CLIMATE CHANGE AND ISULAR URBAN COASTAL AREAS IN THE MEDITERANNEAN: RESILIENCE STRATEGIES AND DESIGN TOOLS. THE CASE OF THASSOS TOWN, GREECE

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ABSTRACT

The paper aims to assess the characteristics and trends of climate change impacts on insular urban coastal areas – focusing on the Mediterranean and especially Greece – and explore the planning and design approaches to address them. The study of different urban waterfront/riverfront redesign projects developed to deal inter alia with the climate change impacts unveiled a common body of adaptation and mitigation strategies and the respective urban design tools adopted and/or implemented in various geographical areas, more or less adapted to and inspired of the local context. Based on these findings, a toolkit of resilience strategies and design tools for urban coastal areas was developed. The applicability and adaptability of the toolkit in specific local conditions was tested through a field research and the elaboration of a strategic plan for the protection, adaptation and resilience of the urban coastal zone of the town of Thassos in the island of Thassos, Greece, aiming at its environmental, functional and aesthetic upgrade. The case study revealed that the need to adopt and implement such strategies is urgent, as well as that the adaptation of the toolkit to the local context increased its applicability, effectiveness and value in strengthening the resilience of this insular urban coastal environment.

KEYWORDS

Climate change impacts; Greece; Insular urban coastal areas; Mediterranean; Thassos; Toolkit of resilience strategies and design tools

1. INTRODUCTION

Coastal areas are increasingly facing the climate change impacts, while contributing to the phenomenon due to the degradation of their natural environment. The intense anthropogenic activities and urbanization of the coastal areas put pressure on coastal ecosystems and often result to irreversible alterations in natural landscapes. Most of the world's largest cities are clustered around coastlines with fragile and vulnerable eco-systems. Extreme weather phenomena around the world have long demonstrated that changes in natural systems can have devastating effects on densely populated coastal urban areas [1].

In the Mediterranean, a significant number of towns, cities and metropolitan areas has been historically developed along the coasts, while uncontrolled linear coastal urbanization caused by legal or illegal secondary housing and settlements and tourist facilities has aggravated coastal zones degradation. The

gravity and the ever-increasing scale of impacts make imperative the need for policy making and action in the context of modern spatial planning, urban resilience and sustainable development.

According to Davoudi[2], the role of planning in adaptation of the built environment to climate change impacts is mainly related to: the location of new developments away from risk areas (flood risks and costal erosion); the design and layout of buildings and urban areas which are resilient particularly to heat waves; and the promotion of sustainable water management in new developments.

The last two decades, several urban waterfront/riverfront redesign projects have been elaborated and/or implemented worldwide, aiming inter alia to address the climate change impacts. All over Europe, spatial planning strategies to address the climate change impacts on urban environment are constantly proliferating, mainly developed by northern European cities. However, implemented urban waterfront/riverfront interventions adopting this perspective as a key element of the planning and design approach are still rare, especially in the Mediterranean.

The paper aims to assess the characteristics and trends of climate change impacts on insular urban coastal areas – focusing on the Mediterranean and especially on Greece – and explore the design strategies and tools to address them. Through the study of different urban waterfront/riverfront redesign projects and the field research of the main case study, i.e. the town of Thassos in the island of Thassos, Greece, the main goal is to develop a toolkit of fundamental resilience strategies and respective urban design tools, which with the appropriate adaptations to the local context could be implemented in other insular urban coastal areas with similar characteristics and vulnerabilities in terms of climate change impacts and challenges.

The interest of this study, which focuses on the elaboration of a strategic plan for the urban coastal area of the town of Thassos, lies mainly in: (a) developing the toolkit and testing its applicability and adaptability to the local context; (b) the future use of the research results by further spatial planning or other sectoral studies on the adaptation and resilience of insular coastal areas.

