ATMOSPHERIC AGENTS AND SPATIAL PLANNING. CASE STUDY OF THE MUNICIPALITY OF ROSIGNANO MARITTIMO IN TUSCANY

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Abstract – In recent years, the municipality of Rosignano Marittimo in Tuscany has been repeatedly affected by more and more intense weather phenomena, which have caused damage to people and urban settlements along the coast. Extreme weather events such as intense downpours, floods, whirlwinds and powerful sea storms, together with critical issues due to ongoing coastal erosion, highlight a number of problems.
The Council administration has recently participated in the ADAPT European project, a Program of transborder cooperation between Interregional Maritime Italy and France - 2014 - 2020, aimed at defining a local Climatic Profile and a Plan of Adaptation to Climatic changes. At the same time, the editing staff of the municipal structural plan has started a method investigation in coherence with the regional Tuscan law no. 65/2014 on the governance of the territory, with the scope of finding answers to some of the critical issues investigated. However, the topic of climatic change expresses deep profiles of uncertainty, due to potential long term climatic response times, as compared to possible actions to be taken today. The evolutionary framework of the coastal belt produces a dynamic definition of a coastline to which the continuous delimitation even of areas of maritime state property assets, correlates in the making. Therefore, the dynamism of the coastline immersed in uncertain flows of atmospheric agents raises a fundamental question to the delimitation of state property areas, on which the political decision maker is called upon to express himself through a territorial planning setup.
The physical definition of the coastal system and the management definition of same are topics that are treated in the present paper, that sets the goal of defining a possible methodological approach through the presentation of the case study for territorial planning in coastal areas, able to define a flexible cognitive framework, by means of which to distinguish strategies in the short and long term, for planning and managing of maritime state property assets.

Introduction: a glance at Gaia

It was in 1979 that James Lovelock began to outline the hypothesis that the Earth could be considered living, governed by large, self-correcting homeostatic cycles. Lovelock calls his hypothesis Gaia, in honour of *Gaia* of the Greeks, because «in the minds of men of antiquity, the Earth has always been the generator and the nurse par excellence [...] and the concept of "Mother Earth" is a category of the spirit that still persists in the great religions.»[4] For Lovelock, the word Gaia «serves to denote [the] hypothesis that the biosphere is a self-regulating entity, that it establishes the material conditions necessary for its own survival and

Referee List (DOI 10.36253/fup_referee_list)
FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)
Claudio Saragosa, Michela Chiti, *Atmospheric agents and spatial planning. Case study of the municipality of Rosignano Marittimo in Tuscany,* pp. 303-311 © 2022 Author(s), CC BY-NC-SA 4.0, 10.36253/979-12-215-0030-1.28

that living matter does not remain passive in the face of what threats its existence.» [4]

In summary, his hypothesis takes into account a number of key aspects, including: «(1) [...] the tendency [of Gaia] to optimise conditions for all life on Earth. [...] 2) [That Gaia has] vital organs within it, as well as others that exist in abundance particularly on its periphery and that can be used. [...] 3) [That Gaia's] responses to worsening changes [must] obey the rules of cybernetics, in which time constant and ring gain are important factors» [4].

The Gaia hypothesis has had mixed fortunes, seen by some as an indemonstrable para-scientific hypothesis. Until recently, scientific and philosophical debate, also linked to the concepts of the Anthropocene and the New Climate Regime, brought it back to the forefront, for example, with the anthropologist of science Bruno Latour [3]. It was precisely in analysing climate mutations, that, Latour began to reflect on the irruption «of this monster, half hurricane, half Leviathan, with a bizarre name, "Cosmocolossus", until I soon merged it into an equally controversial figure I had conceived while reading James Lovelock, the figure of Gaia. I could no longer escape: I had to understand what was coming at me in the rather distressing form of a force that was at once mythical, scientific, political and, probably, also religious» [3]. It is with Lovelock that Latour becomes familiar with the concept of Gaia, as a living planet with an atmosphere in chemical disequilibrium. If this is the case, says the anthropologist, the Earth must have some sort of *agency* «that allows it to maintain, or recover, over billions of years, a state of affairs durable enough to counter the perturbations introduced by external events - the increasing brightness of the Sun, asteroid bombardments, volcanic eruptions» [3]. After a substantial treatment of the subject, which we certainly cannot summarise here, it becomes necessary for Latour to think that the current human inhabitants of the Earth (the Terrans) must overcome their old conceptions of their relationship with Nature, to become aware that they are immersed in Gaia insofar as «the two sides share the same fragility, the same cruelty, the same uncertainty about their destiny. They are powers that cannot be dominated and cannot dominate» [3]. This is why the anthropologist emphasises that a new paradigm should push us «to get rid of the expressions "modern", "nature" and even "ecology", [...to] "move from the Ancient to the New». [3].

