site, ranging from territorial to building features; (4) infrastructure and services, such as sewage, drainage, water supply, electricity, roads or visitor facilities. Moreover, the legal restrictions in the area, historical and constructive data should be incorporated into the investigation, combining different disciplines in order to base scenarios on realistic conditions.

The second step focuses on the CH and its values, starting from an in-depth analysis of the specific attributes of the site that contribute to its authenticity (Boccardi, 2019). According to the Venice Charter (1964) and the Nara Document on Authenticity (1994), the latter is intended as the “ability of heritage to convey the importance of its cultural significance” (UNESCO, 2004). The Nara Document recognizes that multiple aspects of authenticity include “form and design, materials and substance, use and function, traditions and techniques, location and setting, spirit and feeling and other internal and external factors”. The Nara Grid developed by Van Balen (Van Balen, 2008) can be adopted in risk studies for the definition of the most relevant attributes of the site. An attribute is intended as any well-defined part of the site with peculiar heritage value. Particularly, the grid evaluates two sets of features for each site: the “aspects” that are classified as in the Nara Document; and then the “dimensions”, namely the artistic, historic, social and scientific dimension.

The characterisation of hazards and the definition of threats and vulnerabilities for the risk scenarios are part of the third step. Firstly, the identification of the primary hazard on a site is associated to one or more secondary ones, according to a multi-hazard approach. In this phase, geological and hydrogeological maps of the site are key materials, as well as micro-zonation hazard maps reporting specific areas that are prone to various hazards (such as earthquakes, floods, cyclones etc). Moreover, information on past events and the complete history of natural and human-induced disasters are fundamental.

A single reference worst-case scenario or a set of critically selected scenarios can be developed starting from the analyses conducted in the previous steps. Scenarios are targeted on the attributes, and interventions are calibrated on the impact of the event on each attribute. In this way, the Nara Grid provides a prioritization criterion for the DRR strategy.

As part of the fifth step, risk mitigation measures are classified in three groups: (1) strategical and institutional, including the funding, education and networking activities; (2) technical, which are structural, non-structural or material measures; (3) management and planning, referring to organisational regulations or procedures to implement over time. Mitigation measures are selected starting from the comprehensive review conducted by Boshier *et al.* (2019) who offer suggestions to address the challenges related to the DRM of CH. Nonetheless, the set of measures proposed in this paper derives from the investigation of risk scenarios and is thus specific for Italian historic centres, eventually opening up possibilities to further develop local needs and agendas.

A case study approach has been applied to validate the methodology, considering two Italian historic centres. After the definition of site-specific measures for each case study, the

research examines and compares the two strategies in order to identify practical guidelines to inform future policies. Finally, the stakeholder analysis aims at identifying the heritage-related and planning actors of the decision-making process with the objective to guarantee the effective implementation of DRR measures. This process presupposes the involvement of individuals and organizations that have the right of decision and can play a role in the preservation of the attributes of the CH (Council of Europe, 2005).

3. Reggio Calabria and San Gimignano as case studies

This section presents the results of the investigation regarding two case studies: the historic centre of Reggio Calabria in the Southern Italy and the historic centre of San Gimignano in Central Italy. Each case study is analysed separately from stage 1–5, while a unitary discussion on the outcomes is proposed in order to provide preliminary guidelines. In this way, a comprehensive framework for DRR planning is hereby suggested for historic centres, pushing the body of knowledge forward.