2. METHODOLOGY

The methodology of the study consists of the following: (a) bibliographic review of the characteristics and trends of climate change impacts on insular urban coastal areas, especially in the Mediterranean and Greece; (b) review and critical appraisal of climate change and coastal areas policies and institutional framework in EU and national level; (c) identification and recording of mitigation and adaptation strategies and the respective design tools by climate change impact category, through the examination of urban waterfront/riverfront redesign projects located in different geographical regions; (d) field research in the study area to evaluate the current situation and identify the local problems related to climate change impacts through observation, cartographic and photographic material, and collection of data and archival material from involved stakeholders; (e) evaluation of the field data by the SWOT analysis method; (f) testing the applicability of the toolkit through the elaboration of a strategic plan for the protection, adaptation and resilience of the urban coastal zone of the town of Thassos.

3. RESULTS AND DISCUSSION

3.1 Climate change impacts on Mediterranean and Greek urban coastal areas

Mediterranean has been characterized as one of the most sensitive regions in the world in terms of climate change, as the potential impacts on its coasts are expected to be particularly extensive. This is a consequence of both the location of the region, in a transitional zone between the temperate climate in the middle latitudes and the warmer dry climate of North Africa, and its geomorphological, physiographic and anthropogenic features, i.e.

a closed sea surrounded by mountains and highly urbanized coastal areas. These features also explain the intense spatial and temporal variability of atmospheric and hydrological conditions, as well as the various micro-climatic conditions. Data analysis shows that the Mediterranean region tends to be warmer and drier during the last half of the 20th c., which is associated with increased evaporation and reduced runoff. Climate models also predict a general rise in extreme temperatures by the end of the 21st c. However, the exact spatial distribution of changes in temperature and much more in precipitation remains uncertain. Also, the current rate of coastal erosion, of about 1.2 mm per year, is expected to increase rapidly in combination with the increase of floods in low altitude areas due to rising sea levels [3, 4].

Greek coastline is more than 16,000 klm, the largest percentage of which belongs to insular complexes. Intense anthropogenic activities in coastal areas are amplifying the climate change impacts and their effects, exacerbating the current multiple spatial, environmental and socio-economic problems and creating new ones [5]. Of great significance will be the economic effects, as Greek coastal areas host 90% of tourist infrastructure and activities and 35% of productive agricultural land [3]. In general, negative effects are expected in sectors with significant growth potential (agriculture, tourism, energy, aquaculture, etc.), in natural and cultural capital, in urban, coastal and insular areas, in health, although the effects will not always be of the same intensity and will not apply equally to all regions of the country. In some cases, the estimated climate change impacts might even have positive effects, e.g. extension of the tourist season in Northern Greece, strengthening of the solar potential, etc. [6].

Greek islands are affected by all main climate change impacts, i.e. higher temperatures, changes in precipitation, multiplication of extreme weather phenomena and sea level rise (see Table 1). These impacts are expected to have negative effects on key islands development assets and sectors, such as energy, transport and water supply infrastructure, agriculture, tourism and biodiversity [7].

Table 1. Current and projected climate change impacts on Greek islands [7]

Key climate impacts	***Empirical evidence on climate change impacts***	***Projected climate change impacts***
Higher temperatures	The Eastern Mediterranean Sea is warming substantially, particularly the Aegean and eastern Ionian seas	With a predicted global temperature increase of 2°C, the corresponding warming in the Mediterranean Sea is expected to be between 1-3°C.
Changed precipitation/ Change in precipitation	Mean precipitation has fallen	Total water potential is expected to decrease substantially by between 14 per cent and 22 per cent.
Weather extremes	Warm temperature extremes in the summer period have increased	The number of days over 35°C (labelled as 'heat wave days') on some Greek islands will increase by about 10 between 2021 and 2050.
Sea level rise	Satellite data indicates that the Mediterranean Sea level has risen by 2.6 cm overall between 1992 and 2008	Sea level rise is predicted to reach 0.25m and as much as 1m by 2100. The Greek islands likely to be most strongly affected include Lemnos, Samos, Rhodes, Crete and Corfu.

3.2 Climate change and coastal areas policies and strategies at EU and national level

The concepts of mitigation and adaptation, although distinct in early climate change literature and policy, are for long now considered interrelated and both essential in reducing the expected climate change impacts.

