Environmental Dimension into Strategic Planning. The Case of Metropolitan City of Cagliari

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Abstract. Global changes in the Anthropocene are unprecedented in history. They are closely linked to the use of the soil, the sea and the exploitation of natural resources and in turn determine important changes in the values and socio-cultural behavior of entire populations. In this context, the focus on the environmental dimension is the main way to govern the city and territory. In this sense, the environmental assets through the criterion of participation in decision-making processes, the identification and assessment of reasonable plan/program alternatives through the construction of forecast scenarios related to the evolution of the state of the environment constitutes the spatial planning paradigm, from the municipal level implementation strategy and the metropolitan level strategic one. Although in fact all Italian metropolitan cities are oriented towards adopting strategic and sustainable development models, capable of fighting the consumption of soil and natural resources in general, these have not always correspondence in an approach that specific environmental assessments part of the plan process and therefore functional for future governance choices. In this context, the objective of this work is to describe the case of the metropolitan city of Cagliari highlighting how the environmental dynamic and assets should be considered into its (actually in defining phase) strategic plan.

Keywords: Ecosystem services · Strategic planning · Metropolitan cities · Climate change

This paper is the result of the joint work of the authors. For Italian evaluation purposes Maria Elena Palumbo takes responsibility for Sect. 3.1, Luigi Mundula for Sects. 2 and 4, Ginevra Balletto for Sect. 1, Erika Bazzato for Sect. 3.2 and Michela Marignani for Sect. 3.3.

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1 A New Season for the Strategic Planning in Italy

The "strategic" adjective has become commonly used in the language of territorial planning, even if, as often happens, it is not always used with the appropriate level of precision and/or awareness and is now applied in a variety of experiences in an easy way [11].

The origin of the term must be sought in military science and is often linked to the term tactics; a strategy is a long-term action plan used to set up and coordinate actions aimed at achieving a predetermined goal or objective, while by tactics we mean a targeted action aimed at the short term, at a specific and specific episode, a segment of that wider goal which is the field of strategy; in short, the strategy is war, the tactic is the single battle. To win a war (strategy) you can also order a retreat or lose a battle (tactic).

Strategic planning then entered predominantly within the private sector to define the competitive strategies of companies in the markets, aimed at achieving precise business objectives through short-term measures and actions. Strategic business planning is now a consolidated practice and is a basic technique taught in business administration and business administration schools and in recent years it has gradually spread also in the non-profit sector and in the public sector [12].

In many European cities, between the 80s and 90s, strategic planning was included among the tools for territorial and urban planning to experiment with new methods and procedures that would go beyond traditional urban planning tools. A little later, with the new millennium, the territorial strategic planning tools also made their appearance in Italy.

Starting from the early 2000s, in fact, we witness the first Italian experiences of Strategic Planning, both in the urban/administrative sphere and in the disciplinary and transdisciplinary scientific sphere [13]. In those years, the Italian network of strategic cities (which included the pioneering cities of Turin, Florence, Pesaro, Trento, Piacenza and Verona, was quickly established, which was later joined by Venice, Perugia, La Spezia, Naples and the Province of Trento) with the aim of exchanging experiences and good practices, examining the main unresolved political and organizational issues and connecting with the most important experiences realized in the European panorama.

Apart from some pioneering experience, it was practice that imposed a new and relevant reflective approach on theory, especially in the urban field, which viewed the new tool with skepticism, tending to give it a minimalist, pejorative and misleading interpretation. In response to the traditional "plan crisis", strategic planning provides a rational and viable response, allowing to get out of the contrast between cognitive limits and implementation rigidities of regulatory-totalising planning and irresponsibility in terms of interest collective of purely derogatory practices.

However, if at the beginning the strategic territorial planning had a mere voluntaristic nature, it is only recently that in Italy it has become mandatory, even if only for metropolitan cities with the Law 56/2014 (Delrio Law). This Law defined also the metropolitan cities as a new governance level between regions and municipalities replacing, de facto, the Province level. By the way not all the Province has been

replaced by metropolitan cities but only 14[1], and 13 of them (with the exception of Cagliari) are constituted by the same municipalities of the old Province.

2 Resilience, Sustainability and Smartness as the Fulcrum of Strategic Planning Action

In defining their strategic plans, the Italian metropolitan cities have stepped up and started setting their own agendas on the base on sustainability, resilience or smartness concepts focusing in different ways on them.

It's to note that in the last years these concepts have been coupled by researchers and institutions generating crossing paradigms, i.e. incorporating sustainability in smart city approaches for developing a more complex smart sustainable urban model.

The increasing awareness about environmental and sustainability issues related to urban growth and technological transformation is at the basis of the Smart Sustainable Cities concept [14]. The cities which has to face climate change as well as other challenges as concentration of population within an urban area, have become to use this concept widely since mid-2010s [15, 16]. With smart sustainable city, it is described a city "that is supported by a pervasive presence and massive use of advanced ICT, which, in connection with various urban domains and systems and how these intricately interrelate, enables cities to become more sustainable and to provide citizens with a better quality of life" [16]. The new technology, based on the Internet of Things (IoT) [17], allows citizens to be always connected through several devices. The real-time data may provide the opportunity of real-time feedback which may support real-time citizens' decisions in light of sustainable choices. The smart sustainable city allows decoupling high quality of life and economic growth from resource consumption and environmental impact [18].