3.1 *Historic centre of Reggio Calabria*

Reggio Calabria is the most populated and ancient city in the region, with archaeological traces of the II millennium BC and the first urban core dating back to the foundation of the Greek colony in the VIII century BC. The history of the city has been influenced by several seismic events that damaged most of the urban fabric. In fact, it is located in an area with high seismic hazard, along a system of active faults that follows the southern Apennines and reaches the eastern Sicily through the Strait of Messina. These faults originated several catastrophic earthquakes that hit Calabria overtime. After the 1783 earthquake (8 MCS), the reconstruction followed seismic-resistant design codes and plans based on the “chess board” planning rule. It introduced a design composed of rectilinear and perpendicular roads, squared open areas, markets along the longitudinal roads, buildings with a regular and right-angle plant. Furthermore, regulations aimed at (1) fixing the maximum height of buildings according to the width of nearby roads and to the number of citizens, (2) designing regular facades with small, lightweight balconies distant from the corners; (3) promoting the use of wooden elements or bricks and mortar load bearing walls. Further regulations have been adopted after the earthquake and tsunamis of 8 December 1908 that caused the loss of many built-up areas within the historic centre.

The historic centre of Reggio Calabria has been completely rebuilt after the earthquake but still preserves many original cultural assets, such as the archeological site, the Aragonese castle (15th century), several Art Nouveau buildings (first half of the 20th century), the Palazzo della Provincia (1920), Palazzo San Giorgio (1921), Villa Genoese Zerbi (1925), the Church of the Ottimates (records of the Byzantine–Norman period), the National Archaeological “Magna Graecia” Museum. The latter hosts one of the most important collections from Magna Graecia and the Bronzes of Riace (5th century BC). Other than tangible assets, the site is extremely important for the local community, and intangible values are associated to the closeness to the Strait of Messina Landscape and to the presence of traditional festivals, e.g. Madonna della Consolazione (Plate 1).

The main hazards in the area are earthquakes, tsunamis and fires, as emerges from the century-old history of Reggio Calabria. Despite having suffered many earthquakes and disasters, the historic centre still presents a complex vulnerability framework (Figure 2). Social factors are determined by the lack of awareness in citizens and emergency drills, even within civil protection actors. Besides, physical vulnerabilities derive from the unmanaged, continuous modification of buildings neglecting earthquake-proof rules and national laws. The uncontrolled alteration of buildings and urbanisation has not been sided by the corresponding development of roads and infrastructures, determining inefficiency in the



Plate 1.
Definition of attributes
for the historic centre of
Reggio Calabria

Historic centre of Reggio Calabria

<p>HAZARDS</p> <p>Primary: Earthquake High probability</p> <p>Secondary : Tsunami High probability</p> <p>Fire Low probability</p>	<p>VULNERABILITIES</p> <p>Illegal buildings - Buildings built without earthquake rules both in reinforced concrete or masonry - Additional volumes, alterations of structure and morphology of the building, use of incompatible materials - Lack of earthquake-resistant design in buildings</p> <p>Lack of maintenance on buildings</p> <p>Unsafe urban environment - Lack of accessibility - High-rise buildings and narrow roads - Presence of stairs, retaining walls, embankments, terraces - Concentration of strategic and critical buildings (schools, hospitals, military, religious, technological services, transport) - Occupation of public land - Lack of fire protection systems</p> <p>Social system - Lack of risk preparedness of people - Lack of risk awareness of local government</p> <p>Economic - Poor social class</p>	<p>IMPACTS</p> <p>On local people - Loss of lives</p> <p>On local and national economy - Loss of economic activities - Loss of jobs</p> <p>On local identity - Loss of social, artistic, traditional activities - Loss of arts and crafts skills - Loss of natural landscape</p> <p>On heritage assets - Collapse of historical buildings - Destruction of museums and collections - Loss of cultural heritage that is a symbol in local memory - Loss of urban identity as represented by public places for social life - Loss of road functionality and accessibility - Loss of integrity</p>
<p>EXPOSURE</p> <ul style="list-style-type: none"> - Monuments - Inhabitants - Museum and collection 		

Figure 2.
Characterisation of risk
factors for the historic
centre of Reggio
Calabria

waste collection systems, poor and incoherent urban mobility system, lack of public green areas and poor quality of urban fabric, both public and private. Nowadays, entire districts exceed the permitted heights and distance between buildings, with narrow roads and saturation of open spaces (De Paoli, 2012). From the economic point of view, the Calabria Region is among the last in Italy for per capita income, a low industrialization level and a very high youth unemployment rate. This weak economy of the Calabria Region is even more

critical in the light of the financial crisis that affected the entire country in the last decade. Any hazardous event would impact on this vulnerable situation in which little attention is given to the CH assets.

