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ENVIRONMENTAL DESIGN, COASTAL AREAS AND CLIMATE IMPACTS

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ABSTRACT

In the last years, environmental issues have grown in relevance, both in the realm of theoretical work and in their operative dimension. Coastal areas, as liminal urban areas that are characterized by a highly dynamic environment, are also sensitive areas concerning the climate. In this context, the Mediterranean region can be considered a hot-spot of climate change. Based on the theoretical concepts used here, this contribution seeks to identify innovative research methods and analytical models to facilitate decision-making processes for resilient urban renewal on coastal areas. The predictive ability of masterplans depends, indeed, on the integration and the elaboration of different data within such plans.

KEYWORDS

climate change, coastal cities, Mediterranean, urban planning, ID technologies

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This contribution outlines the first phases of an ongoing PhD research project which explores innovative information and knowledge management tools for technologically-advanced and environmentally-focused projects of sustainable and resilient urban renewal. This research is part of an applied-research PhD program, which draws on technical and theoretical support from a company (Mapsat – Telerilevamento Euromediterraneo lt., located in Benevento, Italy), and from the Département Génie Urbain of the Université Paris-Est Marne la Vallée in Paris.

In ancient Greek thought, the ideal relation between man and nature was one where man must adapt to nature, not the other way around. This concept has changed with the establishment of modern thought and later with scientific progress and the spread of positivist thought. This led to conceive of nature as a field which could and should be dominated by technology (Losasso, 2006). In the common sense, the sense of confinement long attached to cities, i.e. the walled cities, has been transferred onto nature itself, which became itself confined within cities (Galimberti, 1999). Today, urban areas cover 2-3% of the earth's surface but host more than half of the world population. Urban areas are responsible for 78% of the global energy consumption and 60% of climate-altering, greenhouse-causing gases. Contrasting climate change must, therefore, start from cities (Bohigas and Montlleò, 2018).

Also, within the architecture world, environmental issues have grown in relevance, both in the realm of theoretical work and in their operative dimension (Campioli, 2009). In the field of technology planning, environmental planning must face the challenge of a new planning approach based on systemic thinking and on the goal of balancing urban transformation with the need to preserve the natural and cultural features of the places that are being transformed (Dierna, 1994). As compared to planning approaches that focus only of sector-specific interventions on buildings and larger structures, environmental planning represents a culturally different alternative (Schiaffonati, Mussinelli and Gambaro, 2011), in that it highlights the need to undertake environmental action within a larger debate on the most appropriate kinds of strategic actions.

Environmentalism emerged in the 1960s as an ethical and practical movement for the defence and preservation of the environment. It is in this period that the awareness towards the negative effects of economic progress and the man-made transformation started to spread. Consequently, several ideas emerged as to how to manage the environmental crisis without compromising technological progress. The critical thought about the fight against pollution thus evolved into a more progressive wish to start and implement sustainable development (Milanaccio, 1998). The role of architecture remains that of mediating between man and the environment. At the same time, however, the need for an environmentally-conscious planning has become widely recognised: a kind of ethical and esthetic planning that can address all parts of the natural environment (McHarg, 2007); is mindful of the wealth and diversity of natural resources and the length of environmental regeneration processes (Tiezzi, 1996).

Although some of the most apocalyptic forecasts turned out to be exaggerated, the

environmental emergency (Gangemi, 2001), once denounced only by few people, has now become obvious and has been translated in national and international policies. This has taken place, e.g., with ever-stricter environmental regulations and control mechanisms, which have been introduced with technological awareness. In this lively debate, the deep linkage between architecture and technology, innovation and environmental planning has emerged. The large project to achieve climatic resilience in coastal urban areas must broaden its horizons, live up to its global and transdisciplinary nature, and absorb new inputs.

By strengthening its ability to collect, systematize, share and transfer data and models from the realm of remote sensing and climate science to the realms of urban planning, it will be possible to develop innovative simulation methods and models. These, in turn, will aid decision-making processes while at the same time increasing the synergies between industry and research. The support of enabling technologies, connected to digital culture and the Industry 4.0, is necessary to acquire and manage data and information coming from differential acquisition processes at different scales. The field of inquiry where the hypotheses will be tested is Mediterranean coastal areas. These are becoming increasingly vulnerable due to the growing impacts of climate change and for their ongoing political and socio-cultural transformations. In particular, this research will look at harbour cities, which feature better opportunities for urban renewal and sustainable development – although strong conservative forces remain there.