Moreover, sustainability has been closely associated with the concept of resilience [19], since this last term "is often used to describe characteristic features of a system that are related to sustainability" [20].

Verma and Raghubanshi [21] distinguishing among three aspects, economic, social and environmental, underline how these have resulted in the development of Sustainable Development Goals [22]. These goals allow both developing and developed Nations to reach sustainable development through a holistic approach. In particular, Sustainable Development Goal 11 vows to "Make cities and human settlements inclusive, safe, resilient and sustainable".

However, there are some authors [23] which disapprove this connection considering resilience as just a label. To be sustainable, cities and urban areas must be ready to face shocks and stresses which undoubtedly sooner or later will occur and will modify the state and the operating ways. In other words, they must be resilient [24]. Coherently with this approach, Beatley and Newman [25] propose the term of Biophilic City. The idea is that to make cities greener, more natural or, in their words, more

[1] The Italian metropolitan cities are: Bari, Bologna, Catania, Cagliari, Firenze, Genova, Messina, Milano, Napoli, Palermo, Reggio di Calabria, Roma, Torino, Venezia.

biophilic, it is important to make them more resilient. This target can be reached in a direct way when investments in green infrastructure – i.e. a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services' in both rural and urban settings [26] – achieve resilience outcomes; or in an indirect way when actions or projects stimulate green and healthy behaviors that in turn serves to enhance the resilience of a city and of individuals.

Over the past decade and from a political point of view, urban resilience concept has emerged as one of the core principles of sustainable urban development widely acknowledged among various agreements such as the 2030 Agenda for Sustainable Development with its dedicated goal on cities—SDG 11, the Paris Agreement on climate change and the Sendai Framework for Disaster Risk Reduction.

It is worth to note that the urban resilience issue has also been associated with the smart city concept [27]. In fact, both concepts "are operationalized on the basis of similar or even the same systems, having similar trajectories of development and similar dilemmas to be solved" [28]. Moreover, these notions aim at improving sustainability and increase the quality of life, although follow different paths. Even if some international organizations or networks as well as a wide number of cities are fostering integrated projects and strategies for building up smarter and more resilient cities, a theoretical framework is still missing.

3 The Metropolitan City of Cagliari (MCC)

In this framework the Metropolitan city of Cagliari started the definition process of its strategic plan in the 2019. The process is articulated in three main phases:

1. *Collecting*: data collection according to an objective approach (desk analysis) and a subjective one (participatory diagnosis);
2. *Frameworking*: identification of the vision, formulation of the objectives and identification of the actions necessary to achieve the objectives;
3. *Assessment and monitoring*: construction of indicators that allow to verify the implementation of the plan and the achievement of the objectives.

Actually, the first phase is concluded and the second one is ongoing. The results of the first phase highlight the central role of the environmental aspect in order to define the strategic pathway.

3.1 Environmental Factors Shaping the MCC

The areas occupied by the Metropolitan City of Cagliari is characterized by a high heterogeneity of the environmental mosaic, as a consequence of a wide variability of the physical, geomorphological, pedological-vegetational and historical-cultural elements.

Geology, Geomorphology and Hydrography
From a geological point of view, the territory of the Metropolitan City falls into three large geological areas:

- Campidano, an area whose geological structure consists of a series of geological formations from the Oligocene up to the recent Quaternary, such as terraced ancient floods, clay soils and recent soils of reclaimed marsh areas. From a geomorphological point of view, this area is characterized by landscape with "conoids", typical in the western sectors of Campidano, or "plains" modified by agricultural activities
- Linas-Sulcis, consisting of three large homogeneous units: the valley area of Cixerri and the foothills. The sedimentation phases can be distinguished in: a pre-Pliocene sedimentation related to the opening of the great tectonic structure known as "Fossa Sarda" and a Plio-Quaternary sedimentation related to the opening of the Campidano graben; the volcanic reliefs; metamorphites and Paleozoic intrusions;
- Sulcis and gulf coasts, with a geo-structural conformation derived from a series of ancient orogenesis, extensional or compressional tectonic phases, volcanic activity and erosion and sedimentation phases over time. Characterized by hills and predominantly rounded forms, this area represents a small portion of the southern sector of the large Oligo-Miocene tectonic structure known as "Fossa Sarda".

The urban area of Cagliari shows a hilly morphology connected to coastal morphological systems by a complex hydrography. The coastal system shows an articulated system of lagoons, ponds, marshes and salt marshes separated from the sea by coastal cords. Dynamics are strongly influenced by intense anthropization, which, by reducing its runoff, has strongly compromised the drainage network of the coastal areal, fundamental for the maintenance of the coastal ponds system.

From a hydrographic point of view, the Metropolitan City of Cagliari falls into the Flumendosa-Campidano-Cixerri sub-basin, which extends for almost 6000 km^2. The main rivers are "Flumini Mannu", major tributary of the pond of Santa Gilla, and "Rio Cixerri", once a tributary of the Flumini Mannu, then artificially separated near the S. Gilla lagoon. The intense urbanization has drastically reduced the recharge potential of the aquifers. The strong contamination also prevents their use for drinking purposes. Further damage derives from the excessive drainage activity near the coasts, which caused the rise of waters with a high salinity.

Climate and Natural and Semi-natural Vegetation

The territory of the metropolitan area is characterised by the Mediterranean macrobioclimate, falling within a upper or lower mesomediterranean and thermomediterranean phytoclimatic belt [1]. Potential vegetation ranges from areas of scrublands and coastal scrub to areas of thermo-xerophilous woods and thermophilic holm oaks, especially in areas belonging to the districts of "Sette Fratelli" and "Monti del Sulcis".

