



Smart technological tools for rising damp on monumental buildings for cultural heritage conservation. A proposal for smart villages implementation in the Madonie montains (Sicily)

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ABSTRACT

The Madonie district, in the inner Sicily, is composed of 21 villages, custodians of heritage, traditions, and values that constitute the identity of this area, now exclusively entrusted to the collective memory of an increasingly elderly and inactive population. In the study area, full of tangible and intangible heritage, technological tools, can revitalize and reuse examples of architecture, especially monumental, whose main problem is a deep rising damp affecting the masonry. That is particularly critical for the historic/traditional architectures. This research implements, in one of the villages of the enclave, a new technology system, namely Information and Communication Technology (ICT) tool, like Charge neutralisation Technology (CNT), in contrast to the usual application of the classic and well-known resolution systems. This kind of methodology has been already applied in many monumental buildings in Italy with brilliant results and supporting the protection, enhancement, and promotion of cultural heritage. In Sicily it was never used and represents, in line with the smart village approach, a viable technology to be applied. The smart village model is one of the increasingly popular research topics globally and provides technologies aimed at preserving the identity of the territory and the historical buildings. Culture, if usable and accessible to all, results as an economic resource, a tourist attraction, and a factor of identity. The goal is to develop these inner areas through the smart villages approach by implementing smart technologies and establishing a synergic union of centers to be more competitive in the Sicilian hinterland, but also at the national level, with respect to the wise use of administrative, political, and governmental strategies. Cultural heritage and innovation, together, retrace the past with a view to modernity. The country's cultural heritage recovered and enhanced is a virtuous strategy to safeguard the identity and value of historic places such as that one of ancient villages and a way to find smart resilient strategies and a sustainability assessment for future communities.

1. The Madonie district: analysis of the area

The Apennine mountainous massif of the Madonie [1], located on the northern Sicilian coast, between the two ancient Imera and Pollina rivers, accommodates in its 39,679 hectares twenty-one scattered minor historic centers. They are positioned between the minimum altitude of the town of Alimena, 218 m, and the maximum one of Geraci Siculo, 1077 m above sea level. Small villages, arranged from coast to mountain and distant from the large centers of urban agglomeration and services as it is visible in Fig. 1. They are also characterized by a diffuse built heritage [2] strongly linked to the local building traditions of the past and to the traditional way of living, strictly conditioned by the territorial morphological characteristics. These minor centers [3] are endowed

with a great potential for attraction and economic development that is till unexpressed.

To fill up this deficit, the proposed research attempts to solve the problems related to the issue of accessibility of the monumental heritage in terms of use, rehabilitation and implementation of the necessary technology, especially for the elimination of rising damp and improving tourist use [4]. In view of the presence of an architectural and natural heritage of inestimable value, it turns to be necessary that the area subject of this kind of research, the Madonie, is inside an UNESCO-recognized Geopark [5] from 2004. And therefore, considering the naturalistic importance of this area, it is important to identify possible technological solutions for the fruition and enhancement of cultural heritage, architectural and natural, present in these places,

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Fig. 1. The area of interest: A view of Sicily with the Madonie District in yellow (top); Aerial photo of the Madonie District (center); Four municipalities around the territory: Petralia Soprana, Castelbuono, Polizzi Generosa and Isnello (bottom from left to right).

without destroying territory and imaging compatible design strategies to be applied [6]. Cultural heritage has universal value for individuals, communities, and societies in general. Unesco has mapped all the world's territories and it is possible to encounter the entire protected heritage divided into World Heritage Sites, Geoparks and Biosphere Reserves; sites selected for their naturalistic value, but above all for their importance in human history, moreover, it is important to preserve it and, more particularly, pass it on to future generations. The Madonie Geopark is precisely one of the largest and most protected areas in the southern Italy [7].

Often heritage is perceived as something that comes "from the past," but – on the contrary – it evolves through people efforts; in addition, the national normative plays an important role in building Europe's sustainable future [8]. This is one of the main reasons to reach out to young people, particularly during the European Year 2022. Cultural heritage comes in many forms and nuances: tangible - for example, buildings, monuments, artifacts, clothing, works of art, books, machines, historic cities, archeological sites; and intangible - practices, representations, expressions, knowledge, skills - and tools, objects and associated cultural spaces - that people value. This also includes languages and oral traditions, performing arts, social practices and traditional crafts; but also, natural ones such as landscapes, flora and fauna; and digital - resources

that have been created in digital form (i.e. digital art or animation) or that have been digitized for preservation (including text, images, videos, recordings) [9].

Through caring for the cultural heritage, it is possible to discover the diversities between the different societies and to strike up a cross-cultural conversation about what Madonie villages have in common [10]. According to Unesco principles, and recognized worldwide, cultural heritage is generally 'the legacy of physical artefacts and intangible attributes of a group or society that are inherited from past generations, maintained in the present and donated for the benefit of future generations'. Tangible, intangible and natural heritage are part of the Madonie area, the digital one, instead, is greatly absent. Cultural heritage [11] should not be left to decay, deterioration or destruction, and for this reason, it is important that digital tools are used to record, document but also to preserve cultural heritage; in this way the enhancement of monuments related to cultural heritage continue to remain accessible to citizens and future generations: it takes the tangible and ensures that it is documented for generations through an intangible medium. Cultural heritage becomes operable only if its ease of access in a material sense for the benefit of potential users is taken care of and ensured [12]. One starting point would be improved by digital technologies for raising awareness on cultural heritage. The concept of

accessibility is also psychological and cognitive in relation to the information available that allows even those without a scientific background to meet the cultural product. A further aspect of accessibility refers to the users' welcome for the presence of ancillary, additional services capable of making the cultural experience easier, more comfortable and stimulating.

