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Special Issue 1.2024

What transition for cities?

Scientific debate, research, approaches and good practices

This Special Issue intended to wonder about the possible transformations for cities towards the sustainability transition. Hence, contributions coming from scholars as well as from technicians have been collected around three main topics: methodologies for prefiguring possible sustainable transitions; urban policies and drivers of the transition; possible projects and applications for sustainable transition. Reflections and suggestions elaborated underline the awareness that the transition process, above all, needs cooperation among decisions, information sharing, and social behaviour changes.

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Re-generate resilience to deal with climate change

A data-driven pathway for a liveable, efficient and safe city

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Abstract
Cities are vulnerable to the effects of the climate. Building resilience to contain the risks for inhabitants, businesses and infrastructures deriving from the impact of climate change represents a challenge for local planners and public decision-makers. To win it, it is necessary to include the most suitable adaptation actions to contain the conditions of vulnerability in the local urban regeneration processes. To this end, the authors have increased and applied a methodology for defining and mapping climatic vulnerability, with a particular focus on the built environment. The main element of integration and updating concerns the use of Copernicus satellite remote sensing data. The application to the case study demonstrates the adequacy of such data for the research needs and the relative utility in terms of spatial resolution of the results. The vulnerability map into a more accurate definition scale helps the planner to integrate the common regeneration goals with more specific climatic resilience goals. In fact, basing on the results obtained for the case study, the authors define adaptive design solutions aimed at regenerating local resilience in terms of liveability, efficiency and safety.

Keywords
Climate change; Urban regeneration; Resilience.

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1. Introduction

Climate change is a long-term phenomenon mainly linked to global warming. It causes significant changes in temperature, humidity and precipitation (Forino et al., 2015). The phenomenon is attributable, directly and indirectly, to human activity (Battiston, 2020), which varies according to population size, economic activities, lifestyles, energy, and land use. Increasing urbanisation and complex patterns of urban economic goods, infrastructure and services make cities particularly vulnerable and less resilient to climate change (Guida, 2021; Balletto et al., 2022; Gaglione, 2022).

In general, resilience and vulnerability support risk description. These concepts are mutually interdependent and inversely related. Resilient systems are able to evolve, as a result of the perturbation, in a state different from that preceding the manifestation of the disorder, ensuring the maintenance of essential functions and the restoration of the structures that distinguish them. A vulnerable system has lost resilience, becoming exposed to the risk of a negative impact that could previously be absorbed. Therefore, the risk is positively correlated to urban vulnerability concept (Beltramino et al., 2022) and negatively to resilience concept.

Strengthening the comprehensive evaluation of resilience is conducive to identifying high-risk areas in cities, guiding regional risk prevention, and providing a scientific basis for differentiated strategies for urban resilience governance (Feng et al., 2021). The containment of the conditions of vulnerability starts from the analysis of the characteristics and the extent of the expected impacts that allows to identify the areas of greatest risk, deepen where and how the phenomena are repeated more frequently, and to define possible scenarios including policies and strategies to increase the resilience of the places, according to the sustainable development objectives. With regard to climatic risk, it is necessary to plan new urban models to obtain social, economic and environmental responses. This planning model allows the urban environment and its users to resist (Bonan, 2020) in the long term, to the external environmental stresses induced by the climatic variations whose course is known, but foreseeable only in part (Sandrini, 2020). According to the Intergovernmental Panel on Climate Change (IPCC) the Mediterranean basin is one of the main hotspots of climate change, or one of the most responsive areas to this phenomenon (Pietrapertosa et al., 2019). Therefore, in this context the use of "climate planning" is crucial in order to reduce the impact of climatic impacts to the scale of buildings and open spaces and to pursue sustainable development conditions in urban areas. The local government level is the most appropriate framework for testing climatic mitigation and adaptation strategies. Cities emerge, in fact, as driving forces for adaptation and resilience to climate change, representing the ideal context to implement low-carbon policies and strategic planning processes shared with citizens and stakeholders (Pietrapertosa et al., 2019).

Many approaches and tools have been developed to measure climatic resilience in cities (Mehryar et al., 2022), many of which, across Europe, are already investing in infrastructure to reduce vulnerability to rising sea levels, adapt to rising temperatures and control air pollution (Pee & Pan, 2022). This effort, of a predominantly autonomous nature, aims to fill the widespread lack of efficiency of political frameworks, also recognized by literature (Pietrapertosa et al., 2019), which should have defined national and regional guidelines to accompany local climate action. With reference to the Italian national context, although the European climate regulation (EU 2021/1119), there is no national legal obligation to adopt the Local Climate Plans. There are no national laws that oblige municipalities to develop any type of plan or strategy aimed at reducing greenhouse gases or adapting cities to climate change, with the exception of the Municipal Energy Plan (Law 10/1991, Art. 5) for cities with more than 50,000 inhabitants and the Urban Plan for Sustainable Mobility (Decree 257/2016, art. 3) for municipalities and their associations with more than 100,000 inhabitants (Pietrapertosa et al., 2019). The recognition of this regulatory gap clearly shows the need to define operational decision support tools that foreshadow or verify the effectiveness of urban regeneration processes (Strippoli, 2020) in terms of reducing vulnerability and increasing resilience.

Therefore, the research intends to cover this gap by proposing the methodological framework described below[1]. In literature, the study of climate change and its impact on urban life is increasingly recognized as a serious, worldwide concern (Waly et al., 2021). From a policy intervention vantage point, addressing the drivers of vulnerability provides a reliable approach to reduce the current vulnerability level and manage potential climate change-induced risks of a system (Yimam & Holvoet, 2023).

The literature findings underscore the importance of evaluating the susceptibility of local areas to climate change and emphasize the need for tailored local initiatives and policies to reduce vulnerability and enhance adaptability in communities (Hossain et al., 2023). In this scenario, urban-planning instruments require a strategic view that enables the integration of climate change variables, aimed at reducing vulnerability and strengthen the resilience of cities (Shao et al., 2021). As stated by D'Ambrosio (2018), the issue of modelling vulnerability to climatic phenomena has long been addressed through statistical matrix methods and approaches and the return of vulnerability levels is mainly related to the assessment of the socio-economic component (Kocur-Bera & Czyża, 2023; Li et al., 2023). Therefore, the research work aims to integrate the socio-economic parameters widely considered in the literature, with a more precise knowledge of the physical-environmental aspects that characterize the territory. The authors define an experimental methodology for direct assessment of climatic vulnerability, and consequently indirect of resilience, with a particular focus on the built environment, including through the use of satellite remote sensing data. These aspects are the main originality of the research. The paper proposes the definition of an innovative tool to support the planning of regeneration interventions promoting adaptation action to the effects induced by climate change in urban contexts. It traces a data-driven path based on the characteristics of settlement and environmental systems to plan liveable, efficient and safe cities.