The vegetation is mainly composed of matorral of evergreen oaks, *Olea europaea* and *Pistacia lentiscus* formations, garrigues and silicic mesomediterranean scrub vegetation [2]. The territory has a high heterogeneity, with 40 different land use coverages [3]. More than half of the territory (52.3%) is represented by wooded areas and semi-natural environments; 31.9% of the area is occupied by agricultural areas, while 10.2% is occupied by artificial surfaces, mainly residential urban areas or industrial, commercial and infrastructural areas. The remaining territory is occupied by an important system of wetlands (3.3%) and water bodies (2.3%).

Coastal Wetland Ecosystem

Coastal wetlands are characterized by a delicate balance linked to the supply of solid materials from water courses: the deposition of sediments shapes the mouth of the rivers and constitute a determining agent in the drainage of the hydrographic-lagoon-sea basin. The functional role of hydraulic regulation of the territory depends on this dynamic equilibrium, that appears particularly relevant during the flood waves following the extreme meteoric events.

The resilience of coastal wetlands is therefore strictly connected to continental contributions which, due to morphological alterations and/or pollution of the areas further upstream of the river basin, may present poor water quality, or be unavailable during the summer period.

The consequences of these phenomena can have a negative impact on the ecology of these environments, specifically on the components of biodiversity of ecosystems (flora and fauna), but also on lagoon production, resulting in fluctuating returns, negatively influencing the ecosystem services provided by the wetlands. In particular, the wetlands of Cagliari are subject to a condition of "urban encirclement" or the tendency to weld of the urban centers of the MCC (Fig. 1), which progressively leads to reducing the residual physical and functional corridors of communication between the wetlands and their feeding basins [4]. These vulnerabilities, added to the future instability caused by climate change, represent a great challenge for the management of coastal wetlands.

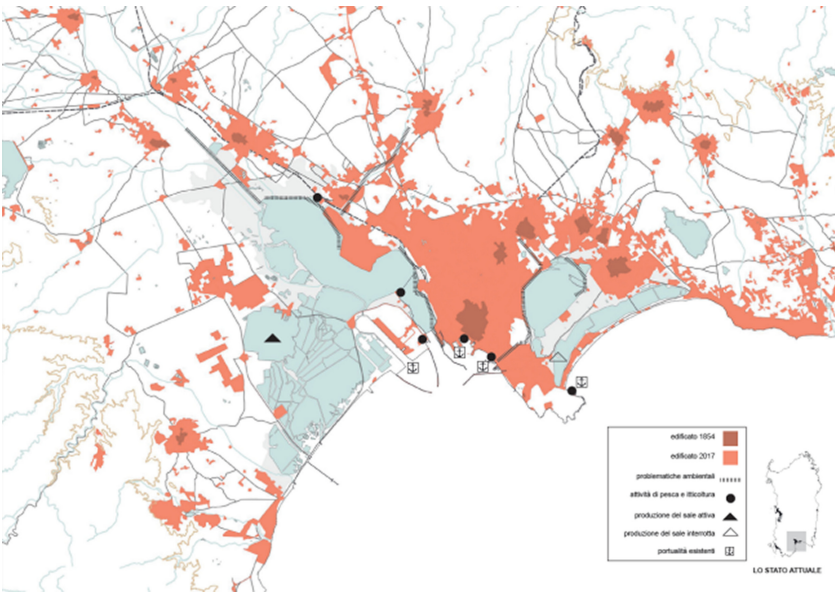

Fig. 1. Current state of the building in the wetland system of the city of Cagliari (*DICAAR-DISVA-CRENOS Interdepartmental research University of Cagliari*)

3.2 Threats and Vulnerability

Climate and Land Use Change

According to the National Climate Change Adaptation Strategy, in the coming decades the impacts resulting from climate change in the European Mediterranean region will be particularly negative and, combined with the effects of anthropogenic pressures on natural resources, it will make this area one of the most vulnerable in Europe. The future climate projections, included in the Regional Strategy of Adaptation to Climate Change of the Sardinia Region (reference period 1981–2010) and performed according to two scenarios, show for MCC an expected increase in the average temperature which varies between +1 °C and +2 °C in the period 2021–2050 (Fig. 2).

As regards rainfall, the projections show an increase in the annual values for the municipalities of the Metropolitan City in the first scenario, and a significant reduction in the second scenario, particularly marked in the municipalities of the eastern arch (Fig. 2). A general slight increase in the number of days with more intense rainfall is also expected, which suggests a future scenario in which rainfall could be concentrated in a limited number of intense events.

