Antonio Leone Carmela Gargiulo
Editors

Environmental and territorial modelling for planning and design

INPUT TeMA*Lab* Dicea UniNa

Federico II Open Access University Press

fedOAPress

Università degli Studi di Napoli Federico II
Scuola Politecnica e delle Scienze di Base

Smart City, Urban Planning for a Sustainable Future

4

Environmental and territorial modelling for planning and design

Antonio Leone   Carmela Gargiulo

Federico II Open Access University Press

fedOAPress

Environmental and territorial modelling for planning and design editors Antonio Leone, Carmela Gargiulo - Napoli: FedOAPress. 2018. - (Smart City, Urban Planning for a Sustainable Future. 4).

Web link:
http://www.fedoabooks.unina.it

ISBN: 978-88-6887-048-5
DOI: 10.6093/978-88-6887-048-5

Selection and double blind review under responsibility of Conference Committee

Università degli Studi di Napoli Federico II
Centro di Ateneo per le Biblioteche "Roberto Pettorino"
Piazza Bellini 59-60 - 80138 Napoli, Italy
http://www.fedoapress.unina.it

Published in Italy

Cover and graphic project: TeMA*LAB*

This book collects the papers presented at the 10th International Conference INPUT 2018 which will take place in Viterbo from 5th to 8th September. The Conferences pursues multiple objectives with a holistic, boundary-less character to face the complexity of today socio-ecological systems following a systemic approach aimed to problem solving. In particular, the Conference aims to present the state of art of modelling approaches employed in urban and territorial planning in national and international contexts.

This book is the latest scientific contribution of the "Smart City, Urban Planning for a Sustainable Future" Book Series, dedicated to the collection of research e-books, published by FedOAPress - Federico II Open Access University Press. The volume contains the scientific contributions presented at the INPUT 2018 Conference and evaluated with a double peer review process by the Scientific Committee of the Conference. In detail, this publication, including 63 papers grouped in 11 sessions, for a total of 704 pages, has been edited by some members of the Editorial Staff of "TeMA Journal", here listed in alphabetical order:

- Rosaria Battarra;
- Gerardo Carpentieri;
- Federica Gaglione;
- Rosa Anna La Rocca;
- Rosa Morosini;
- Maria Rosa Tremiterra.

The most heartfelt thanks go to these young and more experienced colleagues for the hard work done in these months. A final word of thanks goes to Professor Roberto Delle Donne, Director of the CAB - Center for Libraries "Roberto Pettorino" of the University of Naples Federico II, for his active availability and the constant support also shown in this last publication.

Rocco Papa
Editor of the Smart City, Urban Planning for a Sustainable Future" Book Series
Published by FedOAPress - Federico II Open Access University Press

Table of contents

Session 3 - Rural landscapes and well-being: towards a policy-making perspective

Session 4 - Smart planning

Session 5 - Maintenance, upgrading and innovation in cultural heritage

Session 6 - Urban and environmental planners: who is the client? The planners jobs in a new millennium

Session 7 - Big data and data mining

Session 8 - ICT & models: planning for communities

Special session 1: Did we learn lessons? Following the paths of Giovanni Rabino

Special session 2: Ecosystem-based and performance-based approaches for spatial planning

Special session 3: Geodesign

INTRODUCTION

Between 5th and 8th September 2018 the tenth edition of the INPUT conference took place in Viterbo, guests of the beautiful setting of the University of Tuscia and its DAFNE Department.
INPUT is managed by an informal group of Italian academic researchers working in many fields related to the exploitation of informatics in planning.
This Tenth Edition pursed multiple objectives with a holistic, boundary-less character, to face the complexity of today socio-ecological systems following a systemic approach aimed to problem solving. In particular, the Conference will aim to present the state of art of modeling approaches employed in urban and territorial planning in national and international contexts.
Moreover, the conference has hosted a Geodesign workshop, by Carl Steinitz (Harvard Graduate School of Design) and Hrishi Ballal (on skype), Tess Canfield, Michele Campagna.
Finally, on the last day of the conference, took place the QGIS hackfest, in which over 20 free software developers from all over Italy discussed the latest news and updates from the QGIS network.
The acronym INPUT was born as INformatics for Urban and Regional Planning. In the transition to graphics, unintentionally, the first term was transformed into "Innovation", with a fine example of serendipity, in which a small mistake turns into something new and intriguing. The opportunity is taken to propose to the organizers and the scientific committee of the next appointment to formalize this change of the acronym.
This 10th edition was focused on Environmental and Territorial Modeling for planning and design. It has been considered a fundamental theme, especially in relation to the issue of environmental sustainability, which requires a rigorous and in-depth analysis of processes, a theme which can be satisfied by the territorial information systems and, above all, by modeling simulation of processes.
In this topic, models are useful with the managerial approach, to highlight the many aspects of complex city and landscape systems. In consequence, their use must be deeply critical, not for rigid forecasts, but as an aid to the management decisions of complex systems.

