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a cura di Guido Driussi e Zeno Morabito

PREVENTIVE CONSERVATION OF EARTHEN BUILDINGS: MULTI-DISCIPLINARY INTEGRATION OF RISK ASSESSMENT FORMS

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Abstract.
Earthen vernacular architecture is the successful result of centuries of progressive improvements and adaptations to local construction culture in response to environmental conditions, the availability of local resources, and social constraints. Unfortunately, nowadays, this heritage is threatened with extinction everywhere. Preserving and transmitting material evidence, as well as technical knowledge, are the fundamental actions needed to safeguard the vernacular constructive culture and its values of civilisation. The Enhance VERnacular EARThen Heritage (EVER EARTH) project intends to use a multidisciplinary approach to analyse the situation in Piedmont region 20 years after the adoption of the Law 2/2006 enacted to foster conservation and recovery of earthen vernacular heritage. The project aims to evaluate the results of the measures implemented and capitalise on them. It also aims to thoroughly study the risks to which earthen heritage is exposed, and outline strategies that can contribute to the effective protection and enhancement of vernacular architecture and the rural landscape. This paper discusses the issues that emerged during the analysis of natural and anthropogenic risks in earthen buildings, identified during field surveys and data processing. Furthermore, it proposes an integration of existing risk assessment forms to consider both natural and anthropogenic risks, along with specific characteristics of earthen buildings.

Keywords: *earthen buildings, natural and anthropic risks, forms integration, multi-disciplinary approach*

1. Introduction

Earthen vernacular architecture is the successful result of centuries of progressive improvements and adaptations of local construction techniques in response to environmental conditions, the local resources availability and social constraints. Unfortunately, nowadays, this heritage is threatened with extinction everywhere.

The fundamental actions needed to safeguard vernacular construction culture from natural threats (such as water and wind erosion, earthquakes, etc.) are preserving and transmitting material evidence and technical knowledge through the identification of sustainable/compatible intervention methods. However, to fully pursue conservation, these actions must necessarily be preceded by the recognition of the cultural and environmental values inherent in this heritage, in order to also protect it from anthropogenic risks such as abandonment, a reluctance to maintain it, inappropriate interventions and reuse, and people's perceptions. The recovery of traditional vernacular architecture is currently playing a central role in the conservation of built and landscape heritage. As numerous studies have highlighted[1], this type of architecture is deeply rooted in its territorial context and also represents a significant source of knowledge and potential in terms of environmental sustainability. Within this framework, the *VerSus project* has identified fifteen parameters related to environmental, sociocultural, and socioeconomic sustainability[2].

Fig. 1 and 2. Two examples of earthen buildings: to the left, an adobe building in Calosso (Asti province), to the right a rammed earth farm in Pozzolo Formigaro (Alessandria)

These parameters provide analytical tools for studying cases of vernacular architecture and guidelines for contemporary architectural practice. The conservation of vernacular architecture therefore contributes to preserving cultural identity and promoting sustainable building practices. Moreover, in light of the

[1] Mileto 2021

[2] Correia *et al.* 2014

significant threat posed by climate change and resource depletion, it is essential to understand how to optimise the use of local natural resources and design buildings that do not depend on the exploitation of the planet or the transportation of materials over long distances[3]. This also obviously affects the widespread earthen vernacular heritage all over the world, including Italy with its evidence in Piedmont (fig. 1 and 2), Sardinia, Abruzzo, Marche, Calabria, Veneto, Basilicata. The Enhance VERnacular EARThen Heritage (EVER EARTH) project intends to use a multidisciplinary approach to analyse the situation in Piedmont region 20 years after the adoption of the Law 2/2006 enacted to foster conservation and recovery of earthen vernacular heritage.
The project aims to evaluate the results of the measures implemented and capitalise on them, but also to study in depth the risks to which earthen heritage is exposed and outline strategies that can contribute to the effective protection and enhancement of vernacular architecture and the rural landscape. Current risk assessment forms, already studied and set up by different bodies and institutions, include the analyses of natural risks (seismic, meteorological-hydrogeological) and the state of conservation of the building as a whole and of individual architectural elements. However, the anthropogenic risk associated with abandonment, lack of maintenance, incompatible interventions or acts of vandalism, is not adequately considered and recognised[4], nor is the sociological aspect relating to the perception that owners and local administrations have of this heritage. Moreover, the quantification of damage caused by continuous variations in climatic parameters and air pollution, and the assessment of climate change's impact on built heritage, has produced models and tools that must be applied and tested in situ to quantify cumulative damage. Unfortunately, these models and tools have not yet been widely adopted in practical applications or decision-making processes[5].
Furthermore, the forms used for seismic risk assessment are often calibrated for stone or brick buildings (GNDT, Famive, etc.) and do not consider the specific characteristics of earthen buildings. In this regard, the research aims at proposing an integration of the risk assessment forms already in use so as to foster a more effective risk analysis, considering the specific issues affecting the earthen heritage.
Given the work-in-progress nature of this project, this paper primarily aims to present a methodological approach to the conservation of earthen architecture.