Despite the potential tensions between mitigation and adaptation measures, an integrated approach both in regional and local level and the role that spatial planning can play are widely acknowledged [2,8,9]. Thus, early European climate change strategies and policies focused almost exclusively on mitigation. It is only after the beginning of the 21st c. that national and city resilience strategies have been added to policy agendas, aiming both at mitigation and adaptation.

Studying the relevant institutional framework at international, European and national level, EU is clearly at the forefront of international efforts to fight climate change through its climate, environmental and cohesion policy. During the last two decades, climate adaptation is promoted in EU countries, regions and cities by various means, such as networking (e.g. Covenant of Mayors for Climate and Energy), funding climate-proofing investments (e.g. Bioclimatic upgrading of buildings and open spaces), integration of directives and actions into the core policies of the Member States (e.g. National Adaptation Strategies), launch of relevant research and policy programs and tools (e.g. European Climate Change Programmes, EU White Paper on Adaptation, European Climate Adaptation Platform etc.) [10]. In this context, an emphasis has been also given on integrated protection and management policies for the particularly vulnerable coastal areas, through directives, networking and programmes (e.g. EU Recommendation on Integrated Coastal Zone Management, Protocol on Integrated Coastal Zone Management in the Mediterranean, ENCoRE, OURCOAST, PEGASO, THESEUS), to build on existing capacities, deepen the expertise, develop common novel approaches, and disseminate good practices.

Greece is yet at an early stage regarding the institutionalization of actions to address the climate change impacts and the harmonization with EU directives, a fact that also applies to the institutional framework for the coastal zone management. As for the latter, ICZM objectives were integrated into the various sectoral policies (tourism, urban planning, infrastructure etc.) through the Regional Frameworks for Spatial Planning and Sustainable Development. Though, significant problems arise related to both institutional gaps and lack of implementation tools, and the inherent weaknesses and pathogenesis of spatial planning practice and implementation, especially at local level [11]. Concerning the climate change adaptation policies, the National Strategy for Climate Change Adaptation was completed in 2016, while the process of elaboration and institutionalization of the 13 Regional Plans for Climate Change Adaptation is still in progress.

At the same time, several urban interventions, concerning either urban coastal regeneration or bioclimatic upgrading of public spaces, have been implemented during the last two decades, positively contributing to the goal of climate change mitigation and adaptation. However, they are so far implemented in a fragmentary and often piecemeal manner, without being part of an integrated adaptation strategy at the local level. Moreover, they are based on a spatial planning framework whose tools are not related to any coherent adaptation policies and tools. In fact, only Athens and Thessaloniki have elaborated resilient strategies containing mitigation and adaptation goals and measures – as a result though of taking part in the Rockefeller Foundation Programme “100 Resilient Cities” – the effective implementation of which remains to be proven in practice. Yet, there is a constantly evolving research and literature on climate change impacts assessment on Greek cities coastal zones, highlighting the need for immediate action and adaptation policies and tools implementation[12], on developing methodologies and tools to set intervention priorities in urban waterfronts [13], as well as on investigating the vulnerability of densely populated urban coastal areas and testing the applicability of specific planning and design adaptation tools [14-15].

3.3 A toolkit of resilience strategies and design tools for urban coastal areas

To create the toolkit (see Table 2), about 10 urban waterfront/riverfront redesign projects located in different geographical regions were reviewed, three of which were studied and analyzed in detail: (a) the HafenCity project in Hamburg, Germany; (b) the Big U project in Lower Manhattan, New York, USA; (c) the new quay project in Thessaloniki, Greece. The first two are of the largest-scale interventions of this type worldwide – one implemented and one proposed – the planning and design approach of which focuses mainly on dealing with climate change impacts. The third one was selected because it constitutes one of the largest-scale urban waterfront interventions in Greece, even though it did not clearly aim for this goal.

