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From Urban Vulnerabilities to Resilience: Lessons from Messina's Integrated Risk Approach

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ABSTRACT

In the city of Messina, the multiplicity of vulnerable situations is a distinctive feature and is representative of the pervasiveness of the risk conditions present in the Italian territory. The critical residential tissues are part of an extended geography in which, to the conditions of seismic and hydro geomorphological vulnerability, are added additional criticalities including altered natural resources, abandoned infrastructure, brownfields, quarries, and unregulated landfills, etc. Despite this, for Messina, there is still no urban planning tool capable of interpreting in an integrated way the risks present, which instead continue to be addressed on an emergency basis and individually, without considering the interactions that are generated and of further damage. For these reasons, Messina was chosen as a prototypical case study, at the national level, to start an experimentation aimed at developing an urban planning tool capable of a new integrated approach to risk interpretation and management. In this process, a decisive role was aimed at building an updated knowledge of the territory through the identification of widespread critical conditions using multiple GIS tools and thanks to the interaction of some analytical-specialist readings from different sources. The results of this process are represented in a system of maps that are strongly integrated with each other and constitute a working document for the interdisciplinary group drafting the General Urban Plan.

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Highlights:	**Contribution to the field statement:**
- Hazards are increasing due to human impact, especially in climate change and recent catastrophic events. - Messina is a case study for resilient urban policy, involving collaboration for risk adaptation. - The "Integrated Risk Map" synthesizes various risks for effective mitigation. - The "Integrated Risk Map" is a dynamic tool for strategic resilience in Messina.	- In-depth study and construction of a knowledge framework of the vulnerability factors and risks present in urban areas and urbanised territories. - Integrated planning of risks for the mitigation of their effects and the resilience of urban areas.

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1. INTRODUCTION

The concept of risk characterizes cities around the world as an outcome of the processes of uncontrolled urbanization, the decommissioning of productive areas, the resulting high land consumption, the overexploitation of resources, air, water and soil pollution, hydro, and geomorphological vulnerabilities, further accentuated by climate change. The increase in urbanization along coastal areas is a problem as timely as ever since it is precisely along the coasts that the effects of climate change and all other related and interdependent risks are most apparent. In the international scene, the concept of risk has undergone several changes in meaning and significance in recent years aimed at recognizing an increasingly broader and more complex spectrum of this term, officially acknowledging the advances that were being conducted as they were being conducted in scientific debates at the international level. This development can be seen immediately when considering reports from major international specialist conferences. "The exposure of populations and infrastructure to hazards has increased significantly in recent decades, mainly due to urbanization and unsustainable development in hazard-prone areas. Globalization, urbanization and an increasingly interconnected world also increase the likelihood that disaster impacts will cascade across systems." (GAR, 2022) Therefore, the contribution intends to place itself in these research areas by asking the following question: how and to what extent can the risk conditions generated by many interrelated hazards on a coastal territory be addressed to develop urban integrated hazard mitigation plans? Building on these reflections, this article aims to illustrate a pilot project initiated in 2017-2018 and developed by the Italian government mission structure "Casa Italia" and the Municipality of Messina (Sicily, Italy) to test an integrated risk planning approach. A first and important phase of experimentation took place within the process of drafting the Preliminary Urban Plan (called Schema di Massima, approved by Municipal Council Resolution No. 197 of 10/04/2018) that the Municipality of Messina has initiated using the advice of Prof. Arch. Carlo Gasparrini and other external professionals; the authors took part in the working group (Anna Terracciano as technical-operational coordinator, Giovanna Ferramosca as trainee). Since 2022, a process of updating the Preliminary Plan has been underway for which information cannot yet be provided. In this complex context, an integrated reading of the risks present is proposed with the aim of overcoming the sectoral modes typical of traditional Specialist Studies, but also to become the main tool on which to outline the strategic and priority objectives capable of targeting the vision of a "resilient and anti-fragile city," based on adaptive and pro-active tactics and design actions.

These aspects are thus illustrated within this contribution:

1) The definition of materials and methods for the construction of a spatial knowledge framework aimed at returning an Integrated Risk Map, understood as a dynamic and updatable tool, developed and to be interrogated in GIS environments.

2) The definition of the Guidelines for the Environmental and Settlement Systems of the new General Regulatory Plan of Messina, in which is central the role of Blue and Green Infrastructure understood as the new incremental frame on which to base the urban and environmental regeneration of the city as well as the mitigation of risks.

3) The definition of design scenarios in which the SUM - Minimum Urban Structure (to be further defined in the continuation of the drafting process of the Plan itself) is central to the design of the Plan and the design of the city itself, as well as to the processes related to risk management.

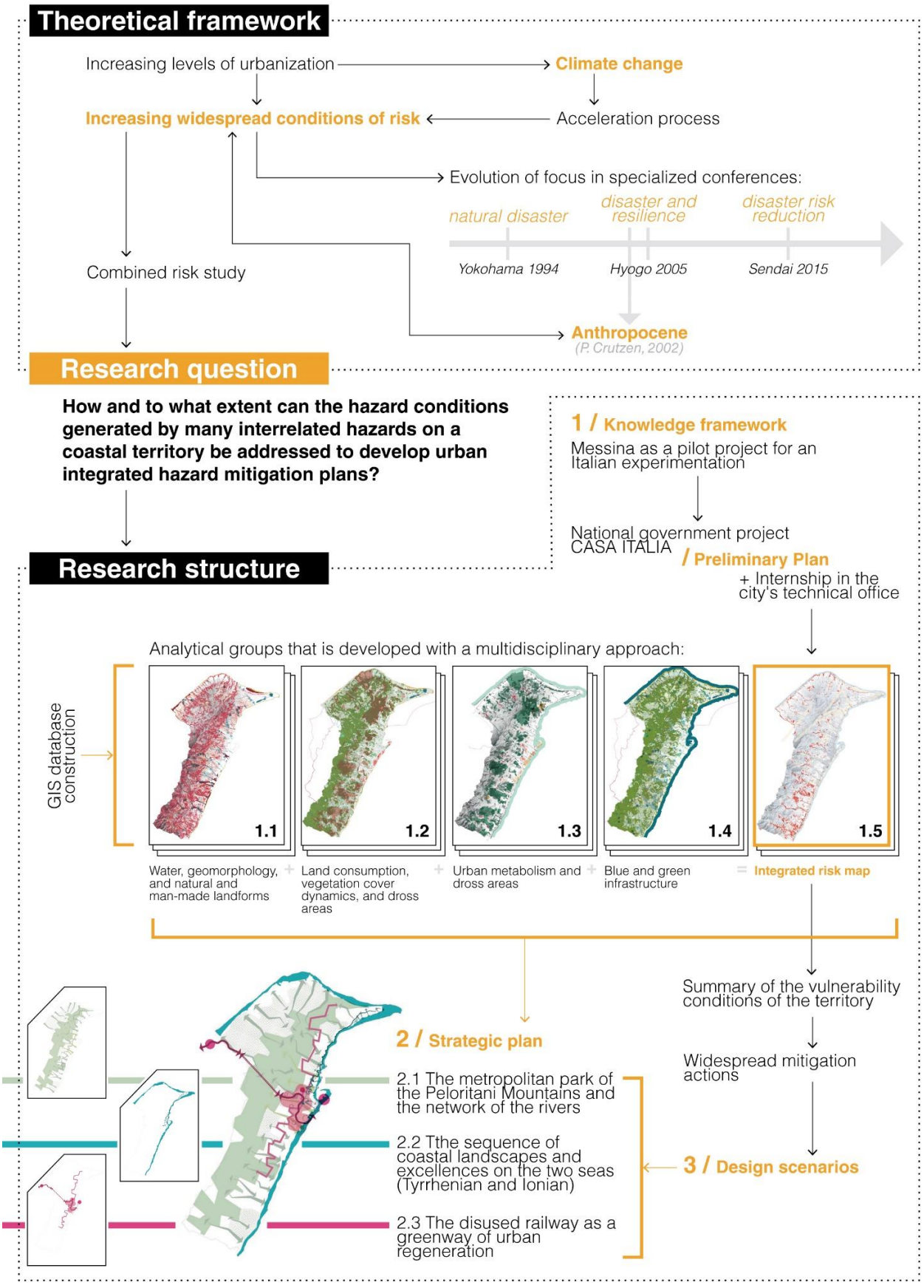

Figure 1. Theoretical framework and methodological process of the research.

1.1 The theoretical frame of reference

Most of the humanity now lives in urbanized areas. According to the latest 2018 United Nations Report, 55% of the world's population resides in urban areas. By 2030, the share of the world's population living in urban areas is expected to reach 60%, while by 2050 it is estimated to reach the 68% threshold; in Europe as of 2018, the population concentrated in urban areas was 74%, while in Italy the threshold is 90%. (WUP, 2018) It is evident that "The future of the world's population is urban." (WUP, 2018) We are thus facing a progressive and uncontrolled *planetary urbanization* (Brenner and Schmid, 2011) that makes people and resources increasingly vulnerable as they become more exposed to an increasing number of global risks (Simpson et al., 2021; Sterzel et al., 2020; Helbiz, 2013). The concept of risk is constitutive of our cities, which is the reason that, as Jabareen (2015) suggests, we should now speak of "risk cities" as a practice that can make a significant contribution to the understanding not only of risk and its social, spatial, structural and physical aspects on our contemporary cities but also on the way cities cope with uncertainties and vulnerabilities.

