Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 180 (2017) 1024 – 1033

Procedia Engineering

www.elsevier.com/locate/procedia

International High- Performance Built Environment Conference – A Sustainable Built Environment Conference 2016 Series (SBE16), iHBE 2016

# Resilience of historic built environments: Inherent qualities and potential strategies

Fabio Fatiguso[a], Mariella De Fino[a]*, Elena Cantatore[a], Viviana Caponio[a]

[a] *Department DICATECh, Politecnico di Bari, Via Orabona, 4, 70125, Bari, Italy*

**Abstract**

The historic built heritage is conceived, in terms of morphology, typology and construction technology, as a responsive and adaptive system to the environmental surroundings. Nevertheless, it is featured by spatial and functional configuration, resulting from a continuous evolution process of social, economic and cultural events for the territory and the community. Thus, it shows inherent characteristics connected with the concept of "resilience", namely the capability to prevent, adjust and overcome changes, even traumatic and catastrophic ones, through natural protection from calamities, exploitation of available resources, transformation of arrangement layouts, aggregation schemes and uses. However, the historic built heritage is affected by specific vulnerabilities, in terms of functional, normative and technological obsolescence, due to increasing requirements of safety, well-being and accessibility, as well as in terms of historic and architectural values, whose conservation and enhancement might conflict with the performance improvement. The present study aims at investigation and assessment of methods and tools that might support the identification of potentialities and criticalities of historic built environments with regard to the urban resilience. For that, a multi-scale approach, from the urban to the building level, and a multi-disciplinary vision, including environmental, economic, social and cultural aspects, is pursued. Particularly, the paper is going to focus on the development and validation of a methodological framework, as decision-making support to identify and control the factors that mostly influence the resilient behavior of the historic built heritage. The application to the "Sassi di Matera", UNESCO site and outstanding compound of rock grottoes, anthropic caves and masonry structures, means to validate the proposed criteria and strategies, in view of their dissemination and replicability.



Peer-review under responsibility of the organizing committee iHBE 2016

*Keywords:* Built Heritage; Assessment methods; Resilience strategies; UNESCO Site

* Corresponding author. Tel.: +39-0805963420; fax: +39-0805963414.
*E-mail address:* mariella.defino@poliba.it



Peer-review under responsibility of the organizing committee iHBE 2016
doi:10.1016/j.proeng.2017.04.262

## 1. Introduction

The resilience – namely the capability of a system, a community or a society exposed to hazards to mitigate, resist, change and recover from the effects in a timely and efficient manner, by keeping its functions and structures – has gained increasing attention within the international debate, at institutional, scientific and technical levels. The topic, which involves different fields – environmental, social, economic and political – depending on the main character of the "resilient system", offers interesting research perspectives for the development of innovative planning and management models of towns. In fact, towns might be considered as complex systems, where an intersection takes place at the local scale among weaknesses and strengths of the natural and manmade "environment", the "society" of citizens and visitors, the "economy" of commerce, labour and tourism and the "politics" of administrators and institutions.

Particularly, there are numerous activities to raise awareness and dissemination on the topic by international organizations such as GFDRR (Global Facility for Disaster Risk Reduction), UNISDR (United Nations Office for Disaster Risk Reduction) and UN-HABITAT (United Nations Human Settlements Programme) [1,2,3], as well as studies of universities and research centres [4,5,6,7,8], aimed at defining principles, criteria and strategies of urban resilience. Among several international experiences, it is worth mention the results of the "100 Resilient Cities" programme, which has focused on the assessment of several representative pilot-cases worldwide and it has identified the main features of the ideal resilient city, in terms of pre-crisis "preparation", crisis "absorption" and post-crisis "recovery" and "adaptation". In detail, the most relevant features are: "reflective", namely able to profit by the critical assessment of past experiences to predict possible transformations and to inform future decisions; "robust" through well-conceived, constructed and managed systems to withstand a crisis without significant structural damage and loss of function; "redundant" and "resourceful", thus showing spare capacity purposively created to accommodate disruption, by multiple pathways to achieve a given need and efficient ways to manage resources under extraordinary pressures; "flexible" in adopting transient and dynamic solutions in response to changing circumstances or sudden crises; "inclusive" and "integrated" in promoting consultation and cooperation among all the social, economic and institutional stakeholders [9].