Climate change in urban coastal environments and the Mediterranean region | According to recent UN estimates, more than 600m people – about 10% of the world population – live in coastal areas, where a high population density coexists with important infrastructures (Fig. 1). Coastal areas are meeting points between land, sea and air; they are important urban liminal areas – meeting points between nature and the work of men. From the ecological perspective, coastal areas are liminal spaces where land and sea influence each other (Mininni, 2006; Fig. 2). Their exposure makes the climate of coastal areas particularly vulnerable. The main risks derive from the rise of sea levels, from coastal erosion and the increase – in both duration and frequency – of extreme climatic events (Fig. 3). Against this background, environmental planning lends itself as a methodological tool to manage the complex interactions among urban planning, environment and sustainable development (Losasso, 2017). This allows decision-makers to manage the climate crisis and face the progressive degradation – in both qualitative and quantitative terms – of the resources of coastal areas (Tucci, 2013).

The Mediterranean Sea is intercontinental; a semi-closed basin surrounded by three continents: Africa, Asia and Europe. As a region, it is the cradle of some of the oldest civilizations on the planet. These civilizations were founded on the sea, which affected both their urban culture and their economic and productive growth. The Mediterranean area is characterized by an extraordinarily rich historic and cultural heritage and by its noteworthy biodiversity and ecosystems. The coast's morphology is very di-

Fig. 1 | A world night view from Space (credit: NASA).

versified complex: ca. 40% of the coast is inhabited and its population density is high. In the coastal area, several anthropic and natural settlements are located. These are strategic in environmental, social and economic terms (Fig. 4).

In Euro-Mediterranean countries, population spreads nearly homogeneously on the territory. On the other hand, Northern African and Middle-Eastern countries present a high demographic pressure along the coast and along rivers, often due to geo-climatic constraints that increase the climate vulnerability of the region and create a high competition ad conflicts for land use and the accessibility of primary natural resources (Ferragina and Nunziante, 2018). The population is expected to rise by 25.8% from 2015 to 2050 (Zupi, 2017)[1]. On the weather and climate level, the region is characterized by a space-time variability and by frequent extreme events (Ruti et alii, 2016). Its semi-closed conformation and the intense urbanization along the coast make the Mediterranean a highly vulnerable area for climate impacts. Against this background, the Mediterranean can be defined as a hot-spot for climate change (Giorgi, 2006).

Environment and climate risk factors | The twenty-two Mediterranean states differ widely among each other for their morphology, as well as for socio-cultural and economic factors. On the environmental and climate level, the main challenges are the rise of surface temperatures – both marine and on the land – the acidification of the waters, and the sea-level rise. Taken together, these phenomena are at the origin of direct effects, such as coastal erosion, increased coastal storms, and the loss of biodiversity. Indirect effects include the increase in migration and socio-economic inequalities (Cramer et alii, 2018). Climate effects directly influence the comfort, well-being and