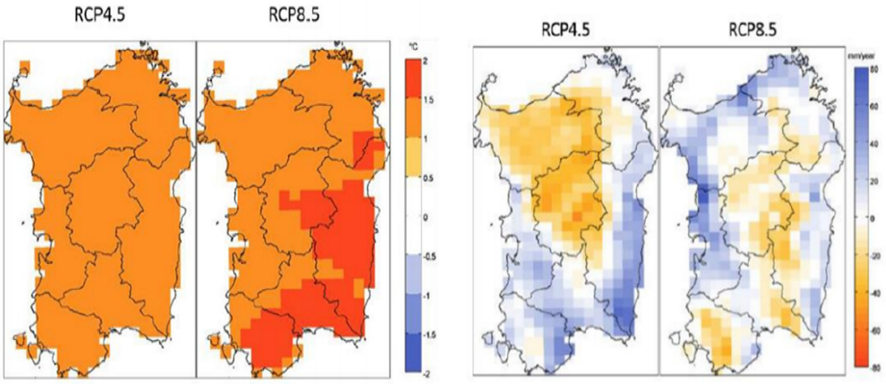

Fig. 2. Anomalies [°C] of the average temperature (left) and anomalies [mm/year] of the AP indicator for the period 2021–2050 (right). (Regional Strategy for Adaptation to Climate Change)

The main vulnerabilities related to the natural landscape are directly or indirectly related to anthropic activities, influencing hydrogeological processes and altering the ecological connections of the territory, through alterations and changes in land use which lead to habitat loss and environmental fragmentation, with a special intensification on coastal areas [5].

Fragmentation and Conservation Status of the Landscape

Landscape level metrics and specific metrics show an overall medium-low degree of environmental fragmentation in the metropolitan area [6]; only 2 municipal territories, out of a total of 17, have a high degree of fragmentation (Fig. 4). The ILC Landscape

Conservation Status Index [6, 7] calculated for the metropolitan area shows an overall conservation status with a high value (ILC = 0.63), except for only one municipality with a low conservation status ($0 < ILC \leq 0.2$) [6].

The analysis of the degree of fragmentation and the state of conservation of the administrative units of the MCC [6] allows to identify the municipal territories that present the most critical conditions and, at the same time, to highlight the territories that would need the implementation of strategies aimed at the protection and/or restoration of natural and semi-natural habitats. By framing the state of conservation and fragmentation of the municipal territories belonging to the MCC within the system of protected natural areas, it is possible to highlight and locate the inconsistencies existing between ecological emergencies and current distribution of the areas subject to conservation actions (Fig. 4).

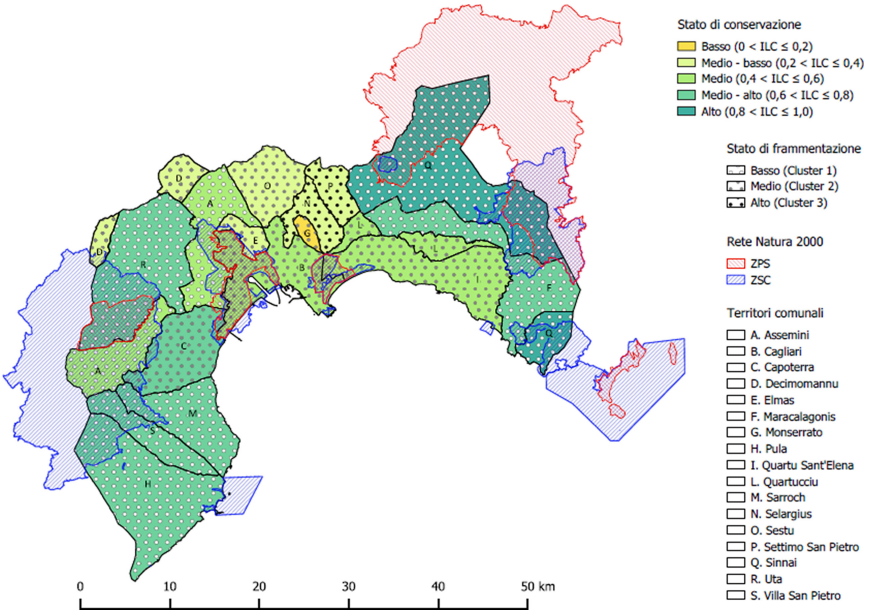

Fig. 3. Protected areas and the Natura 2000 network in relation to the state of conservation and degree of fragmentation of the Metropolitan City of Cagliari. (elaboration of Maria Elena Palumbo)

Hydrogeological Risk

The concept of flood risk pursuant to art. 6 of Legislative Decree n. 49/2010 is linked to the contextual analysis of Flood Hazard (H) and Potential Damage (D). Flood hazard is based on modeling referring to flood events, floods, linked to different return times. The potential damage is based on the analysis of the elements at risk present in the territory and their respective vulnerability.

The planning tools adopted or approved by the Sardinia Region (PAI, PSFF, studies pursuant to art. 8 paragraph 2 of the NA of the PAI) identify 3 hazard classes and increasing probability of occurrence and four classes of potential damage to people, to the socio-economic system and to non-monetizable assets. The Flood Risk map is the results of the overlaying of the Hydraulic Hazard map and the Potential Damage map. In accordance with the operational guidelines prepared by the Italian Ministry of the Environment (MATTM), the Flood Risk identifies four classes of increasing risk degree, ranging from R1 no risk (yellow) to R4 very high risk (red).

Only 4% of the entire territory is subject to very high hydrogeological risk (Fig. 3); this area is mainly concentrated in the territory of the municipalities of Elmas and Cagliari. A complete study of the network is missing: in this context, a lack of coordination between the different levels of constraint and study of the individual branches of the basin represent a major threat.