The worst-case risk scenario of Reggio Calabria considers the occurrence of an earthquake of 7.5 of magnitude originated in the fault in the Ionian Sea of Strait of Messina, the same of 1908 and an induced tsunami affecting the whole coastal area. The waves of the tsunami are estimated to be 13 m high; hence the whole coastal area is hit. Additionally, the breakage of pipelines causes fires in many areas. The earthquake and the tsunami are estimated to damage 90% of the historical buildings and to obstruct all the roads. Most of the CH attributes are hit by the events, particularly the Magna Grecia Museum and the Aragonese Castle, as well as the Art Nouveau buildings along the main road. Open-air archaeological sites are irreversibly damaged. The most damaged area is, therefore, the central part of the historic centre where most of the cultural attributes are concentrated.

Currently, risk reduction measures on CH assets in the area are limited and ineffective. The Civil Protection plan contains measures for the emergency management and the coordination of relief services, but it neglects the role of citizens and their awareness on risks. Hence, multi-level information campaigns should be introduced to raise awareness on a wider set of stakeholders, from local governmental officers to residents and reference communities. Due to the presence of schools and administrative activities into the historic centre, attention should be devoted to critical facilities and their accessibility for daily users, namely workers and students. The relocation of activities can be an option in the most dangerous cases. Further measures can be introduced with the specific objective to reduce the impact of earthquakes and tsunamis on CH assets and people along the coastal line. In this case, early warning systems are deemed to be effective solutions to limit damage within potentially flooded areas. It is also critical to ensure that modifications and new developments do not increase the vulnerability and exposure of people to risks. The “chess board” configuration of the historic centre should be preserved since it provides lower levels of urban vulnerability to earthquakes. In parallel, retrofitting interventions on historical constructions should be encouraged, with priority given to mansions and palaces.

3.2 Historic centre of San Gimignano

The historic centre of San Gimignano is located in Tuscany, and it is listed as a UNESCO World Heritage Site since 1990 thanks to its capacity to retain the medieval atmosphere and appearance. The declaration states that “the Historic Centre of San Gimignano is a cultural site of exceptional value, since it has treasured its architectural homogeneity and its original urban layout. The buildings within the town’s double wall provide a shining example of medieval architecture with influences of Florentine, Sienese, and Pisan styles from the 12th to the 14th century.” Moreover, the historic centre is under National conservation order, and interventions are subject to prior authorisation of the Office for Cultural Heritage (MiBACT, 2004).

The main attributes of the historic centre are: towers, squares, churches, historical walls and gates, Rocca di Montestaffoli, via Francigena, monuments and heritage-listed buildings. The evaluation of the attributes of cultural heritage represents a valid tool to prioritize the objectives of the analysis, addressing the risk characterisation and management. In fact, the scenario area has been selected on the basis of the attributes’ ranking, by focusing on the area with the most important church in San Gimignano, the collegiata or cathedral, with the nearby squares and the Rocca di Montestaffoli (Plate 2).

Nowadays, the town is vulnerable to disasters and prone to several hazards. Besides, the effects of increasing tourism and the related pressure on modifications to the traditional use of buildings pose relevant conservation and safety issues. Since the town is built on a