Based on the introduced contents, the paper is structured as follow. Section 2 presents the methodological framework that feeds the tool to support the planning of climate-resilient regeneration interventions, paining attention to the use of satellite data. Section 3 introduce a frame of the theoretical assumptions underlying climatic adaptive design choices. Section 4 demonstrates the usefulness of the proposed methodology for planning and design of possible regeneration interventions geared to adaptation to climate change in the municipality of Catanzaro (Calabria Region, Italy). In particular, the lines of intervention defined following the identification of specific objectives of regeneration and resilience aim to propose design in areas and spaces already built, increasing the level of quality of living, with regard to environmental and socio-economic aspects, and their resilience to climate change. Section 5 discusses these findings in order to draw useful generalizable conclusions.

2. Methodological framework

Recently, the availability of data, time series, and statistical analysis techniques have allowed a rapid development of risk analysis in various fields and scientific disciplines (Azzimonti et al., 2018), including urban and territorial planning, according to different perspectives and approaches (Fasolino et al., 2019). In order to reduce the risks induced by climate change, the planner must identify the most appropriate adaptation measures on the basis of a prevailing assessment of the areas of greatest vulnerability and least resilience that need adaptation actions (Guida & Pennino, 2022; Ceci et al., 2023).

Adaptation is essential to ensure comfortable and safe places for settled communities (Privitera et al., 2013). To this end, the authors considered as a starting point the experimental methodology for defining domains of local vulnerability to climate change defined in Francini et al. (2020). They update and increase the methodology framework through the use of satellite data, in order to ensure more effective results.

[1] This activity refers to the research project admitted to funding under the University's competitive call - Rectoral Decree 1101/2022 of 29/07/2022.

Subsequently, they define a framework of measures against climate change by analysing some project proposals eligible for funding in Italy from funds of the National Recovery and Resilience Plan. The interest on such projects recognizes the importance turned to the control of the climatic risks from the PNRR with particular reference to the first two environmental objectives of the verification of conformity to the principle DNSH.

Therefore, an in-depth literature study has been carried out on the identified measures in order to verify their importance in terms of liveability, efficiency and safety identified by the authors as relevant resilience parameters.

2.1 Climatic vulnerability assessment

The methodology is based on the additive estimation of three dimensions that define climatic vulnerability in the literature (Pachauri et al., 2014).

In climate change studies (Tessema et al., 2021), the vulnerability of a system is a function of the following parameters:

- climatic exposure, which is the degree to which a system is exposed to significant climatic variations. This component summarizes the information useful for the construction of the climatic profile of the context of interest through the knowledge and monitoring of the 18 meteorological parameters explained in Tab.1;
- sensitivity, the degree to which a system is affected by climate-related stimuli. This component takes into account the physical and environmental conditions of the territory and the physiological and socio-economic status of the settled population such as to make it capable of being affected by climate change according to the 6 parameters reported in Tab.1;
- adaptive capacity, that is, the degree of a system to adapt to climate change. This component aims to measure the skills and resources available to the population in order to have easy access to tools that can facilitate the interpretation of climate-related information through the 6 parameters summarized in Tab.1.

Climatic exposure		Sensitivity	Adaptive capacity
1. Frost days (FD0) 2. Tropical nights (TR20) 3. Maximum value of daily minimum temperature (TNx) 4. Minimum value of daily minimum temperature (TNn) 5. Cold nights (TN10p) 6. Warm nights (TN90p) 7. Summer days (SU25) 8. Maximum value of daily maximum temperature (TXx) 9. Minimum value of daily maximum temperature (TXn)	10. Cold days (TX10p) 11. Warm days (TX90p) 12. Warm spell duration indicator (WSDI) 13. Maximum 1-day precipitation amount (RX1day) 14. Maximum 5-day precipitation amount (Rx5day) 15. Number of heavy precipitation days (R10) 16. Number of heavy precipitation days (R20) 17. Very wet days (R95p) 18. Simple daily intensity index (SDII)	1. Degree of waterproofing (Env-1) 2. Density of tree cover (Env-2) 3. Moisture class (Env-3) 4. Landslide and hydraulic risk (Env-4) 5. Elderly population (Soc-1) 6. Young population (Soc-2)	1. Impact of households with potential economic difficulties (Kno-1) 2. Education level and literacy rate (Kno-2) 3. Internet connection (Kno-3) 4. Climate action planning (Kno-4) 5. Peripherality from services (Res-1) 6. Conservation of residential buildings (Res-2)

Tab.1 Parameters of climatic exposure, sensitivity, and adaptive capacity

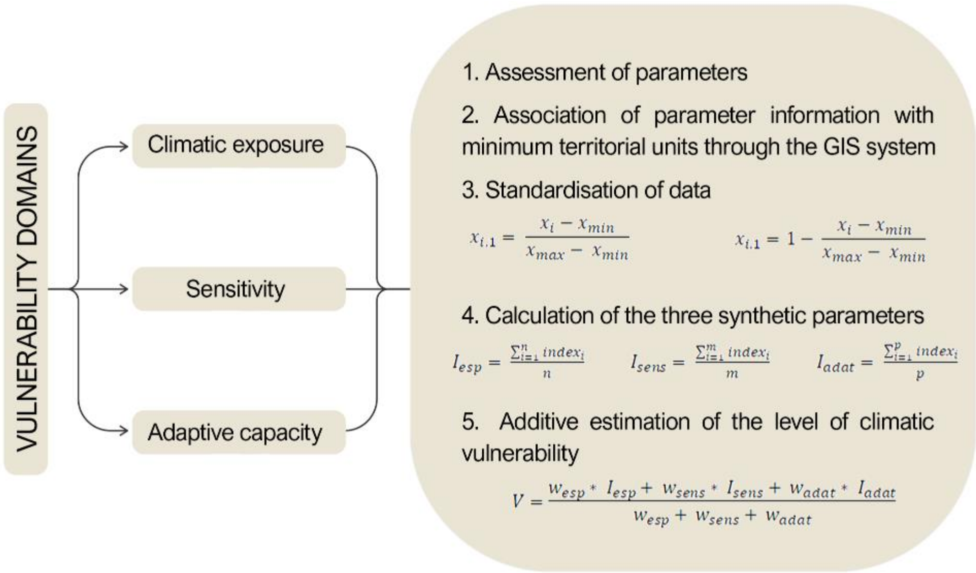

Fig.1 Methodological flowchart

The methodology is replicable in other urban areas. It attributes a set of parameters available on a local scale to each component. It is characterized by the steps shown in Fig.1.