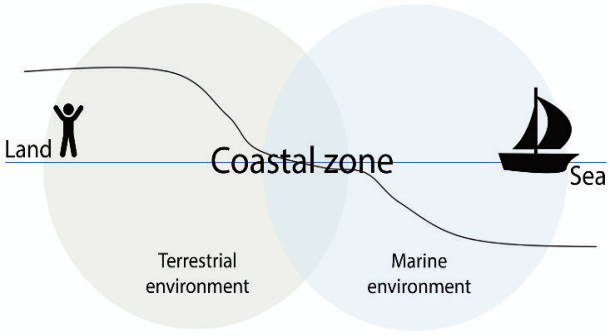
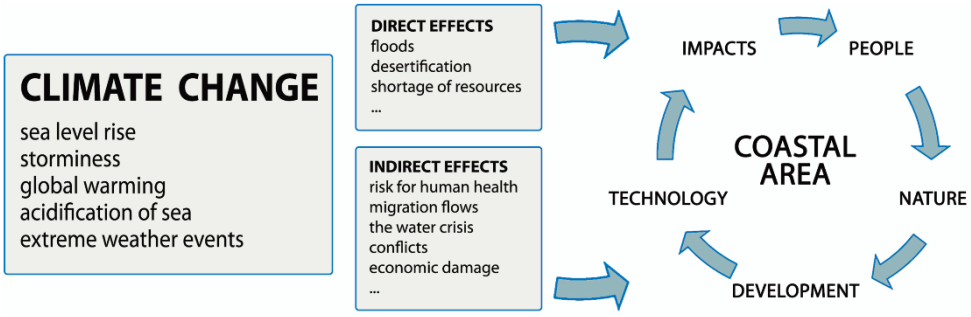
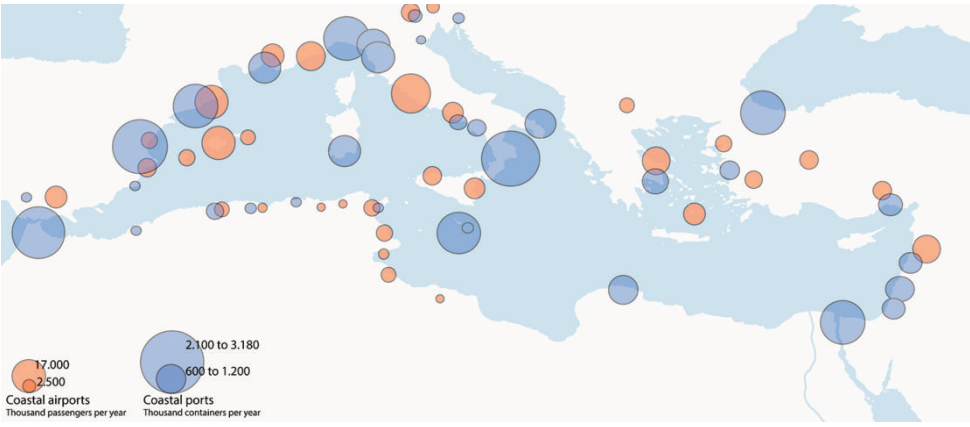


Fig. 2 | The coastal zone, the interaction between terrestrial and marine environment.

Fig. 3 | Climate change in coastal zones.

Fig. 4 | Critical infrastructure among the Mediterranean basin.





security of humans with heatwaves, drought, frost, floods and more generally with extreme meteorological events. Indirectly, climate effects affect humans by worsening the quantity and quality of the harvest, air quality, etc. (Oppenheimer et alii, 2014).

When compared to the pre-industrial period[2], global trends indicate an average temperature rise of 1,1 degrees, whereas, for the Mediterranean area, this rise is forecast by 2050 at 1.5 degrees and is expected to be accompanied by an increased frequency

and intensity of heatwaves. Should no mitigation measure be implemented, in 2040 temperature rise may reach 2.2 degrees, with peaks of 3.8 (Jacob et alii, 2014; Cramer et alii, 2018). In the next decades, we may witness precipitations to decrease by 5% to 10% in European countries, up to 30% in Turkish regions (Vautard et alii, 2014). Fluvial flowrates will shrink (Forzieri et alii, 2014) and desertification will expand in Europe, especially in the south of the Iberic and Italian peninsula, and in the Northern African and Middle-Eastern countries such as Morocco, Algeria, Tunisia, Turkey and Syria (Guiot and Cramer, 2016). The demand for irrigation water for agricultural land will increase (Iglesias et alii, 2012). The quantitative reduction of natural resources will be paired with a decreased quality, especially in the southern and eastern bank of the Mediterranean, which is already vulnerable environmentally, socially, and economically.

The main risks for the coastal and insular areas derive from the sea-level rise (Fig. 5). The flood risk is rising in most Mediterranean countries (Gaume et alii, 2016), with forecast values ranging between 52 and 98 cm by 2100 (Church et alii, 2013). This could rise up to 190 cm according to further models that also consider the interaction of the Mediterranean Sea with the melting of the ice-cap through the Strait of Gibraltar (Vermeer, Rahmstorf and Clark, 2009). The most vulnerable countries are those of the southern and eastern bank of the Mediterranean, such as Morocco, Algeria, Lybia, Egypt, Palestine and Syria (Satta et alii, 2017; Fig. 6). In Italy, the areas that are considered most at risk are those of the north-Adriatic, south-Adriatic and Ionian regions (Antonioli et alii, 2017). At least 49 UNESCO sites, remains of the ancient world and contemporary resources for the tourism economy, are considered to be at risk (Reimann et alii, 2018).

