SPATIAL CONFIGURATIONS AND FLOWS IN THE MORPHOGENETIC PROCESSES OF SETTLEMENTS. A PLANNING EXPERIENCE ON THE TUSCAN COAST

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Abstract – The relationship between man and the environment that produces resources for life is the minimum dimension, around which the comparison with the dynamics of development that generate the settlement arises. This relationship is the conceptual presupposition to contemporary ecology applied to the territory, in which the settlement welcomes the dimension of territory and cities, developed towards the concepts of sustainable design. Their nature as living beings presupposes an intimate, synergistic relationship in which, historically, they co-evolve in symbiosis, changing from time to time, in order to reproduce themselves in balance with local resources. The disturbance of equilibrium would seem to be triggered by the global dynamics developed; the city, the product of cycles of relations between man and earth, based on the use of fossil energy, is transposed into the city, the product of the capitalist production cycle. The introduction of the new functions of living, working, having fun, moving, organizes spaces, denying the primary basic needs related to the well-being of living such as air, climate protection, water and food.

The effects of climate change are manifested before us and increasingly show the fragility of settlement systems no longer able to manage or better resist the phenomena that increasingly affect them.

The process of morphogenesis of cities and territories has sedimented spatial configurations that over time have lost on the one hand the ability to manage a dynamic balance with the metabolism of the reference environment and on the other hand the ability to activate emotions and feelings for the generation of a well-being of living in a place.

Hence the need to rethink the regeneration of settlements, of patterns that are no longer able to manage the modified flows of energy matter.

The contribution, presenting a research experience aimed at planning on the Tuscan coast, has the general objective of outlining and discussing the specificity of the dimensional categories analyzed of the flows of energy in relation to the structures of the territory.

Scientific discussion on the issue has allowed us to experiment with the application of a cross scale survey methodology in territorial context, in order to analyze and recognize what special configurations of the territory are capable of solving the quality of life in the settlement.

Introduction

The relationship between man and the environment, which produces resources for life, is the minimum dimension, around which the comparison with the dynamics of

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development that generate settlement is born. This relationship is the conceptual presupposition of contemporary ecology applied to the territory, in which the settlement embraces the dimension of the territory and the cities. Their nature as living beings presupposes an intimate and synergic relationship in which, historically, they co-evolve in symbiosis, changing from time to time, to reproduce themselves in balance with local resources. Man's relationship with the reference environment (producer of resources for life) is therefore the dimension around which settlement is generated, a place where it is possible to rethink a correct management of matter-energy flows [3], and the local environment within which a dynamic balance of human activities can be assessed.

The methodological path of work assumes the territory as a living subject [6]. The reading of the city and the territory as living systems, presupposes the existence of a synergic relationship, with which settlement and reference environment co-evolve in a complex symbiosis, which, changing from time to time, in order to reproduce a dynamic equilibrium over time, produces a strong structural coupling [7]. Each living system is therefore unique and highly differentiated, it is not isolated and therefore develops in synergy with the reference environment, transforming itself structurally and reproducing itself in a co-adaptive way [7].

But the management of natural systems, to be considered as natural capital, is based on two basic principles: the speed at which resources are withdrawn must be equal to the speed at which they are regenerated. If a living organism adapts to environmental conditions with structural changes, which change its behaviour in the future, then human settlement in a cognitive way evolves over time, preserving its networked organisational scheme and identity [8]. Therefore, each territory, each urban bioregion, objectively unique, in its being a place of management of its own matter-energy flows, is the local environment of reference for the "unfolding" of human activities that configure spaces. These configurations are merely the codification of the spatial organisation of the inhabitants in relation to the physiological characteristics of the place, i.e. the rules of the composition of space. If biodiversity makes each territorial ecosystem singular and exceptional, then each spatial configuration is unique, since it is an expression of the organizational dynamics of the energies inside the ecosystem itself and a manifesto of the morpho-typological aspects generated, but also a space of relationship between the work of the inhabitants and their environment of reference. The dynamics of matter-energy-information flows regenerates in relation to the context of belonging, continuously transforming the intimate rules to the natural capital that adapts in space in a cognitive way. The evolution of the ecosystem maintains the recognizability of the invariant identity characteristics, i.e. the relations between the rule and the configuration in a place.