The innovation element concerns the use of satellite data provided by the Copernicus[2] programme for the sensitivity component, namely the degree of waterproofing, the density of the tree cover and the humidity class. They allow to take into account a situation of extreme vulnerability to climate change represented by highly impermeable areas (buildings and roads), with a reduced percentage of vegetation and humidity. In particular, Copernicus waterproofing products capture the percentage and change of soil waterproofing. Waterproof areas are characterized by the replacement of the original semi-natural and natural soil cover or water surface with an artificial, often waterproof, cover. These artificial surfaces are usually maintained for long periods. Waterproofing captures the spatial distribution of artificially sealed areas, including the level of soil waterproofing per unit surface. The sealed ground level (degree of impermeability 1-100%) is produced using a semi-automatic classification, based on calibrated NDVI. In particular, the reference in this study is the high-resolution land cover characteristics for the year 2018, the last available update year.

The layer Impervious Built-up is a thematic product that shows binary information of building (class 1) and no building (class 0) within the waterproofing profile derived from the IMD 2018 for the period 2018 for the EEA-39 area. The production of the high-resolution built-up level has been coordinated by the European Environment Agency under the EU Copernicus programme.

As regards the density of tree cover, reference is made to the characteristics of the high-resolution land cover for the reference year 2018. The relevant TCD raster product provides information on proportional crown coverage per pixel at a spatial resolution of 10 m and ranges from 0% (all areas not covered by trees) 100%, where the density of the tree cover is defined as the vertical projection of the crown of the trees on a horizontal Earth surface. Finally, the combined product Water and Humidity is a thematic product that shows the presence of water and wet surfaces in the period from 2009 to 2018.

These layers are based on multitemporal and multiseasonal high-resolution optical satellite images. In addition, these layers are also based on radar information (Sentinel-1 data) with a geometric resolution of 10 m on a pan-European basis.

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[2] Copernicus data shall comply with Commission Regulation (EU) No 1089/2010 of 23 November 2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards the interoperability of spatial data sets and services. Copernicus data shall not be subject to Regulation No 1089/2010.

(a) (b)

Fig.2 Maximum spatial resolution of the minimum reference unit (a) census section (b) square mesh net 10 m side

For the definition of this product is used a multitude of optical images and SAR that, covering a prolonged time series of 7 years, aim to capture as much as possible intra-dynamic annual within a given area and lead to a composite image per season (each season covered by 3 months) and per year during the observation period. The reference product is called Water and Wetness (WAW) and is characterised by the following defined classes of (1) permanent water, (2) temporary water, (3) permanent humidity and (4) temporary humidity. This product shows the presence of water and indicates the degree of humidity in a physical sense, assessed independently of the actual plant cover and is therefore not limited to a specific class of land use and its frequencies. The main advantage of using satellite data is that the data sampling scale is more accurate (Fig.2). In fact, in the first version of the methodology the minimum reference unit was represented by the census sections whose dimensions are variable according to the resident population defined by the National Institute of Statistics, as shown in Fig.2(a). Copernicus products selected by the authors in order to increase the above methodology are made available at a spatial resolution of 10 meters. The use of such data allows to increase the number of information points and to obtain a more detailed and uniform representation of the territory as represented in Fig.2(b). Having used indicators sampled at different levels (census section and spatial resolution of 10 meters), the final map was developed taking into account the spatial resolution of 10 meters after resampling the data referring to the census sections to the same scale. Increasing the quality of the result of the application of the methodology, that is the indirect assessment of resilience through vulnerability parameters, the relative potentialities in relation to the definition of adaptive project interventions increase.

3. Best practices in adaptive design to climate change

Adaptation planning has moved from a one-dimensional approach to an integrative approach that interacts with the concept of vulnerability and resilience (Ngoc Le, 2021).

As acknowledged by Fisher et al. (2022), one of the most challenging aspects of adapting to urban climate change continues to be the act of translating knowledge about vulnerability into action for resilience.

To this end, the authors have defined a summary of the main measures taken against climate change by analysing the projects eligible for funding under the Integrated Urban Plans (called PUI) and the National Innovative Programme for the Quality of Living (called PINQuA) funded by the Italian National Recovery and Resilience Plan. The best practices emerged are detailed in measures and actions. They appear closely related to the contents that characterize the wide recent scientific literature with reference to the principles of liveability, efficiency and safety of urban regeneration interventions (Tab.2). Recognizing the specificities of the best practices identified and summarized in Tab.2, it is clear that public spaces are a key system for testing the most appropriate strategies for reducing climate impacts.

In particular, with reference to these three principles, the following should be highlighted:

- urban liveability frameworks developed from a public health perspective seek to identify the tangible aspects of urban policy and infrastructure that shape residents' health and the results of urban sustainability (Lowe et al., 2015);
- an efficient system is important for resilience as it makes possible the cross-scale of synergies between the components of the territory, ensuring a certain degree of stability (Feliciotti et al., 2017);
- safety refers to the promotion of safe processes and relationships between inhabitants, prevention and reduction of risk exposure (López-Contreras et al., 2021; Tira, 2021).

As part of this study, the areas of project intervention are represented, therefore, by public spaces and are identified, based on the results of the mapping methodology described in the previous section, as the most vulnerable areas. In the next section we will demonstrate the usefulness of the framework briefly described here, in order to define possible project interventions.