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

CLIMATE CHANGE AND COASTAL CITIES

A METHODOLOGY FOR FACING COASTAL FLOODING

CARMELA GARGIULO[a]
ROSARIA BATTARRA[b]
MARIA ROSA TREMITERRA[a]

[a] Department of Civil, Architectural and Environmental Engineering, University of Naples Federico II
e-mail: gargiulo@unina.it; mariarosa.tremiterra@unina.it

[b] Institute of Studies on Mediterranean Societies (ISSM), National Research Council
e-mail: rosaria.battarra@issm.cnr.it

How to cite item in APA format:
Gargiulo, C., Battarra, R. & Tremiterra, M.R. (2018). Climate change and coastal cities. A GIS-based methodology for facing sea-level rise.
In A. Leone & C. Gargiulo (Eds.), *Environmental and territorial modelling for planning and design*.
(pp. 115-125). Naples: FedOAPress. ISBN: 978-88-6887-048-5, doi: 10.6093/978-88-6887-048-5

ABSTRACT

Coastal cities represent the main vulnerable areas to the climate change impacts (especially to coastal flooding) because of the high concentration of people and economic assets that will are foreseen to increase in 2100. Since cities are important sites of global climate actions, urban planning plays a key role in the climate change challenge. In particular, the definition of urban adaptation strategies requires the adoption of a systemic approach. Through such an approach, indeed, it is possible to consider in a holistic way all elements, which affect the urban resilience of coastal areas to climate events, such as coastal flooding. However, the literature review and the analysis of urban planning experiences have shown that procedures for assessing the resilience level of coastal cities and tools for addressing decision-makers to implement resilient policies and actions in these areas are not well established. Therefore, the aim of this work is the introduction of a methodology based on a systemic approach for providing urban planning actions in order to improve the resilience of more exposed urban areas to coastal flooding. The proposed methodology takes into account the need to be implemented in a GIS environment to a case study. Moreover, it can be a useful tool for supporting the definition of urban adaptation strategies in relation to coastal flooding impacts.

KEYWORDS

Climate Change; Coastal Cities; Systemic Approach; Adaptation; Coastal Flooding

1 INTRODUCTION

Climate change represents one of the main future challenges at the urban level and cities are still facing its impacts. In this perspective, urban areas are recognized as vulnerable places but they also lead the climate action both at the global and local level. Therefore, spatial planning plays a key role in tackling climate change within the wider sustainable development perspective (Papa et al., 2015; Salata & Yiannakou, 2016).
Considering the worst Representative Concentration Pathway (RCP) by the International Panel for Climate Change (IPCC), for 2010 the mean global temperature could pass 1.5°C, involving several effects such as variability in intensity and frequency of rainfall and sea level rise, among others. In particular, in accordance with the IPCC scenarios sea level could raise in a range between 0.26-0.55 m (for the low emissions RCP 2.6 scenario) and 0.52-0.98 m (for the highest emission RCP 8.5 scenario) (Stocker et al., 2013). Therefore, coastal cities can be considered the most vulnerable urban areas: on one hand, coastal cities are characterized by high concentration of people and economic assets; on the other hand, these areas are potentially exposed to all the impacts of climate change, including coastal flooding. Indeed, future coastal flooding events will become more frequent and severe due to both the sea-level rise phenomenon and storm surges. As highlighted by the European Commission (2013), damage costs are estimated at about €25 billion annually if adaptation will be not implemented in coastal areas.
In light of the above considerations, it appears increasingly clear that it is necessary to adapt coastal cities to make them more resilient to future flooding and guarantee a good quality of life and livability in the coastal urban communities. However, those cities are complex also due to the intersection of two different environmental contexts, land and sea. This complexity requires the adoption of a holistic approach, which considers all the factors of a coastal response to the flooding stimuli.
Currently, urban studies on adaptation of coastal cities are still few and mainly based on the vulnerability assessment. Such approach can have several limitations in relation to the definition of effective urban measures because of its sectorial nature. Indeed, it considers some specific aspects of the urban system (mainly, geo-morphological and social ones) and does not include other important characteristics, including the distribution of the urban activities or the urban layout.
However, the introduction of a resilience-based approach is becoming more common in urban planning and it seems to be more in line with the need to adopt a holistic approach in the challenge of climate change (De Gregorio Hurtado et al., 2015). Unfortunately, the spread of "resilience" definitions in literature represents a relevant limitation for its effective application, especially, in the development of tools for supporting the decision-making process of urban adaptation, particularly in complex urban contexts such as coastal cities.
In detail, the vulnerability assessments and the definition of urban adaptation actions still represents two separate phases of the urban adaptation process, while their integration can represent an effective support in the definition of urban strategies in order to improve the whole urban resilience.
In the light of this, this paper illustrates a methodology for support decision-makers in the definition of urban transformations able to improve the resilience of the urban coastal system in case of coastal flooding events through the adoption of a systemic approach.
This contribution is composed of two parts. The former provides a review about the main studies on the topic and the main actions defined in adaptation strategies of coastal cities. Grounding on this, the latter describes the developed methodology and illustrates the preliminary results obtained by its application.