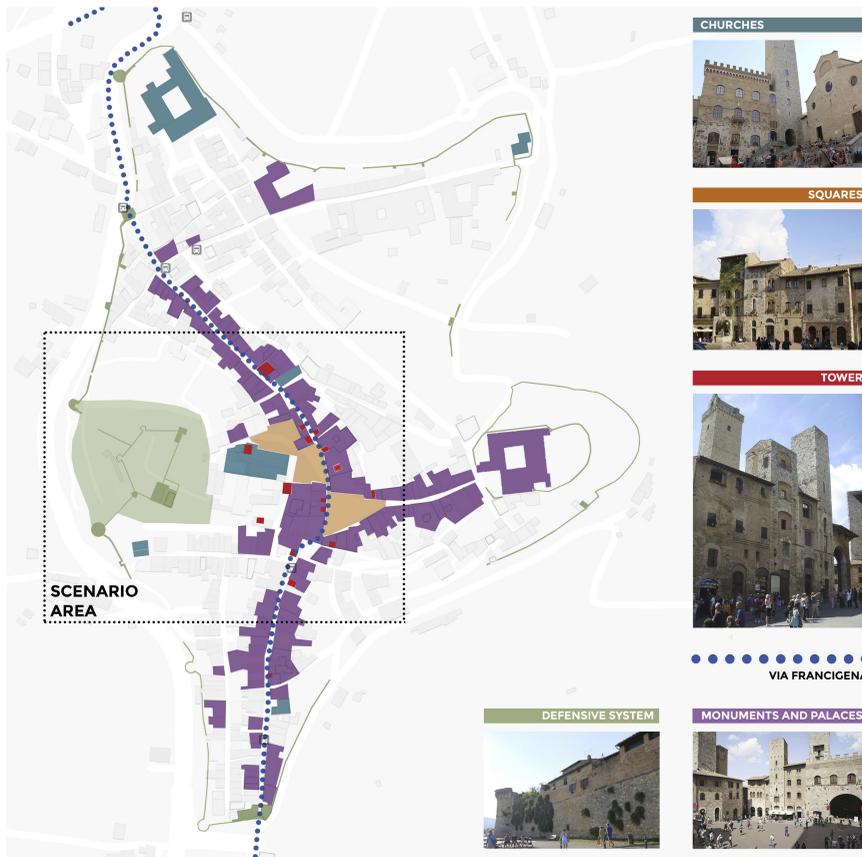


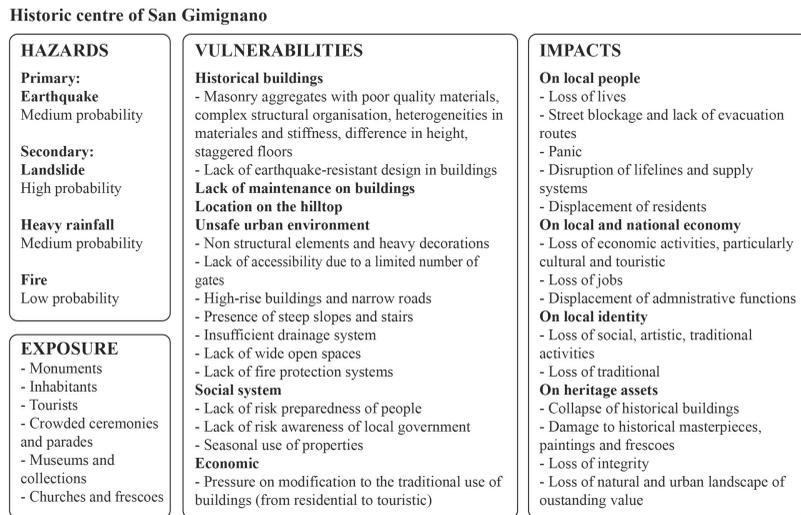
Plate 2.
Definition of attributes
for the historic centre of
San Gimignano

limestone rocks and sandy substratum, the main geological problem concerns landslides. In the eighties, two events damaged the Parco della Rocca and the Town Hall tower. More recently, in April 2018, the eastern side of the historic walls abruptly collapsed due to a landslide induced by heavy rainfalls. San Gimignano is in a seismic-prone area classified as zone 3, and 20 earthquakes have been registered in the area since 1804. Moreover, due to seismic amplification and local instability, landslides may be triggered by earthquakes, causing a chain of events that can be disastrous for the historic centre. Finally, many vernacular buildings in San Gimignano present wooden elements such as roofs, vaults, floors, decorations. Hence, fire may be induced by earthquakes because of burning candles, ruptured gas lines and arcing electrical wires.

