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Brief

Coastal areas in transition. Assessment integration techniques to support local adaptation strategies to climate impacts

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Abstract

FEEM Policy Brief

Land–sea interaction dynamics are physiologically regulated by an exchange of matter (and energy) between the anthropic system and the natural environment. Therefore, the appropriate management of land–sea interaction (LSI)contexts should base on those planning approaches which can holistically support coastal development, such as Maritime Spatial Planning (MSP) and Climate Adaptation Planning (CAP). One of the main limiting factors for this integration is the fragmentation of existing databases and information sources, which compose the territorial knowledge framework. Investigations have sought to address the representation and assessment of "wicked" and interconnected coastal problems. The present research focuses on the production of the necessary information to fill sectorial knowledge gaps and to merge the available data into a single framework. The research methodology is based on remote sensing assessment techniques and is designed to be replicated in other coastal areas to integrate CAP and MSP. The output maps

Abstract

are a result of the empirical application of the integration of the assessment techniques and are meant to support local decision-making processes. The result aims at illustrating and highlighting the relationships between climate change impact vulnerabilities their spatial relation to marine resources and maritime activities. This can support effective actions aimed at environmental and urban protection, the organization of the uses of the sea and adaptation to climate impacts. The application of the assessment techniques is developed on a case study in the north Adriatic Basin. The Gulf of Trieste constitutes a representative case study for the Mediterranean Basin due to its transboundary nature. The relationship and the ongoing projects between Slovenia and Italy make the case study an interesting context in which to test and train the proposed integrated planning approach. Therefore, the study investigates local vulnerability to climate impacts, i.e., Urban Heat Island (UHI) and urban runoff, and the existing relationship between the urban fabrics and the marine environment.

01 Introduction

Coastal management is a complex matter assessed through territorial planning disciplines (Meiner, 2010). This paper presents an innovative and integrated approach developed to address two of the primary issues which affect Mediterranean coasts: climate change impacts and anthropic pressures on the marine environment (Borja *et al.*, 2013; Rojas, Feyen and Watkiss, 2013; United Nations Development Programme, 2017). This study aims to demonstrate that the overlapping of sectoral assessment techniques can lead to one integrated knowledge which can effectively support different planning approaches. The research methodology design combines Maritime Spatial Planning (MSP) and Climate Adaptation Planning (CAP) knowledge framework development into a single planning approach. The efficacy of this theory is empirically deployed on the Gulf of Trieste case study, located in the northern Adriatic Basin.

1.1. Coastal Territories and Climate Change Impacts

In general, climate impacts are linked to the physical shape of coastal regions. Local characteristics can amplify the effect of single impacts or can trigger chained ones. In Europe, there are approximately 140,000 km2 of land located 1 meter below mean sea level (European Environment Agency, 2019). Hence it is crucial to address the climate-related coastal vulnerabilities to avoid damages to the economy, society, and the environment. These regions are often characterised by strategic socio-economic assets (i.e. those linked to tourism, fishing, harbours, and shipyards). This makes coasts particularly sensitive to climate change impacts which primarily expose infrastructure and the local populations. Human activities are also responsible for additional pressures on coastal ecosystems. These activities often generate more immediate impacts than those expected from climate change and aggravate existing vulnerabilities. Therefore, the definition of a Climate Adaptation Planning (CAP) must take specific local socio-economic contexts into consideration. International scientific communities (European Comission, 2009; Preston, Dow and Berkhout, 2013; IPCC, 2014; Wang *et al.*, 2020; Wilson and Bhamra, 2020) state that coastal area adaptation should be iterative and dynamic, in recognition of the continuously evolving dynamics present in coastal territorial systems. Furthermore, adaptation measures should consider the local ecology, economy, society, politics and technology (IPCC and CZMS, 1990; Nicholls *et al.*, 2008; European Comission, 2009; Dietzenbacher, Cazcarro and Arto, 2020; Wei *et al.*, 2020).

The Urban Heat Island (UHI) effect and Urban Run-Off are among the more relevant impacts because of their capability to represent the more common and spread effects of climate change on cities ((EPA), 2017). UHI is a micro-climatic alteration which determines an additional risk for the health of urban populations. It is relevant to consider that even a modest climatic event can significantly impact many people and areas with a high concentration of strategic infrastructure. Besides the high exposure of these assets, urban infrastructural networks tend to amplify these phenomena (Musco, 2016). Therefore, the overlap of climatic events and anthropic stresses can impact both the environment and human activities.