The above-mentioned aspects are specifically relevant when referring to the historic built environments, which show some inherent qualities of resilience. Particularly, this applies to three dimensions of resilience: environmental, socio-cultural and socio-economic [10]. In detail, the environmental resilience refers to the ability to respond to changing climatic conditions by reducing the physical vulnerability to natural hazards. The socio-cultural resilience concerns the development over time of intangible values, such as behaviour, knowledge, construction practice and social cohesion that help to create a sense of identity for a community and awareness on land exploitation and management. The socio-economic resilience invests the relation between productivity and social well-being, in terms of efficient and autonomous management of material resources and people's involvement in decision-making.

For historic urban settlements, such aspects are reflected in the morphology, typology and construction technology, as responsive and adaptive systems to the environmental surroundings, as well as in the spatial and functional configuration, resulting from a continuous evolution process of social, economic and cultural events for the territory and the community. However, despite some inherent qualities of resilience, the historic built environments are affected by specific vulnerabilities, which might prevent form the implementation of modern mitigation, resistance and adaptation models. The reasons are basically the increasing environmental pressures, mainly related to the climate change, which will result in a fairly unprecedented exposure to natural hazards (floods, earthquakes, temperature elevation, ...); the performance deficiencies, in terms of functional, technological and normative obsolescence, due to increasing requirements of safety, well-being and accessibility; the historic and architectural values, whose conservation and enhancement might conflict with the performance improvement.

Thus, the development of methods and tools are highly desirable that might guide the recognition and enhancement of the actual qualities, as well as in identifying and overcoming the vulnerabilities of historic urban settlements, through a set of integrated strategies to ensure the desirable balance between preservation of the original identity and adaptation to new requirements. Based on the outlined issues, a research group at the Polytechnic of Bari has recently focused on the definition and validation of a methodological framework, as a decision-making support to identify and control the factors that mostly influence the resilient behavior of the historic built heritage,

with specific focus on the Mediterranean area, toward the selection of suitable enhancement and improvement solutions.

## 2. Methodology

The research methodology is based on the correlation between the different dimensions of resilience - environmental, socio-cultural and socio-economic - and the different phases of historic built heritage refurbishment - analysis, diagnosis, intervention – as widely recognized and applied by scholars and technicians [11,12,13].

Specifically, it follows a multi-scale approach, from the urban to the building level, and a multi-disciplinary vision, including environmental, economic, social and cultural aspects.

It comprises a preliminary analysis phase, focused on the collection of data and information that outline the scope of interest. The analysis supports the diagnosis phase for the assessment of inherent vulnerabilities and qualities of historic towns, in order to carry on the final phase for the definition of potential enhancement and improvement strategies.

In detail:

I. ANALYSIS PHASE. It comprises:

- Historical-geographical analysis. It concerns the historical evolution of the settlement, from the foundation nucleus to the following development layers, with specific attention to the relationships between natural and built environment, as well as to the processes that led the transformations in time.
- Urban-architectural analysis. It regards the morphology of the territory, the mechanical and hygrometric characteristics of the foundation soil, as well as the urban arrangement, the building typologies, the construction materials and techniques, the mobility, usability and accessibility facilities, also related to the state of conservation and the residual performances of open spaces and buildings.
- Functional analysis. It focuses on uses and functions of the urban built environment, in terms of demographic trends and distribution of residential areas, productive, cultural and touristic activities, real estate market, touristic attractiveness and features of social spaces.
- Normative analysis, at national, regional and local levels, in order to identify the strategic framework programmes, in terms of achieved results and foreseen misusers.

II. DIAGNOSIS PHASE OF VULNERABILITIES AND QUALITIES, namely the assessment of weaknesses and strengths in showing a resilient behaviour in response to risk exposure. Vulnerabilities and qualities are referred to the three dimensions of resilience – environmental, socio-cultural and socio-economic. It is worth underline that such a distinction is useful to systematize, share and discuss the aspects of interest, given that all the dimensions are complementary and interdependent.