Another philosophical horizon is opened by Timothy Morton in outlining the realm of *hyperobjects*[1]. *Hyperobjects* are increasingly emerging in the framework of philosophical reflection as «entities that become visible only by resorting to post-Humean statistical causality» [5]. Among them, Morton puts climate and other recently discovered entities «that make us reflect on our place on Earth and in the cosmos. Perhaps this is the key point: hyperobjects force us to reconsider the fundamental ideas we have about what it means to exist, what the Earth is, what society is» [5]. The emerging *hyperobjects* are a new test of man's positioning within his own world. After the Copernican revolution, which removed man from the centre of the universe, the downgrading of man as a divine creation due to Darwin, the ousting of man from the centre of psychic activity thanks to Freud, etc., it is now

[1] Access to hyperobjects does not occur by travelling a distance, through some transparent medium: the hyperobjects are here, right here, in my social and experiential space. They look at me menacingly like faces pressed against a window pane: and it is precisely their proximity that threatens me. [...] Every day global warming burns the skin of the back of my neck causing me itching, discomfort, a vague sense of apprehension. Evolution unfolds in my genome because my cells are constantly dividing and mutating, because my body clones itself every time one of my sperm fertilises an egg. As I reach out to grab the iPhone charger attached to the dashboard, I break into evolution, into the extended phenotype that certainly does not end at the edge of my skin, but extends into all the spaces that my 'being-human' has colonised.[5]

the *hyperobjects* that pose new problems. In fact, for Morton, «ecological thinking that reasons about hyperobjects does not conceive of individuals as embedded in a nebulous global system, nor, on the contrary, does it theorise about an entity larger than individuals that moulds itself from time to time into individual forms. Hyperobjects stimulate *irreductionist* thinking because they pose scalar dilemmas to which it is not possible to respond by establishing ontotheologically what is more real - the ecosystem, the world, the environment or, instead, the individual» [5].

From a historical point of view, the recent IPCC report (2021) exposes weather changes in every region of the Globe and the entire climatic system without precedents, and is irreversible, in hundreds or thousands of years. The report highlighting human influence on the climate both past and future, contributes to fundamental decision processes for limiting ongoing climatic change, at this stage only possible through a rapid and constant reduction of carbon dioxide (CO2) emissions and other greenhouse effect gases. Today, deciding to reduce climate altering gases on a large scale would mean sure benefits on air quality in the short term, but we would have to wait another 20 to 30 years to see global temperatures stabilize. Differently, the rise in temperature, even by only 1,5°C, would mean changes in water cycles, with heavy rains and flooding on the one hand, and severe drought in several regions, on the other. Coastal areas will be characterized by a continuous rise in sea level with more frequent coastal flooding in a much reduced time scan of events.

In Italy, a new climatic model was presented in 2018, with the variation of level of the Mediterranean, which was the result of a study by a group of ENEA researchers, in collaboration with the MIT of Boston. Its aim was to map coastal areas that risk flooding, as well as planning the territory and making it safe. The studies presented foresee that there will be a loss of tens of square kilometers in Italy's coastal areas by the end of the century, with receding beaches and agricultural areas, where half of the Italian population is concentrated.

Dealing with the problems of the new climate regime, even at the local level, poses a not inconsiderable philosophical and epistemological problematic horizon.