The now-established awareness of risk as a human construct and the definitive overcoming of the idea of natural disaster as an *act of nature* leads to the view that hazards of exclusively natural origin are only those related to natural events such as earthquakes, tsunamis, and volcanic events for which historically we tended to associate the term hazard with "natural phenomena" because they were characterized by sudden or acute impact (UNDRR, 2020). These natural hazards, on the other hand, intersect and overlap with multiple anthropogenic hazards, namely those produced by the ways in which cities have been built and how their *metabolism* has been consolidated (Wolman, 1965; Gasparrini, 2017): hydraulic and hydrogeological risk; soil, water, and air pollution; microclimatic hazards; ecosystem depletion and desertification; and also landslides and floods, which are usually considered natural in origin but are in fact induced and amplified by anthropogenic action (Jabareen, 2015; Sterzel et al., 2020).

Taking into consideration what has happened in the Specialist Conferences at the international level, the change of focus on the issue of hazards becomes evident. From the one held in Yokohama in 1994 and the subsequent review done in 2004, it appears that the focus is still on natural disasters. With the Millennium Declaration of 2000, the protection of the common environment and vulnerable people was set as the main goal by aiming to "intensify cooperation to reduce the number and effects of natural and man-made disasters." In the Report prepared during the Conference held in Hyogo in 2005, attention is paid for the first time to the contribution of human action in exacerbating conditions of vulnerability. Finally, in the 2015 Sendai Framework, the scope of disaster risk reduction was further expanded to include both natural and man-made hazards and the resulting environmental, technological and biological hazards.

The following definitions, produced by the United Nations General Assembly, reflect the evolution over the decades of the field of disaster risk reduction toward a broader scope of hazards leading to events with both short- and long-lasting effects (UNDRR, 2020; GAR, 2022):

- *Hazard* is the human process, phenomenon, or activity that can cause loss of life, injury or other health impacts, property damage, social and economic disruption, or environmental degradation.
- *Exposure* is the assets of interest subjected to risk (such as the environment, economy, buildings, or people).
- *Vulnerability* is the condition determined by physical, social, economic, and environmental factors or processes that increase the susceptibility of an individual, community, assets, or systems to the impacts of hazards.
- *Capacity* is the combination of all available strengths, attributes, and resources within an organization, community, or society to manage and reduce risks and strengthen resilience (UNGA, 2016).

When hazards are combined with vulnerability and exposure, disasters are more likely to occur because exposure increases impacts and vulnerability reduces capacity to deal with them. In fact, disasters are described as "major disruptions in the functioning of a community or society at any scale due to

hazardous events that interact with conditions of exposure, vulnerability, and capacity, resulting in one or more human, material, economic, and environmental losses." (UNDRR, 2020) To support the work set out in the Sendai Framework, UNDRR also developed the "Hazard Definition and Classification Review" within which it sought to apply the *all-hazard* approach (Sendai Framework, 2015; UNGA, 2016; UNDRR, 2020), which aims to broaden the range of hazards considered, overcoming the limitation of considering only those traditionally understood to be of natural origin. More than 300 types of hazards are identified and described in the document (grouped according to the following types: Meteorological and Hydrological, Extraterrestrial, Geohazards, Environmental, Chemical, Biological, Technological, and Societal). However, the limitation of this work lies in not considering so-called cascading or other complex hazards (Simpson et al., 2021; Pescaroli & Alexander, 2018; Helbing, 2013), which are the result of complex human activities (the same limitation is also present in IPCC reports). Other evidence is found by examining the Global Risks Report, compiled annually by the World Economic Forum (WEF) from 2006 to the present. In this time frame, not only has what is considered a risk changed, but it is evident how the range of possible declinations of this term has increased. For illustrative purposes, in the first 2006 Report, the risk landscape is dominated mainly by terrorism, pandemic influenza and other viral diseases, and the rising cost of oil. Problems related to climate change only begin to emerge as a potential risk of a global nature that is assumed to become irreversible in the next 10-20 years; in the 2023 Report, on the other hand, the major risks pertain to, on the one hand, the rising cost of living and an ever-increasing erosion of social cohesion and polarization of society (passing through pandemic crises and global conflicts), and on the other hand, the increased exploitation of natural resources, the exponential growth of natural disasters and extreme weather events, and the failure to mitigate climate change.

The combined reading of these studies confirms to us how emergent the issue of hazards is, and how much more so for territories that have suffered most from anthropogenic transformations that have exacerbated and exacerbated their effects (Simpson et al., 2021; Sterzel et al., 2020; He & Silliman, 2019). The outcomes of this interaction can be seen primarily in climate change and increasingly frequent catastrophic events over the past two decades. Between 1970 and 2000, reports of medium- and large-scale disasters averaged around 90-100 per year, but between 2001 and 2020, the number of such events increased to 350-500 per year (GAR, 2022). The UNFCCC (United Nations Framework Convention on Climate Change) defines climate change as “a change in climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and adds to natural climate variability observed over comparable time periods.” The Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), issued in 2022, also reports alarming information. Global climate change is increasingly increasing its effects on marine ecosystems, freshwater and ecosystem services, settlements and infrastructure, health and well-being, and economies and culture, especially through complex stresses and events. The impacts noted are mainly attributable to climate change, including impacts from extreme events. The Report also illustrates how compound risks have become more frequent in all regions of the world, with widespread consequences; climate change impacts are concomitant with and interact with other significant societal changes that have become even more evident since AR5, including global population growth and urbanization, significant inequalities and demands for social justice, rapid technological change, land and water degradation, biodiversity loss, food insecurity, and global pandemic.

In light of the above, it is evident that the cyclical natural changes in environmental systems, which have always been noted, have been overlaid by the decisive and invasive contribution of anthropogenic activity why it seems appropriate to assign the term *Anthropocene* (Crutzen, 2002) to the current geological era, which is in many ways dominated by humans and seems to allude to the power of humans to disrupt the Earth's ecological processes. (Shiva & Shiva, 2020) In a short article published in the journal Nature in 2002, the Dutch chemist-atmospheric scientist drew everyone's attention to how humanity's rapid expansion in numbers and per capita exploitation of Earth's resources has continued unabated over the years. In the past three centuries, not only has the human population

surpassed 6 billion (and is expected to reach 10 billion in this century), but it is the leading consumer of Earth's resources. What we are witnessing today, therefore, is a change that is proceeding at a very fast pace due to the superimposition of anthropogenic contribution to natural and cyclical climate change. (see Figure 1)

1.2 Italy's widespread vulnerable conditions

The Italian territory is characterised by many vulnerability factors, some of natural origin, and many others of anthropic origin.

As reported by the "Soil Consumption, Spatial Dynamics and Ecosystem Services Report" (2022), drawn up by the National System for Environmental Protection (SNPA), soil consumption in Italy continues to transform the territory at a high rate. In the last year, in fact, new artificial coverings have covered an additional 56.7 km^2 (corresponding, on average, to more than 15 hectares per day); another 8.2 km^2 have gone from reversible to permanent soil consumption, further sealing the territory. (Munafò, 2022) Another fundamental fact concerns the relationship between land consumption and population dynamics; in fact, the link between demography, urbanization and infrastructural processes is not direct and there is an increase in artificial surfaces even in the presence of stabilization, and in many cases decrease, of residents. The urbanized areas on our territory in 2018 were 8,628 km^2, in 2020 they increased to 8,721 km^2. (Munafò, 2022) In this context, Italy is highly vulnerable, precisely because of the pervasive and continuous anthropisation of the territory in areas at risk.

The "Report on the Promotion of Safety from Natural Risks of the Housing Stock", prepared by Casa Italia (2017), reports that 57.2% of residential buildings are in areas of high seismic vulnerability. The municipalities affected by high and very high landslide hazard areas and/or medium hydraulic hazard are 7.275 (equal to 91,1% of Italian municipalities). Landslides are extremely widespread phenomena in Italy, considering that 75% of the national territory is mountainous-hilly. Of the approximately 900.000 landslides registered in the databases of European countries, 620.808 are registered in the Inventory of Landslide Phenomena in Italy (IFFI) and affected an area of 233.700 km^2 (equal to 7.9% of the national territory). It is estimated that in the last fifty years, there have been more than 10.000 victims due to hydrogeological and seismic phenomena, causing economic damages of about 290 billion euros, with an annual average of about 4 billion and with values increasing over time (Dipartimento Casa Italia, 2017).

From the work carried out by Casa Italia in the reconnaissance of all available data (coming from the studies of CNR, ISPRA, ISTAT, ENEA, INGV and MIBACT) to build an integrated mapping of risks for the whole of Italy, the "Map of natural risks of Italian municipalities" was created, edited by Istat. Although the aim was to provide an up-to-date framework of variables and indicators for Italian municipalities, to allow an overall view of the risks of exposure to earthquakes, volcanic eruptions, landslides and floods, the work is still a mere superimposition of separate information that cannot really interact with each other to return an integrated picture but only a summation of information.