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

2 STATE OF THE ART

In the last ten years, several studies have been developed for analyzing the relationships between cities and climate change impacts. In particular, urban studies gave a particular attention to analyze the relationships between urban areas and some specific climate change impacts due mostly to the increase in global mean temperature and the variability of precipitation pattern.
Urban studies on sea-level rise (in general, coastal flooding) and its urban impacts, instead, are few. Indeed, although coastal cities play a strategic role at the territorial level (Nicholls et al., 2018) and represent the most exposed urban areas to the effects of climate change, scientific studies about these areas are mainly sectorial and consider coastal flooding impacts from a geomorphological and/or socio-economic perspective.
In particular, from the analysis of the scientific literature, it emerged that the main studies on this topic concern the coastal vulnerability assessment based on the development of composite vulnerability indices.
Even if these indexes have a similar denomination, they take into account different aspects of coastal vulnerability.
According to Zanetti et al. (2016), it is possible to identify three different approaches to the vulnerability concept for the construction of composite indices in relation to the used variables that are:

- the *geophysical approach*, which is focused on geographical characteristics of the coastal area;
- the *social approach*, which is based on the socio-economic characteristics of the coastal community;
- the *socio-environmental approach*, which summarizes characteristics of geophysical and social approches.

VULNERABILITY APPROACH	INDEX NAME	AUTHORS	SCALE
Geo-physical	Coastal Vulnerability Index (CVI)	Gornitz et al., 1991	Regional
	Sensitivity Index (SI)	Shaw et al., 1998	Regional
	Coastal Vulnerability Index (CVI)	Thieler & Hammar-Klose, 1999	Regional
	Coastal Sensitivity Index (CSI)	Karymbalis et al., 2012	Regional
Social	Social Vulnerability Index (SoVI)	Cutter et al., 2003	Regional
	N.A.	Wu et al., 2002	Regional
	Place Vulnerability Index (PVI)	Boruff et al., 2005	Regional
	N.A.	Li & Li, 2011	Regional
	Coastal City Flood Vulenrability Index (CFFVI)	Balica et al., 2012	Urban
	Socio-Environmental Vulnerability Index for a Coastal Areas (SEVICA)	Zanetti et al., 2016	Local

Tab. 1 Vulnerability Indices in relation to coastal flooding

As shown in Table 1, the concept of coastal vulnerability, initially based on the evaluation of geophysical characteristics, progressively has integrated the socio-economic characteristics. Indeed, some studies (e.g., Cutter et al., 2003) highlight the relevance of social factors in relation to the vulnerability of urban areas, such as the measure of the ability of communities to respond during an extreme climate event. Such ability also depends by the maintenance state of built environment.
According to Balica et al. (2012), the choice of the variables is strictly influenced by data availability and spatial scale of reference (McLaughlin & Cooper, 2011). Indeed, the majority of vulnerability indices were

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

developed for a regional level (see Tab. 1), while vulnerability indices for the local level are few (i.e. Zanetti et al. 2016). In general, the evaluation of vulnerability at local level can contribute more effectively in the definition of urban adaptation actions in coastal areas in comparison with the indices developed to be used at the regional scale.

Moreover, since indices have been developed for measuring the vulnerability of coastal areas, most of them are not able to support directly decision-makers in the definition of the urban adaptation actions for improving the responsive capacity of an urban area to a flooding event. Hence, in order to understand which urban adaptation actions could be implemented in coastal cities exposed to flooding impacts, five urban adaptation plans were analyzed (Tab. 2). They were chosen considering their innovation and the strategies adopted after a catastrophic event (e.g. New Orleans and New York) and the plans adopted to prevent likely extreme events, in particular coastal flooding.

CONTINENT	CASE STUDY	ADAPTATION PLAN/STRATEGY	YEAR
America	Boston	Climate Ready Boston	2016
	New Orleans	Greater New Orleans Urban Water Plan	2013
	New York	One New York. The Plan for a Strong and Just City	2015
	San Francisco	San Francisco Sea Level Rise Action Plan	2016
Europe	Copenaghen	Copenhagen Climate Adaptation Plan	2011
	Rotterdam	Rotterdam Climate Change Adaptation Strategy	2013

Tab.2 The analysed adaptation strategies

Based on possible forecasts, adaptation plans/strategies provide a series of urban adaptation actions in order to develop specific measures at the local level. In general, from the analysis of these plans and strategies, it is possible to identify three categories of adaptation actions in relation to the spatial level of reference. It is possible to distinguish:

- *Punctual actions*, which include all the actions referred to the building scale;
- *Linear actions*, which refer to infrastructure interventions;
- *Land actions*, which are related to the new urban developments or urban redevelopments.