Vulnerabilities are summarised in [Figure 3](#) and are mainly associated to the historical aggregation process of masonry buildings and to the lack of earthquake-resistant design. Moreover, the location on the hilltop, the limited number of gates and the presence of narrow streets contribute to creating a vulnerable built environment. Nevertheless, the main vulnerabilities depend on social factors, such as the lack of risk preparedness and the presence of a huge number of untrained visitors and tourists during summertime.

The risk scenario refers to churches and open spaces, that are deemed to be the most significant due to their tangible and intangible, movable and immovable heritage value. An earthquake of 6–7 MCS intensity strikes the historic centre during celebration of the

Figure 3.
Characterisation of risk
factors for the historic
centre of San
Gimignano



“Ferie Messium”, a medieval festival organized in June. During the historical parade, the narrow streets and open spaces are crowded and host stalls. Moreover, the earthquake activates several landslides on the hill and affects historical buildings: churches and towers are damaged, and the failure of masonry walls causes the fall of blocks. The frescoes in the Cathedral and the collections are heavily damaged. People are in panic and have difficulties in evacuating. At the meantime, fires spreads in the shops hosted in the first and basement floors of the buildings and in the streets where several electrical generators are used for the parade. Even though firefighters are onsite, the staff is not sufficient to manage the disaster and the backup needs 25 min to arrive from the nearest Fire Station.

Although earthquakes are hardly predictable, it is possible to reduce their impact preventing disasters as much as possible. The analysis considers the difficulties in retrofitting the buildings of the whole historic centre due to the presence of different property owners (municipality, church, privates) and the lack of in-depth large-scale knowledge of the built environment. Risk mitigation can be achieved by retrofitting the buildings considered as main heritage attributes, namely churches and towers. Given the great human exposure, especially in peak tourism seasons, the strengthening of historical facades should be promoted in order to limit the falling of debris, to avoid the obstruction of the narrow roads and to guarantee a safer evacuation. In this regard, a constant monitoring of historical buildings improves knowledge and can contribute to the safety assessment of CH. Risk preparedness is equally important and entails the organisation of local rescue teams to salvage CH (especially movable assets) and help vulnerable groups, such as elders and tourists.

4. Comparison and strategic proposals for DRR

The investigations on Reggio Calabria and San Gimignano highlight the site-specific characteristics, ranging from historical, vocational, urban, landscape and physical features of the historic centres and their peculiarities in risk analysis. Nevertheless, the historic centres present similarities in the risk characterisation and, most important, a common need to improve the risk management strategies taking into account heritage values and features. Attributes allow for decoding value of CH not only in its tangible aspects (i.e. form and design, materials and substance, use and function, traditions and techniques, location and setting)

but also in the intangible ones (i.e. spirit and feeling), representing the identity of local communities. Therefore, the evaluation of attributes in the earliest phases of the process is a key issue to engage stakeholders and to establish intervention priorities in the DRR strategy.

The case studies differ in the earthquake-related secondary hazards definition due to the different geography and topography of the territory. In fact, Reggio Calabria is a coastal site that might be hit by a tsunami; instead San Gimignano is located on a hilltop where landslides and soil instability might be triggered. The history of the two centres points to several disasters as resulting from natural hazards; however, there are a number of adverse events and threats like pests, pollution and climate change that are usually not registered but can also effect CH assets, either directly or indirectly. As such, a critical reflexion on the effects of these hazards might be a future development, thus including additional risk scenarios and integrating the subsequent DRR strategy.

In both the case studies, vulnerabilities are mainly determined by the following factors.