Concrete help comes from the National Recovery and Resilience Plan (Piano Nazionale di Ripresa e Resilienza, PNRR) [13] that dedicates 1 billion euros to inner areas in Italy; Digital transition and evaluation of innovative processes for architectural heritage use for inclusive, resource-efficient, safe, resilient and sustainable communities are goals of the PNRR - M1C3 - Investment 2.1 "Village Attractiveness" Mission: Digitization, innovation, competitiveness, culture and tourism; Component: Tourism and Culture 4.0 – SNAI - National Strategy for "Inner Areas" [14] and SNAMI (National Strategy for Inner Mountain Areas); This is one of the Italian policies that gives to these territories money and possibilities to implement strategies and innovative skills. Interventions in this area will be implemented also through the "National Boroughs Plan" a program to support the economic/social development of disadvantaged areas based on the cultural regeneration of small towns and the revitalization, for example, with tourism. It concerns public built heritage and enhancement, response to climate change crises and the smart strategies to improve the resilience and sustainability of cities and urban systems. Within Italy's museums, monuments and archeological areas, the specific technological expertise needed to produce museum products that exploit ICT is absent; this lack determines the need to resort to special forms of partnership with technology providers, i.e., universities, public and private research centers and companies that directly operate in this sector [15]. ICT, for enhancing the enjoyment of cultural heritage, aimed at improving access to UNESCO heritage through augmented and immersive experiences through their cultural heritage, history, arts and traditions. ICT approach can give also a new life to the past including preservation in terms of life [16]. The actions are based on local integrated cultural-based projects, activated aimed at recovering historical heritage, upgrading public open spaces, and creating small cultural services, also for tourism purposes, the creation and promotion of new itineraries and guided tours will be encouraged. The financial support will be introduced also for cultural, creative, tourism, commercial, agribusiness and craft activities aimed at revitalizing local economies by enhancing local products, knowledge and techniques. Nowadays, the dissemination and application of accessibility and usability criteria are still not completely satisfactory, largely due to limited knowledge of the subject: this applies both to companies/organizations that do not always explicitly require it (and should be sensitized to understand the importance of these elements), and to those who design and develop computer applications that do not always have the necessary technical expertise (and should participate in technical training courses to create adequate skills). It is extremely difficult to find accurate statistical data, however, it is widely believed that there is still a low percentage of sites/applications, even from the public sector, that meet all the requirements: this means that access difficulties remain for various categories of people with disabilities/disadvantages in cities, but especially in small villages such as the Madonie one. In Italy more than half of the existing building stock is more than 40 years old [17]; a value that increases a lot, also considering those monumental buildings that make the wealth of the Italian, and Sicilian in particular, historical heritage unique in the world. In the center of Sicily, in the Madonie Park, there are approximately 230 monumental heritage buildings to be preserved throughout the twenty-one villages. The restoration of monumental buildings, or the renovation of basic and diffused buildings in rural centers, must not only represent a need for urban redevelopment [18], but also of preservation and reconstruction of the identity and culture of a place.

The challenge is to preserve this heritage and make these buildings relevant for the new generations: no one wants to see buildings falling into disrepair or lying empty. After years of depopulation and, in some

cases, complete abandonment, Italian villages are ready to reborn thanks to many urban and economic regeneration projects that aim to bring people back to these small territories which constitute an invaluable historical monumental heritage that must be preserved because of rich in ancient traditions, history and culture belonging to the Nation [19]. These are the places where identity, knowledge and trades are preserved, and they conserve a formidable tangible and intangible heritage of tradition and history that is unique in the world. Enhancing this heritage means aiming at a tourism that is not only centered on the great art capitals, but that is built around the thousands of cultural attractions that we have in our country and that can also become a great growth factor. Precisely for this reason, so much is being done in Italy to preserve the heritage of small villages through redevelopment and cultural revaluation projects. Technology applied in cultural heritage, often can be a possible way through which art can be enjoyed by means of mass media and social networks, or of the race to digitize that museum institutions have had to operate in recent years. Underlying this panorama of still uncertain developments, however, is a set of standards and projects, consolidated by years of experience or still being tested, that allow for the effective digitization of different types of cultural heritage, from visual arts to archeological sites to the holdings of archives and libraries but less often to the technology applied on buildings to preserve them and bring their memory to the future. It is the GLAMs, Galleries, Libraries, Archives, Museums, places that preserve the identity of places, stories, old narratives, and the civilization that has evolved over time. Applied technologies range from image scanning and visualization frameworks to the use of augmented reality and artificial intelligence systems capable of restore them. The methodology used also involves the analysis of the territory, the involvement of stakeholders, universities and companies (that if working together can bring innovation) and the participation in the decision of what will be the final output of the project including accessibility and usability based on local peculiarities.

Contained in the Italian Law 4/2004 [20], "accessibility" stands for the ability of information systems, allowing technological knowledge, to deliver services and provide information usable, without discrimination, even by those who due to disability require assistive technologies or special configurations; "assistive technologies" means the tools and technical solutions, hardware and software, that enable the disabled person, by overcoming or reducing conditions of disadvantage, to access information and services provided by information systems.

While Usability, according to International Organization for Standardization (ISO) regulation, refers to the effectiveness, efficiency and satisfaction with which users achieve goals in different contexts. In practice it defines the degree of ease and satisfaction with which interaction between humans and a tool is accomplished. In a concept of a smart village [21,22] accessibility and usability must converge.

In the use of these technical applications there may be barriers that can be taken down promoting projects for the regeneration, enhancement and management of the great heritage of history, art, culture and traditions found in small towns in the territory, integrating objectives of cultural heritage protection with needs of social and economic revitalization, employment revitalization and counter depopulation.

A virtuous smart rehabilitation needs the combination of both accessibility and usability, and a several series of projects are supporting this kind of operation. Intervening "at a certain point in time" in the history of a monument means establishing a dialog that can contain "the stories" that have marked various phases of the life of the monument itself. It means reflecting on events that marked its growth and changed, but it means also transcribing the thoughts of the protagonists who shaped before the image, the "aura" of the monument. Its spirit made of dreams, disappointments individual and collective, of frustrations, of collapses, of oblivion, of interruptions for lack of funds and of new rebirths until the moment in which it is possible to intervene, that is our idea of restoration, recovery and rehabilitation project with its scientific, its rigor and its dose of arbitrariness, of more or less calculated risk, of bet towards a future that you want to give back to what lives mainly

thanks to its past image.

The problem of raising damp in buildings is a highly topical issue, not only because of typical causes resulting from environmental and weather conditions, but also because of the characteristics of certain materials and the effects that can occur over time. A condition that affects old buildings made with traditional technologies and then treated with incompatible materials, but also more recent buildings made sometimes with inadequate characteristics. Water is precisely the common factor that determines the well-known effects resulting in the presence of raising damp and condensation in buildings. Water, in construction, if not properly controlled, ends up becoming a real problem, harmful to build parts and to health and well-being more generally.

If you examine the technologies that building restoration provides and study the different solutions to the problem of rising damp [23–25], there are, in fact, a plurality of possible interventions:

- mechanical interventions: cutting the wall at the base and inserting materials that block rising damp;
- chemical interventions: creation of a chemical barrier inside the masonry;
- electrosmotic interventions: reversing the direction of the water using an electric current;
- evaporating plasters: macroporous plasters that, thanks to their speed of evaporation, rapidly absorb water from the wall and return it to the environment.

The above-mentioned intervention techniques are already obsolete and, nevertheless, involve an enormous amount of work on the masonry, unlike the third proposed method, i.e. the electrosmotic intervention. And it is precisely this study that should be investigated, evaluated and proposed in interventions concerning historic buildings.

The effect over time manifests as the masonry deteriorates, passing through all layers of materials in masonry [26]. A process that, if not properly controlled, is irreversible with the deterioration of the coatings, plasters and bedding mortars that bind the artifacts.