Materials and Methods

Gaia's theory prompts reflection on the feedbacks that are now evident even at the local level. This article brings together the in-depth studies developed on the coastal reality of the municipality of Rosignano Marittimo[2], for an area relating to the coastal strip from Caletta to the sea mouth of the industrial canal of the Solvay Chimica Italia S.p.A. plant.

The municipal administration has recently participated in the European project ADAPT[3], a cross-border cooperation programme between Italy Maritime Interregional and France - 2014 - 2020, aimed at defining a Local Climate Profile and a Climate Change Adaptation Plan. At the same time, the drafting of the Municipal Structural Plan started a methodological investigation[4], consistent with the Tuscan Regional Law 65/2014 on the government of the territory, with the aim of finding answers to some of the critical issues investigated.

[2] The research area falls within the Municipality of Rosignano Marittimo (LI), located in the central part of the Tuscan coast, in the Province of Livorno.
[3] http://www.comune.rosignano.livorno.it/site5/pages/home.php?idpadre=36878
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A first body of studies[5] essentially concerns the definition of the local climate change profile, with particular attention to the variation of rainfall in relation to the future values assumed by the climate indices in the RCP4.5 and RCP8.5 emission scenarios. On the one hand, the work identified the cumulative annual rainfall as a 30-year average with reference to the processing of the indicative values provided by the ISPRA and PNACC studies and the estimates derived from local trends. While on the other hand it assessed the drought phenomenon over time, through the analysis of the maximum number of consecutive dry days per year, by means of the historical elaboration of the average spatialisation between the different measuring stations, with reference to the 2015 ISPRA studies. The analyses performed made it possible to define the rainfall heights of maximum rainfall over time, through Gumbel statistical analysis. In relation to the different studies used to define the local RCP6 and RCP8.5 scenarios, the sea level in future projections was estimated.

A second body of studies is aimed at characterising the vulnerability of the territory through the assessment of the impacts that climate change may generate on urban settlements consistent with the IPCC (2014) definition [2]. The study based on remotely sensed data (LiDAR, high-resolution remote sensing imagery, and from the LANDSAT 8 platform) prepared a methodology [1] for estimating current ground temperatures and future climate projections.

A third body of studies carried out a series of analyses with the aim of providing quantitative information on the evolution of erosion processes[6] that affected the portion of the coastline under investigation in the period between January 2010 and September 2018. To this end, multi-temporal analyses were conducted by studying aerial photos, optical images and satellite radar using PhotoMonitoringTM techniques for the identification and analysis of the geomorphological evolution of the coastline falling within the study area.

A fourth body of studies concerns the analysis of the hydrographic network in relation to rainfall events with the relative hydraulic hazards and 30- and 200-year return times, estimated by law[7].

A fifth body of studies analyses the five meteorological events that have produced significant damage to the area under study over the last eight years, due to the development and transit of tornadoes[8], identified according to two distinct groups of phenomena.

Rosignano come fondamento della redazione del nuovo Piano Strutturale L.R. 65/2014". University of Florence - Department of Architecture DiDAlabs - Laboratory Plans and Projects for the City and the Territory - Research Group: Prof. Saragosa C., arch. Chiti M., arch. Tiffany Geti, urb. Rossi M., urb. Bartali L., urb. Miccio A., urb. Tanganelli A., urb. Iacometti F., urb. Montoro G., urb. Rossi G.

[5] Title: "*Attività di ricerca volta alla definizione del Profilo Climatico Locale e di un Piano per l'adattamento ai cambiamenti climatici con particolare riferimento alla conseguenza dello stesso sugli scenari idraulici del Comune di Rosignano*". University of Florence - Department of Architecture, coord. Prof. Bernetti I. - University of Pisa - Department of Energy, Systems, Territory and Construction Engineering, coord. Prof. Pagliara S.

[6] Title: "*Analisi geomorfologica mediante tecniche di telerilevamento dei processi di erosione costiera lungo la linea litoranea tra Rosignano Solvay e La Mazzanta a supporto degli studi del Piano Strutturale del Comune di Rosignano Marittimo (LI)*", NHAZCA S.r.l., Spin off di Sapienza Università di Roma. Prof. Mazzanti P., PhD Romeo S. Referring to 2019.