III. INTERVENTION PHASE for the selection of suitable strategies and solutions that might exploit and enhance the inherent qualities, also in order to derive from them principles and rules for the definition of improvement measures with regard to the vulnerabilities.

As said, the above-described methodology has been tailored to the Mediterranean historic urban settlements within the ongoing research programme. Herein, the case study of the “Sassi of Matera”, outstanding compound of rock grottoes, anthropic caves and masonry structures in South Italy and UNESCO site since 1993, is presented.

It is worth underline that the site is unique from the environmental and architectural perspectives. Nevertheless, due to its peculiar complexity, it is highly representative of several interesting and challenging aspects related to the urban resilience, including the development in symbiosis with the topography of the area and the local climate, the efficient exploitation of indigenous resources, the transmission of traditional values of the rural culture, as well as the construction practice, expression of an empirical and established wisdom.

As such, it may allow the validation of the methodology toward its replicability and scalability on less articulated and complex cases.

## 3. The "Sassi di Matera"

With reference to the above-described methodology, the analysis phase, at the historical-geographical, urban-architectural, functional and normative scales, has been carried out through archivist and bibliographic sources, records of institutional plans and programmes, as well as results of onsite investigation and survey.

For the sake of shortness, only the most significant analysis data are herein reported, in order to support the discussion of the following diagnosis aspects.

### *3.1. Historical-geographical analysis*

The foundation nucleus of the town of Matera, also known as "Civita", rose up on a promontory "Sperone Mediano" surrounded by two valleys of fertile lands for agricultural activities. Such an arrangement resulted in a natural interaction among settlement, production and defence purposes [14].

During the XIII and XIV centuries, following an initial increase in population, at the bottom of the southeast side of the promontory, characterized by a natural system of terraces and steps, some anthropic caves excavated in the limestone rock started developing as villages for agricultural labourers. Such villages were named as "Sassi" – Italian word for "Rocks", specifically "Sasso Barisano" and "Sasso Caveoso" (Fig. 1).


Fig. 1. The "Sassi" arrangement.

During the XV and XVI centuries, following a further demographic growth, the "Sassi" expanded by structures built beside either/or above caves and grottoes, exploiting the local "tuff" limestone. At that time, a strong contrast, in terms of life quality, started coming to light, between the "Civita" where nobles and members of the clergy lived and the "Sassi" as ghettos surrounded by customs borders [16]. Within such borders, the "Sassi" were arranged in a wide-mesh layout with numerous orchards and cisterns [15].

In the middle XIX century, the "Sassi" achieved the highest density. Therefore, the life quality and the sanitary conditions dramatically worsened, so that, at the beginning of the XX century, they became emblematic of the deprived status of the rural class in South Italy.

Despite the riots and the national measures for the rehabilitation of the site, in 1938 the "Sasso Barisano" and "Sasso Caveoso" counted about 3,000 dwellings. Among them, over 55% was not provided with natural light and air and showed severe moisture problems [17].

Only since 1952, the site was considered by the public opinion as a national emergency. Thus, specific laws were issued for the requalification of the two districts that led quickly to their depletion and abandonment. Since the early

70's, the functional recovery process of the Sassi started. First, a long planning phase was developed. Then, more operation tools were conceived, such as the "Special Law 771" in 1986, whose analysis is deferred under section 3.4.

### *3.2. Urban-architectural analysis*

From the analysis of the historical evolution of the site, the close correlation between the urban-architectural system and the surrounding natural environment clearly emerges. Furthermore, the geo-morphological analysis has pointed out that the territory is mainly characterized by limestone rocks, which has undergone multiple fractures along the "Sassi" side, where a complex system of water flow paths has developed.

From the typological point of view, beside numerous rupestrian churches and architectural monuments, which are not herein described, several types of dwellings might be identified:

- The adaptation to the rock morphology, featured by terraces and steps, has resulted in units with one, two or three levels without internal staircases and with independent entrances at different heights on opposite sides;
- The different aggregation of the basic units (Fig. 2) has resulted in several building typologies: rupestrian caves completely excavated in the rock; mixed dwellings, with a single built vaulted room, the "lamione", connected with contiguous caves; courtyard houses; palace houses with hypogeal ground floor and built first and second floors; monumental palaces, which are featured by several vaulted rooms and decorated facades.