2. Charge neutralization technology for rising damp elimination and prevention in masonry

The interest in the suitable preservation of the architectural heritage [27], and its proper valorization, makes increasing the need for a careful assessment of the condition's microclimate inside historic buildings, to define interventions aimed at containing the dangerous consequences of activating physical processes of deterioration. The solution to rising damp in masonry, and its related problems, is a major component within architectural rehabilitation work [28,29]. Since 1996, the UNI-Normal Cultural Heritage Commission has been studying raising damp in masonry structures, methods of its assessment, and problems concerning terminology and sampling in its working group (WG 19). In rehabilitation/restoration interventions, capillary rising damp represents one of the most recurring pathologies against which most of the applied systems have revealed not at all effective [30]. It is necessary to identify a system that restore masonry and stop capillary rise and the counter-thrust of water from below without going to use plaster or other covering materials [31,32]. The waterproofing interventions of the interior spaces must, therefore, meet two needs: eliminate all the changes made over the years that were not consistent with the type of building constructive system going to create problems to the original arrangement, and renew various constituent technological elements improving the masonry state of the art [33]. In 2000, it was thought to develop innovative electromagnetic-electrophysical technology over pre-existing techniques to counter and/or reduce the effects of rising damp inside masonry [34,35]. This choice was mainly made because of the lack of a definitive solution to the problem and in the face of the insufficient level of effectiveness that systems once considered among the most advanced methods the market could offer had manifested over

several decades of application. Today, thanks to electrophysical dehumidification combined with nanotechnology, we can solve the problem permanently. The main physical phenomena that contribute to masonry damage are thermal surges (expansion/shrinkage cycling), frost (volume increase/disintegration of surfaces), and wind (with the transport of dust produces slow sandblasting of exposed surfaces).

Capillary rise especially occurs in old buildings, where the materials used for their construction usually are very porous (natural stone) and, hence, facilitate the capillary action. To a particular extent, it is a phenomenon of decay diffusely presents in Sicilian masonry, due to the extensive use of calcarenite, a local material strongly present in both monumental and traditional architectures and foundations. Another major problem is a lack of insulation in the foundations of the building: in fact, a sheath is required on the underground masonry that is in direct contact with the ground to avoid proximity to any kind of water. Then there are secondary causes that could contribute to the presence of stains, dampness and plaster crumbling. Among those: water flowing in the ground under the building, loses electrons causing a flow of electric current in the walls that are in contact with the subsoil. This lead, over time, to a deterioration of the materials that make up the foundations. That is, therefore, why capillary action almost always causes the plaster to flake off; the presence of a highly moisture content in the flat: the rising water, in fact, dissolves the salts in the ground or in the masonry itself and brings them among the structure. As a consequence, if in contact with air, the water evaporates making the salts crystallizing into the wall. This leads to further surface wear and the presence of whitish stains on the plaster. Not only that, the presence of moisture can also lead to the proliferation of moulds and other microbacteria. As a result of these fungi, stains on the walls increase and the air quality in the home deteriorates; silicon in building materials: it is a semiconductor with a negative electrostatic charge that attracts water molecules.

So, there are many causes that lead to capillary rise of water. It is therefore necessary to analyze the actual problem and, once the origin of the damage has been established, find the right solution. The lack or interruption of a "protective" barrier triggers most of the degradation phenomena of the building system, which take the form of the appearance of stains on the walls, the disintegration of plaster or building materials or the detachment of paint layers or, more generally, the peeling of paint.

The technology proposed in this research article generates an electromagnetic field inside the masonry that interacts with water molecules and prevents them from rising, while nanotechnology protects the walls from water degradation due to weathering and preserves their breathability. Capillary rising damp is due to a variety of physical phenomena [36,37]: historic buildings, which often lack an adequate insulation system against this phenomenon, are especially affected.

The Charge Neutralization Technology (CNT) is a new approach to the architecture that was conceived to surpass and improve the effectiveness of the various electrophysical systems already in use. After a decade of applications doing by lots of university in Italy, today, represents the most controlled and tested solution against rising damp which acts not on the masonry, but on the water present by neutralizing its charge. Based on a principle of a totally new conception, made possible in 2009, the scientific principle used by this type of technology is based on the application of physical phenomena derived from experimental studies and referred to by insiders as electro-capillarity and electro-wetting. Rising damp has been one of the central problems in the restoration/rehabilitation of the built heritage. In Italy it is being exploring the applications for the elimination and prevention of rising damp in masonry and the preservation of the built heritage [38,39] that cannot be restored with traditional technologies such as the thermal coat that, of course, cannot be used in monumental buildings in which, very often, masonry has paintings and decorations of great value. Capillary rising damp is a pathology that particularly afflicts masonry of the historic architectural heritage particularly affecting the conservation of Cultural Heritage, becomes an even bigger problem when it afflicts



Fig. 2. CNT Complete Sensors Technology (CNT Technology, www.cnt-apps.com).

high-altitude assets that, especially in Sicily for the use of limestone, subject to continuous problems that damage not only visually and structurally but also to health [40]. Scientific and technological research has shown that the mechanical and energetic characteristics such as strength, durability, thermal inertia of materials (i.e.: calcarenite stones, or usually used also in the Madonie district, strongly influenced by the presence of externally absorbed water) could affect the inertial behavior within water capillaries by neutralizing the molecule with the introduction of weak electric fields.

Application of this technology is divided in a first phase, dealing with the observation and data collection of the masonry subject of study, and after that the installation of the CNT dehumidification system [41], for a minimum period of two years, necessary to observations and verifications, and lastly a second phase of analysis and processing of the collecting data.

The Fig. 2 shows the CNT and the use of sensors, with a spherical range of 6 to 15 m, that monitor the raising damp condition of the wall of the entire building and, at the same time, activate an electromagnetic process such that the amount of water present is decreased.

The present study examines some application cases of CNT technology [42], developed in some university in Italy, first and foremost the University of Matera, Turin, Padua, Ferrara, Naples and Lecce, in historical buildings of national interest that, also because of their complexity and historical-artistic relevance, are very significant for appreciating the great versatility and effectiveness of the system. It's important to underline some experiments that have contribute to have good results to the historical buildings in Italy and that can be an important example to apply in other contexts like inner areas [43,44].