It is clear, therefore, that the acceleration imposed on this critical framework by climate change poses an urgent need to rethink the way in which vulnerability conditions are interpreted through more synergetic models of analysis. For this reason, in September 2016 the Government launched the Casa Italia project, a multi-year plan to promote the country's security in the face of its multi-hazard condition. Casa Italia is a mission structure, established by the Prime Ministerial Decree (D.P.C.M.) of 23/09/2016 for the implementation of a project to take care of the housing stock, the territory, and urban areas for the purpose of greater protection of citizens and public and private assets. In June 2017, the "Report on the Promotion of Safety from Natural Hazards of the Housing Stock" was published, with which the intention was (1) to address risks in an integrated manner, according to a multi-hazard approach, focusing attention not on individual risks but on the places where people live, analysing the different sources of risk that may affect a specific place and their mutual interactions; (2) to identify the most effective intervention strategies, also exploiting the opportunities offered by new

technologies. The city of Messina is identified as a case for experimentation. (Dipartimento Casa Italia, 2017)

1.3 The territorial context researched: Messina

The complexity of the multi-risk condition, both territorial and social, addressed in the in-depth study of the Prototypal Case of the Municipality of Messina, has as its main objective of analyzing the feasibility of project scenarios to support the housing decompression of at-risk areas (Dipartimento Casa Italia, 2017). Thus, with the agreement stipulated between the Mission Structure of the Presidency of the Council of Ministers, the Municipality and the National Institute of Urban Planning (INU), the foundations were laid to draw up an Action Plan, thus creating the indispensable premises for a resilient urban policy, capable of prefiguring a new habitability of the city based on virtuous adaptation to risk conditions (General Report of the Outline, 2018).

Messina is a medium-sized city with just under 224.000 inhabitants and a very large municipal territory (211 km^2). Although the population is steadily decreasing, -2.433 inhabitants (-1,08%) since 2021 and -18.260 units (-7,54%) since 2012 (messinaincifre, 2022), land consumption continues to increase: in the two-year period 2019-2020, 28 hectares were consumed, equal to approximately 318 m^2 per inhabitant. (Munafò, 2022) The territory includes a large section of the Peloritani Mountains, characterised by a marked orography, which in short reaches altitudes above 1.100 m above sea level and from which derives the dense presence of river courses (about 70) of torrential character, commonly called '*fiumare*', the main reason for the widespread hydro-geological risk condition. Although the research focuses only on the municipal territory of Messina, some data concerning the entire Metropolitan City are significant. 10% of the territory is affected by landslide risk, that is just over 310 km^2 out of 3,266 km^2; considering landslide and hydraulic risk together, out of 108 municipalities (of which the Metropolitan City is made up) as many as 91 are affected by both risks, i.e. over 84% of the territory. (Triglia et al., 2018) It has a high level of seismic hazard and was completely razed to the ground by the violent earthquake of 28 December 1908 and the subsequent tsunami. According to the "Italian Tsunami Catalogue" available on the INGV website, the coastal territories bordering the Strait of Messina are historically among those in Italy most affected by tsunamis both in terms of frequency and intensity. The damage from the earthquake and tsunami - equivalent to 11th and 10th-degree effects on the MCS scale (Mercalli-Cancani-Sieberg 1930 macroseismic scale) - was recorded in an area of about 600 km^2 with between 70% and 100% destruction of the built heritage. (Tinti et al., 2004)

Historically, the town-planning and settlement history of the city of Messina has been determined by a cyclical relationship between the numerous catastrophic events and the following reconstructions that followed one another over time in an alternation of new planning instruments and spontaneous processes of re-urbanization. After the earthquake of 1908, the city was rebuilt with a high land consumption plan, which envisaged urban growth processes along some streams directed towards the hillsides and confirmed and amplified by the settlement dynamics of the second half of the 20th century, through a succession of oversized plans, including the one still in force, with a pervasive consumption of hillside land and a progressive cementing of some riverbanks. These choices have led to a widespread condition of hydrogeological, hydraulic, and seismic vulnerability that has triggered numerous landslide and flooding events over the years, up to the tragic 2009 landslide in Giampilieri (a suburban area located south of the city centre) that caused 37 deaths. There is therefore an intense cumulation and mutual amplification of the dimensions, complexity, and extension of the factors of danger, exposure, and vulnerability, which undermine the physical security of the territory and human settlements. Added to this is the technical backwardness and lack of integration of the risk maps made available by the superordinate public bodies. (Gasparrini and Terracciano, 2021)

Thus, since the destruction at the beginning of the 20th century, the city has collected a sequence of urban planning decisions that have played a pervasive role in the construction and consolidation of these critical issues. In fact, following the seismic event, it became necessary to build housing for the

evacuees in a short time, which is why a specific Barrack Plan (called Piano Baraccato) was drawn up, the first phase of the Reconstruction Plan established with the enactment of law no. 12 of 12/01/1909, which established the urgency for the city to equip itself with a new Regulatory Plan, entrusted in the same year to engineer Borzì, and drafted between 1909 and 1912. Reconstruction operations were strongly conditioned by the insufficient availability of free areas, as the city was completely overrun by rubble, so that areas outside the then built-up area were identified to accommodate temporary barracks. The overall total of barracks built came to more than 7.600, grouped into 'Villages' or 'Quarters'; their maximum duration was set at five years but many of these areas are still there today. These precarious settlements were the subject of Regional Law No 10 of 1990 specifically dedicated to Messina and, more recently, of Decree-Law no. 44 of 2021 for the rehabilitation of shantytowns. At present, the city of Messina is first in the list of projects selected for the National Innovative Programme for Housing Quality (called P.I.N.Q.U.A., part of the National Recovery and Resilience Plan - P.N.R.R.), with projects concerning the rehabilitation of redevelopment areas and areas destined for urban housing financed for approximately 129 million euros, thus standing as a candidate to become one of the pilot territories in Italy for new regeneration experiments. (Brisku et al., 2023) The complex interplay between the reconstruction phases and the consequent urgency to satisfy the housing emergency of the survivors, together with the need to respond to the demand for housing for the most disadvantaged segments of the population, led to a conspicuous intervention of the public hand, while the settlement types of the public city implemented followed the criteria and rules defined by specific national laws[1] .

2. MATERIALS AND METHODS

2.1 Integrated risk readings. Methodology and fields of application

2.1.1. Knowledge Framework

The first phase of the research has a twofold objective. The first is to construct a broad framework of knowledge on the characteristics of the territory that can provide the appropriate basis for developing development strategies for the territory, with risk mitigation as the focus. A multidisciplinary approach is employed, involving specific professional figures (town planners, geologists, agronomists, GIS technicians, cartography technicians, administrative technicians, photographers) and using data from sectorial studies for certain issues (CUAS 2013, Habitat Map of the Sicilian Region, Habitats of the European Corine Biotopes manual, SITR Sicily Region, ENEA). All data collected from other pre-existing studies and those produced specifically for the new outline were collected in a GIS framework and organized into database families to be able to read all information both separately and together, as well as to ensure real-time access to reliable and implementable data (Sendai Framework, 2015). The overlapping reading of the risk information and its location were the basis for building the next steps as well. The second is to understand how far the hazard factors studied for the Outline were in line with the main scientific references on risk; the “Global Risk Report 2023” (WEF) and the “Hazard Information Profiles” (UNDRR), a supplement to “UNDRR-ISC Hazard Definition & Classification Review - Technical Report”.

The analyses were organized into five families:

1.1 *Water, geomorphology, natural and man-made landforms.* It contains all the information concerning the landslide hazard and the hydraulic hazard exacerbated both by the steep slopes that naturally characterize the territory and by the enormous man-made landforms, the seismic hazard, and the phenomenon of coastal erosion.

1.2 *Land consumption, vegetation cover, dynamics, and dross areas.* It contains all the data relating to land consumption not only resulting from the urbanization processes of recent decades but also

[1] Reference is made to Luzzatti Law No. 254 of 1903, Law No. 43 of 28 February 1949, known as the Fanfani Law and whose interventions were managed by the INA-Casa Institute, Law No. 167 of 1962 and the introduction of the Economic and Popular Housing Plans (PEEP), Law No. 60 of 1963 and the related Gescal Plan.

that resulting from large forest fires, the abandonment of large areas with an agricultural vocation, and the abandonment of many productive areas or areas with non-residential uses.

1.3 *Urban metabolism and dross areas.* It contains all information related to urban metabolism processes, i.e., all areas and artefacts in a state of decay or abandonment (including production areas and mobility infrastructure), all residential areas in a state of severe decay (low quality of life, lack of public infrastructure), disused or illegally used quarries and landfills.

1.4 *Blue and green infrastructure.* It contains all the information on the interruptions or degradation of ecological corridors, i.e., all those sealed areas along the coast or along the slopes of the Peloritani Mountains that should instead be safeguarded.

1.5 *Integrated risk map.* It contains a summary of all the data on hazards analyzed in the previous maps and allows us to read the risks in an integrated manner, thus understanding that today it makes sense not to think of risks individually but in their combination, to be able to tackle them more effectively and find mitigation solutions that look at the complexity of the problems.