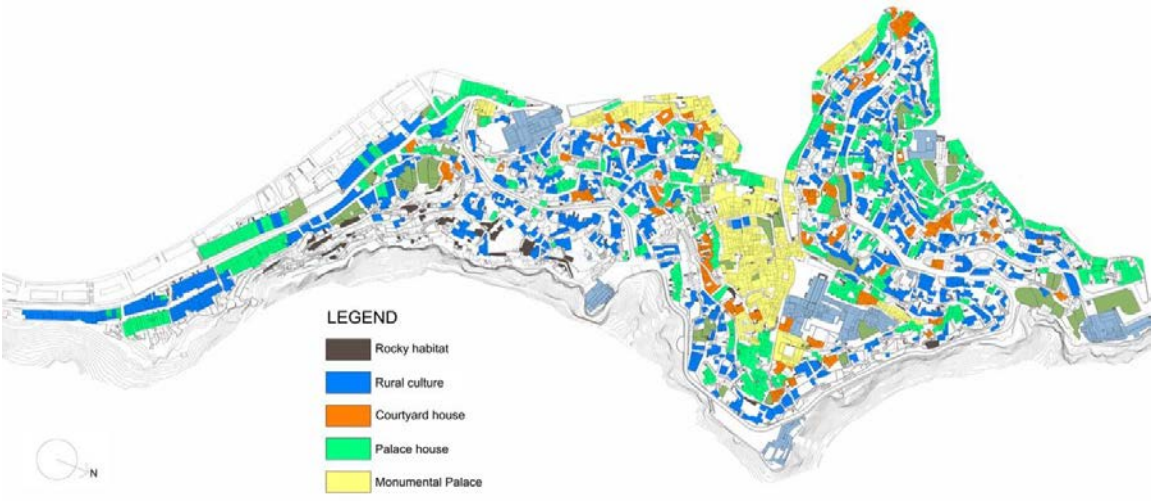


Fig. 2. Building typologies.

Such building typologies are featured by common construction materials and techniques for walls and floors. The walls, which close the hypogea and border the structures built beside either/or above, are thick cavity masonries made out of local "tuff" limestone squared blocks. The floors are barrel vaults with "tuff" limestone at the lowest levels and clay bricks at the highest levels, with deep extension toward the inside that provide the indoor space with natural cooling in summer due to the rock thermal inertia.

The buildings are generally featured by an efficient management system for meteoric waters. From sloping roofs and canals, the rainfall waters flow along vertical distributors, such as natural rock fractures or anthropic pipes from stone quarrying, and gather in underground and elevated cisterns, where they might be adducted through wells.

The mobility in the site mainly exploits the natural terraces and steps. Some connecting routes are paved with high slopes. As reported in the studies that have been developed since the 70's, some buildings, affected by poor sanitary conditions, structural instability and missing connection with the water distribution grids, were abandoned. Despite several requalification actions over the last decades, some of them are not yet recovered (Fig. 3).