In particular, there is a wide spread of *Punctual* and *Linear actions* even if *Land actions* are characterized by a more complexity of interventions. However, all the categories include actions that are related to integrate natural elements (Natural-Based Solutions) in the built environment in order to increase urban resilience (Pelorosso et al., 2018).

Finally, the analysis of the indices developed and the urban adaptation plans and strategies shows that tools are not still capable to address urban transformations in coastal urban settlements in relation to the impacts of coastal flooding. One of the reasons of this gap is due to the wide use of a vulnerability-based approach to face such issue and, consequently, the adoption of a sectorial approach mainly referred to social and geomorphological features, while urban planning requires a more holistic approach for developing effective urban transformations (Papa et al., 2014).

3 DEFINITION OF A METHODOLOGY BASED ON THE SYSTEMIC APPROACH

The methodology was developed according to the General System Theory (von Bertalanffy, 1969) that has been widely applied to the analysis of urban phenomena (Gargiulo & Papa, 1993). According to this

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

approach, a coastal city can be interpreted as a system that is composed of four sub-systems: socio-economic, physical, functional and geomorphological.

Based on this approach, the methodology was articulated into three phases:

- classification of urban coastal areas in relation to their physical and functional features;
- definition of a new composite index for measuring the urban resilience of urban coastal areas;
- definition of a set of urban adaptation actions.

Furthermore, such methodology was set up considering the opportunity to implement it using Geographic Information Systems (GIS). From an urban planning perspective, indeed, GIS can effectively support the decision permits to manage, analyze, process and synthetize spatial data in order to support effectively the decision-making process (Huxhold, 1991).

3.1 CLASSIFICATION OF THE URBAN COASTAL AREAS IN URBAN TYPOLOGIES

In general, a classification of urban area typologies represents a key aspect for a better evaluation of the urban transformations that should be implemented (Gargiulo, 2014).

Usually, scientific studies on this topic distinguish coastal areas in relation to the land use (e.g. McGranahan et al., 2005), while a classification based on functional and physical features of coastal areas is mainly considered in terms of the basic urban/rural dichotomy. However, this classification is not useful for understanding which interventions are possible to implement at the local level in order to increase their resilience.

Hence, both in relation to the literature review and the analysis of the urban adaptation plans, a new classification was defined. The classes of urban coastal areas refer both to their physical and functional characteristics. In particular, the Urban Coastal Units represent classes of urban coastal areas that are homogenous in relation to their physical and functional features. In relation to these, coastal cities can be articulated into six urban coastal typologies that are:

- *Compact Urban Areas:* urban areas characterized by high population density, high dense urban fabric, and a high functional stratification (e.g. historic centers and consolidated urban areas);
- *Monofunctional and Facility Urban Areas:* urban areas characterized by a highly specialized function and a specific physical configuration (e.g. industrial and commercial areas, airports, station);
- *Residential Areas:* residential areas characterized by medium and low population density (e.g. sub-urban areas);
- *Tourist Facility Areas:* urban areas characterized by a variable population density and by the presence of several accommodation facilities and activities related to tourism;
- *Potential Redevelopment Areas:* urban areas abandoned that can potentially be planned for redevelopment (e.g. brownfield sites);
- *Natural Coastal Areas:* coastal areas not urbanized and characterized by the presence of coastal ecosystems (e.g. wetlands).

In order to articulate an urban coastal area in these categories, a set of five indicators was defined. These indicators refer to the land use and the land-use intensity of a coastal area. In relation to the land use, the Urban Atlas classification was taken into account. In particular, the 20 Urban Atlas' classes were reduced into four land-use classes.

In relation to the land-use intensity, the indicators are:

- *Population Density:* it is measured as the number of inhabitants per square kilometer;

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

- *Job-Housing Ratio* (or *Employment to Housing Ratio*)*:* it is measured as the number of employees and the number of inhabitants in the area;
- *Tourism Employment:* it is measured as the percentage of workers in the tourism industry in relation to the total number of workers in the area;
- *Tourist Capacity:* it is measured as the ratio of the total number of accommodation beds and the total of inhabitants in the area.

In order to articulate coastal cities in these six urban typologies, a benchmark value has to be set for each land-use intensity indicators. After mapping these indicators, through the combination of the five maps, it is possible to obtain a classification of coastal cities according to the six urban coastal typologies as described above.

3.2 DEVELOPMENT OF A NEW INDEX FOR MEASURING THE URBAN COASTAL RESILIENCE

The literature review highlighted that there is a widespread use of coastal vulnerability indices. From an urban planning perspective, these indices do not take into account how the urban layout of coastal areas and their functional organization may affect their coastal vulnerability. Furthermore, these indices are based on the critical aspects of these areas and do not take into account those characteristics of the coastal urban system that may improve its response capacity during a coastal flooding event. Therefore, a new composite index was developed. Such index measures the "urban coastal resilience" that is the capacity of an urban coastal system to reach and maintain an acceptable level of functioning and structure during a coastal flooding. In this perspective, this index can be used in urban planning for a better definition of the prevention and preparation stages (Etinay et al., 2018, van Dongeren et al., 2018) in order to reduce the impacts of coastal flooding on urban areas.