Measure	Actions	Liveability	Efficiency	Safety
Increased vegetation in abandoned and degraded areas	Planting of trees and greening with the use of native species. The green areas represent dominant elements for the creation of spaces for the community, for the conservation and enhancement of the present vegetation system	Diz-Mellado et al. (2020); Alderton et al. (2021); Wang et al. (2023)	Baraldi et al. (2019); Badach et al. (2020); Han et al. (2020)	Campagnano et al. (2020); Fisher et al. (2021); Lis & Iwankowski (2021)
Improving the sustainable mobility system	Measures to limit the environmental impact of public transport and infrastructure by reducing land consumption and encouraging public transport services	Jones (2020); Brovarone et al. (2021); Trecozzi et al. (2022)	Cruz & Sarmento (2020); Holden et al. (2020)	Ozaki et al. (2022); Spadaro et al. (2022)
Construction of blue infrastructure	Development of areas characterized by dominant natural elements through the implementation of works of accommodation and mitigation of hydraulic risk, as well as containment of heat waves	Acierno & Coppola (2022); Sepe (2022)	Hamel & Tan (2022); Rosa et al. (2022)	Buldakova (2022); Palliwoda et al. (2022)
Containment of impermeable surfaces in buildings and public spaces	Interventions to increase permeability in built-up areas such as commercial and industrial areas through demineralisation processes of paved surfaces using Nature-Based Solutions	Liu et al. (2020); Sivestrini (2021); Escaffre et al. (2022)	Ruiz-Pérez et al. (2022); Twohig et al. (2022)	Ciriminna et al. (2022); Li & Bortolot (2022)
Energy efficiency of residential buildings	Realization of thermal coat systems, replacement of fixtures, realization of solar screens and modernization of lighting systems	Skalicky & Čerpes (2019); Okoye et al. (2020)	Athmani et al. (2023); Aslam et al. (2021)	Krarti & Aldubyan (2021); Mostafavi et al. (2021)
Production of energy from renewable sources	Implementation of interventions for the production of energy from solar radiation, wind, biomass, tides, sea currents and precipitation	Allam et al. (2020); Aboulnaga et al. (2022)	Akram et al. (2020); Wang et al. (2022)	Wen et al. (2020); Chien et al. (2021)

Tab.2 Overview of the main measures to combat climate change

4. Application and Results

4.1 The Municipality of Catanzaro's climatic vulnerability map

The proposed methodology has been applied to the Municipality of Catanzaro (Fig.3), capital of the Calabria Region (Italy). Catanzaro covers an area of about 112 square kilometres, following the North-South orientation, which goes from the mountain area of Sila to the Ionian coast of the region.

The first settlement developed on three hills but its expansion has advanced over the years developing towards the coast. Today, the territory is divided into 19 districts, divided in turn into suburbs and districts.

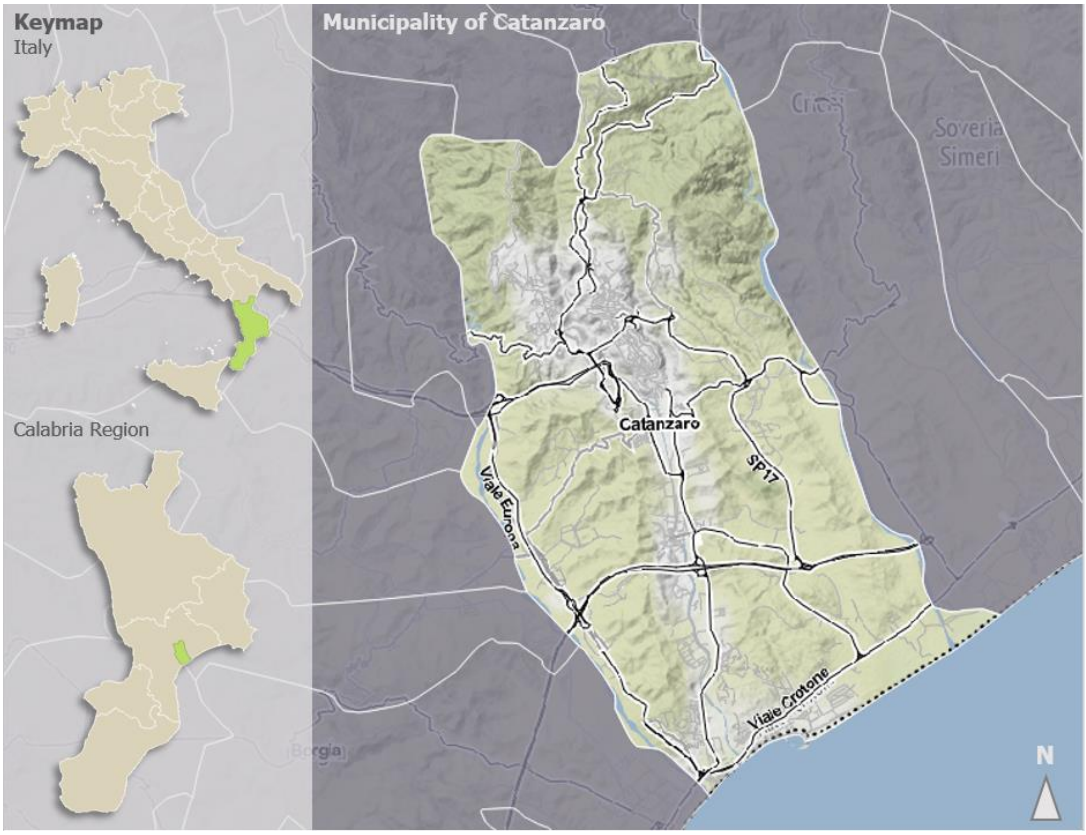

Fig.3 Municipality of Catanzaro's localization

The Municipality is equipped with a thermopluviometric station active in telemetry (cod. 1850) of the Functional Multi-risk Centre of the Regional Agency for the Protection of the Environment of Calabria (called ARPACal) useful for the acquisition of data useful for the sampling of climate exposure parameters (Tab.3). In particular, the data are derived from the historical series of minimum and maximum temperatures and daily rains in the climatological period of the last 10 years, that is between 2012 and 2021. The synthetic parameter of the climate exposure component was then calculated, according to the methodology described in the previous section, obtaining a value of 0.54. They depend on the characteristics of environmental and social capital (Fig.4). The relevant parameters derived from the information provided by the Copernicus satellite data and the Hydrogeological Order Plan.