2. Risk assessmenpocat analyses on earthen heritage

In recent years, risk analysis and assessment applied to earthen heritage have taken on an increasingly important role in scientific and operational debate[6], although they

[3] PIESIK 2023
[4] CARUSO 2024
[5] BONAZZA 2023
[6] MILETO *ET AL.* 2025

remain characterised by an uneven distribution of protection practices. The literature identifies a number of recurring risks affecting this heritage: abandonment, replacement, interventions with inappropriate materials, lack of maintenance, and poor cultural and institutional recognition. These factors are often aggravated by the failure to apply existing regulatory frameworks, or only partially applying them, as in the case of the 2006 Piedmont regional law, which has rarely been translated into effective operational tools.

2.1 Risk management: a state of the art

Risk management is understood as the set of activities aimed at identifying, analysing and ranking risks according to their significance, with the ultimate goal of preventing their occurrence or reducing their negative effects. It is a process that supports decision-making[7], considering uncertainty and the potential occurrence of future events or conditions, as well as their impact on shared objectives[8]. Its application to cultural heritage is a fairly recent trend, as it emerged only in the past twenty-five years[9]. It involves making informed judgments about potential threats—whether specific or general, for example, in the cases of heritage impact assessments (HIA), when modifications to the context can affect a heritage site[10].

At the international level, several studies have experimented with risk assessment methodologies specifically adapted to earthen heritage, demonstrating the possibility of integrating material, environmental and socio-economic factors into structured assessment models. In parallel, leading programmes and institutions such as the Getty Conservation Institute and the WHEAP framework have provided advanced methodological contributions for detailed risk analysis, including through the systematic examination of UNESCO cases, highlighting recurring critical issues related to climate change, anthropogenic pressure and governance, as recently reiterated in the 2025 Getty report[11].

Nevertheless, there are several methodologies that can be successfully applied to earthen heritage. At the national level, the work of the Carta del Rischio (CdR) is an example of the application of a common database for the cataloguing of risks to heritage, constituting one of the first attempts to integrate cataloguing and risk assessment in a geo-spatial database[12]. On an international scale, instead, the 2017 ICCROM Guide for Risk Assessment[13], proposed a unified method to identify, evaluate and mitigate risk factors. Its methodology, called ABC from the three

[7] SRA 2008

[8] ISO 2007

[9] Jokilehto 2000

[10] Francini 2020; Dipasquale *et al.* 2021

[11] Cancino *et al.* 2025

[12] Fiorani, Cacace 2020

[13] ICCROM 2017

factors considered in the analysis, is a proposed tool for a systematic and replicable approach to guide preventive conservation strategies and the definition of intervention priorities. The strength of the ABC model lies in the possibility of integration of natural, anthropogenic and socio-cultural risks in a single, holistic model which allows their direct comparison, in order to better strategise the mitigation interventions. To sum up, the paper presents the methodologies adopted for the multidisciplinary integration of risk assessment tools applied to earthen heritage, starting from a targeted selection of case studies up to the seismic vulnerability assessment. This approach enabled the identification and analysis of both anthropogenic and natural risks, understood as potential risk factors that may compromise the conservation of earthen buildings, in line with the preventive conservation framework outlined in the article.

2.2 Case studies selection

The process of selecting buildings for case studies began by retrieving materials from the archives of municipalities that participated in a census conducted between 2006 and 2010 in the Piedmont region (fig. 3).