- (1) Physical features, namely buildings that have not been constructed to anti-seismic criteria or have not been retrofitted. In Reggio Calabria, illegal modifications in load-bearing structures have been frequent even in recent decades despite the occurrence of earthquakes had promoted an anti-seismic urban reconstruction. Instead, in San Gimignano, vulnerabilities depend on the old-century stratification of constructions that are organised in complex structural aggregates. Their vulnerability strongly depends on the quality of materials and the presence of in-plan and in-height heterogeneities.
- (2) Management deficiencies associated to the lack of maintenance and monitoring of historical buildings and architectural heritage.
- (3) Urban features, such as the concentration of strategic/critical functions, the presence of narrow roads and the lack of open spaces. In both the case studies, a number of historical buildings still host strategic and critical functions even though their safety is not always verified. In particular, emergency operation and coordination centres are established within the administrative functions, such as municipality offices and territorial prefectures. Additionally, the historic centre of Reggio Calabria hosts several schools that are considered as critical facilities for the emergency, given the high number of people into the building.
- (4) Narrow roads are critical because they can be easily blocked and hinder the evacuation of people. This is further compounded by the lack of open spaces that could serve as a meeting area during the emergency, when people have limited time to gather to safer place. Both the case studies are characterised by these vulnerable conditions. The medieval configuration of San Gimignano is a source of authenticity for the heritage site but also introduces critical vulnerable conditions. In fact, debris falling from damaged towers and historical buildings can obstruct the facing narrow and winding streets as well as cause injuries and casualties during earthquakes. In Reggio Calabria, the chessboard plan implemented for the post-earthquake reconstruction is generally efficient, but it tends to lose effectiveness in case of in-height modifications and volume additions. Besides, flood prone areas have been urbanised thus neglecting the tsunami inundation modelling into land use planning.
- (5) Social issues related to the lack of risk preparedness in resident population and capacity-building activities with key stakeholders.

Apart from these common aspects, there are site-specific issues that involve economic vulnerabilities and exposure. Reggio Calabria is characterised by a poor social class that is

not interested in or cannot afford the retrofitting of properties and buildings. This issue is amplified by a weak tax/reward regulatory framework at regional level that is not able to stimulate recovery and retrofitting processes. Territorial and local planning in the historic centre of Reggio Calabria has been largely ineffective and most importantly has not learnt from past disasters. As a confirmation of this, regulations allowed for adding balconies and floors, as well as using different materials in historical buildings. Moreover, the evolution of the contemporary city is growing without any disaster-proof plan and is reproducing the virtuous original chessboard plan that was characterised by a regular layout of straight and perpendicular roads, open spaces and built-up areas.

San Gimignano is strongly affected by the great number of tourists, the seasonal use of properties and the parallel abandonment by residents. These phenomena are causing modifications to the traditional use of buildings, thus exacerbating the functional substitution towards tertiary-sector activities. There is a relationship between these phenomenon and risk analysis. In fact, exposure in San Gimignano is deemed to be high because it comprises residents, tourists and visitors. Furthermore, the loss or damage to the urban fabric would result in huge economical losses due to the concentration of activities and jobs into the historic centre.

Despite the abovementioned site-specific issues, the comparison allows for identifying common intervention measures and generalise a framework for DRR in historic centres. The measures are listed in [Table 1](#) and classified in three groups (strategic and institutional, technical, management and planning), as described by the methodology. For each measure, several aspects are clearly outlined, namely the involved stakeholders, administrative levels and the estimated qualitative costs. Stakeholders can be identified within the institutional, public and private sector. Public and institutional actors include the governmental bodies (national, regional and local), the Cultural Heritage Office and UNESCO, the Civil Protection system, the fire and police departments, research centres, museum boards. Instead, private actors are local communities, private owners, parishes, interest groups, professionals, insurance companies and organisations (e.g. ICCROM, ICOMOS, and others).