Climatic exposure	Unit of measure	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
FD0	Days	0	0	2	0	0	4	0	2	0	1
TR20	Days	93	67	62	74	59	71	73	90	86	80
TNx	°C	28.6	25.8	24.8	26.3	25.1	27.9	24.7	25.5	25.6	29.2
TNn	°C	0.2	1.2	-2	1.5	0.1	-4.4	1.2	-1.1	2.9	-0.1
TN10p	%	9.8	9.6	9.8	9.8	9.8	9.8	9.8	9.6	8.7	9.3
TN90p	%	9.6	9.8	9.3	9.3	9.8	9.6	9.8	9.6	10.1	9.8
SU25	Days	121	112	106	99	109	111	117	123	109	116
TXx	°C	37.8	38.8	36	36.7	33.8	36.9	33	35.8	34.8	39.9
TXn	°C	5.8	6.6	7.1	6.2	3.5	2.5	6.9	5.8	6.2	2.3
TX10p	%	9.6	9.8	9.3	9.8	8.7	9.8	9.3	9.3	9.8	9.8
TX90p	%	9.6	9.6	9.8	9.8	9.3	9.8	9.8	9.6	9.8	9.8
WSDI	Days	22	9	13	6	0	20	14	10	8	26
RX1day	mm	104.2	140.4	79.6	73.6	80.6	201	101.2	58.6	109.8	70.2
Rx5day	mm	179.8	215.6	188.6	142.8	98.8	249	229.6	124.8	158.8	92.4
R10	mm/Day	12.4	13.9	10.9	16.6	12.2	11.7	15.0	12.2	9.8	10.3
R20	Days	35	37	28	34	36	20	43	43	20	37
R95p	Days	16	19	15	22	15	8	24	24	7	13
SDII	mm	634.4	731.4	557.8	744.8	567	542.6	853.8	525.8	463.6	487.8

Tab.3 Evaluation of climatic exposure parameters on the data recorded by the rain thermometer 1850 ARPACal