For the construction of this last map, further synthesis readings were developed to further understand and deepen all the risk factors that characterize the territory under study: (x) the Geologist's Specialist Study and (xi and xii) the first matrix experimentation for the Integrated Risk Map developed within the thesis work (developed by Ferramosca G., Orefice O., Prisco C. and Spera S. as part of the degree course in Territorial, Urban and Landscape-Environmental Planning P.T.U.P.A. (a.y. 2017/2018) of the DiARC Department of Architecture of the University of Naples "Federico II") "Messina territorio co-stretto. Integrated approach to risks to plan the resilient city".

x. The "Map of risks of natural origin" consists of a joint reading of the risks deriving from:

a) the morphology of the territory and the composition of the soils, identifying all the areas affected by landslide hazard (source: ENEA and the Geological Study) and the buildings exposed to this vulnerability, the areas subjected to steep slopes, the areas with slopes between 34° and 55°. The Geological Study[2] reports that the upheavals were concentrated not only in the presence of sparse scrub vegetation or along bare surfaces but also within terraced slopes with dry-stone walls characterized by sparse cultivation and walls in a state of decay. These conditions, together with slope inclinations of more than 34°, are at the root of the disruptions caused mainly by poorly tap-rooted root systems of citrus groves, which contribute to the spreading and loosening of the soil. Large complex landslides are considered to be of high hazard due to their imposing size and state of activity, characterized by slow, almost continuous movements. (Geological Survey, 2018).

b) the structure of the territory, through the mapping of active faults capable of and with very high hazard (ENEA and ENEA Study, 2013) and the buildings exposed to this vulnerability.

c) the water system, identifying the areas affected by hydrogeological hazard (PAI, 2011) and the relative buildings exposed to such vulnerability, the areas where soil liquefaction phenomena have occurred and those where there is a potential risk of liquefaction, and the areas affected by the phenomenon of coastal erosion. As far as hydrogeological vulnerability is concerned, in the mountainous areas of Messina, it is noted that even in conditions of not particularly intense meteorological events, considerable damage can occur. This is due to the concomitance of land collapses and landslides, which complicate the containment of the event and make it safe, thus increasing the risk to people and property. At the same time, one must also consider the constant and capillary practices of unauthorized building, and the uncontrolled exploitation of the soil and its resources, which greatly contribute to generating conditions of vulnerability. As far as the last

[2] Geologist Paolo Pino was appointed for the Specialist Study by D.D. No. 155 of 19/01/2018. All the documents produced (bearing the initials SG) for the Outline prepared in 2018 can be consulted at the following link: https://comune.messina.it/servizi-terr-urban/schema-di-massima-prg-2018/

The data taken as reference for the drafting of the Outline dates back to the update of the Basin Master Plan for Hydrogeological Structure - PAI adopted by D.P.R. no. 118 of 21/03/2011 (available at the following link: https://www.sitr.regione.sicilia.it/pai/bac102-fiumedinisi. htm) and subsequent integrations carried out by means of a study on the state of geomorphological hazard in the Municipality of Messina dated 31/07/2014, an activity aimed at the Environmental Safeguard Variant in collaboration with the Territorial Planning and Soil Defence Service of the A.R.T.A. The latest update was approved by D.S.G. no. 393 of 23/12/2021 and the elaborations will be used for the future update of the Outline ("Schema di Massima).

phenomenon is concerned, the long coastline of Messina is highly critical due to a multiplicity of factors, mainly of an anthropic nature, which over time have led to the fragmentation of ecosystems and the degradation of contexts. In addition, there is a progressive phenomenon of erosion of the sandy shores with phenomena of severity along the Tyrrhenian side, while on the Ionian side, the compromised areas are more reduced (Geological Study, 2018). (see Figure 2)

xi. The "Map of ecological-environmental risks", which consists of a joint reading of the risks arising from:

a) from the plan residue, i.e., abandoned, and unrealized standard areas.

b) from the ineffectiveness of governance in the housing field, which manifests itself in areas with degraded conditions, historical villages in the hillside areas that are being abandoned and buildings of cultural-historical value in a state of abandonment and/or degradation.

c) the lack of effective governance for water cycle management, identifying areas without sewerage sub-services, areas without water sub-services, areas with sewage plants that discharge wastewater directly into the sea, and the location of purifiers

d) the inefficiency of waste cycle management, identifying disused landfills and areas with illegal waste spills (source: Messina Ambiente s.p.a.)

e) the strong pressure of transport on the urban environment, by sea, rail, and road.

f) the improper use of the land, identifying forested areas affected by fire (source: Copernicus) abandoned terraces for agricultural use (Agronomic-Forestry Study, 2018), disused areas and buildings of the production chain, disused railway transport lines and their abandoned stations, riverbanks improperly used for roading (but also as extensions of private appurtenances of homes, for the spillage of usual waste, etc..), stretches of coastline with banned bathing (Region of Sicily, 2017). (see Figure 3)

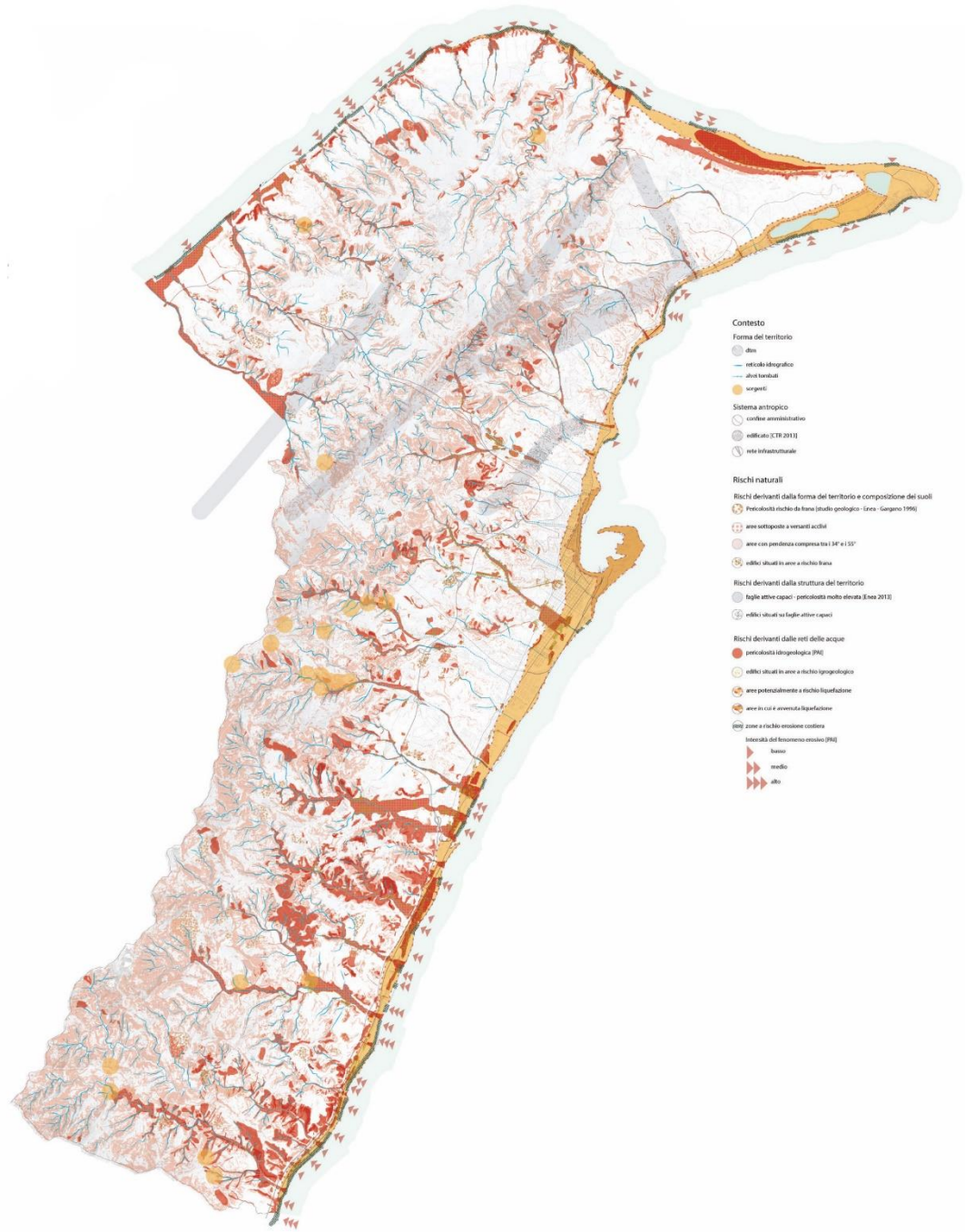

Figure 2. Natural risks.