Strategic and institutional measures aim to improve risk awareness on urban cultural heritage and risk preparedness in communities, as well as to support risk reduction in private heritage-listed properties. This group of measures promotes a change process that fosters the cooperation among institutional, public and private stakeholders at all levels. Costs range from low to medium because they mainly include human resources (e.g. institutions, voluntaries, and communities) facing a great organisational effort in managing stakeholders. Technical measures are directed towards the built environment, with attention to single buildings under threat. Interventions mainly concern the seismic retrofitting and the structural reinforcement on cultural heritage. Given the large scale of the problem, priorities are established by applying the methodology (step 2) and evaluating the attributes of the site. Technical measures involve local governments, the cultural heritage office that monitors the preservation of heritage values, professionals called upon to design interventions and insurance companies. This group includes more expensive measures due to costs relating to human resources, materials and equipment. Finally, management and planning measures ensure the availability of resources for the DRM in the historic centres, thus acting at local level. The group includes monitoring actions on the compliance with regulations and standards.

5. Conclusions

The paper aims to present and validate an integrated methodology for risk characterisation and management of CH sites. It is a qualitative data-driven approach to large-scale investigations that involves official urban and heritage repositories, hazard maps, historical

Hazard	Measure	Stakeholder	Level	Cost	
Strategic and institutional	E, Ls, F, T	Include cultural heritage into the specific DRM plans, i.e. "risk management plans for historic centres"	NG, RG, LC, CP, CHO	Mu, HC	M
	E, Ls, F, T	Establish, organise and train rescue committees for emergency evacuation of cultural heritage (especially movable assets) and sensitive groups (elders, tourists, children, ...)	LG, CP, CHO, Pa, Mb, C	Re, HC, Mu, Bu	L
	E, Ls, F, T	Launch public campaigns to raise awareness about cultural heritage, risks, and incentives for DRR	NG, CP, CHO, Org	Na, Re, Mu	M
	E, Ls, F, T	Capacity building with key stakeholders (parishes, museum staff, tourist guides)	CP, UNESCO, Org, Mb, Pa, Ig, C	Mu	L
	E, Ls, F, T	Guarantee annual inspections of private cultural heritage properties to collect and update information, documentation, and data	LG, CP, C, O	Na, Re, Mu, HC	L
	E, Ls, F, T	Promote the retrofitting of private properties by means of incentives and funds	NG, RG, LG, P, C, O, I	Na, Re, HC	M
	E, Ls, F, T	Establish private-public partnerships and launch fundraising campaigns for ordinary and extraordinary activities	Mb, Ig, Org, C	Na, Re, M	L
	E, F	Engage communities for the drafting and adoption of special regulations for public celebrations	LG, CP, CHO, FP, Ig, C	Mu, HC	L
	E, F	Retrofit and reinforce monuments, towers, churches, and palaces	LG, CHO, Pa, O, P, Mb, R, P, I	Bu	H
	E, F	Ensure the safety of non-structural elements (e.g. chimneys, decorations, lamps, etc)	LG, CHO, O, Pa, P, I	HC, Bu	M
Technical	F	Improve fire protection measures	LG, FP, CHO, R, P, O, Ig	Mu, Bu	H
	Ls, T	Improve the drainage system and reinforce the retaining walls	LG, CP, P	Mu	M
	E, Ls	Promote the adoption of traditional construction methods and compatible techniques	LG, R, P	Re, Mu	M
	E, Ls, F	Implement regular maintenance of buildings, routes, and equipment	LG, O, C, Ig, I	Mu, HC, Bu	H
	E, Ls, F, T	Provide emergency kits and identify storage areas for the equipment	LG, CP, FP, C	Mu	L
Management and planning	E, Ls	Schedule regular monitoring of buildings and retaining walls	LG, CHO, R, P	Mu	M
	E, T	Identify evacuation shelters and storage areas for CH	LG, CHO, CP, Mb	Mu	L
	F, T	Implement early warning systems	LG, CP, R	Mu	M
	E, F, T	Promote adaptability of uses/functions in underperforming (from the structural or emergency viewpoint) buildings subject to relocation	RG, LG, CP, Ig, P, I	Mu, Bu	M
	F	Promote regular inspections to verify the compliance with fire safety standards of commercial activities (smoke detectors, fire extinguishers, evacuation routes, fireproof materials)	LG, CP, Mb, Pa, FP, C, Ig, I, O	HC, Bu	M