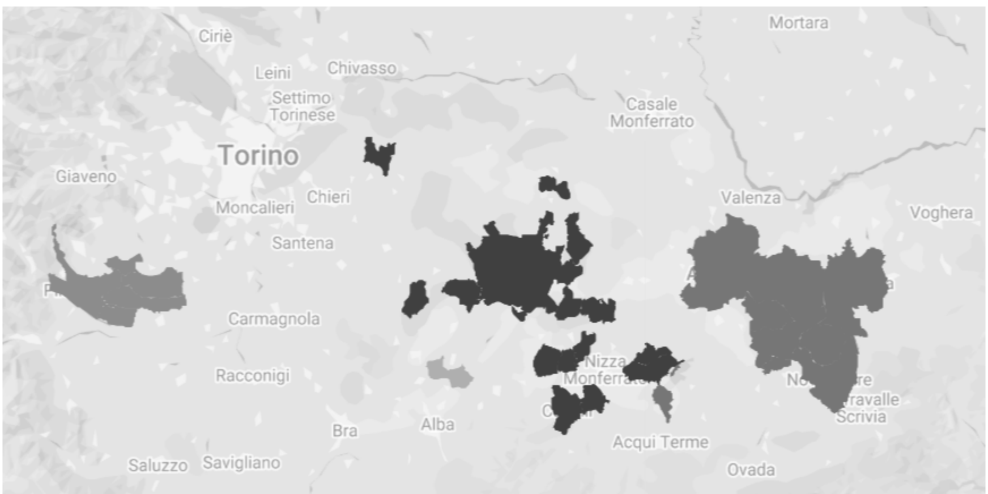

Fig. 3. Map of the municipalities which participated in the 2006-2010 census

The initial selection was based on the value of the catalogued buildings, with less significant cases (such as remains of perimeter walls) being excluded. Around 200 buildings were identified, with the majority located in the provinces of Alessandria (almost 50%) and Asti, and smaller percentages in Turin and Cuneo. To quickly select 50 buildings for re-census and risk analysis, remote location tools were utilised to geolocate the buildings based on their addresses (fig. 4). The next phase involved using street view tools available on the web to remotely assess the buildings. This

was the actual selection phase, where parameters were considered and assigned a weight/value between 1 (poor) and 5 (excellent). The total sum of these parameters allowed for the final choice of case studies.
The parameters that were adopted for this study included accessibility, presence of exposed portions of earthen material, visibility of the structure and construction systems, integrity and authenticity of the building, and architectural value. Over 50 buildings were carefully selected based on their significance and substantial use of earthen materials. These buildings were representative of various types, such as farmhouses, religious buildings, and public buildings, and were evenly distributed throughout the Piedmont region to showcase the different earthen construction techniques used. The final phase of the study involved a thorough survey of the territory to accurately assess the condition of the selected buildings. It was discovered that in some cases, the available images from remote tools were not up to date and that over time, invasive interventions may have been carried out on the structures, compromising their authenticity.

2.3 Preparatory activities for anthropogenic risk analysis

The research project focuses on the strengths and weaknesses of the actions implemented so far to safeguard and promote the reuse of vernacular earthen architecture, proposing versatile and replicable intervention methodologies in other contexts. In this perspective, it is particularly interesting to analyse the situation in Piedmont, and in particular in some of its southern provinces, which are characterised by a rich heritage of earthen buildings and have been the subject of specific conservation and restoration interventions, thanks not only to the work of cultural associations but also to the enactment of Regional Law 2/2006.
As part of the more general EVER EARTH research project, a series of interviews was conducted with qualified witnesses, selected according to a “cascade” method, in which the research group identified an initial wide range of interesting subjects to interview, and then obtained from them the names of other subjects to contact for subsequent interviews. The interviews covered a selected number of topics, starting from a value-assessment of earthen heritage, continuing towards a risk identification and finally addressing propositive conservation scenarios (Tab.1).
The interviews were conducted between May and October 2025, based on a series of open-ended questions designed to elicit responses that were as spontaneous and detailed as possible from the interviewees – 38 in total (25 men and 13 women), with different roles, skills and areas of expertise – all of whom shared direct experience and knowledge of earthen heritage buildings in southern Piedmont. Specifically, the interviews involved 17 professionals (mostly in the field of architecture), 16 owners of earthen buildings, 10 representatives of public institutions (7 of whom operate in the areas under investigation – mayors or former mayors – and 3 at the central regional level: representatives of the Region or the Superintendency), and 3 representatives of associations aimed at promoting earthen buildings. From a

territorial point of view, 22 interviews were conducted in the province of Alessandria (as it is particularly rich in earthen buildings), 7 in the province of Cuneo and 6 in the province of Asti; finally, 3 interviews were conducted in Turin, with the same number of representatives from institutions competent in all 3 provincial territories under analysis.

theme 1: perceptions and opinions on earthen heritage: general knowledge and opinions of earthen buildings in the area	questions 1 to 4
theme 2: risk identification on earthen heritage: threats and dangers to earthen buildings	questions 5 to 6
theme 3: conservation of earthen heritage: economic, social and professional resources needed, enhancement needs for earthen heritage	questions 7 to 10
theme 4: the future of earthen heritage reuse opportunities for earthen buildings, earth as a viable building technique	question 11 to 13

Table 1. Structure of the interviews developed by the authors.