2.1. Milestone case studies of CNT applications

In Italy, one of the most important examples of application of CNT tool was done in Palazzo Te [45] in Mantua that was built between 1524 and 1534 by Architect Giulio Romano and represents a typical example of architecture of Mannerism style. It was built under Federico II of Gonzaga, Duke of Mantua, and it is, today, an important International Center for Art and Culture. Originally the palace externally was probably also painted, but colors have disappeared, and the paintings are today only visible in the frescoes of the precious interior rooms. Faced with serious problems of rising damp that afflicted the historic building since historical times, several alternative technological systems had been experimented over several years that had not yielded appreciable

or, at any rate, definitive good results. The rehabilitation interventions involving the palace in recent years have addressed the important issues of protection and conservation. An important and numerous series of interventions were planned, all aimed at restoring Giulio Romano's masterpiece to the best of preservation and visibility, to offer visitors the opportunity, to enjoy a unique and unrepeatabe cultural experience, equal to the international importance of the palace [46]. The virtuous Administration of Palazzo Te decided to implement CNT [24,25], instead of applying other methods present in commerce, and so diagnostic investigations done had shown the presence of strong aggression by capillary rising water on the masonry made by historic brick and lime mortar masonry. The phenomenon affected perimeter and also partition walls evidenced by widespread paint exfoliation and saline efflorescence. The origin due to the nature of the soils made of marshy and lacustrine area on which the building stands was a suggestion about the presence of water in the subsoil, at a short depth from ground level, favors a drawing and stagnation of water in the area on which the foundations insist, from which precisely the capillary rise was triggered according to a continuous and uninterrupted cycle. In January 2010, the system was installed with the sensors and the final thermographic testing verification was controlled two years later. The application of this methodology led to a substantial regression and disappearance of the pre-existing capillary rising damp. After 9 years, other tests were done and confirmed the maintenance of the exemplary result of the complete drying of the masonry.

Another effective application of CNT was in the historic Church of the Confraternity of Mercy in Turin [47]; during the restoration works in the presbyterial area where other protection works for the safe performance of the elimination of infill and superfetation were implemented. The church in recent years has undergone major restoration work that was completed in 2009 and restored the original lighting scheme of the structure and the full legibility of the stucco work. It was also evaluated the opportunity to eliminate the wall raising damp from capillary rise by applying the CNT system [26]. After the installation and through the protocol of acquisition and comparison over time of thermographic images, repetition of the thermographs on an annual basis, integration of thermographs with spot measurement of the wet contents of the solid wall by means of tests carried out in accordance with the procedure specified in standard rules UNI 11,121 that is about the measurement with calcium carbide hygrometer.

The final thermographic 3 years after the installation of the CNT technology, highlighted the definitive disappearance of the previous



Fig. 3. Palazzo Te in Mantua (left) and Misericordia Church in Turin (right) (©Lombardia Segreta, 2021 and Fondazione Programma Barocco, 2017).

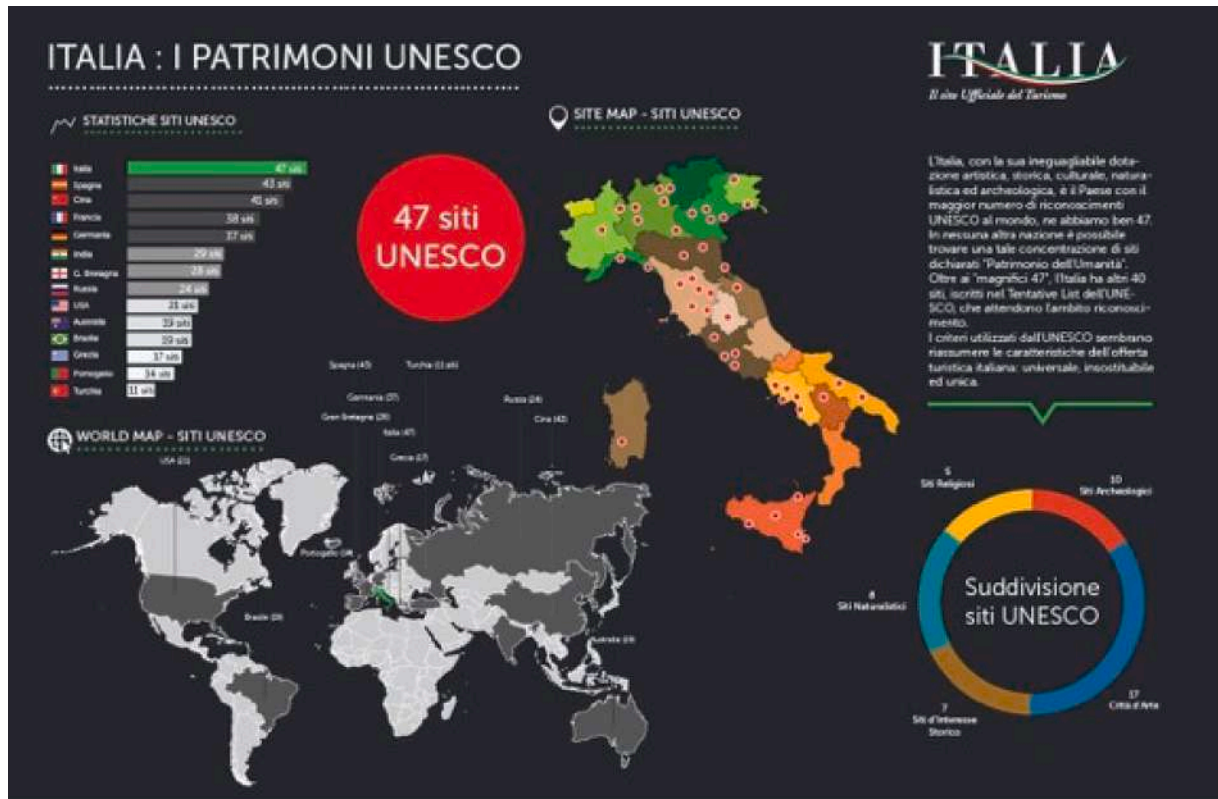


Fig. 4. UNESCO site map in Italy (© Club Magellano, 2022).

wall raising dump from capillary ascent in all the sample areas under observation and showing the achievement of residual values of less than 1 wet content, 5% and therefore corresponding to the physiological humidity of the solid bricks constituting the walls. The maintenance in operation of the CNT plant, preventing the resumption of the phenomena of capillary ascent, will ensure the permanence of the conditions of hygrometric equilibrium reached by the masonry, Fig. 3.

Others particularly significant applications on monumental buildings like these [48,49] were also carried out at National Museum in Rome, at Diocletian Bath in Rome, at Saint Sepolcre Crypt of San Vittore in Ciel d’Oro (Saint Ambrose church) in Milan, Capodimonte Museum in Naples and Villa Reale in Monza, Buon Pastore Building at University of Salento in Lecce, Cathedral Crypt in Lecce, Railway Museum di Pietrarsa in Naples, San Matteo Church in Lecce, at Crypt of San Giovanni Maggiore Church in Naples, Museum of Ancient Art, Orange Loggia in Marfisa d’Este Palace, Rectorate of the University and Ermellini Hall in Renata Palace di Francia in Ferrara; bringing, likewise, a more than inspiring result.

These are lots of very important examples of how technology can help our heritage and make it usable and maintainable for the rest of the

years without massive interventions on it.