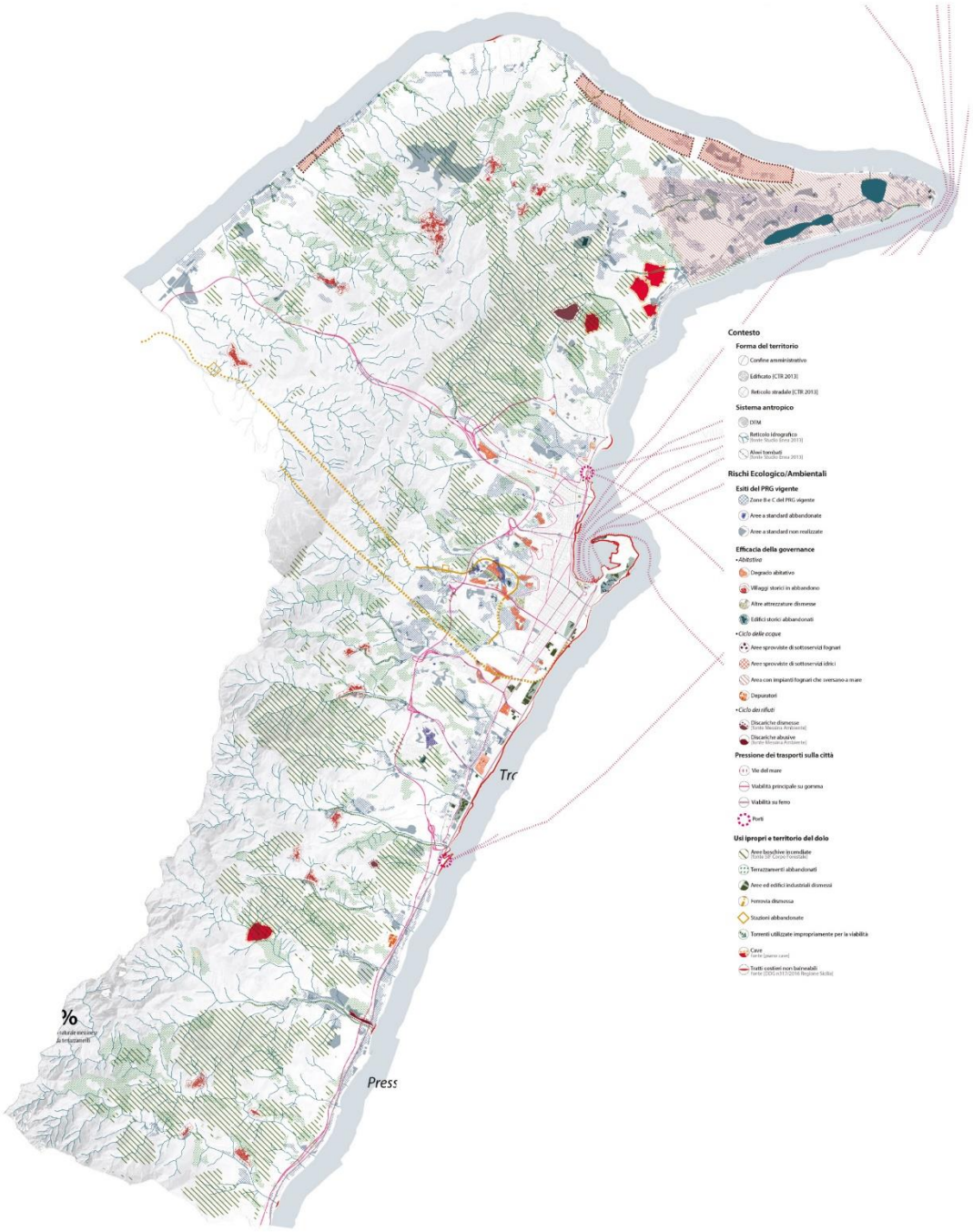

Figure 3. Ecological-environmental risks.

xii. The "Map of risks of an economic-social nature", which consists of a joint reading of the risks arising:

a) by the crisis in production cycles, which has taken the form of the abandonment of terracing for agricultural production, the decommissioning of large industrial areas, and the failure to create areas for production under the current PRG. (Agronomic-Forestry Study, 2018).

b) from the crisis of the housing cycle that has generated so-called 'dormitory' residential areas (i.e., with no services for the community), areas mainly intended for seasonal, and tourist use, hillside villages subject to depopulation dynamics and with difficult accessibility.

c) the analysis of the physical qualities of public housing.
d) from the improper uses and the perception of insecurity, which take the form of the identification of areas with poor accessibility, with inadequate or difficult viability (especially in cycle-pedestrian mode), with improper and precarious roads.
e) the criticalities of the infrastructure system, consisting of a dense network of tracks with static structural problems. All these mappings were superimposed with the perimeters of the nuclei of local identity. (see Figure 4)

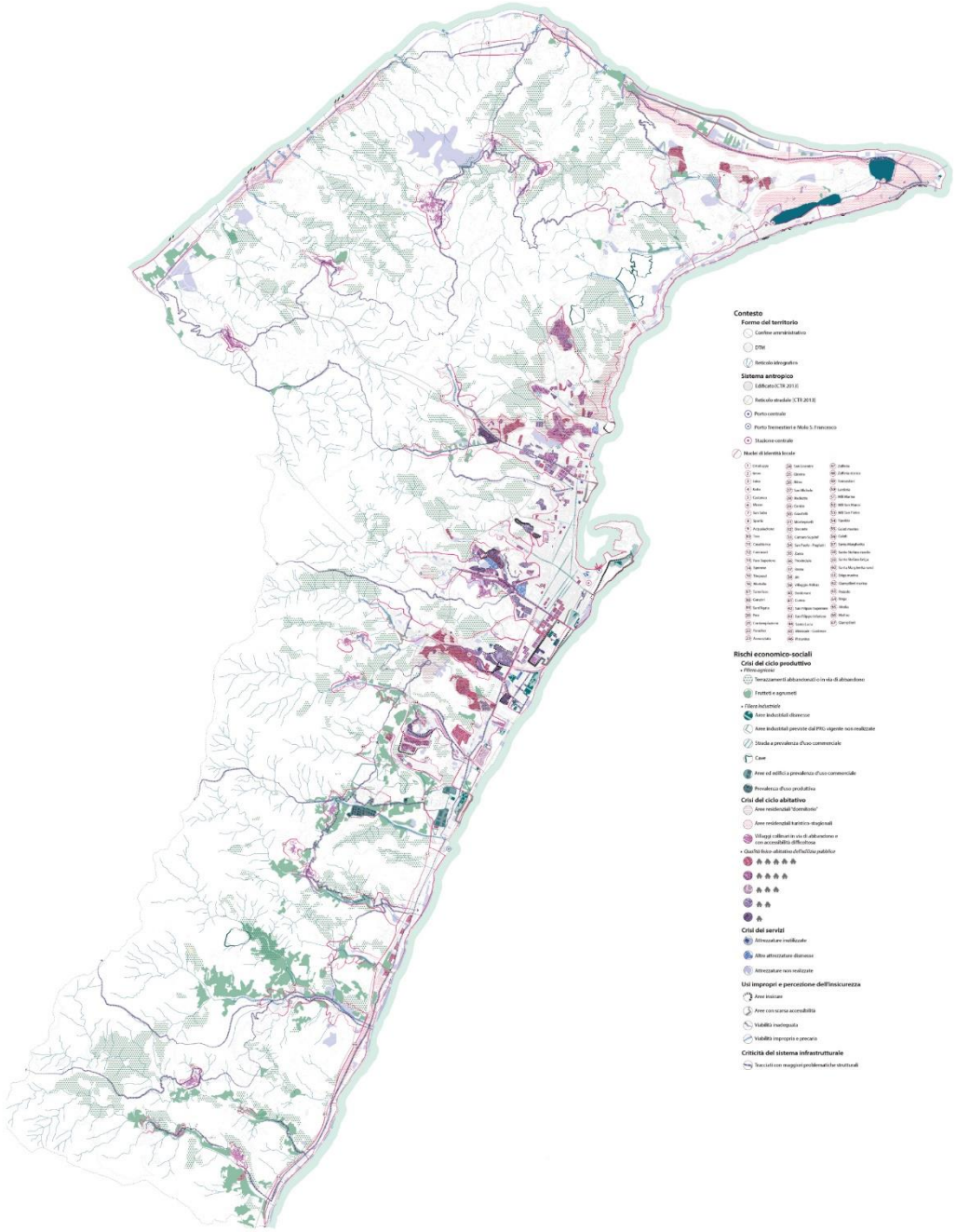

Figure 4. Economic-social risks.

With the construction of these integrated readings of vulnerabilities in the "Schema di massima", a particularly critical picture emerges in which a large part of the territory is subject to two or more risks at the same time.

With the hydro-geological risks, an initial experiment of a multi-risk matrix was constructed, through which it was possible to identify the areas and buildings most affected by multiple exposures, preparatory to the realization of the Integrated Risk Map. (see Figure 5) This matrix crosses seismic hazard with hydraulic and landslide hazard, while the methods for assigning the feasibility/susceptibility class are standardized to homogeneous areas for geological hazard, hydraulic and hydrogeological vulnerability, and seismic hazard. The presence of at least one high or very high hazard is sufficient to determine a polygon with a high-risk level. The coincidence of the same area of territory of several high geological hazards entails greater restrictions, although the risk class remains the same. The indications of limitations and constraints arise from and make specific reference to the type of hazardous phenomenon that determined the assignment of the risk class. Therefore, the overlapping of several hazard areas results in more limiting factors and defines polygons with mixed characteristics (Geological Study, 2018). Following these criteria, the "Integrated risk and building susceptibility map" is drawn up, which makes it possible to highlight sub-areas that are unsuitable for building because they are subject to unacceptable natural hazards (red areas), and areas that are suitable 'on condition' of preventive risk mitigation measures (consolidation, regulation, drainage, etc.) or specific preventive technical measures, adaptations and precautions to be observed during the building phase (orange areas). (see Figure 6) In the light of this mapping, the building stock subject to multiple risks is 4% of the total, corresponding to approximately 2.644.000 m^3; of these, 18,856 m^3 are churches and religious institutes (0,7%), 184.623 m3 are productive buildings (6,7%), 2.526.682 m^3 are residential buildings and services (92,6%, of which 86.000 m^3 are barracks). For a large proportion of these buildings, within the strategies of the Schema di massima, it is assumed that they can be relocated to non-risk areas and that the freed areas are redeveloped and renatured.