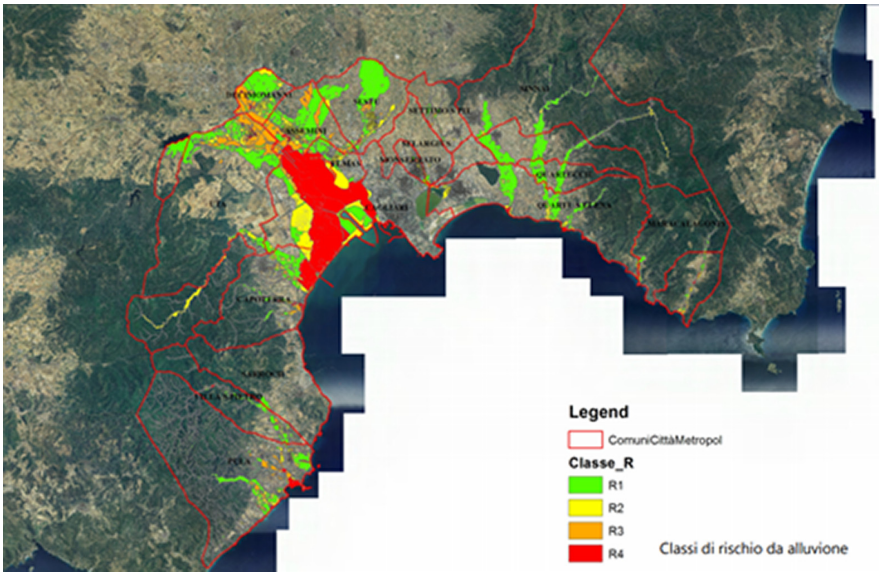

Fig. 4. Flood risk map of MCC (Color figure online)

Drought and Wild Fires

The following indicators can be used to map the vulnerability to fire and drought risk as developed in the project Life "Master Adapt" (https://masteradapt.eu/?lang=en):

- exposure indicators, used to identify the main categories of activities and services exposed to fires and droughts, including the percentage of industrial and residential areas that could be mainly affected by fires and droughts;
- sensitivity indicators, which indicate how much the potential impact of climate change will be greater for each category of environmental typology involved;

- indicators of adaptive capacity, calculated considering the level of education, the economic resources available per capita, the people employed in the agricultural and forestry sectors, the people employed to manage the risk of fires and the presence of fire risk plans, as well as projects o plans relating to adaptation to climate change for each municipality;
- global vulnerability indicators, derived from the aggregation of the normalized values of the global sensitivity index and the global adaptive capacity index.

As regards fires, there is a general low level of sensitivity in almost all the metropolitan area, because of the presence of vast irrigated lands and green urban areas. The adaptation capacity for the area is medium, therefore the global vulnerability index is classified at medium level (class 3).

As regards the drought, an average sensitivity to drought is reported for the area, apart from the municipalities of Sinnai and Villa San Pietro with a medium-high sensitivity level. The municipality of Cagliari reported a sensitivity class of 2. The global vulnerability index is therefore classified at a medium and medium-high level with classes 3 and 4 (Fig. 5).

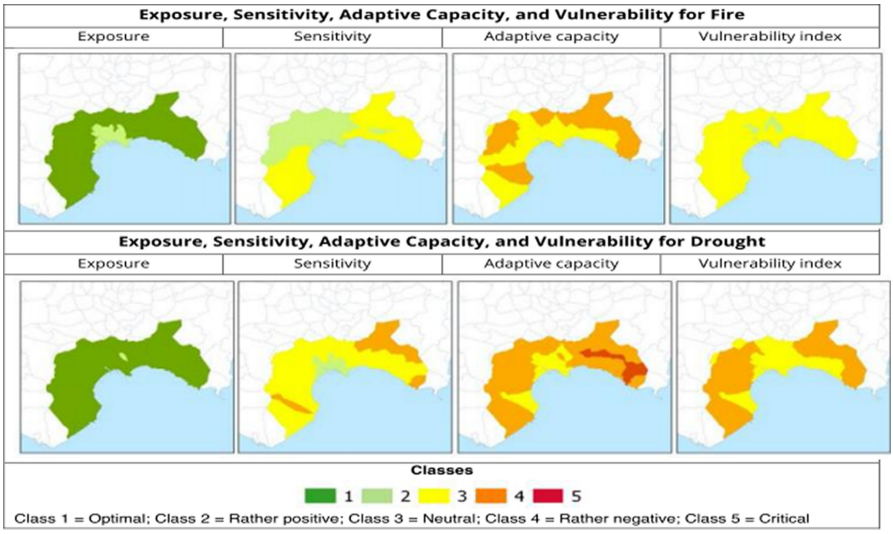

Fig. 5. Global exposure, sensitivity, adaptive capacity and vulnerability for fires and droughts in the MCC. (Life Project "Master Adapt")

Climate projections indicate a marked future heating for the MCC, with an increase in the minimum, maximum and average temperature (from +1.3 °C to −3.6 °C, depending on the CPR scenario and the future period considered). It is also expected a sharp increase in hot extremes (summer days, consecutive dry days, etc.) and a decrease in cold extremes. A slight general reduction in total rainfall is also expected, which could exacerbate fires and drought.

Heat Waves

To map the vulnerability related to heat wave risk as developed in the project Life "Master Adapt" (https://masteradapt.eu/?lang=en) the following indicators can be used:

- exposure indicators, considering the population density, which determines the "Urban Heat Island" effect;
- sensitivity indicators, considering heat related diseases and deaths, two categories in direct relation with the intensity peaks of the urban heat islands (UHI), therefore representative for studying the sensitivity of the heat waves;
- indicators of adaptive capacity to cope with heat waves, considering the level of education, the economic resources available per capita, the unemployment percentage and the number of medical points and projects related to climate change.
- global vulnerability indicators, derived from the aggregation of the normalized values of the global sensitivity index and the global adaptive capacity index.