This scenario, characterized by scarce water resources, drought, increased intensity and frequency of extreme events and sea-level rise, highlights the all-important connection linking climate change and the sharpening of conflicts for the access to primary resources: land, water, and food (Reuveny, 2007). Scientific research demonstrates how the socio-economic instability and food insecurity, caused by the ever-growing climate change, directly affect the intensity and direction of migration (Latour, 2018; Fig. 7). For example, the environmental and socio-political changes in Syria caused a huge migration towards safer and less vulnerable areas (Renaud et alii, 2011).

New perspectives for urban renewal projects in coastal areas | Based on the literature presented above, this research project seeks to develop models and methods to aid decision-making processes within sustainable and resilient urban regeneration in coastal areas in contexts of climate change. Climate change, it is argued, is going to affect the planning of city-sea ecosystems; influence political decisions; and be an important factor in the choice among different approaches and methods of environmental planning.

Environmental approaches for public space renewal are becoming increasingly strategic for risk forecast and risk prevention, for climate change adaptation, for vulner-

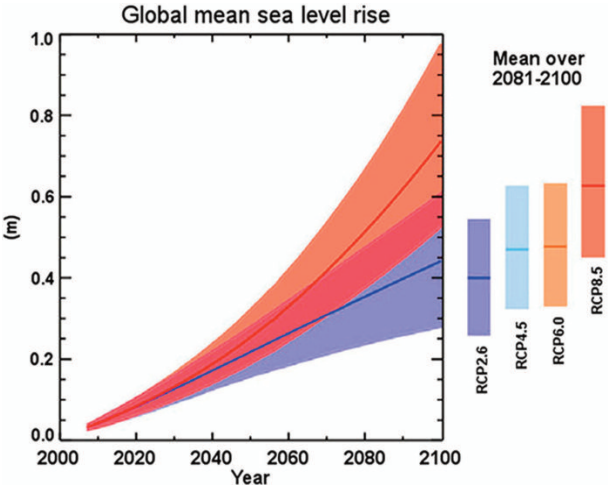


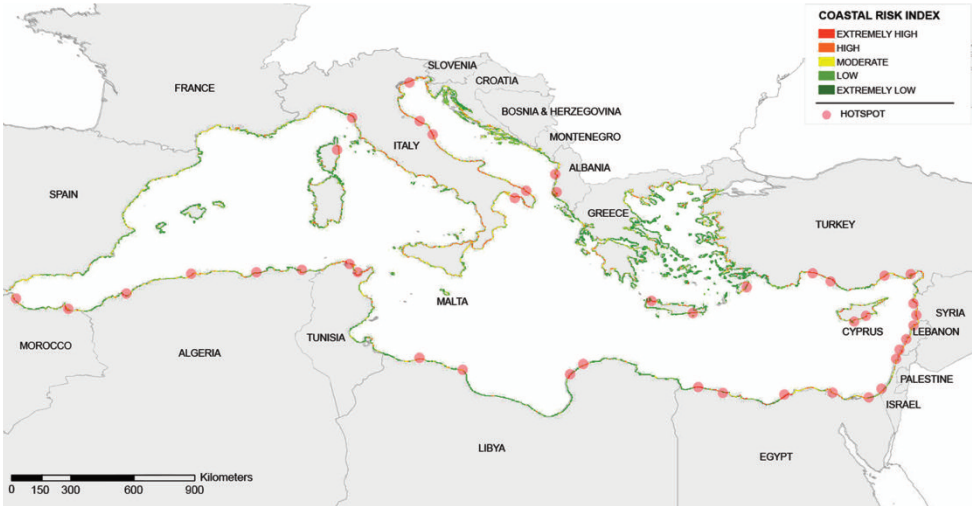
Fig. 5 | Global mean sea level rise (credit: Antonioli et alii, 2017).