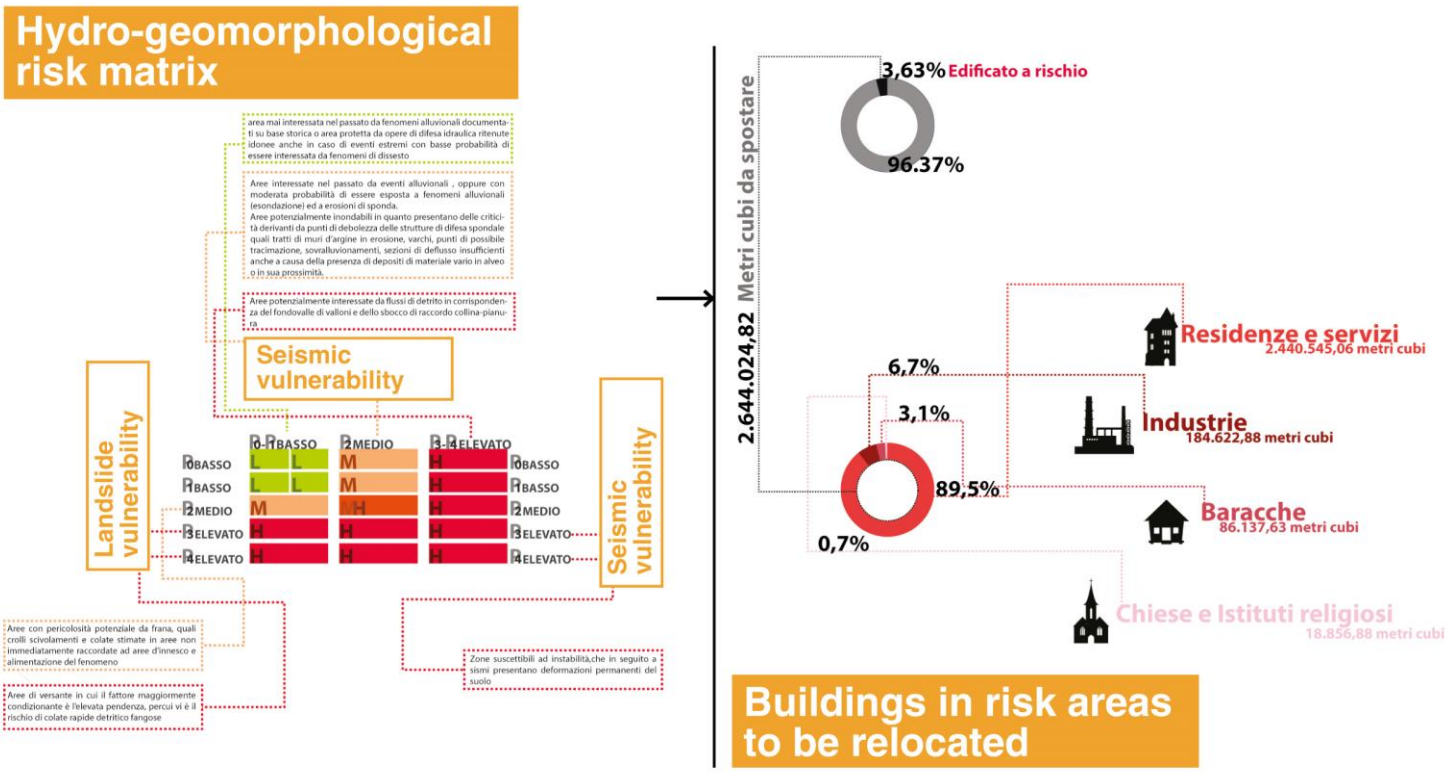

Figure 5. Integrated risks map construction matrix.

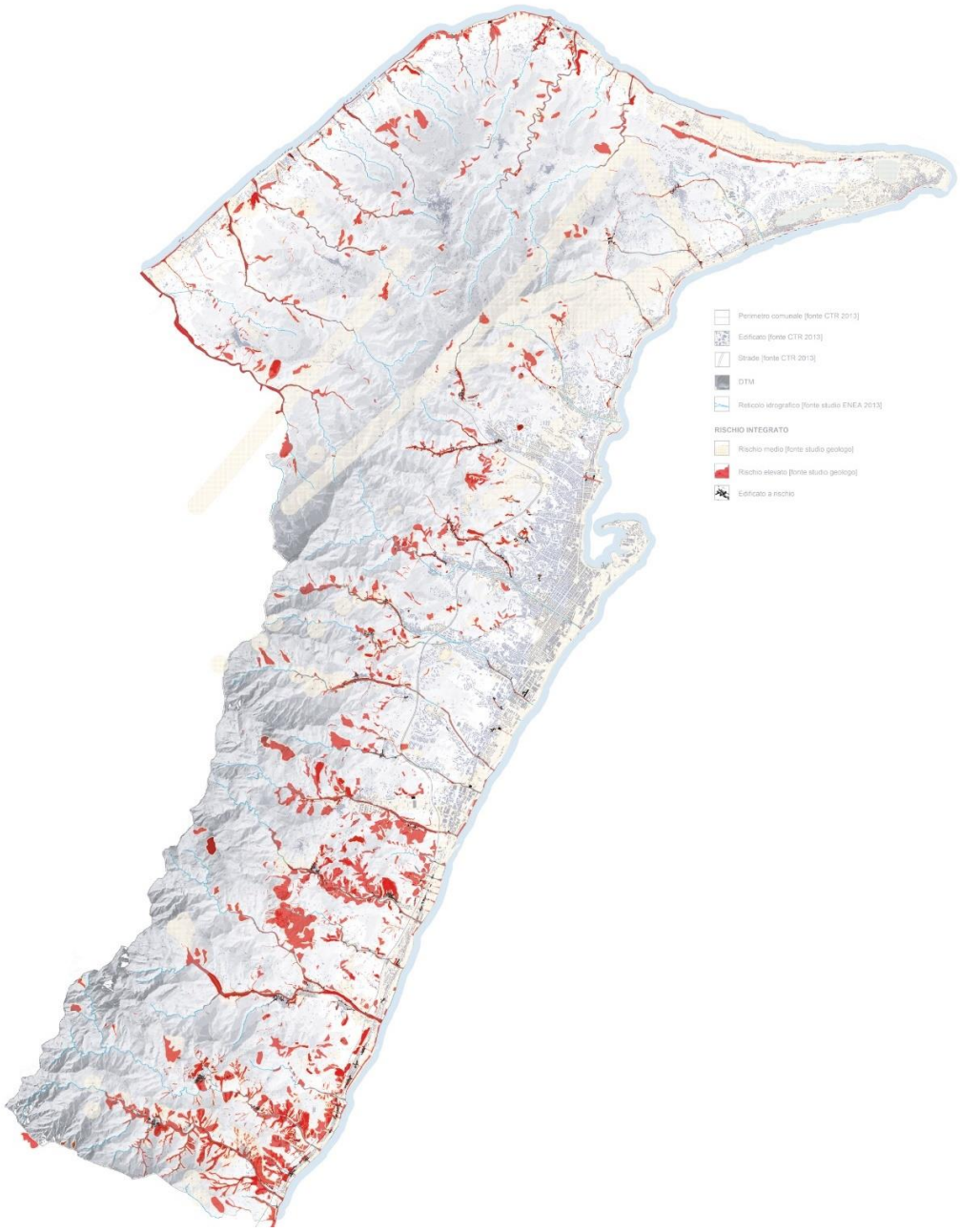

Figure 6. Integrated risks map.

To achieve the second objective, on the other hand, the analyses were sought by consulting the "Global Risk Report 2023" (WEF, 2023) and the "Hazard Information Profiles" (UNDRR, 2021). The former identifies 32 global risks, organized into six categories (Economic, Environmental, Geopolitical, Societal, and Technological); the latter identifies 302 risks, organized into clusters (Meteorological and Hydrological, Extraterrestrial, Geohazards, Environmental, Chemical, Biological, Technological, Societal). (see Figure 7) Comparing the type and content of the analyses carried out for the drafting of the Maximum Outline (Schema di massima) for the city of Messina and the risks recognized by the two main organizations active in this scientific field, it emerges that the latter, although in-depth and valid for phenomena on a global scale (as explicitly stated in the WEF document), show some shortcomings in recognizing certain danger factors that derive either from the interaction of two or more concomitant dangers or from phenomena that are not mentioned at all and that mostly pertain to the social sphere.