But the disturbance of equilibrium seems to be triggered by developed global dynamics, the city, the product of cycles of relations between man and earth, based on the use of fossil energy, is transposed into the city, the product of the capitalist productive cycle. The introduction of the new functions of living, working, having fun, moving, organizing spaces, deny the basic needs linked to the well-being of living such as air, climate protection, water and food. The disturbance of this balance is also increased by the global dynamics that are emerging both in the organisation of the urban environment and in the climate change that is being generated. The parallel manifestation of these two trends generates a fragility to which we are still responding with inadequate solutions, daughters of the emergency.

The contribution proposed in this essay addresses the above issues through the presentation of the research carried out within the collaboration for the definition of the new

Urban Plan (L.R.T. 65/2014) and aimed at the development of adaptive strategies capable of regenerating new homeostatic balances in a coastal territory over time. In particular, the delicate environment of the groundwater of the lowland, considerably corrupted by the presence of nitrates (due to certain uncontrolled anthropic actions) and chlorides (given by the advancement of the salt wedge caused by the huge withdrawals of water from drinking wells for the now unsustainable summer tourist loads) is the starting point on which we propose a first reflection on the themes of the circularity of the matter-energy flows of the territory and the need to govern the tendential closure of the vital cycles of human settlements [2] [5], overcoming those forms of settlement, manifested in the present, scarcely able to absorb the effects that are manifested synergistically between anthropic dynamics and climate change in progress [4].

Materials and Methods

The area investigated in the research study coincides with the administrative area of the Municipality of Rosignano Marittimo (LI) located in the central part of the Tuscan coast. The municipal territory has a population of 30 672 inhabitants and an extension of 120 square kilometres. The study area, hinged along the coast on the barycentre represented by the settlements of Rosignano Solvay and Castiglioncello, includes a flat part extending southwards by the river Fine for about 10 km with a coastal strip characterized by dune and back dune deposits, and a mainly hilly part extending northwards for about 10 km sloping westwards towards the sea with a mainly rocky coast.

In 2018 the Municipality started the drafting of the urban plan and, given the complexity of the commitment required and the strategic nature of the objective to be achieved, required the collaboration of the Department of Architecture of the University of Florence[1]. The research aimed at analysing the settlement load incident on the territory as a topic of discussion in relation to the environmental criticalities highlighted by two studies carried out in parallel with reference to the criticality of underground water resources[2] and ground temperatures[3] [1].

The initial phase of the work first investigated the demographic aspects of the area, aiming not only at the quantitative evaluation of the resident population, but also at the evaluation of the qualitative mutation of the age groups, in relationship to the geographical distribution. The demographic data[4] provided by the Municipality recruited in the research were: overall population; characteristic of the population by age group; foreign population.

[1] Research Coordinator: Prof. Claudio Saragosa. Title: "Lo studio dello Statuto del Territorio del Comune di Rosignano come fondamento della redazione del nuovo Piano Strutturale L.R. 65/2014". DiDAlabs - Laboratory Plans and Projects for the City and the Territory - Research Group: Prof. Claudio Saragosa, Arch. Michela Chiti, Arch. Tiffany Geti, Urb. Maddalena Rossi, Urb. Lorenzo Bartali, Urb. Agata Miccio, Urb. Alessio Tanganelli.

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

[3] 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". Dipartimento di Architettura dell'Università degli Studi di Firenze, coord. Prof. Iacopo Bernetti - Dipartimento di Ingegneria dell'Energia, dei Sistemi, del Territorio e delle Costruzioni dell'Università degli Studi di Pisa, coord. Prof. Stefano Pagliara.

[4] Data granted by the registry office of the Municipality referring to 31/12/2018.

Each of the previous data was investigated bearing in mind: the aggregated data provided by ISTAT in order to guarantee the demographic dynamics over time, i.e. in order to elaborate an idea on the dynamism of the phenomena and therefore on possible trends; geolocalized anagraphic data through the distribution of georeferenced house numbers on the vectorial cartography of the Region of Tuscany[5].

The municipality does not differ much from the emerging demographic phenomena in Italy, one of the oldest countries in the world. If in the second half of the '60s in our country there was the phenomenon of the baby boomer (a showy increase in the birth rate linked to the variations in the economic conditions of the nation closely linked to the phenomenon of industrialisation-urbanisation-economic and cultural growth), in the years closer to today the phenomenon has slowed down drastically until it is reversed.

In fact, today's situation sees a demographic crisis linked to the decrease in births even if, but with problematic implications, there is not a drastic decrease in the population given that we are witnessing a substantial lengthening of life expectancy and a consistent phenomenon of immigration from other nations. In short, with respect to a stability in the quantity of populations there is a substantial qualitative variation in the characteristics of the population as a whole.