Fig. 6 | Coastal Risk Index map of the Mediterranean, spatially depicting five levels of risk (credit: Satta et alii, 2017).

Next page

Fig. 7 | Mare Nostrum (credit: M. Sestini, 2016).

Fig. 8 | San Vincenzo dock, Naples.



ability reduction and the planning of mitigation measures (Losasso and D'Ambrosio, 2014). Resilience towards natural and anthropic risks is thus connected to the functional-spatial and environmental conditions of an area, to the decision-making and other governance-related processes, as well as to technical and construction-related factors (Losasso, 2018). In urban contexts, adaptive design configures itself as a strategic intervention both in the short and in the middle term; mitigation measures, however, are almost always postponed into more or less far future (D'Ambrosio, 2018).

Environmental planning has absorbed the importance of the technological innovation-environment pair and contributes to the urban renewal process with an integrated and multi-disciplinary approach by integrating it with material and immaterial techni-

cal contributions (Cangelli, 2015). Coastal areas are, therefore, no longer mere borderlines between marine and land-related models, but are now seen as diverse spaces with different anthropic and natural characteristics; a multi-scalar assemblage of materials, complex and heterogeneous natural and anthropic phenomena (Russo, 2015). Coastal areas thus become laboratories for the experimentation of innovative approaches and plans, to be carried out with environmental consciousness and technological innovation, towards climate adaptation and mitigation goals.

Port cities will be at the center of the analysis, for it is there that the opportunities for urban renewal and sustainable development are most pronounced (Fig. 8). In the global economy, indeed, maritime transportation is the main mobility choice for both

goods and people (UNCTAD, 2017). With the expansion of the Suez Canal, naval traffic in the Mediterranean has further increased (SRM and AlexBank, 2018; Fig. 9). While this increase has benefitted the economy of several countries by creating additional jobs, maritime activities pollute not only the port areas themselves, but also the surrounding regions, by occupying land and water and by contaminating land, water, and air (Estrada, 2012; Fig. 10). Furthermore, technological innovation in logistics rendered several areas obsolete – many of which are now unused. This scenario is further complicated by the growing impacts of climate change and, although the medium-long term forecasts are damning, port planning is dominated by a short-sighted approach that favours more evident and immediate socio-economic changes (Reguero, Losada and Méndez, 2012).

Methodological approach | In its broader definition, urban renewal includes several cultural and planning-related approaches for the environmental, social, and economic improvement of urban coastal areas. It seeks to do so by adding value to the pre-existing urban fabric, improving their livability, the quality of their buildings, of their spaces and their energy and mobility system to balance, through mitigation and adaptation measures, the growing consequences of climate change. The prevention of critical or hazardous events in urban coastal areas is a fundamental driver for the implementation of sustainable and resilient urban regeneration. However, it requires innovative planning methods, i.e. methods that can manage the complexity of all the information that is necessary for both direct urban renewal and retrofit strategies sustainably and smartly and to manage the technological and environmental solution in a multi-scalar fashion. The predictive ability of urban renewal projects depends increasingly on the integration and elaboration of data and information within operational models that are used in support of the relevant decisions.