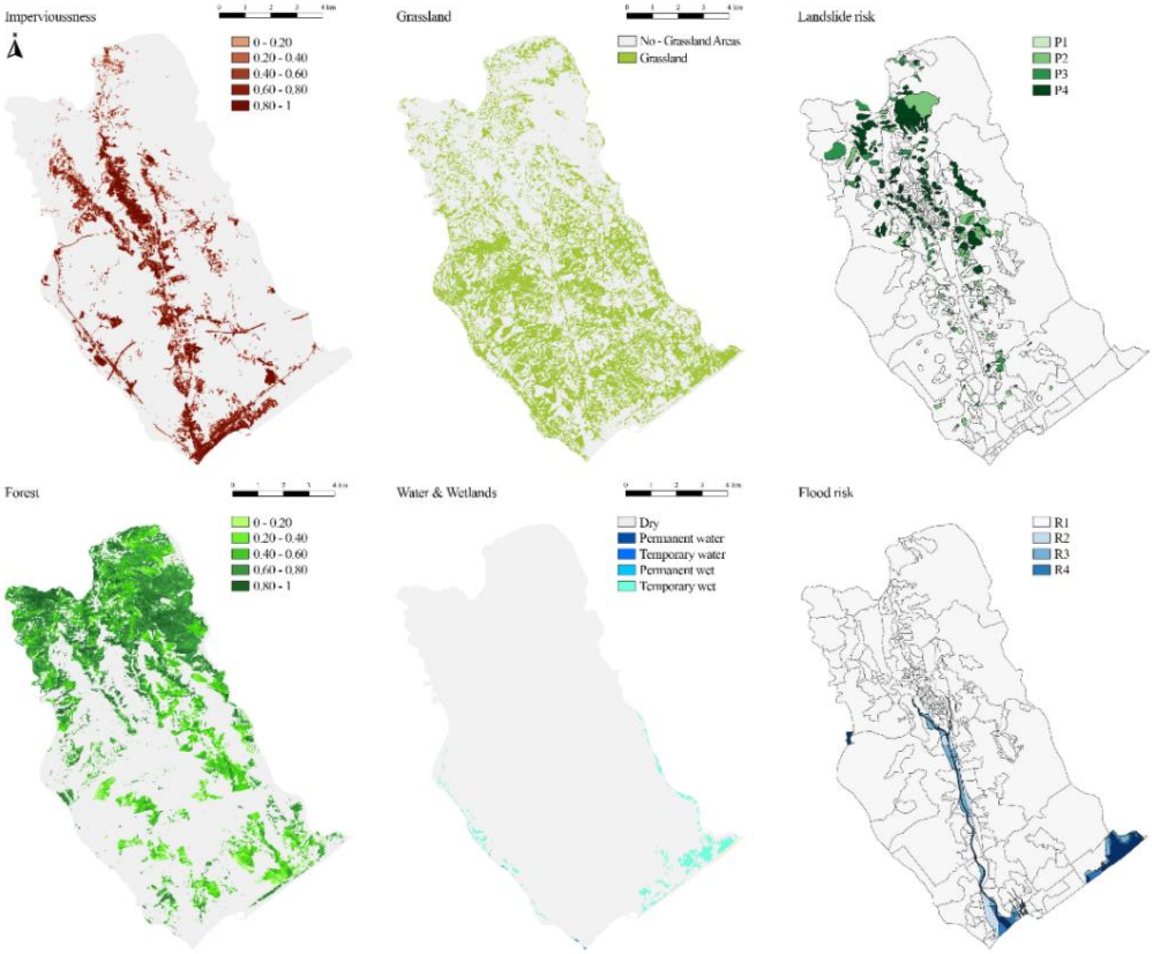

Fig.4 Mapping of some sensitivity parameters related to environmental capital

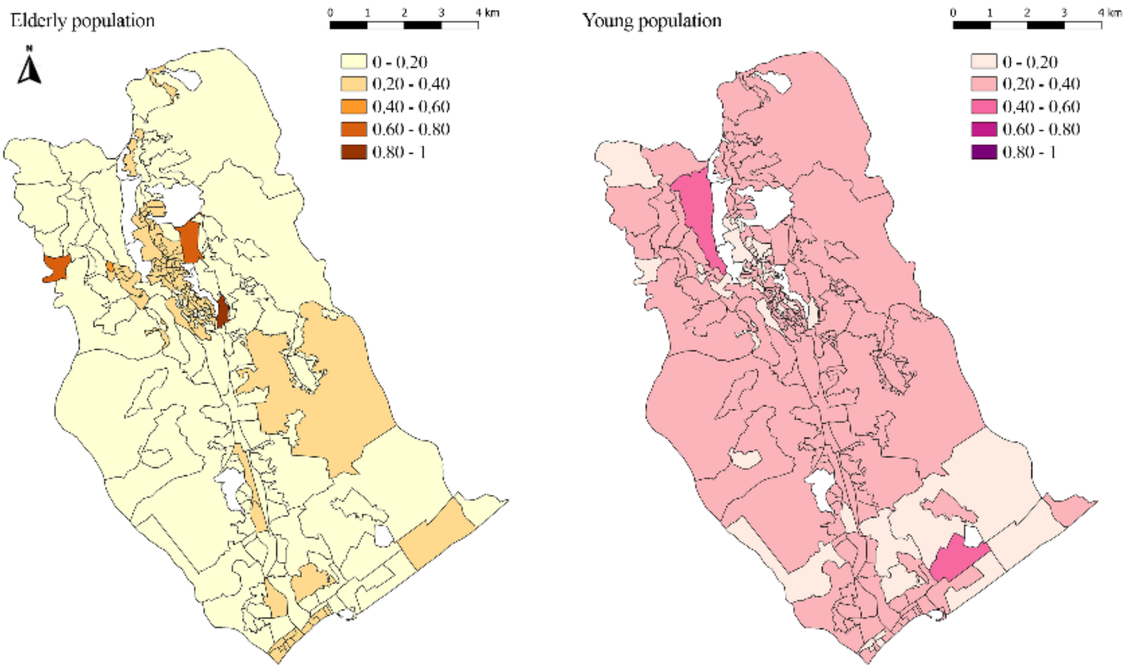

Fig.5 Mapping of some sensitivity parameters related to social capital

The elements belonging to the share capital are taken from the data of the National Institute of Statistics and have allowed to define the parameters relating to the elderly and young population (Fig.5). The two parameters influence the development of the climatic vulnerability map because they have a physiological and socio-economic status that makes them susceptible to climate change. Fig.4 shows the results obtained in GIS.The parameters relating to adaptive capacity assume unique value in the municipal context, with the exception of the state of conservation of buildings.

The category of knowledge allows to observe if the inhabitants have skills or have easy access to tools that can facilitate the interpretation of the information. A higher level of education allows society to be more resilient as it is able to cope with dangerous events. With the category of resources, we analyse what the territory offers at the level of services and properties. For the parameter of the state of preservation of residential buildings, depicted in Fig.6, the presence of buildings in good or excellent condition contributes to reducing urban vulnerability.

Sampled parameters of the three components of climatic vulnerability, the transfer of information in the GIS environment allows the different data levels to be presented together in the same map. Based on the data collected and the parameters obtained, the mapping relative to the Municipality of Catanzaro is the one shown in Fig.7 and allows you to visualize through colour bands the different levels of vulnerabilities.