Italy is home to 55 UNESCO sites, a world record on par with China (whose territory is 30 times larger than Italy’s), and 61 places protected by the Fondo Ambiente Italiano (FAI). These are places that collect centuries of history, culture and traditions, and whose value goes far beyond their beauty. Italy is the country with the largest number of UNESCO-protected sites in the world, Fig. 4, but the terrible conditions they are in are to be assessed and considered, which is why the present research seeks to find innovative, technological and sustainable strategies, such as CNT technology, to preserve and enhance it. It could be done not only in big cities, but also in little villages in which cultural heritage is still preserved and has not undergone any changes due to the increasingly attractive offer of big cities.

The CNT application has been tried in many regions of Italy, from Basilicata to the North of Italy, but never in the South of Italy, and especially in Sicily. For this reason, this research focus on this kind of application because, precisely in the Madonie land, the research is intended to preserve, a priceless heritage of history, art, culture, tradition and tangible heritage that needs care and maintenance in order to return it to the citizens of tomorrow. Technology, when applied in such

Table 1

List of monumental and artistic heritage in Polizzi Generosa, investigated and prepared by the author based on a literature review and research on state of the art.

Typology of buildings	Name of Buildings	
Churches and Religious Buildings	1. Cathedral S. Maria Assunta (Santa Maria Maggiore)	
	2. Santa Orsola Church	
	3. Carmine Church (Chiesa della Misericordia o del Santissimo Crocifisso)	
	4. Santa Maria delle Grazie Church (called also Badia Nuova)	
	5. San Francesco Auditorium	
	6. San Gandolfo la Povera Church	
	7. Santa Margherita Monastery and Church (Badia Vecchia)	
	8. Santa Maria del Castello Church	
	9. San Girolamo Church	
	10. San Gandolfo Hermitage	
	11. Commenda Church	
	12. San Nicola De' Franchis Church	
	13. Santa Caterina Church	
	14. San Pancrazio Church	
	15. Udienna Church	
	16. Santa Maria Lo Piano Church	
	17. S. Antonio Abate Church	
	18. Santa Maria della Porta o degli Schiavi Church	
	19. SS. Trinità dei Cavalieri Teutonici Church	
	20. Annunziata Church	
	21. San Domenico o del Santo Spirito Church	
	22. San Nicola dei Mulini Church	
	23. Pietatella Church	
	24. Collegio di Maria Church	
	25. S. Giuseppe Oratory	
	26. Ruins of Commenda dell'Ordine Sovrano Militare di Malta Church	
	27. Compagnia del SS. Rosario Oratory	
	28. Town Hall (ex Convento dei Gesuiti)	
	Civic and Historical Buildings	29. Lancia di Brolo e Museo del Giocattolo Antico Municipal Library
		30. Civic Archaeological Museum
		31. Ex Palace Notarbartolo - Madonite Environmental Museum M.A.M.
		32. Gagliardo Palace
		33. Carpinello Palace

contexts, can restore dignity to places and promise a dignified future, but most importantly, guard, once again, a cultural heritage of inestimable value.

3. Smart rehabilitation in Polizzi Generosa

One of the richest villages, in terms of monumental heritage, in the Madonie territory, is Polizzi Generosa [50,51], known as the Florence of the Madonie District, due to the several numbers of monuments in its territory having a huge amount of cultural heritage needing protection to be passed over the next generations. Polizzi Generosa is a noble town with innumerable monumental, artistic, environmental and historical-cultural attractions. It rests on a high spur that, detaching itself from the highest peaks of the southern Madonie, juts out toward the Northern Imera valley. Wide and spectacular, therefore, are the views it offers: on one side the high peaks of the Sicilian Apennines-where some of the most beautiful paths of the Madonie unfold and the only specimens in the world of Madonie fir trees grow in the wild-which crown the valley of vegetable gardens and hazelnut groves; on the other side a long theory of gentle reliefs that follow one another as far as the provinces of Agrigento and Caltanissetta [52]. Its origins are very ancient and the town can be reached from three different routes, and from each one, once it shows-just after a bend, a pass, or between forest wings-you get a different impression. The most beautiful view is most likely enjoyed when arriving from the mountain road, especially when clouds are layered at lower elevations creating the characteristic "swell" and the town seems to float in a sea of clouds, waiting to take off. According to

historians it is the Sicilian Athens mentioned by Diodorus Siculus, others that it was founded by Byzantines. What is certain is, confirmed by numerous archeological finds from the 4th-2nd centuries B.C. unearthed over the years, that Polizzi has been inhabited since ancient times, while the present nucleus most likely developed during Byzantine rule. Notable development it then had with the arrival of the Normans and even more in the centuries to come, becoming one of the most important towns in Sicily and among the few state-owned towns on the island. Frederick II gave it the title of Generosa (meaning "the generous") and over the centuries it gave hospitality to various rulers. Among them were Queen Elizabeth, wife of Peter II of Aragon, who founded the Monastery of Santa Margherita; her son Lodovico, king of Trinacria; Queen Maria, wife of Martin the Younger; Queen Bianca of Navarre; and Emperor Charles V. This fostered the growth of Polizzi and enabled it to be enriched with many monumental and artistic assets in 134,7 km² of extension that can be admired in their splendor today. Table 1 lists the main historical heritage of the town.

Recently, the municipality of Polizzi Generosa, Fig. 5, won the chance for urban regeneration through participation in several calls made available by the Ministry of Culture for inner areas participating with the ranking of "Local Projects for Cultural and Social Regeneration within the framework of the investment Attractiveness of Villages provided for by the PNRR". Among the Madonie municipalities on the ranking list it is one of the 229 Italian villages that the state intended to regenerate with Culture and Beauty, along with Isnello, Gratteri and San Mauro Castelverde Municipalities. It is important to emphasize that the choice of Polizzi falls on the important possibility compared to the twenty-one municipalities in the Madonie area that have submitted additional projects, which unfortunately have not been financed. Moreover, Polizzi Generosa is currently the only municipality in the Madonie area to have an agreement with the University of Palermo aimed at improving the urban environment and developing strategies for the recovery and enhancement of the town. The project presented by the Administration entitled "G.A. Borgese Genius Loci. Discovering the Territory and Traditions. Culture and Beauty for the Regeneration of the Borough in the 140th Anniversary of the Birth and 70th Anniversary of the Death of Giuseppe Antonio Borgese" is among those eligible for 1.6 million euros in funding. With this call of the National Office of Culture (Ministero della Cultura, MIC) it was just the opportunity to put everything in place and make finally a virtuous project achievable. The project proposal passed the evaluation and so Polizzi won the challenge on which it had staked everything with the help of seventeen private partners, thirteen private and four public.