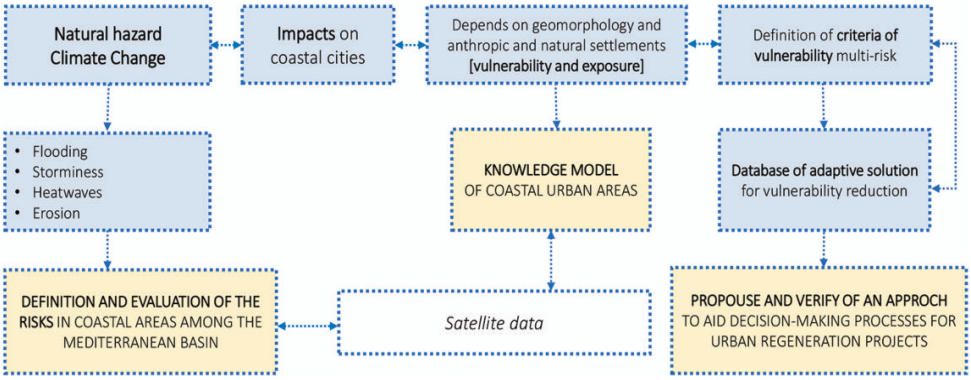
This research will first consist in researching the main (international, national, and local) databases available in a trans-disciplinary and multi-scalar fashion. Upon this basis, it will be possible to define functional-spatial and technological-environmental indicators and parameters to investigate innovative modes of information and knowledge management for technological and environmental planning. It will then define an analytical model based on the morphologic and settlement-related characteristics that influence climate-related risk in coastal areas. Such characteristics will be identified through tailored indicators of the anthropic and natural system. Mainly, it will be taken in analysis the risks deriving from sea level rise, from the increase in intensity and frequency of storminess and heatwaves. For comparative purposes are going to be analyzed the metropolitan areas of Naples, Nice and Barcelona, three European coastal cities of the Mediterranean, characterized by a historic and compact urban-port waterfront. In the concluding phases, the research intends to offer and test an approach to facilitate decision-making on a local scale to evaluate the resilience and adaptation characteristics of specific technical solutions. In this process, enabling technologies

Fig. 9 | The global maritime scenario (credit: B. Schmidt on www.flickr.com).

Fig. 10 | The Portvell, Barcelona.

become fundamental support to increase the ability to collect, systematize, share and transfer data and models from the realm of geo-spatial information and climate sciences to those of urban planning (Fig. 11).

The research follows an inductive, deductive and finally a comparative approach. It will draw on different and broad disciplines to define specific procedures to transfer GIS information for the development of innovative middleware tools for modeling

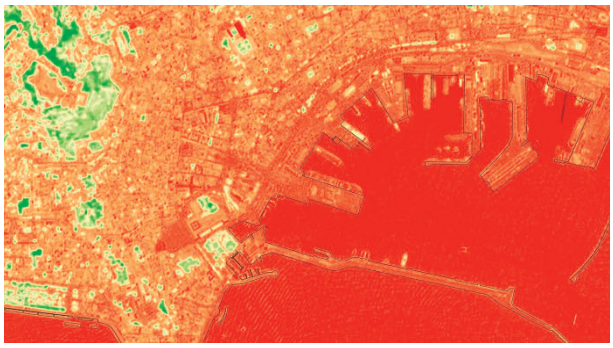


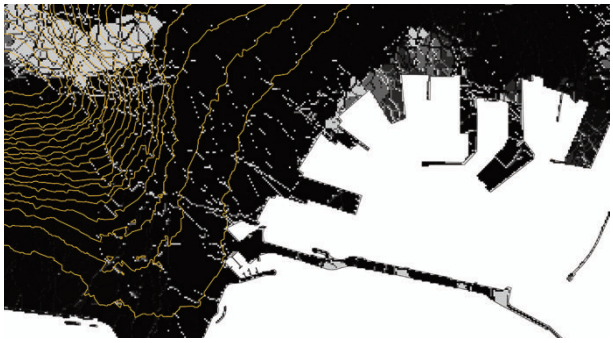
and simulating multi-scalar adaptive design solution. The work is inherently quantitative rather than qualitative.

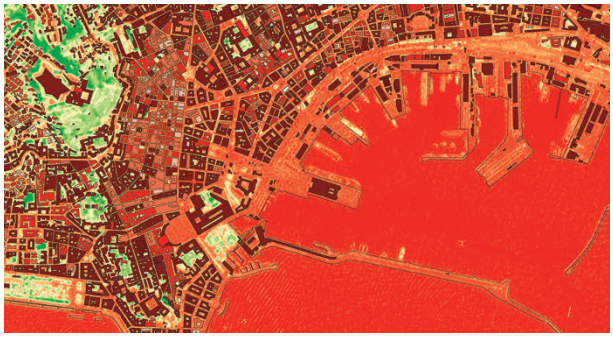
The introduction and the support of the enabling technologies | Among enabling technologies, satellite remote sensing and Geographic Information Systems seem to be the most promising tools to provide and manage environmental information. Such information is necessary to plan, implement, and monitor projects and management procedures for urban development and sustainable and resilient urban renewal in climate-affected coastal areas. The available remote-sensing data[3] have enormous potential, in terms of spectral and temporal accuracy, for portraying climate adaptation and sustainable development in cities of the coastal area that are characterized by a highly dynamic environment. Through satellite images, it is possible to extract specific and constantly updated indicators to help plans, programs, and projects, as well as to help with monitoring and evaluation procedures for environmental impacts, by creating a database of the morphologic and settlement characteristics of the relevant areas.