Considering the literature review and the adaptation strategies' analysis, twelve characteristics and their relative variables were identified. According to the systemic approach described above, those characteristics were articulated into four categories (Tab. 3).

CATEGORY	CHARACTERISTIC	CATEGORY	CHARACTERISTIC
Socio-economic	Education	Functional	Transport network
	Age		Ground floor uses
	Employment		Public facilities
Physical	Imperviousness degree	Geo-morphological	Slope
	Building typology		Water body
	Conservation of buildings		Distance from coastline

Tab. 3 Index's characteristics

Concerning the weighting method for developing the index, a multi-attribute decision-making methods developed by Thomas Saaty (1987) was used, namely the Analytic Hierarchy Process (AHP) . About the choice of the aggregation method, the new index was developed as a linear aggregation of variables calculating the weights for each variable by means of the AHP technique.

However, in order to use the AHP and considering the lack of information in literature about the relationships among the selected indicators', a Delphi survey was necessary. Indeed, the Delphi study is used when "there is incomplete knowledge about a problem or phenomenon". The Delphi study was carried out on an

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

international panel of 135 experts, composed of academics and researchers of the topic, professionals and technical experts working in public administration with experience on the issue of coastal flooding. After collecting the experts' opinions, thanks to the AHP, it was possible to calculate the weights of each characteristic. In particular, to date, the opinions expressed by the experts highlight that the main importance is played by the geo-morphological characteristics (about 34%), while socio-economic ones have less influence on the urban resilience of a coastal area (18%).
Finally, the index measures four urban coastal resilience's levels, articulated as *high*, *medium-high*, *medium-low* and *low*.

3.3 DEFINITION OF THE URBAN ADAPTATION CLASSES

Adaptation of urban coastal areas represents a need for coastal communities in order to reduce their vulnerability to coastal flooding impacts and, at the same time, it can be an opportunity for increasing the quality of life in those areas. The possible adaptation approaches for coastal communities are mainly three (Nicholls et al., 2007):

- *Accommodation:* it considers modifications to the urban layout and organization in relation to the flooding exposure;
- *Protection:* it includes the placement of natural (soft measures) or infrastructural (hard measures) barriers in an exposed area in order to reduce the impacts of flooding events;
- *Retreat:* it concerns the delocalization of activities and communities from high-risk areas to low-risk areas.

Although the differences among these three approaches, it is possible to articulate urban transformations referred to them according to systemic approach. Therefore, urban adaptation actions can be expressed by the concepts of (i) land use, (ii) land-use intensity, and (iii) urban form.
Land use expresses the relationships between the urban activities localized in an area and the adapted urban space (Gargiulo, 2009). Land-use intensity indicates the amount and degree of urbanization of an area (Wellmann et al., 2018) in relation to its main urban function. Urban form refers to the urban physical characteristics that include housing type, street type, etc.
In relation to these three urban factors, four classes of urban adaptation actions were defined:

- Maintain the land use (1);
- Reduce the land-use intensity and maintain the urban form (2);
- Reduce the land-use intensity and change the urban form (3);
- Change the land use (4).

Each of these classes is linked to a specific adaptation approach. In particular, (1) and (2) are referred to the Accommodation approach, while (3) and (4) are respectively referred to the Protection and the Retreat approach. In relation to the resilience levels measured by the index described above, the range of the urban adaptation actions is inversely proportional to the urban coastal resilience level: if the resilience level is *high*, the urban transformations will be poor (e.g. A.1); otherwise, if resilience level is *low*, the urban transformations will be more significant (e.g. R.4).

4 CONCLUSION

This paper illustrates a methodology developed for supporting decision-makers in the definition of effective urban transformations that are able to reduce the impacts due to coastal flooding on urban areas. As

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

emerged from the literature review and the analysis of the adaptation plans, the difficulty to define spatial planning tools for supporting decision-makers in the definition of effective urban transformations of urban coastal areas depends from the use of approach based mainly on the vulnerability concept that considers specific urban aspects, in particular social and geo-morphological ones. Instead, the urban coastal adaptation is a complex issue that requires an approach that considers the complexity of urban coastal systems.

In this perspective, the methodology described in this paper was developed adopting a systemic approach. This approach permits not only to consider the complexity of relationships between coastal cities and coastal flooding impacts but also to overcome the current limitations of the scientific debate. In particular, due to the sectorial approach adopted for the coastal vulnerability assessment, there is still a gap between the measurement of the ability of the coastal system to respond to flooding stimuli (resilience) and the definition of effective urban adaptation actions to reduce the impacts of coastal flooding. The use of the systemic approach, instead, provides more guarantees to fill this gap and support better decision-makers in the management of the future urban transformations along the coastline. Furthermore, in relation to these aspects, such methodology was developed considering its application in GIS environments in order to support more effectively the decision-making process.