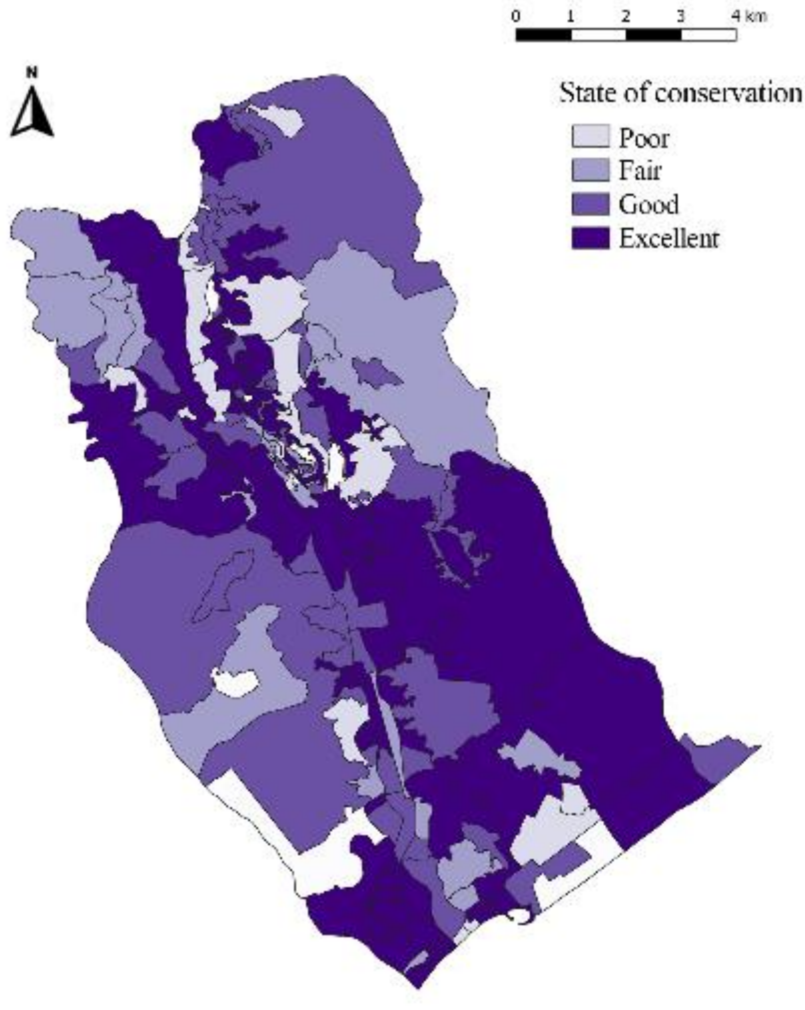

Fig.6 Conservation status of residential buildings

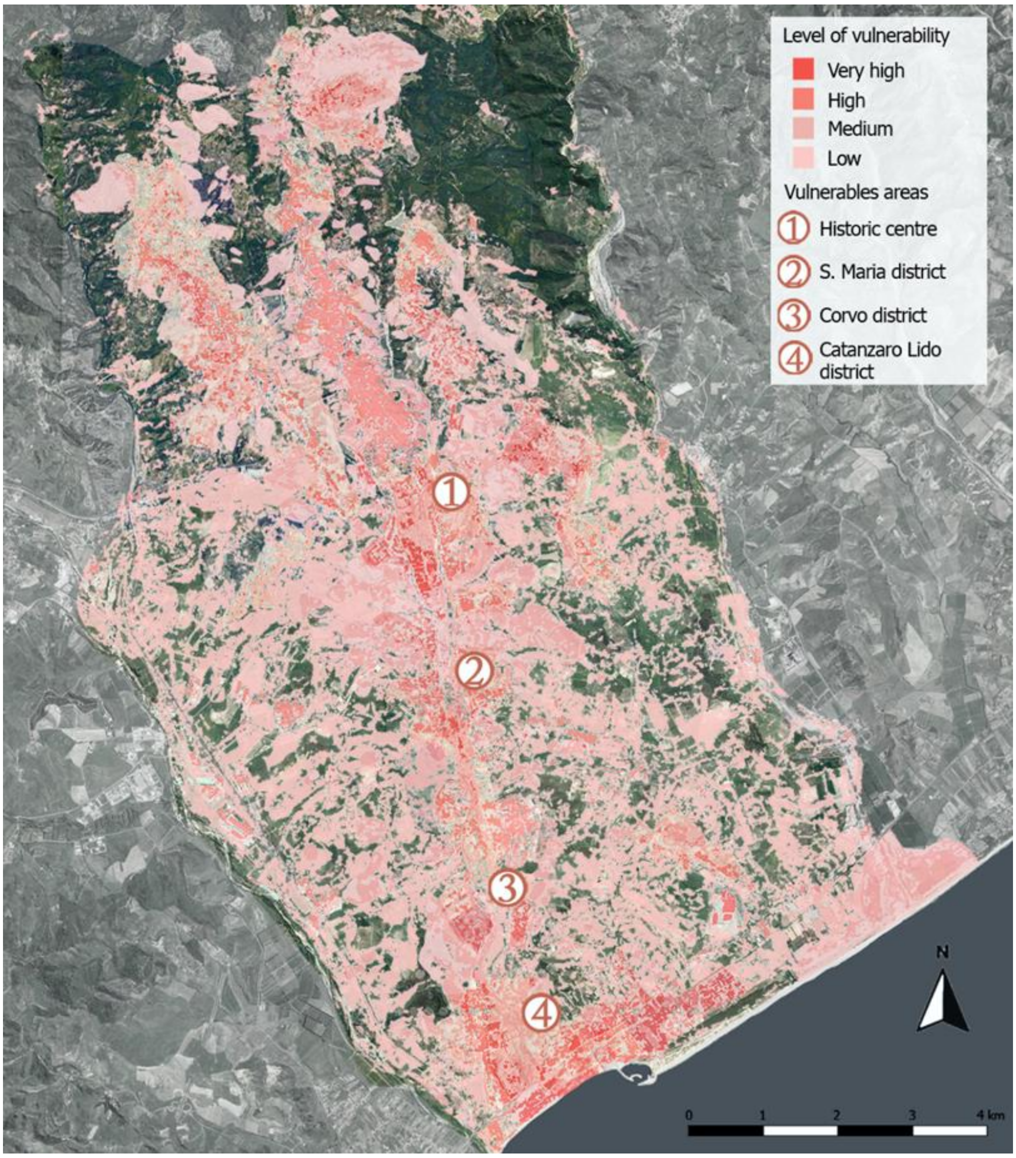

Fig.7 Municipality of Catanzaro's climatic vulnerability map

4.2 A context-based adaptation strategy for urban regeneration project

The elaboration of the climatic vulnerability map is a fundamental element because it is the starting point to integrate the appropriate adaptation measures in the urban regeneration processes of the Catanzaro context. By proposing possible design solutions, the authors intend to demonstrate the importance of supporting these processes through data-driven methodologies to achieve better results. In this specific case, the vulnerability map is useful to identify the priority areas of intervention and address the project interventions for the regeneration of areas and public spaces already built, increasing environmental quality and improving resilience to climate change. In fact, the definition of the Mapping of local climatic vulnerability has made it possible to identify the most vulnerable areas on the territory of Catanzaro that is those that are most likely to be at risk because they are less resilient, where to test some of the measures presented in section 2.2. In particular, in the analysed context it is possible to observe an average level of vulnerability spread throughout the territory and four areas with a particularly high level. These areas are located in the historic centre and in the districts of Santa Maria, Corvo and Catanzaro Lido.

The focus was on the two areas located further south, namely the districts of Corvo and Catanzaro Lido, which, due to the settlement characteristics described below, make it possible to demonstrate the urgency of integrating the most appropriate mitigation measures into urban regeneration processes.

The choice of the Corvo district is justified by the particular socio-economic condition that characterizes it.
The district, in fact, houses a large settlement of public housing, characterized by the absence of infrastructure and services. The history of this district begins with an unfavourable situation that led to greater degradation when, in the eighties, such residences were assigned to Roma citizens, because of the eviction of their huge camp located in another district of the city of Catanzaro, creating a difficult coexistence with the population already present. These situations of degradation and marginalization continue to the present day, determining the permanence of a complex social situation.
The coastal area of Catanzaro Lido, which is older than the Corvo district, is located on the southern outskirts of the town of Catanzaro. With the establishment of the university complex in the nearby Germaneto district, the area has undergone a huge demographic increase, to the detriment of the ancient area of the city. This sudden increase has led the city to face a greater demand for housing supply and a consequent uneven development. This problem still persists today and is the cause of considerable criticalities such as the presence of unmanageable traffic especially in the daytime peak and weekend night hours that lead the neighbourhood to be frequented by many young people due to the presence of numerous locals.
The main regeneration objectives for the two districts under study are:

- define integrated interventions that combine architectural recovery with the introduction of new urban activities and functions;
- restore the "sense of place" especially in spaces that have become marginal solving the lack of identity of a community;
- define a unitary development strategy that guarantees quality standards, low costs, minimum environmental impact and energy savings;
- contain the consumption of new soil.

Alongside the regeneration objectives are the resilience objectives aimed at increasing the ability of the system to cope with risks while preserving its essential functions and its adaptability and transformation capabilities. By narrowing the field to climatic risks, the main targets of resilience aim to:

- understand the vulnerability that characterizes the territory, recognizing how "understanding how shock and stress increase risks is the first step towards building resilience" (Urban Land Institute, 2018);
- making the territory socially resilient by strengthening employment and housing opportunities;
- redefine how and where to build through understanding the function and geography of systems;
- maximising co-benefits, improving quality of life and potential economic development.

The objectives of regeneration and resilience described are intended to stimulate the resilience of the city in assuming a management of public space that is able to respond to the new needs of the people living in them, revitalising the social fabric in disadvantaged areas and offering a new model of living for the weakest sections of the urban population. The actions that identify individual projects or proposals for specific action are the result of a planning process that, starting from the general objectives of regeneration and resilience, leads to the identification of the lines of project intervention, which define the specific objectives to be pursued in the proposed regeneration of the districts of Corvo and Catanzaro Lido.
In particular, the adopted strategy is articulated in three lines of participation that, echoing the principles of reference anticipated in section 2.2, describe the characteristics that are intended to attribute to the two areas: liveability, efficiency and safety. The goal of the line of action "liveable neighbourhood" is to improve the quality of life, or strengthen the conditions of use of the neighbourhood through the implementation of elements that can encourage its development and contribute, in general, to the definition of a smarter city.