[7] Title: "*Studio idrogeologico preliminare al nuovo Piano strutturale*". Edited by Myricae srl, Geotecno Studio Associato, Chiarini Associati. Referring to 2019.

[8] Title: "*Analisi degli eventi con trombe d'aria su Rosignano (LI)*". Edited by Consorzio LaMMA – Laboratorio di Monitoraggio e Modellistica Ambientale per lo sviluppo sostenibile, Area della Ricerca CNR. Referring to 2021.

Results

Gaia's Feedback

Studies on the variation of rainfall in climate change show a projection of a contraction of time-concentrated weather events. The climate change we are currently seeing the effects of, therefore, does not involve a substantial variation in the amount of rainfall over the year, but a concentration in particularly intense events. This variation has a relationship with the modelling of the terrain and the existing hydraulic reticulum, which was formed under totally different rainfall conditions and is therefore capable of disposing of different meteorological phenomena. Already, the hydraulic reticulum entered into distress at a 30- or 200-year probability interval. With the variation of rainfall and its concentration in particularly intense events, the entire system, characterised by the modelling of the soils, if not redefined quickly, will enter into crisis, producing critical phenomena, even of considerable danger, that will be difficult to manage with simple prevention and civil protection.

A second analysis concerns the variation in temperature over time with particular reference to the perception of heat on the ground. Here, too, there is a substantial variation in environmental conditions over time. The variation can in fact change the habitability of entire parts of the city, which tend to become excessively hot over time, profoundly affecting living comfort. Entire public areas, used to perform various urban functions, may, as conditions currently stand, be unfit for any use for most of the daytime hours, especially in the summer season.

One of the most important feedbacks, due to climate change, is the rising sea level. The rise results in the ingress of sea water into the parts of the land located at lower altitudes and therefore particularly into the sandy parts of the coast. This phenomenon is intimately linked to what is happening with the problems of coastal erosion due to changes in sea currents and the reduction of solid contributions to the sea due to the use of riverbed materials and other works that interrupt the transport of solid materials. In reality, the coastal strip is

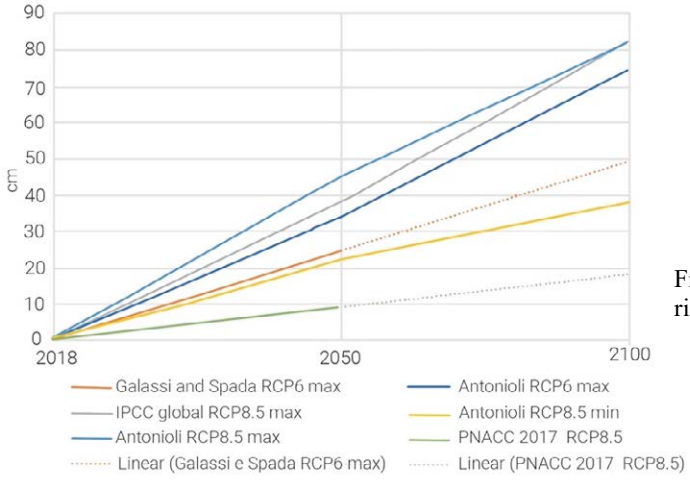

Figure 1 – Sea level rise analysis.

an important resource for the reality we are trying to study. In this very limited strip of land, partly sandy, partly rocky, all the seaside tourist activity takes place, which feeds a substantial local economy. The loss of this coastal strip, which constitutes the vital seaside tourist park, will entail the necessary revision of the tourist economy that has been produced over time. A tourist economy whose foundations are based not so much on specialised enterprise as on the complex management of the existing built heritage.

More difficult to correlate with climate change, are calamitous events that have occurred recently in the area. These were a series of tornadoes that hit the coast, causing damage to both building structures and street vegetation. Many residential structures and some sports facilities were blown over, and many of the vegetation furnishings, mostly consisting of pine trees of a certain age and therefore size, were felled. Both the building materials and the large trees that were felled produced events that bordered on tragedy.