In this perspective, future developments of this work will concern the GIS implementation and the application of such methodology to a case study. In particular, it will be necessary to define an operative framework for the development of the methodology in the GIS environment. Hence, through the analysis of the case study's application, it will be possible to not only assess the correctness of the methodology but also consider the opportunity to develop a new operative GIS-based tool for supporting more effectively decision-maker process.

REFERENCES

Balica, S.F., Wright, N.G., van Der Meulen, F. (2012). A flood vulnerability index for coastal cities and its use in assessing climate change impacts. *Nat. Hazards*, *64*, 73–105. doi: https://doi.org/10.1007/s11069-012-0234-1

Boruff, B. J., Emrich, C., & Cutter, S. L. (2005). Erosion hazard vulnerability of US coastal counties. *Journal of Coastal research*, 932-942. doi: https://doi.org/10.2112/04-0172.1

Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social vulnerability to environmental hazards. *Social science quarterly*, *84*(2), 242-261. doi: https://doi.org/10.1111/1540-6237.8402002

De Gregorio Hurtado, S., Olazabal, M., Salvia, M., Pietrapertosa, F., Olazabal, E., Geneletti, D., D'Alonzo, V., Di Leo, S., & Reckien, D. (2015). Understanding How and Why Cities Engage with Climate Policy: An Analysis of Local Climate Action in Spain and Italy. *TeMA. Journal of Land Use, Mobility and Environment*, Special Issue ECCA 2015, 23-46. doi: http://dx.doi.org/10.6092/1970-9870/3649

Etinay, N., Egbu, C., & Murray, V. (2018). Building Urban Resilience for Disaster Risk Management and Disaster Risk Reduction. *Procedia engineering*, *212*, 575-582. doi: https://doi.org/10.1016/j.proeng.2018.01.074

European Commission (2013). *Commission Staff Working Document. Climate change adaptation, coastal and marine issues* (SWD(2013) 133 final). Retrieved from https://ec.europa.eu/clima/sites/clima/files/adaptation/what/docs/swd_20

13_133_en.pdf

Gargiulo C. (2009). Sistema urbano e Complessità. In Papa R. (Ed.), *Il governo delle trasformazioni urbane e territoriali. Metodi, tecniche e strumenti* (pp.23-46). Milano, IT: Franco Angeli. EAN: 9788856811476

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

Gargiulo, C. (2014). *Integrazione trasporti-territorio. Strumenti, interventi e best practices verso la Smart City*. Napoli, IT: Clean. ISBN: 9788884972583

Gargiulo, C., & Papa, R. (1993). Caos e caos: la città come fenomeno complesso. *Per il XXI Secolo: una enciclopedia e un progetto* (pp. 297-306). Retrieved from http://www.fedoa-old.unina.it/1064/1/CAOS.pdf

Gornitz, V. (1991). Global coastal hazards from future sea level rise. *Global and Planetary Change*, *3*(4), 379-398. Retrieved from https://doi.org/10.1016/0921-8181(91)90118-G

Huxhold, W.E. (1991). *An Introduction to Urban Geographic Information Systems*. New York, US: Oxford University Press. ISBN: 0195065344

Karymbalis, E., Chalkias, C., Chalkias, G., Grigoropoulou, E., Manthos, G., & Ferentinou, M. (2012). Assessment of the sensitivity of the southern coast of the Gulf of Corinth (Peloponnese, Greece) to sea-level rise. *Open Geosciences*, *4*(4), 561-577. doi: 10.2478/s13533-012-0101-3

Li, K., & Li, G. S. (2011). Vulnerability assessment of storm surges in the coastal area of Guangdong Province. *Natural Hazards and Earth System Sciences*, *11*(7), 2003-2010. doi:10.5194/nhess-11-2003-2011

McGranahan, G. , Marcotullio, P.J, Bai, X., Balk, D., Braga, T., …, & Zlotnik, H. (2005). Urban systems. In R. Hassan, R. Scholes and N. Ash (Eds.), *Ecosystems and Human Well-Being: Current Status and Trends* (pp. 795-825). Washington DC, US: Island Press. Retrivied from https://www.researchgate.net/publication/318348846_Chapter_22_Urban_Systems

McLaughlin, S., & Cooper, J. A. G. (2010). A multi-scale coastal vulnerability index: A tool for coastal managers?. *Environmental Hazards*, *9*(3), 233-248. doi: https://doi.org/10.3763/ehaz.2010.0052

Nicholls, R.J., Wong, P.P., Burkett, V.R., Codignotto, J.O., Hay, J.E., McLean, R.F., …, & Woodroffe, C.D. (2007). Coastal systems and low-lying areas. Climate change 2007: impacts, adaptation and vulnerability. In M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden & C.E. Hanson (Eds.), *Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change* (pp.315-356). Cambridge, UK: Cambridge University Press. Retrieved from https://ro.uow.edu.au/cgi/viewcontent.cgi?referer=http://scholar.google.it/&httpsredir