2.4 The interviews

Among the respondents (including those who own a house built of earth), there is a high level of knowledge and awareness regarding the characteristics, types and history of the buildings covered by this survey.

The main advantages of earthen heritage cited were the robustness of the buildings, their stability, historical value and sustainability (especially with regard to the raw materials available locally, their excellent insulating properties and the degradability of the materials in the event of collapse following abandonment). On the negative side, respondents highlighted aspects relating to the greater fragility of earthen buildings and the associated maintenance and renovation problems, especially due to their high costs (generally higher than those for other types of buildings). With regard to general perceptions, the interviewees believe that there is a widespread feeling of disinterest on the part of both the resident population and many construction workers in these areas, even in municipalities with earthen buildings. During the interviews, technical and professional skills were identified as the main resource on which to focus for the restoration of heritage buildings, followed (in order of importance, according to the interviewees) by the need to provide economic incentives for owners and to adapt regulations to the specific case of these buildings. Among the other proposals that emerged from the interviews for enhancing the value of earthen heritage, the most notable are, first and foremost, informing and raising awareness among both citizens and public bodies, and then promoting these buildings for tourism. With regard to the opportunity to construct new earthen buildings, the interviews revealed a wide range of opinions, ranging from those in favour (often imagining a “hybridisation” of earth with other construction techniques) to those strongly opposed, considering this construction technique a relic of the past. With regard to the future, fears and pessimistic views tend to prevail, with the scenario of progressive abandonment and, therefore, further degradation of the heritage of earthen buildings now considered inevitable.

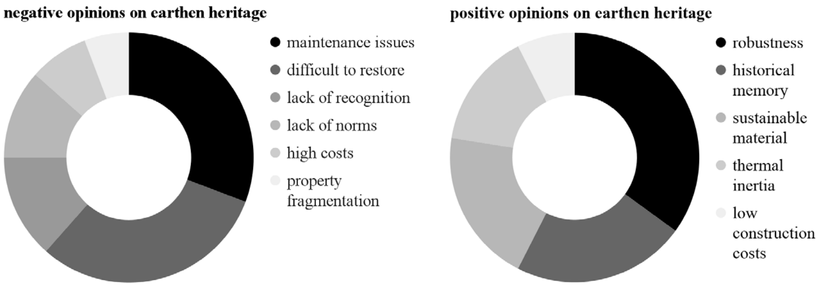

Fig. 4. Pie charts of some of the interviews' results

3. Risk assessment and evaluation activities

Parallel to the interviews, the risk assessment phase has been conceived as an integrated process combining existing tools for seismic hazard evaluation with anthropogenic vulnerability and the state of conservation of earthen buildings.

3.1 The state of conservation of earthen heritage in southern Piedmont

The site activities related to the definition of the state of conservation of the buildings analysed included the investigation of various aspects using different types of assessment forms, such as basic census, construction systems and morphology, state of conservation, anthropogenic vulnerability, and seismic vulnerability (fig. 5). The analysis of the construction systems and morphology form was carried out using a structured form, in order to identify wall materials and typologies, thickness, floor and roof configurations, connection details between structural elements, presence of tie rods or reinforcement systems, and alterations introduced over time. Freehand drawings of plans, sections and significant elevations were produced to identify load-bearing and infill walls, floor and roof layouts, and materials used.
Anthropogenic vulnerabilities were analysed through a structured assessment form enabling the recording of transformations, changes in use, maintenance practices, and pressures exerted by the urban and infrastructural context. The aim was to understand how socio-economic dynamics and management decisions influence the deterioration processes of earthen architecture. Building use conditions and the level of abandonment were evaluated, distinguishing between continuous use, occasional use, and total or partial abandonment, since continuity of use is closely linked to the presence of routine maintenance. The compatibility of past interventions was observed, with particular attention to the use of inappropriate materials and repairs that may alter the hygrothermal or structural balance of earthen walls. Indicators of neglect—such as invasive vegetation, inefficient rainwater drainage systems and

poorly maintained roofing—were also documented, as these often reflect deficiencies in long-term management rather than intrinsic structural weaknesses. Contextual pressures, including proximity to new constructions or transport infrastructure, were considered to assess their influence on both conservation conditions and the relationship between the building and its rural landscape.