1.2. Research Questions

This study aims at demonstrating that the integration of sectoral planning approaches would be a viable first step to generate proactive and responsive territorial governance models. Furthermore, it could lead to an effective and sustainable management of complex phenomena, such as the interrelated dynamics of climate change and human pressures on ecosystems. The research is structured around the following research questions (RQ):

RQ1. How can climate change adaptation trigger and support a successful convergence between "Land and Urban" and "Sea and Maritime" planning approaches in an LSI context?

RQ2. How can terrestrial vulnerability assessment, marine and maritime knowledge frameworks converge to define a multisystemic vision of the territorial priorities?

RQ 3. Does the result between the integration between MSP and CAP in an LSI context favour and generate trans-sectoral strategic action?

RQ 4. Can the ongoing Urban and Regional Planning processes effectively be enriched by the integration of the cognitive frameworks of CAP and MSP?

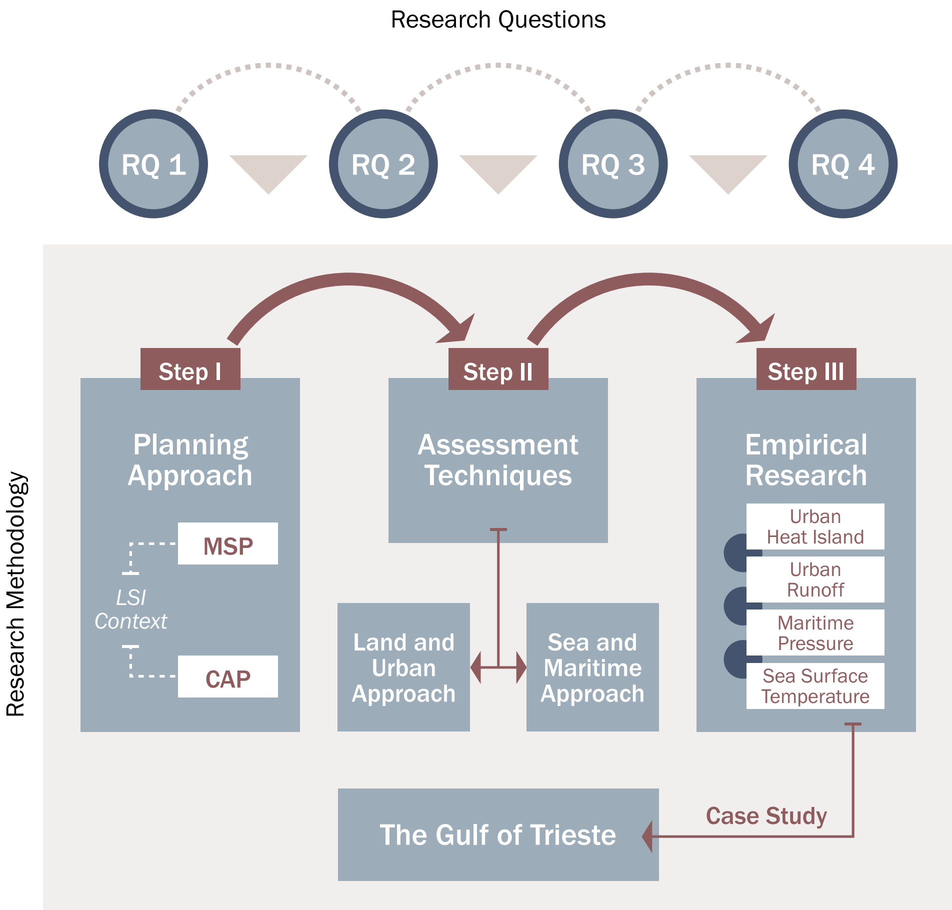
02 Production and consumption

The research methodology is organized in 4 sections aimed at answering the research questions and to support the development of the initial hypothesis: *Research Design; Planning Approach; Assessment Techniques; Empirical Research*.

2.1. Research Design

The initial phase of the research consists of developing the design of the investigation process. Figure 1 presents the workflow through which the research is structured. Research questions RQ1, RQ2, RQ3, RQ4 are integrated into the 3 operational steps of the research methodology and support the made operational decisions.