=1&article=1192&context=scipapers

Nicholls, R. J., Brown, S., Goodwin, P., Wahl, T., Lowe, J., Solan, M., ... & Wolff, C. (2018). Stabilization of global temperature at 1.5° C and 2.0° C: implications for coastal areas. *Phil. Trans. R. Soc. A*, *376*(2119), 20160448. doi: https://doi.org/10.1029/2002EO000216

Papa, R., Galderisi, A., Majello, M. C. V., & Saretta, E. (2015). European Cities Dealing with Climate Issues: Ideas and Tools for Better Framing Current Practices. *TeMA. Journal of Land Use, Mobility and Environment*, Special Issue ECCA 2015, 63-80. doi: http://dx.doi.org/10.6092/1970-9870/3658

Papa, R., Gargiulo, C., & Zucaro, F. (2014). Climate Change and Energy Sustainability. Which Innovations in European Strategies and Plans. *Tema. Journal of Land Use, Mobility and Environment, 0*. doi:http://dx.doi.org/10.6092/1970-9870/2554

Pelorosso, R., Gobattoni, F., Ripa, M., & Leone, A. (2018). Second law of thermodynamics and urban green infrastructure - A knowledge synthesis to address spatial planning strategies. *TeMA. Journal of Land Use, Mobility and Environment, 11*(1), 27-50. doi: http://dx.doi.org/10.6092/1970-9870/5326

Saaty, R. W. (1987). The analytic hierarchy process—what it is and how it is used. *Mathematical modelling*, *9*(3-5), 161-176. doi: https://doi.org/10.1016/0270-0255(87)90473-8

Salata, K., & Yiannakou, A. (2016). Green Infrastructure and climate change adaptation. *Tema. Journal of Land Use, Mobility and Environment, 9*(1), 7-24. doi: http://dx.doi.org/10.6092/1970-9870/3723

Shaw, J., Taylor, R.B., Forbes, D.L., Ruz, M.-H., Solomon, S. (1998). Sensitivity of the Coasts of Canada. *Geol. Surv. Can. Bull.*, 505. doi: https://doi.org/10.4095/210075

Stocker, T. F., Qin, D., Plattner, G., Tignor, M., Allen, S. K., Boschung, J., ... & Midgley, P. (2013). *IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK and New York, USA: Cambridge University Press. Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_SPM_FINAL.pdf (Last access 24th

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

September 2018)

Thieler, E.R., Hammar-Klose, E.S. (1999). *National Asssessment of Vulnerability to Sea-Level Rise: Preliminary Results for the U.S. Atlantic Coast*. Reston, US: United States Geological Survey.

Wellmann, T., Haase, D., Knapp, S., Salbach, C., Selsam, P., & Lausch, A. (2018). Urban land use intensity assessment: The potential of spatio-temporal spectral traits with remote sensing. *Ecological Indicators*, 85, 190-203. doi:https://doi.org/10.1016/j.ecolind.2017.10.029

Wu, S. Y., Yarnal, B., & Fisher, A. (2002). Vulnerability of coastal communities to sea-level rise: a case study of Cape May County, New Jersey, USA. *Climate Research*, *22*(3), 255-270. doi: http://dx.doi.org/10.3354/cr022255

Zanetti, V. B., de Sousa Junior, W. C., & De Freitas, D. M. (2016). A Climate Change Vulnerability Index and Case Study in a Brazilian Coastal City. *Sustainability*, *8*(8), 811. doi:10.3390/su8080811

van Dongeren, A., Ciavola, P., Martinez, G., Viavattene, C., Bogaard, T., Ferreira, O., ... & McCall, R. (2018). Introduction to RISC-KIT: Resilience-increasing strategies for coasts. *Coastal Engineering*, *134*, 2-9. doi: https://doi.org/10.1016/j.coastaleng.2017.10.007

von Bertalanffy, L. (1969). *General system theory: foundations, development, applications* (Revised Edition). New York, US: George Braziller. Retrieved from https://monoskop.org/images/7/77/Von_Bertalanffy_Ludwig_General_System_Theory_1968.pdf

WEB SITES

City and County of San Francisco (2016). *San Francisco Sea Level Rise Action Plan*. Retrieved from http://sf-planning.org/sea-level-rise-action-plan

City of Boston, Green Ribbon Commission (2016). *Climate Ready Boston. Final Report*. Retrieved from https://www.boston.gov/departments/environment/climate-ready-boston

City of Copenaghen (2011). *Copenaghen Climate Adaptation Plan*. Retrieved from http://international.kk.dk/artikel/climate-adaptation

City of New York (2015). *One New York. The Plan for a String and Just City*. Retrieved from https://onenyc.cityofnewyork.us/wp-content/uploads/2018/04/OneNYC-1.pdf

Rotterdam Climate Initiative. (2013). *Rotterdam Climate Change Adaptation Strategy*. Retrieved from http://www.rotterdamclimateinitiative.nl/documents/2015enouder/Documenten/20121210_RAS_EN_lr_versie_4.pdf