Note(s): Earthquake = E; Landslide = Ls; Fire = F; Tsunami = T
 Local government = LG; Regional government = RG; National Government = NG; Cultural heritage Office = CHO; Civil Protection = CP; Fire and police department = FP; Communities = C; Interest groups = Ig; Professionals = P; Parishes = Pa; Owners = O; Museum boards = mb; Research centres = R; Insurance companies = I; Organisations = Org
 Municipality = Mu; Historic centre = HC; Region = Re; Nation = Na; Building(s) = Bu
 Low = L; Medium = M; High = H

Table 1.
Matrix for DRR in historic centres: hazards, intervention measures, stakeholders, administrative levels, and qualitative costs

knowledge and fieldwalking surveys. As such, the methodology is inclusive towards existing databases and proposals and promotes a holistic vision to DRR planning by bridging disciplinary gaps. In particular, it could be the missing connection between the Risk Map of CH and the SUM, thus encouraging the application of preventive and programmed conservation policies. In fact, the application of the proposed framework might allow for overcoming several limitations of previous proposals. Firstly, the single-asset analysis proposed in the Risk Map of CH is overcome by extending the field of actions to the entire historic centre, which must be protected as a whole and not only in its singularities. This is even more important when dealing with multi-hazard risk scenarios that include induced vulnerabilities and second-order effects on the physical, environmental and socio-economical aspects. Secondly, the clear definition of values proposed in this work could be the basis for focusing the SUM on historic centres, thus overcoming the general concept expressed by the “historical memory and identity” sub-system.

The procedure is divided into several steps and emphasises the multidimensional value of the cultural assets. In particular, the second step evaluates the specific attributes of the CH site that contribute to its authenticity, in accordance with the Nara Grid and the guidelines of International bodies. Starting from the recognition of the value of each single asset, we can consider the historic centre as a large-scale group of values that are precisely decoded. This phase is certainly one of the key points of the methodology since it allows for prioritising interventions and it guides the development of the subsequent analyses.

The following steps consist in the evaluation of hazards, vulnerabilities and exposure of the site under investigation and therefore in the formulation of the most likely risk scenarios on which mitigation measures are targeted. Although it is a rapid and qualitative methodology, it has the advantage of integrating several topics in a multidisciplinary comprehensive framework. In particular, it includes the risk evaluation based on a worst-case scenario, up to the risk management that encompasses the selection of the most effective prevention, preparedness, response and recovery measures.

The methodological approach was validated through its direct application to two historic centres of the Italian peninsula, Reggio Calabria and San Gimignano. The results provide further evidence of the necessity to conduct pre-disaster analyses and develop DRM plans to reduce any potential impact of hazardous events on heritage sites. In spite of the specific features of the case studies, there are a number of common issues regarding vulnerabilities and exposure. Besides, the comparison between the DRR strategies provides the opportunity to suggest a series of intervention practices for historic centres within a generalised model. The proposals are guidelines serving as a trace that site managers and practitioners can follow to reduce risks while keeping in mind the actual site-specific problems and respecting the genius loci (places, local characteristics and identity).

The effectiveness of the procedure, however, relies on the capacity of analysts to interpret initial data whose availability and reliability is paramount. Consequently, a positive contribution would derive from the refinement of data and the deepening of their detail level, for instance by conducting seismic micro-zoning studies and seismic vulnerability analyses of structures, or by developing repositories on human exposure. This information affects the designation of risk scenarios and the localisation of interventions but does not undermine the validity of the procedure and the risk management guidelines. A broader range of risk scenarios would allow for defining a more robust multi-hazard approach to DRR. However, the overall methodology is effective thanks to its adaptability to different scales and contexts, responding to the common need for an integrated, shared and rapid methodology for reducing disaster risks in cultural heritage sites.

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