Fig. 5. Field survey findings

The state of conservation was analysed through a dedicated survey form that enabled the systematic recording of decay phenomena and alteration patterns. Deterioration processes related to environmental exposure were distinguished from those resulting from human intervention and classified according to a graded intensity scale ranging from absence to critical condition. The integration of descriptive, photographic and evaluative data provided a comprehensive overview of the conservation status. The results indicate that the most significant criticalities are not associated with severe structural instability, but rather with inappropriate past interventions and insufficient maintenance, which may progressively compromise the durability of the buildings.
For assessing seismic vulnerability at the territorial scale, it is in general necessary to use tools capable of analysing a statistically meaningful number of buildings.
During the preliminary phase of the study, four buildings were analysed using: (i) level 2 GNDT forms, developed for rapid typological assessment, and (ii) employing the FaMIVE (Failure Mechanisms Identification and Vulnerability Evaluation) method, which focuses on the collapse mechanisms of historic masonry buildings. The compilation of the GNDT forms requires the qualitative assessment of a series of appropriately weighted construction, geometric, and structural parameters. The result is the definition of a vulnerability index (Iv). The parameters include, among others, the type of masonry (earthen masonry is excluded), the regularity of the floor

plan and elevation, the effectiveness of connections between walls and floors, the quality of the floors and roof, the state of conservation, and interactions with adjacent buildings. The second level GNDT approach is empirical-statistical. This enables rapid classification of vulnerability across large building stocks, making the method suitable for planning studies and intervention prioritisation.

	C. Saraschieri	C. Clavaria	C. Sant'Angelo	C. Remotta
Lateral capacity (%g)	0.16	0.27	0.26	0.26
Vulnerability index (-)	6.1	3.74	3.85	3.86
Damage index (-)	1.22	1.22	1.35	1.35
Main failure mechanism	IP	IP	OOP	OOP
Vulnerability class	HIGH	MEDIUM	MEDIUM	MEDIUM
Number of storeys	2	2	2	2
Crack angle	58	58	0	0

Table 2: Synthetic results of the FaMIVE analysis. IP: in-plane, OOP: out-of-plane

The FaMIVE method, by contrast, is based on the identification and analysis of the collapse mechanisms of historic masonry structures, with explicit reference to in-plane, out-of-plane, and combined mechanisms. Hence, the vulnerability index is derived from the calculation of collapse multipliers and the combination of fragility and damage extent. In the analysed cases, three of the four buildings exhibit medium vulnerability for in-plane, out-of-plane, and arch effect mechanisms, and one exhibits high vulnerability for the in-plane mechanism and medium vulnerability for the out-of-plane mechanism. Table 2 shows the synthetic results for the four analysed cases, reporting the most vulnerable mechanism resulting from each example. Lateral capacity reflects the worst condition for the "Cascina Saraschieri" and is linked to the highest vulnerability index. The outcomes underscore that both the longitudinal shape of the building and the absence of ring beams, sometimes connected to thrusting roofs, pose marked threats to both in-plane and out-of-plane response mechanisms, suggesting that proper earthquake risk-mitigation measures should also be included in a wider-ranging conservation project.

4. Conclusions

Although the amount of available data remains limited due to the work-in-progress nature of this study, the present contribution aims to propose a methodological approach to the conservation of earthen architecture. In order to implement appropriate and timely conservation/maintenance measures on architectural heritage,

preventing the loss of the property or its authenticity and reducing intervention costs, a risk assessment is required that takes into account not only aspects purely related to physical deterioration due to natural agents but also those related to human activity.
The study carried out in the EVER EARTH project on vernacular raw earth architecture in the Piedmont region highlighted shortcomings in the risk assessment forms currently used in relation to the characteristics of earthen construction, as well as gaps relating to the lack of specific analyses of anthropogenic impact.
The implementation of the risk assessment forms together with the analysis of anthropogenic impact has provided a more complete picture of the phenomenon that is leading to the disappearance of this heritage, sometimes with unexpected results. For this reason, the next research steps are focused on two different aspects: first, in addition to structural and conservation analyses, climatic risk assessment activities have been undertaken. These analyses are based on the examination of historical and recent climatic datasets for the study area, with particular focus on precipitation patterns and wind intensity. Given the high sensitivity of earthen materials to water action and wind-driven rain, special attention is being paid to trends in extreme rainfall events, seasonal concentration of precipitation, and variations in wind exposure. Secondly, the research teams are concentrating their effort on defining a more accurate risk assessment form that integrates all the factors examined in this study, as well as a matrix in which the different risk variables are given a value in order to obtain a tool that allows us to identify which cases should be prioritised in conservation interventions. Such a tool aims to move beyond sectoral evaluations and offer a replicable methodology that can be adapted to other regional and international contexts where earthen architecture constitutes a significant component of cultural heritage.

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