Secondarily, the research has analysed the phenomenon of tourism in relation to the spatialization of the receptive structures in the territory. In relation to the last theme, the area of analysis presents itself as a coastal territory and in some periods of the year it becomes an important tourist destination. Analysing the data of the Regional Tourism Observatory[6], with an average of hotel and non-hotel tourist presences, it has been possible to see how the load of tourists is concentrated in the months from May to September.

The analysis carried out distinguishes the high season period from the low season and considering the average monthly presences based on the 2011-2014 average presences both for hotel and non-hotel structures, we can compare two periods at the antipodes of the calendar: January (3282 average presences) and August (190 015 average presences).

But tourism in Rosignano is not simply assessable taking into account only professional structures, which are obliged to declare the presence of arrivals and presences in their accommodation facilities. In fact, it is necessary to be able to estimate also those tourists who, again for tourist reasons, will come to stay in the Municipality for some periods of time, that is, in short, it is necessary to be able to estimate also those tourists who, not staying in professional structures (hotels, campsites, tourist villages, etc.) wish to spend their holidays in houses or property or for rent.

In this case it is, at least so far, a "ghost" dynamic which does not emerge in official statistics but which must be estimated because, of course, it generates a considerable settlement load and requires a higher amount of services than those which must in any case be reserved to the stable resident population and determines a significant impact on environmental resources.

To this end, the analysis carried out was based on the current size of the building stock, with the identification of the volumes that could potentially be used as residences and

[5] The topographical base of origin is the one provided by the Region of Tuscany and updated by the SIT office of the municipality as of 2013. The cartography shows the integration of the topographic database in scale 1:2000 (in the main centres) and in scale 1:10 000 for the rest of the territory.
[6] Data referring to the year 2014.

therefore take on the role of an indicator of the potential settlement load useful to understand the latent capacity of the territory to accommodate additional inhabitants although non-residents.

From the basic data (database of vector files in shape format), the information extrapolated from: DB anagraphic (useful to know the current number of residents for each house number that has been frozen); CTR DB[7] (useful to know the sizing of the properties); DB house numbers (useful to associate anagraphic information to buildings); DB ground floor urban land use (field surveys in order to identify buildings with a ground floor that is not used as a residence); the parameters of DM 1444/68 to estimate the minimum living volume required by law for an individual.

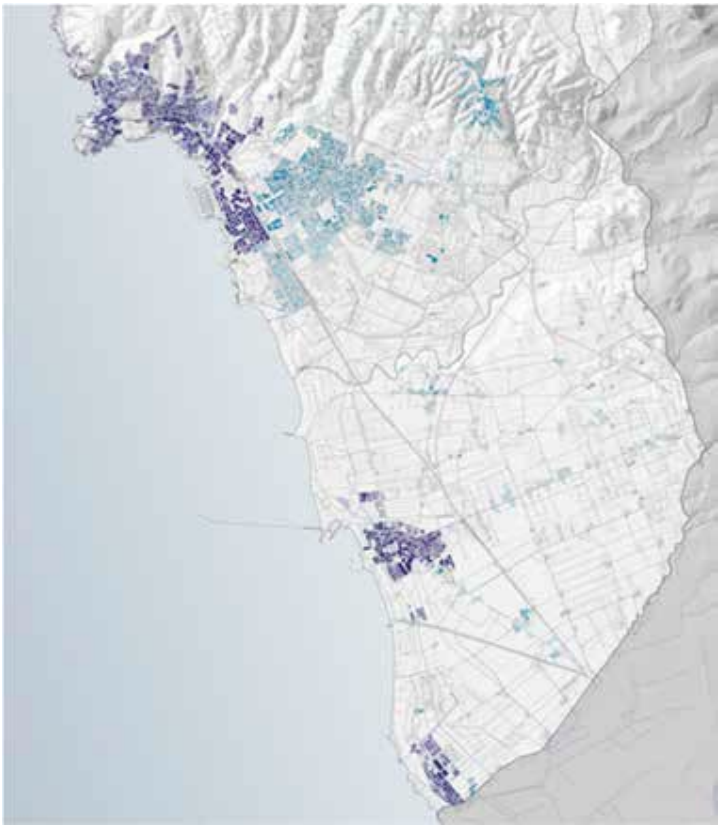

Figure 1 - Distribution of the density of the potential settlement load.