Figure 1. Research Design Organization



Step 1 defines the planning approach adopted, and the integration between MSP and CAP in an LSI context, to support its implementation perspective. Step 2 presents the investigation techniques for the development of land and sea knowledge frameworks, to produce an integrated and replicable investigation methodology. Step 3 applies the investigation techniques for climate change impacts and marine pressures on the Gulf of Trieste case study. The 3 Steps approach proposes an integration process at different levels which can be replicated in other coastal contexts.

2.2 Planning Approach

This research proposes a planning approach which integrates Climate Adaptation Planning and Maritime Spatial Planning. The integration of these two systems requires shared geospatial information, relevant to multi-temporal, multi-scalar, and multi-disciplinary assessments.

Land-based information is processed by computational and data analysis technologies (vector and raster) from both local geo-databases and raw satellite data. The methodology is based on theoretical and procedural frameworks, tested and validated in scientific literature (Pistocchi, 2001; Pozzer, 2015; Maragno, 2018; Maragno *et al.*, 2020; Maragno, Fontana and Musco, 2020). The approach considers the vegetational, thermal and urban morphological parameters; Normalized Difference Vegetation Index (NDVI); Land Surface Temperature (LST); run-off coefficients (φ). These parameters can be used to describe urban spatial structures and their vulnerability level.

The maritime approach bases on ecological, environmental, and socio-cultural information, and maps economic and territorial assets (see dataset of the Adriplan.eu portal: (Adriplan, 2015). This approach does include some hybrid computational methods, similar to those used by the land and urban approach, for calculations such as the estimate of the Sea Surface Temperature (SST).

The knowledge framework developed through this planning approach aims at allowing a technical comparison between land and sea which can help spatial planning to recognise existing interactions.

2.3. Assessment techniques

This research uses operative processes which can support the knowledge framework development to assess the main issues related to LSI contexts. The "Land and Urban" approach is oriented to assess UHI and Urban Runoff phenomena, due to their relevance both for the extension of their impacts and the interest for these issues of ongoing projects. Specifically, the IPCC and the EU community recognize the importance of these climate change effects and the necessity to support local-to-regional Climate Adaptation Planning processes. Moreover, their nature is deeply linked to coastal urban areas morphological characteristics and their effects consequently impact marine ecosystems and maritime activities. To prove this relation the "Sea and Maritime" approach spatializes the available information about sea uses and correlating the overheating of land through a Sea Surface Temperature (SST) assessment (Syariz *et al.*, 2015; Xing *et al.*, 2015; Ndossi and Avdan, 2016; Cahyono *et al.*, 2017; Saptarini *et al.*, 2017; Fu *et al.*, 2019; Jang and Park, 2019). These techniques are presented in their abstracted form and empirically implemented in the Gulf of Trieste case study to demonstrate their tailored replicability.