Events related to intangible values of the town including concerts, music and theater festivals and reviews, art exhibitions, seminar and residential and other meetings to be held year-round and for 5 years. Four are the tangible interventions on cultural heritage, including the construction of a new accommodation facility, upgrading part of the urban center of Cilluffo Street, the musealization of the Palace of Culture with the realization of an immersive museum as well as also in the Borgese house, the realization of the Music Park in the Municipal Auditorium, the infrastructure of the urban center with the realization of literary paths air in the footsteps of the texts of G.A. Borgese, the realization of coworking stations at the Municipal Library in Umberto I square. Through a subsequent call, additional resources, amounting to 800.000 euros, will be allocated to support businesses that carry out cultural, tourist, commercial, agribusiness and craft activities located in the financed municipalities or that intend to settle in the same villages selected for the implementation of cultural regeneration projects. Polizzi Generosa, in these years, has also received fundings also for the recovery of the Church of Santa Maria Jesus Lo Piano, Fig. 6, a virtuous process to restore the building and to give attention to one of the most important places of the village and for the whole community. Projects that make Polizzi a regenerated and enhanced town center capable of becoming an attractor and offering more opportunities to those who live and work there. An unprecedented prospect of regeneration now opens for the city



Fig. 5. Aerial view of some monumental buildings in Polizzi Generosa.

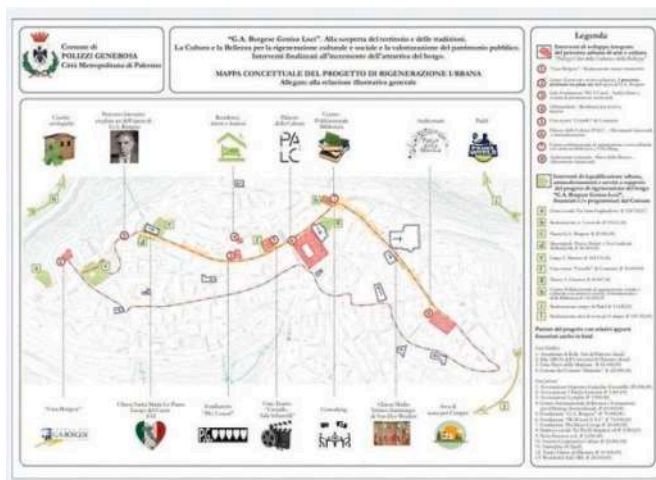


Fig. 6. PNRR Project of Polizzi Generosa and a Drone Photo of Polizzi Generosa (on the left), Rising dump plaguing one of the monuments of the municipality of Polizzi Generosa (on the right) (@FAI - Fondo Ambiente Italiano, <https://fondoambiente.it/luoghi/chiesa-santa-maria-gesu-lo-piano?ldc>).

and a long, complex but fascinating path that will engage the next 5 years and that will have to see the whole community involved and united in an unprecedented and close relationship between public and private so that from this scenario a concrete opportunity for development and regeneration can really emerge [53,54].

In order to save the rest of the monumental heritage, the opportunity of the CNT in this kind of territory could be a smart strategy to preserve the remaining part of monumental heritage today not included in funds received.

Through the application of this kind of technology it could be possible to preserve, enhance, protect and manage the built heritage. The preservation of cultural heritage is ensured through consistent, coordinated and planned study, prevention, maintenance and

restoration activities. Starting with monitoring everything that has been left out of funding, through the CNT method, which moreover also provides a resolution to the problem, albeit not in a short time frame, can be a smart and cutting-edge strategy to guard what gives value to the place and the community while making it usable and in excellent condition for more substantial interventions in the future.

That is why it is important, especially now, to integrate advanced technologies for heritage monitoring and preservation into a future vision in which the ferment and desire to move forward at a fast pace to achieve great results is strongly present in the area, both on the part of the administration and citizens. In this way about 35 historical properties can be saved, but, first of all, the past of Polizzi Generosa, the story and the culture can still be projected into the future and form a solid

foundation for future generations [55,56].

4. Implementation of technology as a best practice to enhance the territory of Madonie

Thinking about the amount of assets that can be recovered and maintained over time also thanks to the further use of technological tools such as the CNT, it is really possible to imagine, Polizzi Generosa, a new cultural hub to be appreciated both as citizens and tourists. Capillary rising damp is a problem that exists in all historic buildings and cannot be always solved by traditional methods. Such technology ensures durability, recovery and maintenance of the historical asset, but most importantly longevity by ensuring its permanence for future generations. Very important for the history and cultural identity of our country, Italian villages are experiencing an increasing process of depopulation, which threatens their survival. For this reason, the Italian Government has launched lots of possibilities: the idea is to transform Italian villages into boroughs of the future in which to concentrate all available technologies, digitizing public administration and turning them into places where the impact of innovation on society can be assessed, while amplifying their potential to attract tourists [57,58]. Villages in our country that have already opted for digital innovation are so not so much. Technology allows us to rediscover and return to our past, if only for a vacation. An opportunity for small centers, which can revive a new offer aimed not only at tourists but also at workers, as an opportunity to improve the quality of life of residents. A revitalization of the attractiveness of these centers, which needs to be accompanied not only by the regeneration of spaces, but also by the organization of targeted reception services. A process that will also find support with dedicated funding lines, activated both at the central and regional level, to encourage digital transformation and innovation in smaller realities. A change also aimed at rethinking the connection with urban centers, to develop new synergies and encourage a reduction in the gaps between cities and inland areas. It is necessary to lead the administrative entity in a path of co-design that, starting from the analysis of contextual conditions, leads to outline for priorities of action for the revitalization, promotion of the cultural heritage in villages and the systematization of new models of reception with the reworking and development of technical elaborations, useful for the programming of processes and the involvement of the local reality [59]. The community of Polizzi Generosa is having a great opportunity, and the application of these systems is not only useful for the protection of the monumental assets present, but to collect and preserve the identity of a place like the historic village. History, art, culture tradition, in so few square kilometers that make the Madonie a unique cultural center like few in Italy. Among the best practices to be implemented, certainly, in addition to the technological part and the application of the CNT system for masonry restoration [60], the involvement of administrations, citizenship, of participatory processes of co-design, stakeholders, scientific partners such as the university, can bring great breath to a little village like Polizzi Generosa and make it a new attractive pole for the Madonie. The union also of businesses and third sector societies reactivate the local economy by fostering virtuous paths of social, economic and administrative renewal. If then the step taken by Polizzi were to be extended to the other twenty villages in the territory, then yes, one could speak no longer of a smart village, but of a virtuous enclave of smart villages working together with a single purpose: the revitalization of the Madonite territory. Physically preserving cultural heritage is certainly the first step, but the possibility of the enjoyment of these artistic assets should certainly not be lacking. Promoting culture also means spreading awareness of our own cultural heritage, in line with what Article n°9 of our Constitution. An active community is also intelligent when everyone can do his or her part to contribute to a common goal: the good of the city and the rebirth of a place that is as beautiful as it is important to the history of Sicily, and of course, Italy.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.sfr.2023.100116](https://doi.org/10.1016/j.sfr.2023.100116).