[7] http://www502.regione.toscana.it/geoscopio/cartoteca.html?cmdUrlComp=N4YwXA2qYOQC4HsQGEAWBTEBrGAaAhmMALYIAm6YARAK4B2IG2A8nBgE4DOVu6dc7AJ6QADLirs4AfRD5JCOJnwA6EAICMIrMs6oADj3XjJU%2FMQBGMvp1V8BASyl0aIADbpHAJhHr1PT8bSauzKmlg8AMyBUpwAZgh0ZAjKqPaurtwAurh6CAiukFQASgAqyACCpcwlAKIVPMUl5QCyAEIAkiXtyDUAcgDKAKqV7Q2lyCVFYyX9AGLMvQAizFSZAL5r60AAA&x=664355.56&y=4802362.75&scale=1055832.2731144577

The interpolation of the data made it possible to calculate for each building both the potential volumes useful for living and the equivalent potential inhabitants and this result was transferred to the geometries of the relative lots for a better representation of the phenomenon. The data returned is relative only to an empirical estimate of the potential load of inhabitants of each building, and it is released in a static status that does not make appreciate the oscillations that occur during the year.

To evaluate the phenomenon in a dynamic way, therefore, it is necessary to insert the time variable (evaluate the phenomenon of the population present with a monthly scan).

For a better spatialization of the result and to be able to better distinguish the estimates of the potential population, a distinction has been made between areas with a high or low tourist vocation. For this purpose it seems reasonable to identify: the coastal area, very rich in professional tourist facilities, bars and restaurants, such as the part of the territory where most of the volumes, in summer, will probably be rented to tourists.

These areas are identified in the dark blue cartography; the part of the hinterland that does not have a clear tourist definition, with professional tourist facilities as in the other parts of the territory. In this case it is possible to assume that existing residential buildings not occupied by residents can be used less intensively. These areas are identified in the light blue colour cartography.

The areas coloured in dark blue are those that could potentially be the most affected by tourist phenomena, while in light blue are represented those with less tourist influence.

As part of the process of revising the cognitive framework of the Urban Plan, the Municipality of Rosignano wanted to carry out a detailed hydrogeological study of the portion of the municipal territory occupied by the coastal and alluvial lowlands located south of the main town. This area is home to superficial aquifers, included in the first 20÷30 metres of depth, historically vulnerable in relation to the presence of nitrogen (mainly nitrates) and chlorinated pollutants (NaCl from saline intrusion). The study analysed the hydrogeological component with particular reference to the qualitative and quantitative aspects of the underground water resource constituted by the multilayer lowland aquifer present in the southern part of the municipal territory. This is a vast area of the coastal and alluvial plain, about 40 square kilometres, home to many tourist and agricultural settlements and activities and, above all, almost all of the public aqueduct water withdrawals. Through an extensive measurement and sampling campaign, piezometry, electrical conductivity and chloride and nitrate ion concentrations were determined in selected wells with significant statistical representativeness.

Results and discussion

In relation to the distribution of population density it is possible to note some interesting phenomena. In particular, it is clear that while some urban areas not facing the sea are more densely inhabited, others (such as the hamlet of La Mazzanta or Castiglioncello), which are closer, are sparsely inhabited. This phenomenon is certainly linked to tourism, especially seaside tourism. The coastal areas, even if strongly urbanized, are very little inhabited since the houses are mainly used in the summer period when it is possible to activate the activities related to bathing. A large part of the buildings present can therefore be identified as second homes and therefore used by non-residents only for a few days a year, especially during the summer. The low population density has, in other cases, other

explanations: the morphology of the settlement made up of a layout of a few building volumes in large green areas (model of the garden city); or (perhaps in the historical hillside centres) phenomena of abandonment or underuse of the existing building heritage. In other cases we find a high density due to processes of formation of the settlement that have favoured the residency and the construction of properties as first house on morphologies that provide building objects of considerable size, such as economic and social housing areas.