The morphological features of soils and the answer to hydraulic cycles

The events, summarised in the previous paragraph, have a violent impact on the pre-existing morphological system. If the forms that occur in the various territorial realities are forged over time for the correct flow management, at the moment in which the flows (of matter and energy) change in their quality and quantity, the shapes may become inadequate to respond to the necessary flow management work. Their inadequacy may lead to an alteration of the sense of well-being felt in inhabiting them or, more seriously, they may represent an obstacle to the flow and potentially even become lethally dangerous.

In the first case, by example only, the reduction in the surface area of coastal areas, especially sandy ones, may lead to the abandonment of the coast's use for tourism purposes, reducing the economy linked to hospitality, whether professional (hotel structures, catering establishments, loisir services) or in second homes (much of the existing building stock in the area under study is destined for hospitality, especially during the summer period). Again in the first case, the variation in ground temperatures can generate urban areas, under the current morphological and material conditions, that are difficult to use for a large part of the population (especially the somewhat elderly); in fact, heat islands are formed that can poorly guarantee the well-being necessary to carry out many activities.

In the second case, again as an example, the situation can even become lethal. Let us think of the inability of the existing hydraulic system to handle very intense punctual meteorological phenomena, producing more and more floods that, at least in the local situation we are studying, with buildings also subjected to levels below the water flow level, can have dramatic effects. Or let us think of the vegetal furnishings that, also taking into account their ageing, are subjected to phenomena linked to previously unknown winds, are literally eradicated, ruining them to the ground in a way that is sometimes catastrophic for things and people.