References

- [1] V. Forgia, A. Ollè, J.M. Vergès, Early pastoral communities in the mountains of Sicily. Prehistoric evidence from Vallone Inferno (Scillato) in the palaeoenvironmental framework of the Madonie mountain range, *J. Anthropol. Archaeol.* 61 (2021), 1011238. VolMarchISSN: 0278-4165.
- [2] V. Forgia, *Archaeology of Uplands on a Mediterranean Island. The Madonie Mountain Range in Sicily*, Springer Editor, Berlin, 2019. ISBN: 9783030152222.
- [3] S. Lucatelli, D. Luisi, F. Tantillo, *L'Italia lontana. Una politica Per Le Aree Interne*, a cura di, Donzelli Editor, 2022. Rome, ISBN: 9788855223386.
- [4] V. Vitiello, R. Castelluccio, *Il Risanamento Delle Murature Affette Da Umidità Da Risalita Capillare, Il metodo CNT*, 2019, pp. 97–152. Luciano Editore, Naples.
- [5] E. Reynard, J. Brihla, *Geoheritage. Assessment, Protection, and Management* (2017). Amsterdam, ISBN: 9780128095317.
- [6] N. Wise, T. Jimura, *Tourism, Cultural Heritage and Urban Regeneration. Changing Spaces in Historical Places*, Springer Editor, London, 2020. ISBN: 9783030419042.
- [7] Ente Parco delle Madonie, *The Madonie park Geological guide. Madonie, a Story Two Hundred Million Years Long*, Ente Parco delle Madonie Editor, Petralia Sottana, 2012. ISBN: 9788895775074.
- [8] *Transforming Our World – The 2030 Agenda for Sustainable Development*, United Nations – Resolution Adopted by the General Assembly on Sep 25, 2015. <https://sdgs.un.org/2030agenda> [accessed 30 March 2023].
- [9] B. Ubertazzi, *Intangible Cultural Heritage, Sustainable Development and Intellectual Property*, Springer Editor, Berlin, 2022. ISBN: 9783031081033.
- [10] A. Anselmo, *Madonie. L'arte e La Storia*, Kalós Editor, Palermo, 2021. EAN: 9791280198105.
- [11] E. Panzera, *Cultural Heritage and Territorial Identity*, Springer Editor, Berlin, 2022. ISBN: 9783030944674.
- [12] C. Holtorf, A. Hoegberg, *Cultural Heritage and the Future*, edited by Taylor & Francis Ltd Editor, Milton Park, 2020. EAN: 9781138829015.
- [13] *National Recovery and Resilience Plan (PNRR)*, Italian Law D.L. n. 36/2022, available at, <https://italiadomani.gov.it/content/soget-ng/it/en/home.html> [accessed 15 February 2023], 2023.
- [14] *National Strategy for "Inner Areas" – SNAI*, available at <https://www.agenziacoesei.one.gov.it/strategia-nazionale-aree-interne/?lang=en>; 2022, [accessed 2 February 2023].
- [15] M. Rossetto, *Capillary Rising Damp in Historical buildings: Charge Neutralization Technology – a Needful Zero-Impact Instrument to Prevent and Resolve the Problem Once and For All*, Polytechnic of Milan, Italy, 2013 in proceedings of the scientific congress "Built Heritage 2013: Monitoring Conservation Management" Milan18-20 november.
- [16] B. Zwegers, *Cultural Heritage in Transition*, Springer Editor, Berlin, 2022. ISBN: 9783030937713.