The specific objectives of this action line are:

- redevelopment of the habitat of neighbourhoods with the inclusion of high-efficiency urban furniture;
- redevelopment of public squares and spaces through the reduction of paved surfaces;
- promotion of public green spaces by creating green areas and urban gardens;
- promotion of interventions in sports facilities using efficient systems and materials according to the principles of sustainability;
- promotion of alternative housing solutions with the promotion of social housing and student housing.

The intervention line "efficient neighbourhood" intends to spread services to the person at the scale of the neighbourhood such as the construction of gardens and meeting areas and the implementation of shops in the premises not used. In addition, there are initiatives and projects that involve citizens who, through the collaboration of professionals, can contribute to achieving shared regeneration goals.

This line of action concerns the overcoming of the mono-functional character of the "dormitory district" of the Corvo area and the criticality of the Lido area relating to mobility. The specific objectives of the action line are:

- increase of specific services for residences and promote meetings with citizens to discuss issues;
- encouraging the use of public transport and the provision of bike sharing and cycle paths;
- improvement of waste collection activity thus avoiding the accumulation of garbage in residential areas.

With reference to the last line of intervention, the adjective "safe" alludes to actions that contain the effects of extreme weather events that have characterized especially the neighbourhood of Lido and, as a result, helping to make it an environmentally safe neighbourhood.

The actions are aimed primarily at areas near the Fiumarella stream and the Alli river where, in the past, sudden heavy rainfall has created severe hardship to the population.

Fig.The specific objectives of this strand are:

- maintenance of watercourses by cleaning and removing vegetation that invades the riverbed;
- control of the built with the promotion of expansion policies that do not allow the inclusion of infrastructure in areas close to the waterways;
- introduction of monitoring networks with the activation of flood pre-announcement measures;
- implementation of blue infrastructure as works of accommodation and mitigation of hydraulic risk.

The planning activity, in particular, involves two areas belonging to the Corvo district and one belonging to the Catanzaro Lido district and insists on uncovered areas with the aim of creating useful services for the community (Fig.8).

Fig.8 Plans and renderings of the interventions

For the first district, the realization of a public space through the de-waterproofing of the soil is proposed. The aim of the intervention is to make the place accessible to the citizens of the neighbourhood, thinking of older people, through the promotion of activities useful to make them part of a large community. The second project focuses on the theme of sustainable mobility through the creation of a cycle path with the use of ecological materials and the promotion of the practice of recycling through the installation of recycling incentives. For the Catanzaro district, Lido proposes, instead, near a school building, the construction of an urban garden used both by citizens living in that area, and by the school for educational activities. The aims of the creation of an urban garden are many and include environmental education, food, and the preservation of agricultural biodiversity. The projects, although briefly described, aim to support, in particular, three of the measures already illustrated, namely: increased vegetation in abandoned and degraded areas; improvement of the sustainable mobility system; containment of impermeable surfaces in buildings and public spaces.

5. Discussion and conclusion

Public responses to impacts associated with climate change at the local level are mostly shaped by prevailing socio-cultural knowledge systems, supported by resilience thinking in the face of change and adversity (Iñiguez-Gallardo & Tzanopoulos, 2023). According to the same authors, climate change mitigation and adaptation planning and action must be informed and implemented within specific contexts. Communities depend on local policy tools to identify threats, determine goals, and implement strategies. As a result, many cities around the world have developed climatic adaptation plans to reduce climatic impacts in recent decades (Tu & Yu, 2023). To this end, nature-based solutions (Mazzeo & Polverino, 2023) enhance the potential for climate change mitigation and adaptation in cities. Among the environmental benefits of these measures, increasing biodiversity, increasing carbon storage, reducing extreme temperatures and controlling rainfall (Epelde et al., 2022). The evidence presented by this study indicates a possible path for the improvement of urban resilience oriented to the realization of a liveable, efficient and safe city with respect to climate change. The main idea behind this study is that to ensure greater synergy between the processes of urban regeneration and containment of climatic risks it is necessary to base planning choices on a quantitative and spatial analysis of climatic vulnerability local. To support this position, the authors have updated and applied an experimental methodology of climatic vulnerability mapping to the Municipality of Catanzaro. In particular, the update of the methodology has allowed to introduce a reflection on the usefulness of using satellite data in order to obtain better results in terms of spatial resolution of the output mapping. The application of the methodology has proved to be a useful opportunity to quantify and localize the main issues of the context of interest, enabling you to plan climatic adaptive design strategies and interventions consistent with the characteristics of the analysed context and in line with the best practices and principles known to the specialist literature in the field.

In the planning phase of the interventions, in order to define a set of transformation actions, the objectives of regeneration and resilience have been defined. Tackling these objectives synergically presupposes the development of innovative design methods, which must be able to manage the complexity of information and orient urban regeneration strategies in a multiscale perspective. In the proposed case, the defined interventions attempt to respond to the so-called "housing issue", understood not only by referring to socio-economic aspects, but also by analysing issues such as degradation, habitability and sustainability of public spaces. The actions that identify individual projects or proposals for specific action are the result of a planning process that, starting from the study of the state of the art and the general objectives of regeneration and resilience explained, leads to the identification of the lines of project intervention, which define, in turn, the specific objectives that are intended to pursue in the districts of Corvo and Lido and the Municipality of Catanzaro.

The strategy adopted attributes to these districts three lines of action representative of the principles attributed to the two areas are liveability, efficiency and safety. Although the proposed methodology is not yet able to fall into the totality of climatic issues, or to consider the entire management of building and urban processes, the results described provide a first cognitive and experimental input in relation to the definition of climatic adaptive design interventions for the study area. They are useful to guide innovative processes of planning and design. In this regard, future research developments consist of deepening these issues in depth with a focus on the link between infrastructures and communities for the climate resilience of urban, but also rural and coastal areas, also through the activation of a research group between the authors' Department and the Italian Institute of Atmospheric Sciences and Climate, National Research Council (ISAC/CNR). In general, the results presented show that urban planning is the preferred area for understanding the level of local vulnerability, assessing expected impacts and identifying priorities for action. In this regard, according to Fisher et al. (2022), a common problem is the difficulty that planning staff may encounter in tracing the specialist information that can be used to develop policies and strategies as part of a comprehensive and comprehensive programme of interventions and projects that ensure climatic resilience. It emerges, therefore, the need to activate collaborations and support activities of local authorities to encourage the interaction between competing skills and institutional subjects in order to determine shared paths in the definition of urban development processes based on the effective translation of knowledge about vulnerability into action for resilience.

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Image Sources

Figg.1 - 8: Authors' elaboration

Author's profile

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