The global heat wave vulnerability index, however, reports a higher class for the hinterland of Cagliari. Climate projections indicate an increase in extreme temperatures, especially on tropical nights (21–61 days) and on summer days (22–53 days). This could lead to a greater vulnerability for heat waves, in particular for the municipality of Cagliari (Fig. 6).

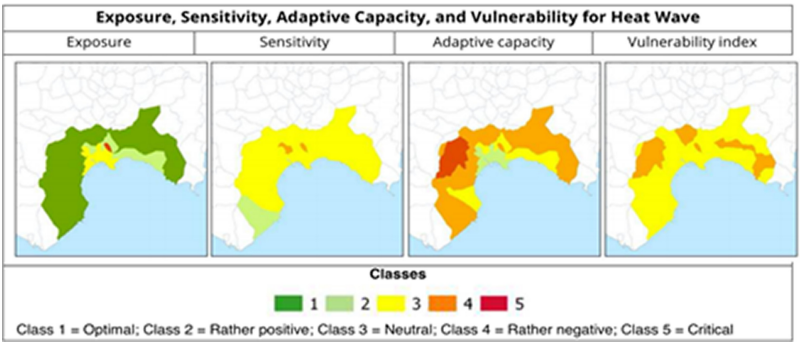

Fig. 6. Global exposure, sensitivity, adaptive capacity and vulnerability for heat waves in the MCC. (Life Project "Master Adapt")

3.3 The Main Environmental Assets to Build the Strategic Plan on

The strong characterization of the Metropolitan City of Cagliari highlights how the environment should be at the center of the targets of the strategic plan. In particular, there are some assets to be considered as main reference: coastal wetlands, protected areas and hills system.

Coastal Wetlands

The wetlands of Cagliari constitute a single environmental macrosystem consisting on the western side of the Santa Gilla lagoon, Macchiareddu salt pans and Capoterra pond,

which, together with the Molentargius-Saline system, located symmetrically east of the city, complete the belt of wetlands of the city. In the overall view of the Metropolitan City, the pond of Nora or Sant'Efisio, in the municipality of Pula, is also included.

The wetland system of Cagliari is one of the most important wetlands in Italy and in the Mediterranean basin: it represents a highly complex system, affected by strong alterations and multifaceted environmental dynamics given by the overlaps between natural habitats, production systems, infrastructure and ecological systems.

The wetlands of the MCC, with the traditional fishing, salt cultivation, combined with activities for recreational, tourist and cultural purposes (visits to the park and salt marshes, birdwatching, fish tourism, sport fishing etc.), represent a social, cultural and economic wealth, closely linked to the MCC natural capital. This natural capital (e.g. the landscape and the biodiversity therein) structured in communities rich in highly specialized species, with functions related to resilience and resistance to drastic environmental variations, represent a reservoir for ecosystem goods and services [8].

The coastal wetlands system of Cagliari (Santa Gilla lagoon, Macchiareddu salt marshes and Capoterra pond) are characterized by different levels of exploitation for production, settlement and infrastructure. In addition to traditional fishing and water-culture activities, salt extraction and agricultural activities, industrial structures and plants coexist with some areas of urban functions (service areas, infrastructures, purification and green areas). public). In the same area we find concentrated the strategic large infrastructures of Porto Canale, the International Airport, railway and road network and the industrial area of Macchiareddu and Elmas, for which the lagoon represents both a point connection and separation (Fig. 1).

Terrestrial Protected Areas and Green Infrastructures

The MCC territory hosts several types of protected areas s.l., such as permanent oases of fauna protection and capture, IPA areas (Important Plant Areas), IBA areas (Important Bird Areas), Ramsar areas ("Stagno di Santa Gilla" and "Stagno di Molentargius"), Regional Natural Parks (Molentargius-Saline Regional Nature Park and Gutturu Mannu Regional Nature Park) and Natura 2000 Network sites. The latter is represented by 12 Special Conservation Zones (SACs) and 4 Special Protection Zones (SPAs), falling totally or at least in part within the MCC. The area belonging to the Natura 2000 network amounts approximately to 52,000 ha of SAC areas, of which more than 31,000 ha fall entirely within the territory of the MCC and approximately 49,000 ha of SPA areas, of which about 18,000 ha fall entirely within the MCC.

Protected areas can be considered as core areas of the green infrastructure, showing a great potential to create a network for the protection of the natural capital of MCC [9, 10].

The Calcareous Hills of Cagliari

According to some scholars, the name of Cagliari (*Krly*) derives from a "*particular geophysical condition: the imposing masses of bare and craggy limestone rocks of the current castle and of Mount S. Elia, bleached … are the most characteristic and suggestive*, Emidio De Felice". Cagliari, therefore, is simply the place of the white hills.

These biotopes therefore represent a characterizing and identifying element of the territory, but they also have a naturalistic and environmental relevance. In fact, Capo S. Elia Promontory and the calcareous hills rise in the southern part of the Campidano plain, the only limestones emergencies of south-eastern Sardinia, places where, in some

cases, high levels of biodiversity are preserved. In the last 50 years, the development of the city has profoundly changed these sites and in the near future a further alteration of the environments is expected with a strong compromise of naturalistic values.