- [17] M. Cappola, C.A. Garzonio, *Architectural Heritage in Mediterranean port Cities, Contributions & procedures for knowledge & conservation*, Florence, EAN, 2013, 9788879706247. EDIFIR Editor.
- [18] R.R. Thakur, A.K. Dutt, S.K. Thakur, G.M. Pomeroy, *Urban and Regional Planning and Development*, Springer Editor, Berlin, 2020. ISBN: 9783030317751.
- [19] Luna, A., *L'Italia (ri)nascce dai Borghi. Progettare il passato per conservare il futuro*, 2023, Diadema Editor, Association "I Borghi più belli d'Italia", link url: <https://borghipiubelliditalia.it/2023/01/17/presentazione-volumi-the-most-beautiful-borghi-of-italy-e-litalia-rinascce-dai-borghi>, [accessed 21 April 2023].
- [20] Italian Government, *Italian Law n° 4 January 2004, also called "Stanca Law" - Measures to facilitate access to IT tools for users and, in particular, persons with disabilities*.
- [21] V.I. Lakshmanan, A. Chockalingam, V. Kumar Murty, S. Kalyanasundaram, *Smart Villages. Bridging the Global Urban-Rural Divide*, Springer International Publishing, Berlin, 2022. ISBN: 978-3-030-68457-0.
- [22] S. Darwin, *How to Create Smart Villages: Open Innovation Solutions for Emerging Markets*, Black Radish Book, Syracuse, New York, 2020. United States ISBN: 978-1732135369.
- [23] L.H. Son, G.C.S. Yuen, *Dampness in Buildings. Building Maintenance Technology*, Macmillan Building and Surveying Series, Palgrave, 1993, https://doi.org/10.1007/978-1-349-23150-8_14. London.
- [24] E. Barreira, R.M. Almeida, *Infrared Thermography for Building Moisture Inspection*, Springer, Cham, 2019. Switzerland.
- [25] L. Ruiz Valero, V. Flores Sasso, E. Prieto Vicioso, *In situ assessment of superficial moisture condition in façades of historic building using non-destructive techniques. case stud*, *Constr. Mater.* 10 (2019) e00228. Matera.
- [26] R. Burkinshaw, M. Parrett, *Diagnosing Damp*. London, RICS Books, London, 2002. ISBN: 1842190970.
- [27] D. Camuffo, *Microclimate For Cultural Heritage*, Elsevier, Amsterdam, 2019. ISBN: 978-0-444-64106-9.
- [28] P. Mytton-Davies, *A Practical Guide to Repair and Maintenance of Houses*, Taylor & Francis, Milton Park, 1988. ISBN: 1850320160.
- [29] P. Reddin, *Inspecting And Diagnosing Disrepair*, Routledge, London, 2015. ISBN: 9781138802087.
- [30] D. Marshall, D. Worthing, R. Heath, N. Dann, *Understanding Housing Defects, Estates Gazette*, London, 2013. ISBN: 9780080971124.
- [31] D. Marshall, N. Dann, *House Inspector, Estates Gazette*, London, 2005. ISBN 9780728204898.
- [32] M. Como, *Statics of Historic Masonry Constructions*, Springer International Publishing, Berlin, 2017. ISBN: 978-3319547374.
- [33] A. Bambilla, A. Sangiorgio, *Moisture and Buildings. Durability issues, Health Implications and Strategies to Mitigate the Risks*, Elsevier, Amsterdam, 2021. ISBN: 9780128210970.
- [34] S.L.C Hugo, *Hens Building Physics – Heat, Air and Moisture*, Ernst & Sohn, New Jersey, 2017. ISBN: 9783433031971.
- [35] D. Kouis, F. Zezza, M. Kouis, *10th International Symposium on the Conservation of Monuments in the Mediterranean Basin. Natural and Anthropogenic Hazards and Sustainable Preservation*, Springer International Publishing, Berlin, 2018. ISBN: 9783319780931.
- [36] M. Argiolas, *L'umidità Da Risalita muraria. Diagnosi e sistemi Correttivi*, Maggioli Editore, Rimini, 2020. ISBN: 8891640034.
- [37] E. Pinto Guerra, *Risanamento Di Murature Umide e Degradate*, Palermo: Flaccovio Editore, Palermo, 2020. ISBN: 9788857910574.
- [38] V. Vitiello, N. Rossetto, *Heritage 4.0. Cultural sites the Integrated System C.N.T. For Rising Damp Diagnosis – Recovery – monitoring*. In: *Atti del IX Convegno Internazionale Diagnosi for the Conservation and Valorization of Cultural Heritage MANN - Museo Archeologico Nazionale di Napoli, Cervino Edizioni. Gugliano in Campania*, 2018. ISBN 9788895609423.
- [39] P. Scarzella, M. Zerbinatti, *Recupero e Conservazione Dell'edilizia storica. L'insieme, Le parti: Interrati e fondazioni, partizioni, coperture, Chiusure e Aggetti*, Alinea Editore, Firenze, 2009. ISBN: 9788860553737.
- [40] R. Castelluccio, V. Vitiello, *Deleting of Rising Damp in the Archaeological Site of Piazza Armerina Through the Application of the Technology By Neutralizing Electrical Charge T.N.C.*, In: *AUTORE, World heritage and degradation. Smart design, Planning and technologies. Le Vie Dei Mercanti, XIV International Forum, Naples*, 2016.
- [41] M.W.J. Prins, W.J.J. Welters, J.W. Weekamp, *Fluid Control in Multichannel Structures By Electrocapillary Pressure*, Philips Research Laboratories Eindhoven, The Netherlands, 2001. *Science*, Vol.291, Eindhoven.
- [42] K. Salemink, D. Strijker, G. Bosworth, *Rural development in the digital age: a systematic literature review on unequal ICT availability, adoption, and use in rural areas*, *J. Rural Stud.* 54 (2017) 360–371.
- [43] W.J.J. Welters, L.G.J. Fokkink, *Fast Electrically Switchable Capillary Effects*, Philips Research Laboratories Eindhoven, 1998. *The NetherlandsLangmuir*, Vol. 14, No. 7, Eindhoven.
- [44] H. Moon, S.K. Cho, R.L. Garrell, C.J. Kim, *Low Voltage Electrowetting-On-Dielectric*, University of California, Los Angeles (UCLA), 2002. *Journal of applied physics*, Vol. 92, No. 7, 1 Los Angeles, October.
- [45] A. Belluzzi, *Palazzo Te a Mantova*, Franco Cosimo Panini Editore, Collana Mirabilia Italiae, Modena, 1998. EAN: 9788876868085.
- [46] U. Bazzotti, *Palazzo Te a Mantova, Guide Skira*, Skira Edizioni, Losanna, 2005. ISBN: 887624146, EAN: 9788876241468.
- [47] Balzani, M. (cur.). *Il recupero luministico presso la chiesa Confraternita della Misericordia a Torino /Ostorero, Carlo - In: restauro, recupero, riqualificazione: il progetto contemporaneo nel contesto storico / - STAMPA, Milano: Skira*, 2011, ISBN 9788857212135. - pp. 269-275.
- [48] R. Castelluccio, V. Vitiello, M. Rossetto, *Heritage 4.0. Cultural sites. The integrated System C.N. T. For Rising Damp Diagnosis - recovery- monitoring*, IX International Proceeding AIES, Naples, Italy, Cervino edizioni, 2018.
- [49] R. Castelluccio, V. Vitiello, *Deleting of Rising Damp in the Archaeological Site of Piazza Armerina Through the Application of the Technology By Neutralizing Electrical Charge T.N.C.*, *Le Vie dei Mercanti -XIV Forum Internazionale di Studi, Naples*, 2016, 1457-1466.
- [50] L. Albanese, *Storia Di Polizzi. Le chiese, Il clero, San Gandolfo*, Edizioni Arianna Editor, Geraci Siculo, 2017. ISBN: 9788899981211.
- [51] S. Anselmo, Polizzi. *Tesori di Una Città Demaniale*, Sciascia Editor, Barcelona, 2006. ISBN: 9788882412395.
- [52] A. Salemi, *Il Recupero e La Conservazione Delle Fabbriche tradizionali. Le patologie Da Umidità*, Gangemi Editore, Roma, 2016. ISBN: 9788849250978.
- [53] P. Gasparoli, C. Talamo, *Manutenzione e recupero. Criteri, Metodi e Strategie Per L'intervento Sul Costruito*, Firenze: Alinea Editore, 2006. ISBN: 9788881258598.
- [54] I.T. Steffan, *Design For all. Il progetto Per Tutti*, Maggioli editore, Santarcangelo di Romagna, Ravenna, 2012. ISBN: 8838761809.
- [55] Rolando, A., Scandiffo, A., *Milan-Turin: a bundle of infrastructures to access a network of places. Between cultural heritage and landscape. In Heritage architecture landesign. Focus on conservation regeneration innovation. Proceedings of the XI International Forum Le Vie dei Mercanti (Aversa-Capri, June 2013)*, ed. Gambardella, Carmine. Napoli: La Scuola di Pitagora. Napoli: La scuola di Pitagora editrice, 2013, ISBN 9788865422908.
- [56] V. Guallart, *The Self-Sufficient City*, Actar, Barcelona, New York City, 2012.
- [57] R. Bolici, L. Mora, *Dalla Smart City Alla Smart region. In City 2.0. Il futuro Delle città. La sfida Delle Smart Cities Tra Opportunità e Necessità*, Altea, 2012 eds. Bertello, Agnese, and Blanchetti, Emilia. Milano.
- [58] J. Rifkin. *The Third Industrial Revolution. How lateral Power is Transforming energy, the economy, and the World*, Palgrave MacMillan, New York, 2011, ISBN 9780230115217.
- [59] Cruz-Cunha, M., Maria; Miranda, Isabel Maria and Gonçalves, Patricia. *Handbook of Research on ICTs For Human-Centered Healthcare and Social Care Services*. <http://www.igi-global.com/dictionary/developing-countries/7401> [accessed 21 March 2023].
- [60] K. Salemink, D. Strijker, G. Bosworth, *Rural development in the digital age: a systematic literature review on unequal ICT availability, adoption, and use in rural areas*, *J. Rural Stud.* 54 (2017) 360–371. Elsevier, London.