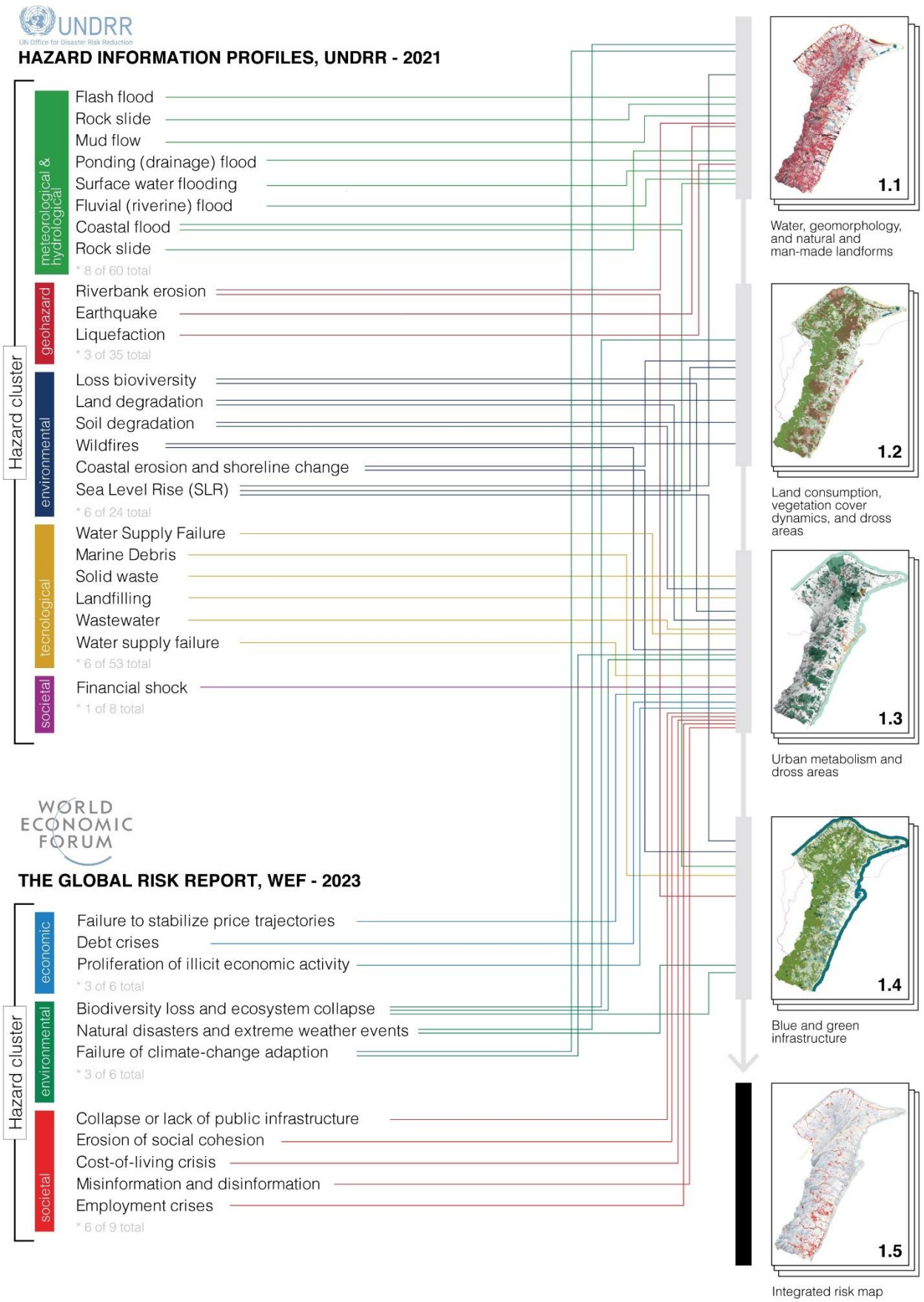

Figure 7. Comparison with UNDRR and WEF risk clusters.

3. RESULTS AND DISCUSSIONS

3.1 Guidelines for environmental infrastructure design: landscapes and intersystem actions

The construction of the "Integrated Risk and Susceptibility Map for Urban Regeneration" is thus intended to be the dynamically updated reference for a strategy to combat and adapt to a multiplicity of ecological-environmental, social, and economic risks. It is a multi-scalar, metropolitan and local strategy, which is mainly based on the creation of a network of Blue and Green Infrastructure (GBI)[3], starting from the existing ones, capable of counteracting fragile conditions and, at the same time, maximizing biodiversity and the production of ecosystem services also in urban areas (Gasparrini and Terracciano, 2021).

Reducing climate risks and increasing resilience to the impacts of climate change are objectives enshrined in the Paris Agreement and the Sendai Framework of Reference (UNISDR, 2015) to which the Italian government adhered along with many other governments during the 21st Conference of the Parties held in Paris in 2015. By defining such goals and priorities on a global scale, the Sendai Reference Framework emphasizes the reduction of risk, exposure and vulnerability and the strengthening of resilience at all levels through the "implementation of integrated and inclusive socioeconomic, environmental, technological and institutional measures" (Spano et al., 2020). The metropolitan city of Messina also adhered in 2017 to the Bologna Charter for the Environment with the objective of promoting sustainable development models, thus also hinging on the goals proposed by the United Nations 2030 Agenda, drafted in 2015.

3.1.1 Strategic plan

The second phase of the research proposes a Strategic Vision for the City of Messina capable of achieving a vision of a resilient and anti-fragile city. Such a city vision is built through three Strategic Projects, defined within the disciplinary framework of reference outlined (paragraph 1.1) and constructed within a dimension of innovative and updated knowledge of the territory, based on the integrated interpretation of risks, as outlined (paragraph 2.1). The first focuses on "The metropolitan park of the Peloritani Mountains and the network of the rivers", the second focuses on "The sequences of coastal landscapes and excellences on the two seas (Tyrrhenian and Ionian), the third focuses on "The disused railway as a greenway of urban regeneration".

The main strategic lines are: (1) to combine in a sustainable way the reduction of hazard and exposure to risks, (2) to widely reduce the vulnerability of buildings and building fabrics to natural and anthropogenic risks, (3) to reorganize the water cycle and urban drainage, (4) to safeguard regenerate and qualify soils, (5) improve air quality and the urban microclimate, (6) create a network of environmental infrastructure of landscape quality, (7) promote new forms of circular economy and collaborative social processes oriented towards green and adaptive urban regeneration. The principles inspiring these strategic guidelines are aimed at combating soil consumption, increasing soil permeability on a widespread basis, recycling water and abandoned soils also by enhancing urban and peri-urban agricultural uses, radically rethinking sub-services, spreading urban drainage and plant densification works, also to reduce the fragility conditions accentuated by climate change (for which the Mediterranean is a *hot-spot*).

The Schema di massima of Messina is thus supported by some underlying strategies that build its rules and projects, within a broader reference scenario on a national and European scale, in which the relevance assumed by the interpretative and design dimension linked to blue and green infrastructures (Mell, 2015, 2018) is central, with their role as eco-landscape load-bearing framework for a new urban regeneration capable of providing adaptive and dynamic solutions, within a systemic and multi-scalar approach.

[3] Blue and green infrastructures are reflected in the European Union's extensive production of policies and strategies over the past 10 years, the 2009 White Paper on Adaptation to Climate Change (European Union 2009) and the European Biodiversity Strategy. climate change (European Union 2009) and the European Biodiversity Strategy (European Union 2010), not to mention the 2013 Green Infrastructure Strategy. It is the significance of these networks that has suffered in recent years from an essentially environmental perspective, out of step with the multidimensional complexity that has been emerging in the European landscape. (Gasparrini and Terracciano, 2020)

On the whole, the "Guidelines for the Environmental Infrastructure Project" (see Figure 8) aim at the safeguard, protect and requalification of the natural and anthropic landscapes characterizing and qualifying the city and the territory of Messina through the strengthening of the great territorial ecological connections and matrices and, at the same time, the consolidation and strengthening of the widespread system of urban permeability, the protection of biodiversity and the eco-sustainability of the cultivation systems and landscape qualities determined by age-old agricultural traditions, with not only an environmental but also an economic impact due to the tourist vocation, of which the agrarian landscape is an essential component, are based on the interaction of the following factors:

- the acknowledgement of addresses, prescriptions and constraints contained in the super-ordinate Plans and in the national and regional laws concerning specific sectors and components of the territory, as recalled in Chap. 2, starting from the PTPR Regional Territorial Landscape Plan - Area 9 for Messina and the PAI.
- the evaluation of the interpretative outcomes of some specialized analyses drawn up to support the PRG to represent an updated cognitive framework of the territory and of the risk conditions, as contained in the Geological Study (called SG documents) and in the Agricultural-Forest Study (called AF documents).
- the evaluation of the interpretative outcomes of some analyses developed to represent the environmental components characterizing and qualifying the Messina landscape as contained in all the A5 documents of the Environmental System.
- the outcomes of the first evaluations for the identification of the Urban Regeneration Areas (called ARU) contained in the elaborated P2.2 Settlement and Services System. Project Guidelines.