The promontory of Capo Sant'Elia consists of reliefs aligned according to the SE-NO direction. Cala Mosca divides the promontory into two parts, one higher in the east (136 m) and one in the west, called Sant'Ignazio (94 m). The promontory of Sant'Elia to the south is joined to the other hills by flood lands of the Pleistocene. The hills of Cagliari are emergencies set on the terminal part of the Campidano plain, partly eroded by the quarries and compromised by the building development, they are distributed along two alignments with direction NNO-SSE and include the hill of S. Michele, the hill of mount Claro, the hill of Tuvixeddu - Tuvumannu, mount Is Mirrionis, the hill of Castello, the hill of Monte Urpino, the hill of Mount Mixi, the hill of Bonaria and the hill of San Bartolomeo.

Where natural vegetation is still present, the hills retain high values of naturalness in the urban area, representing unique reservoirs for biodiversity. For example, the garrigues present in these territories are recognized as of particular botanical interest: in addition to the presence of Sardinian endemics (*Genista corsica* (Loisel.) DC., *Helichrysum italicum* (Roth) G.Don subsp. *tyrrhenicum* (Bacch., Brullo & Giusso) Herrando, JMBlanco, L.Sáez & Galbany), these plant communities are characterized by having plant species that have a Mediterranean-Eastern gravitation (*Satureja thymbra* L., *Thymbra capitata* (L.) Cav., *Poterium spinosum* L.) which differentiates them from other plant communities in Sardinia that generally show a Western-Mediterranean floristic contingent. In particular, the Promontory of Sant'Elia (Cagliari) is the only place where *Poterium spinosum* is present in Sardinia and represents the western limit of distribution of the species at a global level (Natura 2000, habitat 5420: *Sarcopoterium spinosum* phryganas), while on Colle San Michele we can find a widespread population of *Satureja thymbra*.

On the other hills of Cagliari, in the remaining fragments of natural vegetation, the garrigue vegetation appears floristically depleted compared to that of Capo Sant'Elia. For these reasons, the Promontory of Capo Sant'Elia and the system of the hills of Cagliari still characterized by the presence of spontaneous vegetation are of strategic importance for the preservation of urban diversity. These elements, closely correlated with the human settlement, could identify some of the nodes of the green infrastructure of the MCC, to be developed for the conservation of biodiversity and its sustainable use in the urban area.

4 Conclusions

The Metropolitan City of Cagliari is characterized by an important amount of environmental assets but at the same time presents a high degree of vulnerability due to internal characteristics but also to external pressures, due primarily to climate change, to which it is subjected. The definition of a medium-long term development perspective must necessarily deal with this situation and must include within its development vision the integration of the principles of sustainability, resilience and smartness.

The smartness pursues sustainability through creating a digitally-enabled environment which promotes a more efficient use of energy consumptions and a more effective management of networks. The more a city is innovative, the more information and communication technologies is used improving the quality of life and the sustainable development. Uncertain events such as weather and climate negative events at urban level, together with a growing population which increases the urban sprawl phenomenon, feature the need of creating and maintaining prosperous social, economic and ecological systems through sustainable urban systems [29]. Moreover, the capability of a city planner to develop a strategic approach that adopts a wide and long-term vision may contribute to make a city more resilient and less vulnerable. Climate resilience as well as a digital environment may contribute to support strategies for reducing vulnerability and achieving sustainability. In fact, the more information and data are available from multiple sources in a smart city context the more it may facilitate the knowledge of potential climate-related risks and damages. This may increase urban resilience due to a more conscious planning and decision-making process in reducing urban vulnerability. Finally, technology may contribute to better planning and managing a resilient city through the improvement of city's adaptive capacity and the implement of city's mitigation strategies [30].

As a consequence, these three definitions provide a common paradigm of future urban development and structure. The city's evolution aims at increasing the quality of life and reducing vulnerability following a sustainable path of development in the near future as well as guaranteeing further progress in the future. This new paradigm for a sustainable, digital, and less vulnerable city may be defined as "bright city" [31], where combined actions are implemented in order to maximize city's efficiency and management efficacy and without increasing negative externalities and long-distance conflicts [32].

References

1. Canu, S., Rosati, L., Fiori, M., Motroni, A., Filigheddu, R., Farris, E.: Bioclimate map of Sardinia (Italy). J. Maps **11**(5), 711–718 (2014)
2. ISPRA, Istituto Superiore per la Protezione e la Ricerca Ambientale: Gli habitat in Carta della Natura (Schede descrittive degli habitat per la cartografia alla scala 1:50.000). Manuali e Linee Guida 49/2009, Roma (2009)
3. RAS, Carta dell'uso del suolo. Sardegna Geoportale. http://www.sardegnageoportale.it/index.php?xsl=2420&s=40&v=9&c=14480&es=6603&na=1&n=100&esp=1&tb=14401. Accessed 20 May 2017. Accessed 01 June 2020
4. De Martis, G., Mulas, B., Malavasi, V., Marignani, M.: Can artificial ecosystems enhance local biodiversity? The case of a constructed wetland in a mediterranean urban context. Environ. Manag. **57**(5), 1088–1097 (2016). https://doi.org/10.1007/s00267-016-0668-4
5. Marignani, M., et al.: Identification and prioritization of areas with high environmental risk in mediterranean coastal areas: a flexible approach. Sci. Total Environ. **590–591**, 566–578 (2017)
6. Bazzato, E., Marignani, M.: Landscape and species integration for a nature-based planning of a mediterranean functional urban area. In: Gargiulo, C., Zoppi, C. (eds.) Planning, Nature and Ecosystem Services, pp. 630–639. FedOAPress, Naples (2019)