Table 2. Toolkit of resilience strategies and design tools for urban coastal areas

Mitigation and adaptation strategies	***Urban design tools***
Decrease of CO2 emissions by reducing urban trips and the use of natural resources	Mixed land uses
	Production and use of green energy
	Creation of sustainable mobility infrastructure (public transport, traffic calming, pedestrian and bike routes)
Reduce of energy consumption	Bioclimatic and Energy Building Design
	Use of bioclimatic/ environmentally friendly materials in public space design
	Energy efficient street lighting including photovoltaic lighting poles
Microclimate improvement Reduction of heat absorption and reflectivity of materials, reduction of heat dissipation into the environment	Reduce and/or replacement of hard surfaces, use of permeable paving
	Use of vacant ground floor spaces for public parking
	Creation of open-air green parking
	Increase of green spaces and vegetation
	Creation of greenways/ shaded paths (alleys) along the coastline
	Use of appropriate plant material, resistant to salinity
Flood protection	Elevation of buildings and new infrastructure
	Creation of elevated and/or floating piers/ platforms/paths
	Creation of breakwater islands
	Creation of bridging berms
	Creation of floodable lawns/terrace parks/terrace steps sitting
	Creation of self-regulating tide gates
	Creation of erosion and flood protection infrastructure
	Creation of detachable walls under highway bridges
	Maintenance of retaining walls and embankments
	Public information facilities using technology
Creation of new and enhancement of existing green and blue infrastructure assets	Creation of planted breakwater islands/ bridging berms
	Creation of floodable lawns/terrace parks
	Creation of new, mainly linear, green spaces
	Creation of greenways/ shaded paths (alleys) along the coastline
	Stream rehabilitation and/or daylighting
	Construction of wetland terraces and self-purifying waterscapes
	Use of rain gardens, biofiltration planters and bio-swales
Recycling and reuse	Use of recycled/recyclable materials
	Use of waste-management systems

3.4 Adaptation of the toolkit in the local context: the case of Thassos town urban waterfront

The urban coastal zone of the town of Thassos constituted the case study to test the applicability of the toolkit. The town and its surroundings lie between the mountain and the sea, in a place with remarkable natural wealth and potential. The development of the island since the 1980s has been mainly based on the mass tourism model, in a period when climate change did not concern local communities.

The town is organized in two main parts: (a) the one developed within the limits of the old settlement, which presents an organic urban tissue, medium to high density with medium plot ratio but high building coverage percentage, mixed land uses, lack of open public spaces and ad hoc dispersion of the existing ones, mobility and parking problems, typical morphological building structure of a small-sized Greek city with no traditional character, and dispersed but overgrown archaeological sites; (b) the extension which is being developed on a greenfield based on a mainly orthogonal plan, with low to medium plot ratio and building coverage percentage, residential and tourist land uses, many unbuilt spaces but lack of designed open public spaces.

Between the two parts lies a stream which is officially recorded, mapped and managed. The coastal zone was shaped and structured without any long-term strategy or planning, meeting the needs arising each time. Today, it is characterized by the existence of many different port facilities (ferry port, tourist marina, port of fishing vessels), the proximity of a large part of the urban fabric with the seafront and the existence of swimming shores.

The town and the island already present significant vulnerabilities, which are expected to strengthen by the negative effects of climate change, such as:

- Rising temperatures are already affecting energy and water supply infrastructure with increased demand and costs for cooling and water during the summer, agriculture with increasing diseases in crops and biodiversity with the introduction and reproduction of alien species.
- • Change in the mean precipitation directly affects the surface and underground water, thus reducing the supply of drinking water, a phenomenon intensified during intense tourist activity period, while the risk of fires increases due to prolonged drought.
- Increase in extreme weather conditions affects both maritime transport and port facilities, as well as the coasts themselves by intensifying their erosion; it is also expected in the long term to cause a decrease in tourist inflows due to high risk.
- Rising sea level is expected to cause malfunctions of the port facilities, due to the reduction of their distance from the sea surface.

The elaboration of the strategic plan for the protection, adaptation and resilience of the urban coastal zone of the town of Thassos was based on: (a) an extensive field research and an elaborated SWOT analysis evaluating and classifying the findings by three sectors: natural environment, anthropogenic environment and climate change; (b) the application of the toolkit and its adaptation to the local context. Aiming at the environmental, functional and aesthetic upgrade of the urban coastal zone, the mitigation and adaptation strategies and the respective design tools proposed are presented in Table 3.