Waggoner & Ball Architects. (2013). *Greater New Orleans Urban Water Plan. Vision*. Retrieved from https://www.dropbox.com/s/ov3t7r8i4vwx2sk/UWP%20Vision.pdf?dl=0

AUTHOR'S PROFILE

Carmela Gargiulo is Full Professor of Urban Planning Techniques at the University of Naples Federico II. Since 1987 she has been involved in studies on the management of urban and territorial transformations. Since 2004, she has been Member of the Researcher Doctorate in Hydraulic, Transport and Territorial Systems Engineering of the University of Naples Federico II. She is Member of the Committee of the Civil, Architectural and Environmental Engineering Department of the University of Naples Federico II. Her research interests focus on the processes of urban requalification, on relationships between urban transformations and mobility, and on the estate exploitation produced by urban transformations. On these subjects she has co-ordinated research teams within National Project such as Progetto Finalizzato Edilizia - Sottoprogetto "Processi e procedure" (Targeted Project on Building – Subproject "Processes and procedures), from 1992 to 1994; Progetto Strategico Aree Metropolitane e Ambiente, (Strategic Project Metropolitan Areas and Environment) from 1994 to 1995; PRIN project on the "Impacts of mobility policies on urban transformability, environment and property market" from 2011 to 2013. Scientific Responsible of the Project Smart Energy Master for the energy management of territory financed by PON 04A2_00120 R&C Axis II, from 2012 to 2015. She is author of more than 90 publications.

Rosaria Battarra is an architect, since 1998 researcher of the National Research Council - Institute of Studies on Mediterranean Societies (ISSM). She carries out her research activity at the Department of Civil, Architectural and Environmental Engineering of the University of Naples Federico II, developing research on the issues of urban renewal and how to implement urban transformation actions. More recently, the research interest has turned to the themes of

 ISBN:978-88-6887-048-5 DOI:10.6093/978-88-6887-048-5

governance of the metropolitan city, in the light of the increasingly widespread use of the "smart city" paradigm. She is adjunct professor at the Faculty of Engineering of the University of Naples Federico II. From 2007 to 2014 she was head of the Department of Planning and Real Estate of the Urban Transformation Company Bagnolifutura S.p.A.. She is author of numerous papers presented at national and international conferences and over 40 publications.

Maria Rosa Tremiterra is an engineer and a Ph.D. student in Civil Systems Engineering at University of Naples Federico II. She received a master’s degree in Architecture and Building Engineering with a thesis on urban strategies for improving sustainable mobility in European cities. In 2014 she won a one-year grant for post-lauream education and research within the Project Smart Energy Master at the Department of Civil Engineering, Building and Environmental Engineering, University of Naples Federico II. Currently, her PhD research focuses on definition of methods and tool for the adaptation of urban areas, in particular, coastal cities, to climate change impacts.

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5

Antonio Leone is full professor of Environmental and Territorial Engineering at the Tuscia University. Degree in Civil Engineering. Member of the Teaching College PhD "Land and Urban Planning" at Politecnico di Bari and "Environment and landscape design and planning" at Sapienza University of Rome. Participant and responsible in several projects financed by the European Union within 5th Framework Programme, Interreg IIIB Research Program, COST-actions, LIFE programme and other national and regional research programs (e.g. Nature 2000 sites). Member of Scientific International Committee for Metropolitan Strategic Master Plan "Terra di Bari". Author of about 150 papers and scientific articles on the main international journals related to the management of the environment and landscape and to the engineering of the territory, for the most part of which he also carries out the activity of an anonymous reviewer.

Carmela Gargiulo is full professor of Urban Planning Techniques at the University of Naples Federico II. Since 1987 she has been involved in studies on the management of urban and territorial transformations. Since 2004, she has been Member of the Researcher Doctorate in Hydraulic, Transport and Territorial Systems Engineering of the University of Naples "Federico II". She is Member of the Committee of the Civil, Architectural and Environmental Engineering Department of the University of Naples "Federico II". Her research interests focus on the processes of urban requalification, on relationships between urban transformations and mobility, and on the estate exploitation produced by urban transformations. On these subjects she has co-ordinated research teams within National Project such as Progetto Finalizzato Edilizia - Sottoprogetto "Processi e procedure" (Targeted Project on Building – Subproject "Processes and procedures), from 1992 to 1994; Progetto Strategico Aree Metropolitane e Ambiente, (Strategic Project Metropolitan Areas and Environment) from 1994 to 1995; PRIN project on the "Impacts of mobility policies on urban transformability, environment and property market" from 2011 to 2013. Scientific Responsible of the Project Smart Energy Master for the energy management of territory financed by PON 04A2_00120 R&C Axis II, from 2012 to 2015. She is author of more than 130 publications.

ISBN:978-88-6887-048-5
DOI:10.6093/978-88-6887-048-5