In these "Guidelines for the Design of Environmental Infrastructure", major strategic fields for multiscalar and inter-systemic actions are identified:

- *the Peloritani landscape-nature patches*, for which measures are planned to enhance the wooded landscape as a large core area of a larger metropolitan park in Messina that extends as far as the coastal, historic, and consolidated city, through the safeguarding of natural and high-natured features, as well as the progressive recovery and restoration of burnt wooded areas using native species.
- *the fiumare landscapes* for which mitigation programs and actions are envisaged for the hydraulic risk and the overall integrated risk system through operations for the improvement of surface waters, the progressive renaturation of natural torrents and the reconversion as tree-lined avenues for those tombed in urban contexts, the elimination of improper uses along the riverbeds, the redesigning of roadbed sections, the reclamation and redesigning of the mouths of the riverbeds in the sea, together with the preservation and enhancement of the Ganzirri and Faro lake landscape and the hydraulic devices built by the British Army in the early 19th century.
- *the landscape-rural matrices* for which measures are envisaged to enhance the agrarian landscapes by safeguarding the connotative features of the agrarian slope landscapes along the river valley hinterlands, the agrarian landscapes on the valley floor characterized mainly by arable crops and irrigated wood crops such as citrus groves and the coastal agrarian landscapes in the sub-plains areas, together with the encouragement of a process of consolidation of agricultural terraces in use and the restoration of those in a state of abandonment, through the promotion of traditional production within rural development policies and plans.
- *the linear coastal landscapes* for which coastal reconfiguration interventions are envisaged through erosion mitigation operations, beach nourishment and redevelopment of sandy shores and the related dune systems through naturalistic engineering techniques together with the preservation, enhancement, and implementation of the back-dunal vegetation by reinforcing the Mediterranean maquis and the Posidonia seagrass beds to overcome their degraded and fragmented condition.
- *the urban ecological constellation* for which regeneration, valorization, and implementation of the existing and potential system of micro and macro-green spaces are envisaged in order to rethink the relationship between the city and open spaces, encourage sustainable management for soil and water,

thus also contributing to implement the endowment of urban standards for a new offer of multifunctional and leisure time spaces through the following declinations.

- *the urban and peri-urban landscapes* for which actions are envisaged to secure and ecologically oriented regeneration of certain critical tissues such as disused urban service areas and buildings or those destined for incongruous and temporary uses, environmentally critical settlements, areas, and buildings for industrial and craft activities that have been partially or totally disused, together with the more general design of ARU urban regeneration areas.

3.2 Guidelines for the design of the settlement system: urban and environmental regeneration areas (ARU)

3.2.1 Design scenarios

In the "Settlement System. Guidelines and Executive Prescriptions" also contains an initial identification of the Urban and Environmental Regeneration Areas (ARU) to be subjected to "Executive Prescriptions". These Areas were identified through the interaction of different interpretative insights:

- the enumeration of high-risk buildings and textiles, as inferable from the "Integrated map of risks and susceptibility to urban transformation", to be affected by demolition interventions without reconstruction in situ and compensatory relocation in safe areas of Messina's territory, without consumption of new soil.
- the location of areas of greatest urban, building, and social decay attributable to precarious and unstructured settlements where more intensive urban transformation and regeneration interventions are needed.
- the identification of parts of the unconsolidated fabric in need of redevelopment and densification to achieve more structured and qualified physical and functional arrangements.
- the selection of waste and derelict areas and buildings requiring recycling and reuse to outline new physical, social, and functional life cycles.
- the identification and extension of ARUs refers specifically to those parts of the territory affected by interventions that require detailed urban coordination and public evidence procedures due to their complexity and urban relevance.

Among these, as a result of the reflections developed, the ARU1 - Areas of high risk exposure and settlement decompression and incremental renaturation - are of particular relevance, in which the buildings and building fabrics falling within the high-risk areas, identified by the "Integrated map of risks and susceptibility to urban transformation", are included, i.e. in which the particular critical condition of exposure to hydrogeological, hydraulic and seismic risks entails the need to provide incentive and rewarding devices of an urban, financial and fiscal nature, useful to solicit compensatory transfers - in ARU2, 3 and 4 - of the volumes to be demolished and demolished, hydraulic and seismic risks entails the need to provide incentives and rewards of an urban, financial and fiscal nature to encourage compensatory transfers - in the ARU2, 3 and 4 areas - of the volumes to be demolished and not rebuilt on site, through planning over time that hinges on the "Register of volumes", on the coordination of the planning and management of interventions with the aforementioned ARUs and on the provision of interventions for the renaturation of the areas affected by demolitions.

Figure 8. Guidelines for the Environmental Infrastructure Project.

4. CONCLUSIONS

With the inclusion of this case study in the Casa Italia experimentation program, the intention is to provide the drafting of the general land-use plan (in Italy abbreviated as PRG) with the knowledge and tools to make urban planning choices that aim at a vision of a "resilient and anti-fragile city" (Taleb, 2013; Blečić and Cecchini, 2016), having as a reference the capacity of a territory to respond with awareness to conditions of stress and change, particularly extensive and intense in the territory of Messina, connected to the interaction of a multiplicity of risks of an environmental nature, thus reducing exposure and vulnerability, without compromising its identity, but rather revitalizing and updating it from a spatial and social cohesion point of view (General Report of the Outline, 2018).

The proposed contribution - in terms of the hypotheses supporting the study, the methodology deployed, the tools used, the experimental framework within which it is set, and the results achieved - fits perfectly into that strand of research that investigates methods and practices, starting from the multiple risk conditions of a territory, in particular a coastal territory, to develop urban plans with an integrated approach to risk mitigation.

The participation as a prototype case of the Municipality of Messina in the Italian Government's mission structure Casa Italia, in which the process of drafting the Preliminary Urban Plan is hinged, constitutes a very important reference on a national and international scale for the drafting of latest-generation Urban Plans that aim at a vision of a resilient and anti-fragile city. In fact, the process illustrated in this contribution builds an exemplary case study in which the sectorial methods typical of traditional Specialised Studies are surpassed. In fact, the Plan's structuring choices are based on the knowledge and awareness acquired through an integrated approach to the risk dimension, in which strategic and priority objectives are based on adaptive and proactive tactics and planning actions. The results achieved can in fact constitute a virtuous model for the Plan, necessarily based on the paradigm of urban and environmental regeneration, the fight against land consumption and the mitigation of risks (including those arising from climate change). This contribution in fact provides:

1) the definition of materials and methods for the construction of a knowledge framework of the territory aimed at returning an Integrated Risk Map, intended as a dynamic and updatable tool, developed and to be interrogated in GIS environments.

2) the definition of the Guidelines for the Environmental and Settlement Systems of the new Urban Plans in which the role of the Blue and Green Infrastructures is central, understood as the new incremental frame on which to base the urban and environmental regeneration of the city as well as the mitigation of risks.

3) the definition of design scenarios in which the SUM - Minimum Urban Structure (to be further defined in the continuation of the drafting process of the Plan itself) is central in the design of the Plan and in the design of the city itself, as well as in the processes related to risk management.

This involved: (a) a circular process between knowledge construction and strategy definition, whereby differentiated objectives and project actions are defined in relation to the risk condition of the areas in question; (b) a multi-scalar approach that leverages mainly on the creation of a network of blue and green infrastructures (Mell, 2015, 2018), starting from the existing ones, capable of counteracting fragile conditions while maximizing biodiversity and the production of ecosystem services, also in the urban context. One of the most innovative aspects - which, however, needs the widest possible sharing among citizens and support in the political action of local administrations - is the identification of the Urban and Environmental Regeneration Areas (ARU) in the "Settlement System. Guidelines and Executive Prescriptions", in which the ARU1 "Areas of high exposure to risks and settlement decompression and incremental renaturation" are of particular relevance, which include buildings and building fabrics falling in high-risk areas, i.e. areas in which the particular critical condition of exposure to hydrogeological, hydraulic and seismic risks entails the need to provide incentive and rewarding devices of an urban planning nature, financial and fiscal nature, useful to solicit compensatory transfers - in the ARU2, 3 and 4 areas - of the volumes to be demolished and not rebuilt on site, through a programming over time that hinges on the "Register of volumes", on the planning

and management coordination of the interventions with the aforementioned ARUs, and on the forecast of interventions for the renaturation of the areas affected by the demolitions. Further innovative elements that define the Urban and Environmental Regeneration Areas (ARUs) and that can therefore constitute a valid model to be followed in similar cases are:
- the localization of the areas of greatest urban, building, and social decay attributable to precarious and unstructured settlements where interventions of more intense urban transformation and regeneration are needed.
- the identification of the parts of the unconsolidated fabric that need redevelopment and densification interventions to achieve more structured and qualified physical and functional arrangements.
- the selection of discarded and abandoned areas and buildings that require recycling and reuse interventions to outline new physical, social, and functional life cycles.

Finally, for the continuation of the research work for the drafting of the new General Regulatory Plan for Messina, in agreement with the Civil Protection, the definition of the Guidelines for the Minimum Urban Structure (SUM), destined to guarantee adequate escape routes, gathering areas and shelter in the emergency phase following calamitous events, must assume greater centrality. The SUM, in this perspective, must also coincide with the network of the primary public space of the urban identity on which to converge as a priority adequate public resources and actions for the growth of social and cultural awareness on the part of local communities, and not only constitute an eventual escape route in relation to a potential calamitous event.

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