2.4. Empirical Research

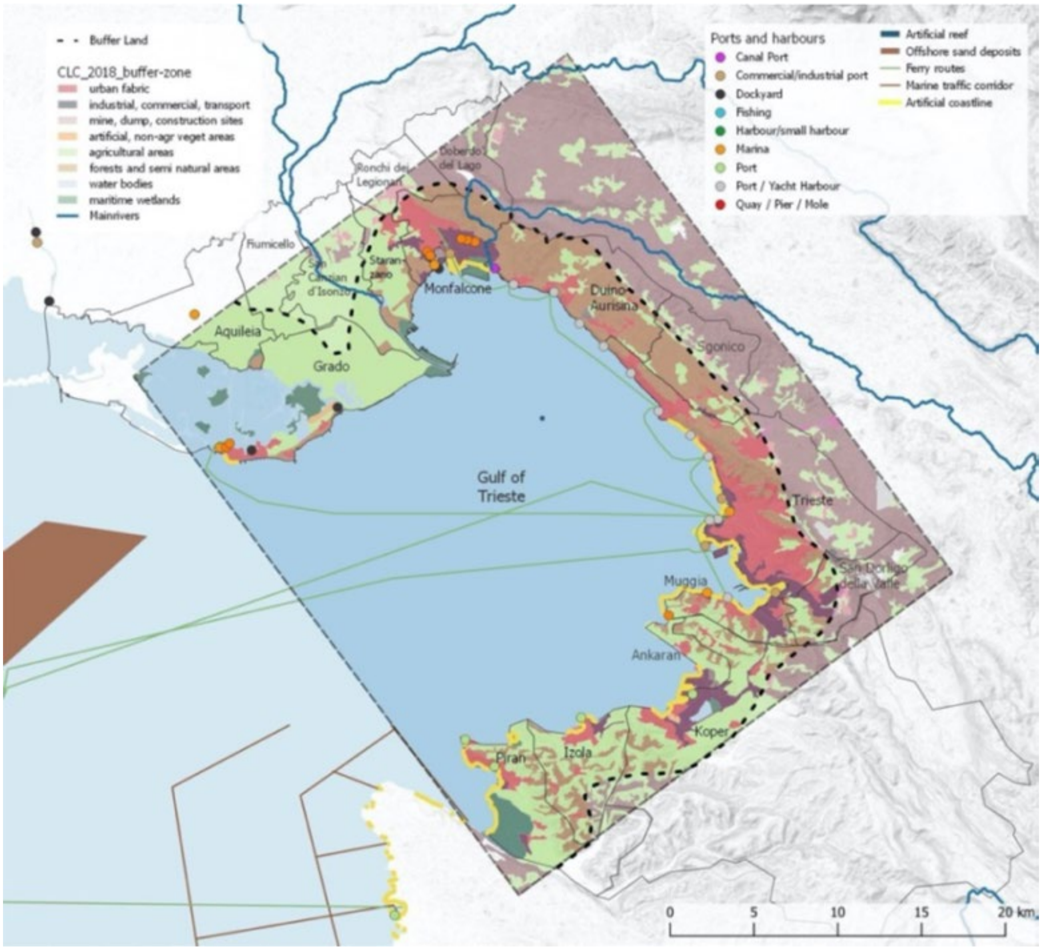
Empirical Research is the third step of the Research Methodology presented in Figure 1. The empirical elaboration has the objective to answer different RQs. The case study choice considers the opportunity to test the possible implementation of the planning approach within ongoing projects aimed at MSP and CAP. Two of the more relevant ongoing projects with a strong connection to LSI planning in the Mediterranean region are the Interreg Italy-Slovenia project "Supporting Energy and Climate Adaptation Policies" (SECAP) and the European Maritime and Fisheries Fund (EMFF) "Towards the operational implementation of MSP in our common Mediterranean Sea" (MSP-MED). The Gulf of Trieste is a study area in both these projects, so the authors' choice is connected to the opportunity of implementing the proposed integrated Planning Approach within these ongoing activities. Moreover, SECAP is oriented to develop a transboundary adaptation strategy and representing a strong and innovative example of CAP on coastal areas. Differently, MSP-MED is a project which has the challenging objective to develop shared Mediterranean guidelines for the Maritime

Spatial Planning based on the concept of the Integrated Coastal Zone Management (ICZM). From this perspective, the Gulf of Trieste case study can be considered one of the best option to implement in the immediate an integrated knowledge framework and can be considerate the appropriate context in which undertaking an integrated Planning Approach among MSP and CAP.

2.4.1. Case Study

The study area locates in the north-east of Italy, at the border with Slovenia and Croatia, and covers the entire Gulf of Trieste (Figure 2). The selected area is representative of Adriatic and Mediterranean general LSI contexts. The research uses mapping techniques to understand regional criticalities and opportunities and present different administrative regions and maritime space (Menegon *et al.*, 2018). The urban areas have a high built-up index, with a high proportion of residential fabric (Morino, 2019; Picciulin *et al.*, 2019).