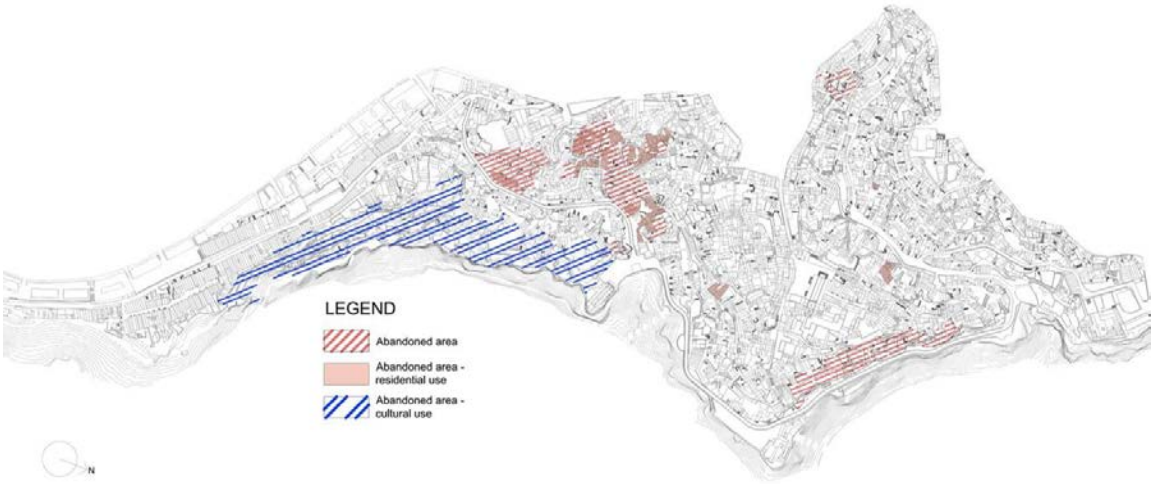


Fig. 3. Current abandoned areas.

### *3.3. Functional analysis*

The analysis of historical data has showed that the main users of the “Sassi” have always been the agricultural labourers from the surrounding fields. This information is useful to understand the prominent residential use of the site. This has also affected the initial urban requalification directives, which only recently have envisaged the possibility to provide the area with commercial activities and craft laboratories before and with touristic facilities (hotels, restaurant, leisure centres) afterwards, in order to revitalize the site and enhance the attractiveness for visitors. Nowadays, there is a 1.57 residents/tourists ratio, with subsequent rapid increase of reception and accommodation structures. Furthermore, the analysis of historical data has revealed the key role of the “neighborhood” in the social life of the community, as proved by numerous public squares and semi-open courtyards, common wells, cisterns, gardens and orchard, where close relationships among people guaranteed mutual protection, assistance and sustenance. Such relationships were mainly connected with the rural life in the “Sassi” and are now almost lost.

### *3.4. Normative analysis*

The analysis of regulatory instruments is useful for understanding the operational opportunities for suitable interventions, as well as the occurred transformation processes. In fact, the “Sassi” have been under debate since 1952, following the sanitary emergency that affected the living conditions of the peasant classes in the city of Matera. The main legal instruments for the site, born after the “Special Law 771” in 1986 are as follows:

Firstly, the Biennal Plan in 1988, limited to certain areas of the “Sassi”, aimed to re-ensure the habitability and introduce new urban functions. Thus, the measures were focused on the conservation and rehabilitation of the buildings without affecting their typological and historical values, as well as on the introduction of commercial activities, specialized training laboratories for restoration and preservation of the cultural heritage, touristic and cultural initiatives. Such interventions were also combined with design of rupestrian green areas and pedestrian mobility paths that would improve the accessibility of the site. Furthermore, 18 "areas of uniform planning" were identified, in order to develop compatible guidelines and best practices for the refurbishment, according to principles of safeguard and preservation of the architectural and constructional identity. Then, the second Biennal Plan in1994 was extended to the entire urban area, in order to enhance the overall cultural landscape, following the same principles and methods of the previous plan. Finally, the third Biennial Plan in 2004 was delivered as instrument for

the cultural, urban and legislative review of the general requalification programme. The programme was developed according to a conservative approach, through recovery of original typological-architectural features and functional uses, based on the identification of homogenous intervention comparts. The proposal aimed to restore the typological identity of the "Sassi", by eliminating some forced transformations. Moreover, it focused on the urban chambers, to be recovered as social places for the community against some initiatives of private use and on the abandoned areas to be reconnected within the urban framework.

## 4. Inherent qualities and vulnerabilities

Based on the results from the phase I of analysis, the phase II of diagnosis has been developed, in order to assess the inherent qualities and vulnerabilities of "Sassi", with reference to the environmental, socio-cultural and socio-economic dimensions of the urban resilience for historic sites (Table 1).

It is worth restate that such a distinction means to highlight the predominant dimension of the following aspects, which are still integrated and correlated within the joint vision of the general topic. Furthermore, it is worth underline that inherent qualities and vulnerabilities take into account the risk factors throughout the time. In detail, the vulnerabilities are identified projecting in the future the effects of their evolution, even if they are not currently hazardous in some cases. On the contrary, the qualities are assessed based on their role in the past, as conditions that help the historic site overcome environmental, social and economic pressures over the centuries and persist as resistant, responsive and adaptive ecosystem in the present.