Using monthly data on the fluctuation of the population (residential and potential) and creating a series of 12 frames one for each month of the year, where the geometries of

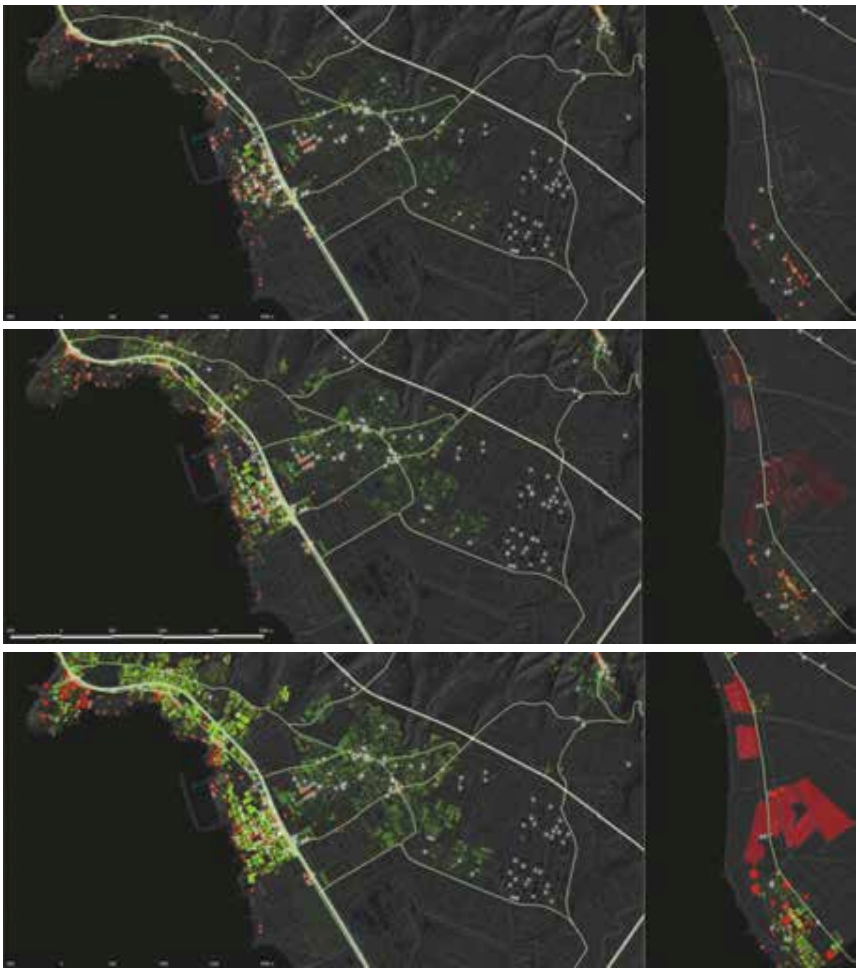

Figure 2 - "Breath of the city" Extract in relation to 3 specific months: January, April, August. It is possible to identify the areas most affected by the increased settlement load. The red dots show the hotel or extra-hotel activities, while the green color show the lots built according to the fluctuation in population density during the course of the months.

the built lots are switched on or off in proportion to a greater or lesser presence of potential inhabitants, it is possible to have a dynamic sequence of how presences, or rather the settlement load, change within the municipal territory during the year.

By defining in this way an equivalence between the potential of each building in relation to the order of magnitude of daily presences for each month, the potential monthly inhabitants that each building could host have been identified.

The graph below shows an estimate of the population that can potentially be hosted during the year. This estimate is obtained by interpolating the potential settlement load redistributed over the various months with the trend of tourist flows in professionalised structures (thus assuming that the tourist flows measured for professionalised structures are similar to those that can also occur for structures used for non-professionalised tourism, second homes). From the graph it emerges that the reception potential in non-professionalised structures (second homes) appears to be considerably higher than the reception, measured, that we have in professional structures (hotels, campsites, tourist villages, etc.). numbers which, although they are estimates, can bring out what the characteristics of the tourism phenomenon in the Municipality of Rosignano Marittimo are.

This estimate of the presence of tourists, which is added to the residents' estimate, allows us to reflect also on the phenomena related to the metabolic balance that must be sought for the urban systems under study.