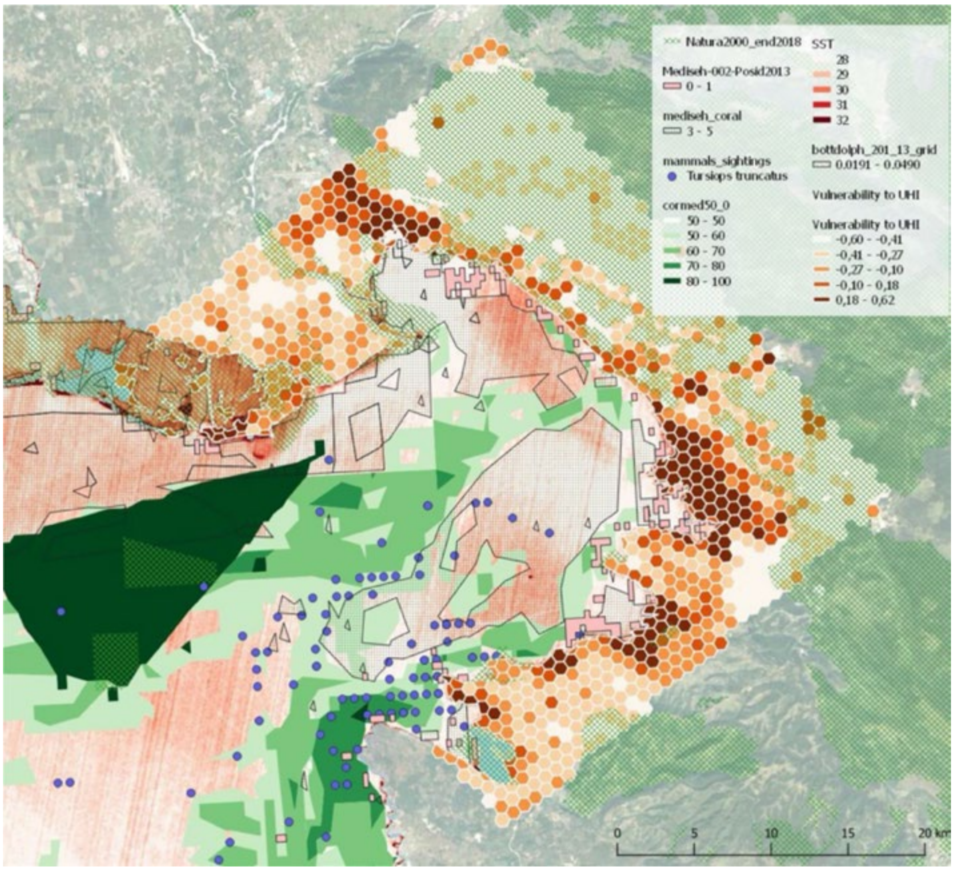
Figure 2. Gulf of Trieste study area



03 Discussion

This study is based on the ADRiatic Ionian maritime spatial PLANning (ADRIPLAN) project's database, which allowed to integrate into the Planning Approach knowledge framework the information about the ecological and biological interconnections of the area. Terrestrial and marine dynamics, analysed through the obtained maps, allowed the consideration of the relationships between these two systems, from a planning perspective increasing the understanding of the LSI context.
The proposed integrated Planning Approach knowledge framework plays a fundamental role in understanding the complexity of the connections between land and maritime contexts. Merging different information allows the implementation of multi-disciplinary and multi-systemic perspectives. Figure 3 represents the results overlapping of the Empirical Research, overlaid to provide an integrated, holistic re-examination of the relationships between the maritime and terrestrial environments of the case study area.

Figure 3. LSI area: systemic analytical map



Conclusion

Responding to the RQs highlighted the opportunities and the implication of an integrated planning approach for coastal areas.

The answer developed for RQs 1 and 2 consists of the development of a territorial unit - the hexagonal grid (Maragno, 2018) - which can contain information with different nature and origin. From this perspective, the authors define a tool through which integrate information that already exists and finalize their output reading. The necessary condition to implement this approach is the will to use the already available tools and to share information among public authorities. This process generates the opportunity to systematically analyse the responses of the marine-coastal environment to the pressures produced by human-driven processes and climate change. The integration process between CAP and MSP demonstrates the need and the opportunity of holistic management of LSI dynamics (Figure 3). The conclusion of this study remains open to new researches and the urgency of a pragmatic understanding of the ongoing processes remains strong.

The Empirical Research (Figure 1) confirms the strategic nature of the work answering to RQs 1 and 3 and presents a tool which can be scaled and replicated on other coastal contexts. The assessment developed on the Gulf of Trieste case study considers synergistically land and sea components. This combination relates different territorial information levels to a specific area and can be updated and modified over time with new technological skills and knowledge. The result achieved by the study can support an integrated coastal planning approach, where local planning processes are supported by summary maps which characterize and facilitate the choice of intervention measures (RQ4). The proposed framework for a new LSI planning model could support i) guidelines to monitor the performance of planning outcomes; ii) methodologies to support environmental protection and the sustainable development of coastal areas; iii) spatial modelling algorithms and remote sensing analysis techniques to support the implementation of cognitive frameworks concerning urban and territorial planning.

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