Table 1. Inherent qualities and vulnerabilities of "Sassi di Matera".

| Resilience dimensions | Vulnerabilities | Qualities |
|---|---|---|
| Environmental | Va1. Morpho-typological arrangement and mechanical characteristics of the soil | Qa1. Management systems of rainwater |
| | Va2. Planimetric layout and distribution of underground and surface waters | Qa2. Bioclimatic behaviour |
| | Va3. Physical-mechanical characteristics of "tuff" stone as building materials | Qa3. State of conservation of hypogea |
| | Va4. Liveability of indoor spaces | |
| Socio-cultural | Vsc1. State of conservation of comparts | Qsc1.Local construction tradition |
| | Vsc2. Use of urban chambers | Qsc2. Social value of places |
| | Vsc3. Accessibility | |
| Socio-economic | Vse1. Connection with the modern city | Qse1. Touristic development |
| | Vse2. Development of tertiary sector | |

In detail, among the environmental vulnerabilities:

Va1. Morpho-typological arrangement and mechanical characteristics of the soil. The plateau of the Murge is a karst topographic plateau, featured by tectonic movements and discontinuities that cause the separation of limestone blocks. The fractures across the blocks result in sliding planes, particularly along the Sassi side. Furthermore, the limestone soil at low elevation and across the canyon shows heterogeneous, even poor, mechanical properties. Such conditions might cause, in the medium-long term, some differential failures in the foundation soil, with following vertical translation either/or rotation of the buildings above, eventually worsened by the presence of underground dolines, sinkholes and caves.

Va2. Planimetric layout and distribution of underground and surface waters. The territory is featured by a distinctive arrangement of direction lines and collections areas, where underground and surface waters flow and gather. In some cases, such conditions might be critical due to the permeability of the limestone. The following rising dampness would be responsible of poor indoor air quality, especially when ventilation is lacking. Moreover, it might progressively affect the soil cohesion and resistance. Furthermore, in the vent of very severe rainfalls, the water flow rate might exceed the capacity of distribution and drainage facilities, with potential floating of squares and building roofs.

Va3. Physical-mechanical characteristics of "tuff" stone as building materials. The construction tradition of "Sassi" is based on masonry structures made out of "tuff" limestone as onsite quarried. However, such a material is very vulnerable to chemical and physical stresses from atmospheric agents and ground water aquifer, which might cause erosion and desegregation, eventually resulting in future structural instability of the buildings above.

Va4. Liveability of indoor spaces. The hypogeal development of the built environment might result in thermal, visual and air quality conditions, which could be inadequate according to current requirements and standards. Thus, the selection of incompatible uses either/or maintenance activities might trigger functional, physical and normative obsolescence.

Among the socio-cultural vulnerabilities:

Vsc1. State of conservation of comparts. Within the urban site, some comparts still show abandoned open spaces and decayed buildings, with wild vegetation and missing protection and control systems. Such areas might be suitable for illicit activities with hazardous effects on the safety of the surrounding occupied areas.

Vsc2. Use of urban chambers. The "Sassi" are currently featured by the closure of public urban chambers by fences, orchards, gardens and gates by private users. As a result, the full fruition of the open spaces is limited. Moreover, the isolation attitude alters the social relationships and the cultural identity of the places.

Vsc3. Accessibility. The vehicle accessible roads in the "Sassi" are only three, whereas all the remaining routes are generally narrow and steep with unstable floor tiles. Consequently, the site is currently inaccessible to disabled people. Moreover, in the long term perspective, the evacuation in the event of an emergency (fire, flooding) might be critical.

Among the socio-economic vulnerabilities:

Vse1. Connection with the modern city. The site is still quite disconnected with spaces, structures and functions of the modern town. Thus, the fruition of some facilities in Matera is quite limited for residents and tourists.