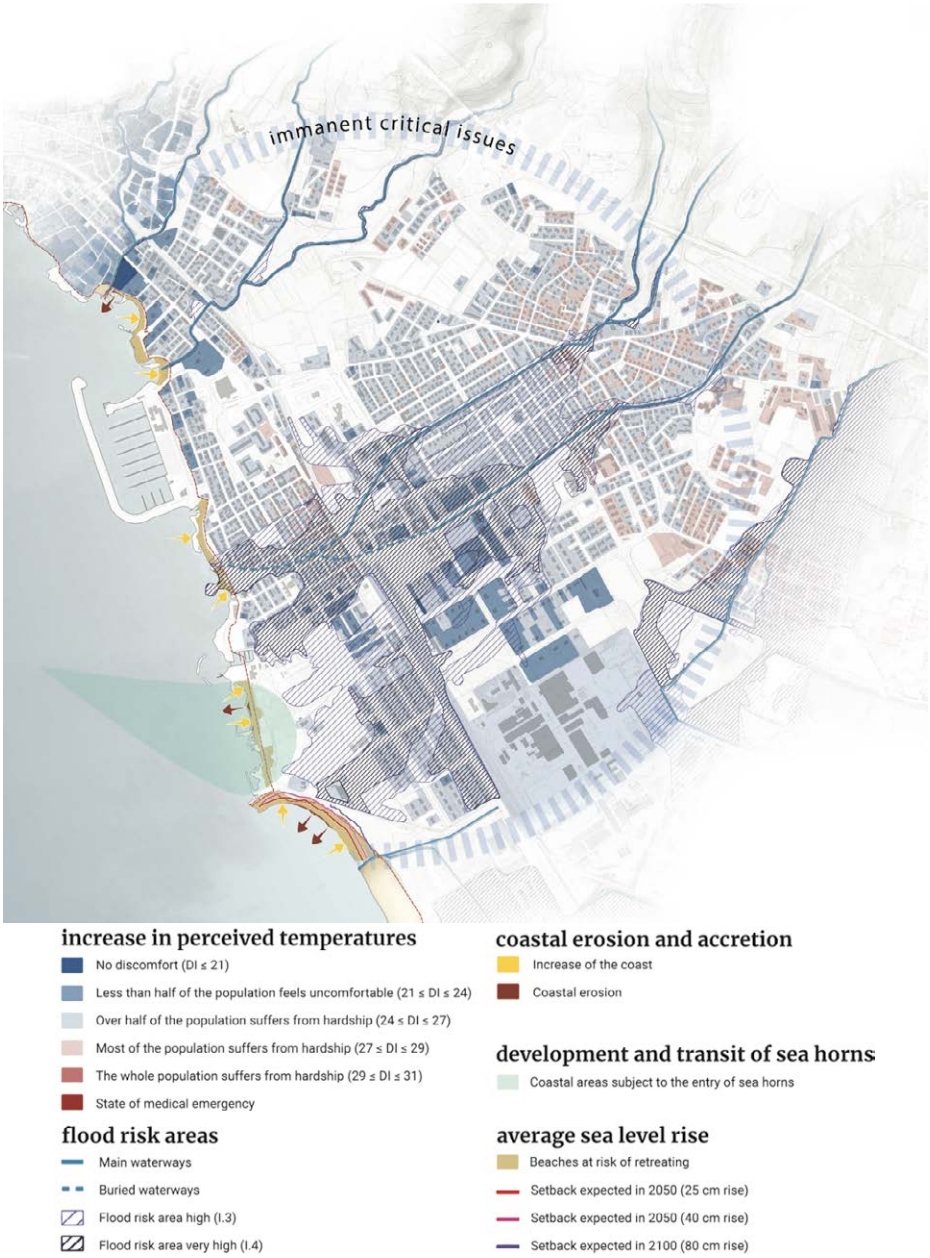

Figure 2 – Immanent critical issues: perceived temperatures (discomfort index), flood risk area, coastal accretion and erosion, sea level rise.

Immanent criticalities, settlement pattern and climate change resilience issues

Unfortunately, the morphological conditions of the hydraulic network and human settlement have evolved over time under completely different environmental conditions. This entails a difficult adaptation, being mostly rigid structures, to the changed conditions. In this context, the re-configuration of space becomes necessary, driving even urban planning to be challenged with innovative interventions to modify physical structures and the existing vegetation system of significant magnitude.

It will be necessary, for example, to re-organise the entire hydraulic system that has stratified over time. The hydraulic network, in fact, will not be (and was not even under the meteorological conditions of the past) able to manage rainfall flows that are significantly different in quality and quantity from those currently being experienced. It will be necessary, therefore, to act by modifying the hydrographical structure, both with lamination basins designed to slow down the flow of water, but also, at times, with the overall re-designing of the network so as to, if possible, increase or deviate the flow that involves the most compact human settlement areas.

The vegetation apparatus, which enriches our cities, will have to be substantially revised, both to avoid, as we have seen, the abatement due to high-energy events (tornadoes) that occur on the coast more and more frequently, and to combat, as far as possible, the growth of heat islands that are increasingly present in this phase of climate change. Vegetation is undoubtedly an effective regulator of ground temperature, although its arrangement must find perceptive relations with the deep identity of the urban configured space, composed of squares, streets, blocks, buildings with their own relational needs. On the other hand, it is also with the reconfiguration of the urban built environment that positive effects can be achieved in controlling ground temperatures. The reorganisation of the built space could take place with systems that provide shade, such as covered pathways, arcades, building protection systems, etc. A different organisation of urban water management could also play an interesting role, with systems for conserving the flowing water resource and its reuse with respect to the possibility of cooling the built environment.

Moreover, town planning must be confronted with socio-economic aspects, for example in the case under study, in the definition of a new model of tourist reception and in the redefinition of the relationship between man and the resources of the system related to bathing, which will see their significant changes. The problem now becomes particularly interesting, given that the management of state-owned maritime areas will have to be reviewed with the application of the new regulatory apparatuses linked to the decrees on competition in application of European Union directives. In this case, it is a matter of finding a functional balance between reception and use of the coast and the sea, which must in any case envisage an overall reorganisation of the system and of the ways of using the resource, which will appear increasingly varied and limited in size over time.

Conclusion

As, albeit in extreme synthesis, has become evident, the studies that have been prepared for the coastal reality of Rosignano Marittimo show that climate change is no longer

just a process distant from local perception, but that on the contrary it has significant effects right in the various territories: the feedbacks from the biosphere take on consequences that were previously unimaginable. From this process, it is necessary to set up a series of activities to modify the forms that constitute the settlement patterns in order to adapt these morphologies towards the modified flows generated by climate change. The operations are substantial and are declined by the concept of urban regeneration. It is therefore not just a matter of managing the emergency, but activating a process of settlement system reconfiguration.

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