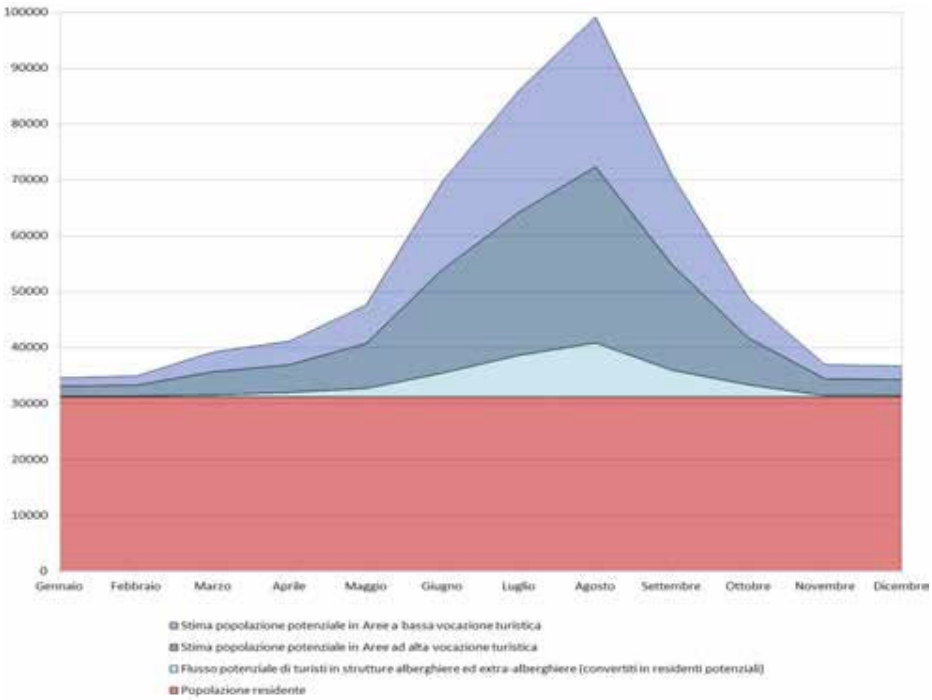

Figure 3 - Estimation of population fluctuation during the year.

From the cartographic comparisons it emerges that in different parts of the municipality we have urban pattern that have led to: low land index; low if not zero settlement of residents; high quantity of volumes normally used to accommodate presences in the summer season. This phenomenon must make us reflect on a system of services and urban planning standards differentiated for the individual parts of the urban fabric (characterized or not characterized by buildings used by residents) and above all on an urban metabolism (water, wastewater, waste, energy, etc.) differentiated over time: subjected to less stress in the autumn-winter-spring period compared to the summer period.

Due to the increase in the summer settlement load according to the methodology presented, it has been possible to understand that the human activities responsible for lowering the soft water table beyond pumping are the reduction of infiltration by soil sealing. Therefore, the lowering of the water table due to higher water withdrawal than the recharge and recall of salt water, could be further aggravated by natural factors such as the decrease in rainfall and sea level rise and at the same time the advance of sea water with intrusion of wedges and salt tongues. In addition, it was possible to observe that a large part of the coastal lowland aquifer was heavily polluted by nitrates with worsening characteristics and in any case with concentrations almost everywhere above the danger threshold. The methodology applied has made it possible to find that nitrates arrive in groundwater by leaching from the soil of excess nitrogen coming mainly from the treatment of agricultural land with chemical and organic fertilizers but also, in a concentrated way, from unpurified civil discharges and from livestock farms.

Conclusion

The proposed method made it possible to geolocalise the data on population distribution in relation to the settlement structure of the territory under examination. This approach has made it possible to highlight and understand the dynamics of real and "ghost" tourist flows, as well as to analyse these phenomena in relation to the effects of climate change and critical issues on water resources. As a matter of fact, the volumetric balance shows a deficit in the annual water balance of the aquifer such as to draw locally within the aquifer 0.68 million m^3/year of sea water and almost all the outputs are equally divided between pumping and drainage of the aquifer carried out by hydraulic reclamation works, with a slightly higher incidence of the latter. At the same time, the distribution of nitrate concentration in the surface water table shows an important worsening of the hydrochemical quality in the central part of the plain (Vada hinterland), with values today higher than the legal threshold (50 mg/l) in a wide area that goes from the coastline to the municipal border, where there are few isolated areas with concentrations below the attention threshold.

The results have shown that the maps produced can provide useful information for spatial planning and therefore contribute to the definition of long-term political and structural strategies and thus to the fundamental decision-making process in an urban planning process.

But if the current settlement model has proved to be fallacious, how is it possible to proceed with the identification of design solutions capable of mitigating critical issues or adapting the model to change? The work represents a first contribution on which to develop a methodology for evaluating those forms of settlement, those spatial configurations capable not only of managing the dynamic homeostatic balance in a renewed structural coupling with

the reference environment, but also of stimulating emotions for those who will perceive such spaces. Future developments in research therefore aim at analysing spatial configurations in order to evaluate their degree of adaptation and therefore their survival, maintaining their identity according to that continuous process of selection (attempts, comparison, elimination of errors) in which the proposed configuration compared with a selective environment in which it unfolds is continuously improved both from the point of view of the capacity to manage the ecological flow and from the point of view of perceptive rightness.

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