Vse2. Development of tertiary sector. Over the last decades, the number of visitors has dramatically increased. Moreover, the designation of Matera as European Capital of Culture 2019 will certainly strengthen such a positive trend. However, the emerging touristic attractiveness has resulted in the uncontrolled development of the tertiary sector. Beside some commercial, manufactural and handcrafted activities, often tourists-customized, numberless bed&breakfasts, hotels, room rentals have developed. Such a tendency might be quite critical in the long-term perspective. In fact, if the touristic flows keep growing, Matera will run the risk to become a "museum town", where all the residents move out due to the increasing costs and the crowded environment. On the contrary, if the touristic flows go down, the area will be abandoned by touristic shop keepers and operators with consequent functional and physical decay.

Among the environmental qualities:

Qa1. Management systems of rainwater. The urban arrangement has developed across the natural paths where the waters flow and gather. In most cases, connected sloping roofs, canals, underground and elevated cisterns enabled the collection of a great quantity of rainwaters. Moreover, well-designed and well-maintained protection and drainage systems prevent from infiltration and condensation and provide recycled water for domestic uses and irrigation. Thus, the management systems of meteoric waters might be useful for a "redundant" and "resourceful" resilient town under crisis.

Qa2. Bioclimatic behaviour. The massive walls, both excavated in the rock and built form the rock, show a desirable thermal regulation function for the indoor spaces. In fact, the inherent inertia attenuates and delays the temperature peaks, especially in summer. Thus, the indoor spaces exhibit a "resistant" behaviour to the external environmental conditions. That thermal stability is also favourable in the medium-long term, taking into account the increasing average seasonal temperatures.

Qa3. State of conservation of hypogea. The static conditions of the hypogea are generally satisfactory, with limited evidence of failures of the rock vaults. The grottoes are actually emblematic of the inherent resilience of the "Sassi". Although the identification of compatible uses is challenging, the underground strictures have proved to be "resistant" to any sort of seismic and geological risk.

Among the socio-cultural qualities:

Qsc1. Local construction tradition. The construction practice featuring the vernacular architecture is an invaluable material and immaterial heritage, which proves the "resourcefulness" and "flexibility" in the anthropization of the natural environment. Such an empirical building "art" represents the keystone of the social and

cultural identity of the town. Thus, its conservation and enhancement are paramount in order to transmit the values that history has proved as resilient, due to their persistence against traumatic events throughout the centuries.

Qsc2. Social value of places. The social identity and cohesion are highly desirable to overcome hazardous conditions. Thus, the traditional social system featuring the "Sassi" community should be preserved to promote a "reflective" resilient town. The concept of "neighbourhood", basic unit of the society, where close relationships among people guarantee mutual protection, assistance and sustenance, should be safeguarded as basis of a community able to react to hazardous though cooperation and communication.

Among the socio-economic qualities:

Qse1. Touristic development. The increasing touristic attractiveness has triggered a series of funding schemes within the framework programmes for retrofitting, reuse and management. Particularly, interesting development perspectives are feasible to start up activities and facilities for residents, beside the visitors, in order to create a balanced functional distribution among residential, cultural, artistic, commercial and social uses, as well as to support the restoration and conservation of monuments.

The above-mentioned diagnosis aspects are herein discussed with reference to the whole urban site. Nevertheless, they might be easily applied at the compart, building and construction component scales, in order to identify and assess specific potentialities and criticalities. For instance, Fig. 4 shows a diagnosis table for the Compart "A", based on the analysis of morpho-typology, construction materials and techniques and state of conservation of a limited and distinctive portion of buildings and open spaces.


Fig. 4. Analysis of inherent qualities and vulnerabilities at the compart scale.

## 5. Toward resilient strategies

Within the general methodology, the historic-geographic, urban-architectural, functional and normative analysis, as well as the diagnosis at the environmental, socio-cultural and socio-economic levels, pave the way for the identification of the compatible strategies, provided that measures and interventions should overcome the distinction among different thematic areas and outline some development scenarios, which include and interpret the multidisciplinary complexity of the urban resilience.

Thus, for the case study of the "Sassi di Matera" is ongoing the definition of suitable solutions, which might be referred to some transversal macro-areas of intervention. Among them, the restoration and retrofitting of the buildings, by reinforcement and dehumidification works (Va1, Va2, Va3) with traditional techniques, are paramount to give cultural and technical continuity to the local construction practice (Qsc1), by preserving the architectural identity (Qa3) and the bioclimatic performances of the structures (Qa2).