7. Pizzolotto, R., Brandmayr, P.: An index to evaluate landscape conservation state based on land-use pattern analysis and geographic information system techniques. Coenoses **11**, 37–44 (1996)
8. Millennium Ecosystem Assessment (Program): Ecosystems and human well-being. Island Press, Washington, D.C. (2005)
9. Blasi, C., et al.: The concept of land ecological network and its design using a land unit approach. Plant Biosyst. **142**(3), 540–549 (2008)
10. Capotorti, G., et al.: Do National Parks play an active role in conserving the natural capital of Italy? Plant Biosyst. **146**(2), 258–265 (2012)
11. Martinelli, F.: La pianificazione strategica in Italia e in Europa - Metodologie ed esiti a confronto. Milano, Franco Angeli (2005)
12. Stanghellini, S., Bonifaci, P.: La pianificazione strategica. http://www.iuav.it/Ateneo1/docenti/architettu/docenti-st/Stefano-St/archivio-p/Corso-di-P/02a_Pianificazione-strategica–2014-15-.pdf
13. Camagni, R.: Cinque tesi a proposito di pianificazione strategica urbana. In: Pianificazione strategica per la governance del territorio – Modelli e soluzioni per garantire la sostenibilità e la realizzazione efficace del piano strategico del territorio. Lattanzio Group Srl, Milano (2006)
14. Höjer, M., Wangel, J.: Smart sustainable cities: definition and challenges. In: Hilty, L.M., Aebischer, B. (eds.) ICT Innovations for Sustainability. AISC, vol. 310, pp. 333–349. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-09228-7_20
15. Al-Nasrawi, S., Adams, C., El-Zaart, A.: A conceptual multidimensional model for assessing smart sustainable cities. J. Inf. Syst. Technol. Manag. **12**(3), 541–558 (2015)
16. Bibri, S.E., Krogstie, J.: Smart sustainable cities of the future: an extensive interdisciplinary literature review. Sustain. Cities Soc. **31**, 183–212 (2017)
17. ITU: Shaping smarter and more sustainable cities. Striving for sustainable development goals. ITU, Geneva (2016)
18. Addanki, S.C., Venkataraman, H.: Greening the economy: a review of urban sustainability measures for developing new cities. Sustain. Cities Soc. **32**, 1–8 (2017)
19. Folke, C., Carpenter, S., Elmqvist, T., Gunderson, L., Holling, C.S., Walker, B.: Resilience and sustainable development: building adaptive capacity in a world of transformations. AMBIO: J. Hum. Environ. **31**(5), 437–441 (2002)
20. Carpenter, S., Walker, B., Anderies, J.M., Abel, N.: From metaphor to measurement: resilience of what to what? Ecosystems **4**(8), 765–781 (2001)
21. Verma, P., Raghubanshi, A.S.: Urban sustainability indicators: challenges and opportunities. Ecol. Ind. **93**, 282–291 (2018)
22. United Nations: Transforming our world: The 2030 Agenda for sustainable development. New York, (2015). https://www.un.org/pga/wp-content/uploads/sites/3/2015/08/120815_outcome-document-of-Summit-for-adoption-ofthe-post-2015-development-agenda.pdf. Accessed 12 May 2020
23. Timon, M.: The rise of resilience: linking resilience and sustainability in city planning. Urban ecology at The New School in New York City, New York (2014)
24. Pierce, J.C., Budd, W.W., Lovrich Jr., N.P.: Resilience and sustainability in US urban areas. Environ. Polit. **20**(4), 566–584 (2011)
25. Beatley, T., Newman, P.: Biophilic cities are sustainable, resilient cities. Sustainability **5**(8), 3328–3345 (2013)
26. EU EC: Infrastrutture verdi – Rafforzare il capitale naturale in EU. Comunicazione della Commissione al Parlamento europeo, al Consiglio al CESE e al Comitato delle Regioni, COM (2013) 249 final (2013)

27. Arafah, Y., Winarso, H., Suroso, D.S.A.: Towards smart and resilient city: a conceptual model. IOP Conf. Ser.: Earth Environ. Sci. **158**(1), 1–20 (2018)
28. Baron, M.: Do we need smart cities for resilience. J. Econ. Manag. **10**, 32–46 (2012)
29. Papa, R., Galderisi, A., VigoMajello, M.C., Saretta, E.: Smart and resilient cities. A systemic approach for developing cross-sectoral strategies in the face of climate change, TeMA. J. Land Use Mobility Environ. **8**(1), 19–49 (2015)
30. Buzási, A., Csete, M.S.: Adaptive planning for reducing negative impacts of climate change in case of hungarian cities. In: Stratigea, A., Kyriakides, E., Nicolaides, C. (eds.) Smart Cities in the Mediterranean. PI, pp. 205–223. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-54558-5_10
31. Mundula, L., Auci, S.: Smartness, sustainability and resilience: are they related? In: Monteiro, J., et al. (eds.) INCREaSE 2019, pp. 568–586. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-30938-1_44
32. Borruso, G., Balletto G.: Materiali tecnologici, risorse e conflitti. La sfida per la smart city. Conflitti, Edizioni Edicusano (2020)