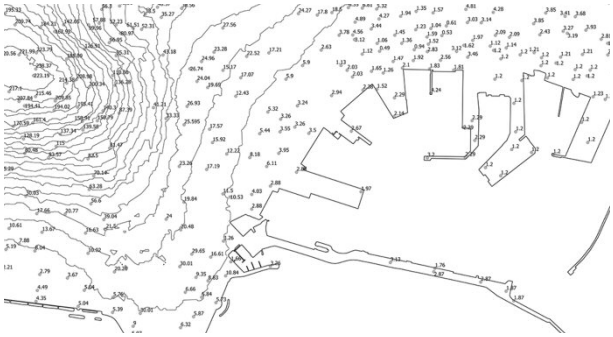
This stage of the research, based on satellite images, focuses on the analysis of how the coastline has changed, of the built environment and on green areas in the metropolitan city of Naples. This research is based on two indexes: the NDVI (Normalized Difference Vegetation Index), and the NDWI (Normalized Difference Water Index). By integrating satellite data with differentiated databanks (such as those provided by the Italian statistical institute, or ISTAT), the research will then create new analytical models for satellite geographical information. (Figg. 12-15). In this phase, sample resolution cells (2x1 km wide) will be considered. Possible issues might arise while downscaling them for urban-scale projects: here the multi-scalar approach will be all-important to define the right resolution for the relevant characteristic.

Remote sensing is evolving as a highly relevant tool for socio-economic and environmental analysis and turning into an important instrument to contrast the ever-growing climate effects. The goal is to increase the synergy between research and industry









Previous page
Fig. 11 | Methodological approach.

Figg. 12-15 | GIS processing of satellite images of Naples, July 2019 (credit: www.planet.com).

through digital and smart processes with a multidisciplinary and innovative approach in the context of the expected knowledge-sharing scenarios.

Conclusions | On the Mediterranean coastal areas, which are highly vulnerable to climate factors, the important task of urban renewal must be managed in the context of environmental and climatic challenges. These must be seen in connection to the relevant economic and social challenges. This project is currently in its first phase, and its first goal is to understand and analyze the Mediterranean coastal areas and the relevant climate trends to investigate the linkages between climatic hazards, the morphology of the regions, and the features of the human settlements. After acquiring remote sensing images on sample areas, the research is elaborating GIS models based on differentiated databanks to define quantitative indicators and parameters.

Four macro-criteria structured in sub-indicators have been identified: the use and infrastructure of soils belonging to the urban system, the geomorphology and shoreline condition of the coastal area which, together with a defined hazard, influence the degree of exposure of the territory. This phase of the research will allow a classification of the most significant coastline sections (Italian, French and Spanish). This will be then formalized in sheets and thematic maps that will identify the characteristics of the regions and the respective risk index. The second phase of the research will focus on identifying, in a multi-scalar fashion, the most effective adaptive strategies for coastal areas. Later, it will test their applicability and transferability to sustainable and resilient urban renewal projects.

Notes

1) The Italian Centre for International Politics (CSPI) estimates that between 2015 and 2050 the Mediterranean population will increase by 25.8%. Except for the European countries, for which it forecasts a 2% decrease, the other countries are expected to grow by 49.7% – Northern Africa, 66.8% – Middle-East, and 18.8% – EU Candidates (Zupi, 2017).

2) The pre-industrial period indicates the decade preceding the productive and territorial industrialisation, i.e. from 1880 to 1889.

3) The satellite sector, oriented to the expected scenarios of knowledge sharing and resilience thinking, offers a fundamental contribution to the high resolution of spatial, spectral and temporal images processed through digital and smart processes. Satellite missions such as Copernicus Sentinel make their open data available at medium resolution; other for-profit missions offer higher-resolution data such as Pléiades, EROS-B, and WORLDVIEW-2/3, that are used for different scopes.

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