Furthermore, along with the intervention on physical obsolesce and pathologies, the reuse will guarantee the desirable conservation, maintenance and control of the buildings. However, functions and activities should ensure balanced distributions of residential, touristic and socio-cultural uses (Vse2), high compatibility with the morphology, typology and microclimate of the indoor spaces (Va4) for temporary or permanent occupation and wise understanding of the territory needs and requirements (Qse1).

Such a reuse should also include the recovery of the public nature of the urban chambers (Vsc2), the requalification of abandoned and decayed areas (Vsc1), as well as the enhancement of the relationship with the water resource, by exploitation of available collection and drainage structure at the compart scale (Qa1) and the improvement of urban water management systems (Va2).

Finally, the opportunity to strengthen the physical and functional connection with the modern town (Vse1) and to guarantee higher accessibility levels (Vse3) might be achieved through the installation of compatible, non-invasive and reversible systems for fruition and mobility of the site.

The application to the case study has supported the validation of the methodology toward the replicability for similar historic urban sites. Moreover, the results, although coming from a unique pilot case, have shown specific aspects of the general themes, in terms of relations among analysis data and diagnosis factors toward suitable solutions for enhancement of qualities and improvement of vulnerabilities, within the safeguard of the social and cultural value of the built heritage.

## References

[1] Global Facility of Disaster Reduction and Recovery (GFDRR). The World Bank, Building principles, tools and practice; 2012.
[2] UNIDSR. How To Make Cities More Resilient. A Handbook For Local Government Leaders. A contribution to the Global Campaign 2010-2015, March 2012, Geneva.
[3] The World Bank, The Australian Group, Building Urban Resilience. Tools for building urban resilience: integrating risk informatio into investment decision, in www.gfdrr.org , Washington; 2012.
[4] Roggema R. Towards enhanced resilience in city design: a proposition; Land, 2014, Vol.3, pp. 460-481.
[5] Jabareen Y. Planning the resilient city: concepts and strategies for coping with climate change and environmental risk. Cities, 2013, Vol. 31, pp. 220-229.
[6] Allan P, Bryant M. Resilience as a framework for urbanism and recovery. Journal of Landscape Architecture, 2011, Vol.6, No.2, pp. 34-45.
[7] Sharifi A, Yamagata Y. Principles and criteria for assessing urban energy resilience: A literature review, Renewable and Sustainable Energy Reviews, 2016, Vol. 60, pp. 1654-1677, ISSN 1364-0321.
[8] Meerow S, Newell JP, Stults M. Defining urban resilience: A review, Landscape and Urban Planning, 2016, Vol. 147, pp 38-49.
[9] The Rockefeller Foundation, City resilience and the City Resilience Framework - www.100resilientcities.org, 2015.
[10] Correia M, Dipasquale L, Mecca S (Eds.). VERSUS: Heritage for Tomorrow. Firenze, University Press, 2015.
[11] De Freitas VP. A State-of-the-Art Report on Building Pathology, CIB FEUP Editor, Porto. 2013. ISBN: 978-90-6363-082-9.
[12] RehabiMed, Traditional Mediterranean Architecture. Rehabilitation: town and territory, in www.rehabimed.net, Barcelona, 2007.
[13] RehabiMed, RehabiMed guide to the rehabilitation of traditional buildings, in www.rehabimed.net, Barcelona, 2007.
[14] Isnardi G. L'ambiente geografici. Saggi Introduttivi, UNRRA Casa - Prima giunta, Roma, pp. 15-23, 1956.
[15] Giura Longo R. Sassi e Secoli, Galleria studio Ed., Matera, 1966.
[16] Tafuri M and Restucci A. Un contributo alla comprensione della vicenda storica dei Sassi. Repubblica italiana, SassiSassi Concorso internazionale sui Sassi di Matera, Matera, 1974.
[17] Crispino L. Inchiesta demografica sull'abitato dei Sassi e sulle malattie sociali della città di Matera, Tip. Conti, Matera, 1938.