Table 3. Adaptation of the toolkit to the case study of the Thassos town

Mitigation and adaptation strategies	***Urban design tools***	***Imple-ment-ation***
Decrease of CO_2 emissions by reducing urban trips and the use of natural resources	Mixed land uses (change of land use in the urban centre from General Residence into Central Functions)	ST*
	Production and use of green energy	MLT*
	Creation of sustainable mobility infrastructure (traffic calming, enlargement of sidewalks, pedestrian and bike routes)	ST
Reduce of energy consumption	Bioclimatic and Energy Building Redesign	MLT
	Use of bioclimatic/ environmentally friendly materials in public space design	ST
	Energy efficient street lighting including photovoltaic lighting poles	ST
Microclimate improvement Reduction of	Reduce and/or replacement of hard surfaces, use of permeable paving	ST

heat absorption and reflectivity of materials, reduction of heat dissipation into the environment	Creation of open-air green parking	ST
	Increase of green spaces and vegetation	ST
	Creation of greenways/ shaded paths (alleys) along the coastline	ST
	Use of appropriate plant material, resistant to salinity	ST
Flood protection	Creation of floating piers/ platforms/paths	MLT
	Creation of breakwater islands	MLT
	Creation of floodable linear terrace park	ST
	Creation of erosion and flood protection infrastructure	ST
	Public information facilities using technology (Center for environmental and climate change education)	MLT
Creation of new and enhancement of existing green and blue infrastructure assets	Creation of planted breakwater islands	MLT
	Creation of floodable linear terrace park	ST
	Creation of new, mainly linear, green spaces	ST
	Creation of greenways/ shaded paths (alleys) along the coastline	ST
	Stream rehabilitation	ST
	Use of rain gardens, biofiltration planters and bio-swales	ST
Recycling and reuse	Use of recycled/recyclable materials	ST
	Use of waste-management systems	ST

* Short-term, ** Medium/Long-term

Comparing Tables 2 and 3, it is evident that all mitigation and adaptation strategies, as well as most of the corpus of the identified design tools could be used in the case study of Thassos. This proves the high degree of the toolkit applicability.

Regarding the mitigation and adaptation strategies, this is rather expected as they were developed to address the climate change impacts on urban coastal areas, which in fact are similar. Their intensity, though, depends on the geographical area, while the vulnerability of the urban area depends on its inherent features, i.e. its form, structure, organisation, etc. [14]. Both these factors, the climate change impacts intensity and the urban coastal area vulnerability, obviously determine the degree of necessity for short or medium/long-term implementation of the strategies. To some extent, the same goes for the respective urban design tools. It should be noted though that the tools that were not adopted are those which would be appropriate either for interventions in more densely urbanized areas with large- scale degraded infrastructure and/or severe water pollution problems or for larger-scale interventions with new urban coastal development.

Thus, the adaptability of the toolkit seems to be related to: (a) the intensity of climate change impacts and the prioritization of the mitigation and adaptation strategies and the respective design tools; (b) the scale of the intervention; (c) the size, form, structure, density and current environmental response of the urban coastal area which determine its degree of vulnerability; and (d) the local implementation and resource capabilities and limitations.

4. CONCLUSIONS

The role of strategic and physical spatial planning, both in terms of mitigation and adaptation is crucial. The study of the design approaches developed to address inter alia the climate change impacts on urban coastal areas unveiled a common body of strategies and tools adopted and implemented in various geographical areas, more or less adapted to and inspired of the local context.

Greece still has a long way to go regarding the taking of measures and actions to address the climate change impacts on urban coastal zones and especially the insular ones. The case study of the town of Thassos, revealed that the need to adopt and implement such strategies is urgent, as well as that the adaptation of the toolkit increased its applicability, effectiveness and value in strengthening the resilience of this insular urban coastal environment.

Analysing a larger number of case studies worldwide could lead to a more complete form of the developed toolkit, as well as to a more

detailed categorization of strategies and tools by geographical area, which plays an important role in determining the climate changes impacts already taken place or expected to take place in the future. Thus, this categorization would be useful in setting priorities and adopting the appropriate planning and design tools by geographical area, while formulating resilience and climate change strategies and policies. Also, establishing a larger sample of case studies could lead to the identification of the local conditions which should be considered in the process of adapting the toolbox in each context.

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