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Coastal use synergies and conflicts evaluation in the framework of spatial, development and sectoral policies

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ABSTRACT

Coastal zones are submitted to pressures, due to population growth and continuous expansion of human activities, which become more intense by the effects of climate change. These pressures lead coastal administrators and stakeholders into taking actions to protect and further develop the coastal zones. Those actions are not always within the framework of spatial plans. Land-Sea interaction is an important factor that should be taken into account during the implementation of Spatial Plans. To this end, assuring the coherence between coastal terrestrial and marine planning is a prerequisite, as the coastal zone is the link between marine and terrestrial space. This paper aims to identify the land and sea uses interactions that result from a series of projects. As case study, the wider area of Heraklion, Crete Island, is considered. In Heraklion area, a series of projects in coastal zone are proposed to be implemented, by different stakeholders operating in the area. The methodology follows, a holistic decision making procedure that include the analysis of alternatives, categorisation and quantification of the consequences and implementation of trade-offs, aiming to introduce a method to assess the interactions between future land and sea uses, identify the land and sea uses interactions by quantifying the consequences of each intervention.

1. Introduction

Coastal zones hold a significant role to the human society and have great environmental, economic, social, cultural and recreational importance (UN, 1992; EC, 2002). Due to their characteristics, they are considered among the most productive, exploited, inhabited and threatened areas (Agardy et al., 2005; Kiousopoulos, 2008). In recent decades many social, economic and environmental reasons, led people to the coast (coastalisation), where the environmental conditions (clima, natural environment, etc.) are qualitatively better (Newman, 2005). Moreover, tourism growth is a key factor of the rapid expansion of built-up areas along the coasts (Kizos et al., 2017). Beyond the socioeconomic benefits, coastal ecosystems contribute also in maintaining global biodiversity (Maes et al., 2005). In Greece the importance of coastal zone is reflected in the fact that most of the population (permanent and secondary residences) and the economic activities are concentrated there (Gounaridis and Koukoulas, 2016; Tsilimigkas and Kizos, 2014).

Coastal landscape and ecosystems are under severe pressure due to their environmental sensitivity and uses concentration. An increasing population in the coastal zone, along with the expansion of the economic activities, threaten even more the environmental and the social coherence of coastal zones (EC, 2002; Luz Fernandes et al., 2017; Tsilimigkas et al., 2016b). Those pressures cause many negative social, economic and environmental impacts such as landscape degradation, land use conflicts, degradation of natural and cultural heritage properties, land waste, coastal erosion, etc. (EEA, 2006; Pili et al., 2017; Stathakis and Tsilimigkas, 2015).

These pressures, enhanced by the effects of climate change and natural hazards, are compromising the viability and conservation of coastal resources and increase socioeconomic risks (EP&C, 2013; Dawson et al., 2009). Although threats to the coastal environment arise from natural hazards, the main triggering factor is the human-made innervations. In the coastal zone, there are two major types of conflicts: (a) conflicts among human activities (user-user conflicts) and (b) conflicts between human activities and the environment (user-environment conflicts) (Kiousopoulos, 2008; Ehler and Douvere, 2009).

The European Union directive "Establishing a framework for Maritime Spatial Planning (MSP)" (Directive, 2014/89/EU) obliges each EU Member State to enact and implement MSP at the latest by 31 March 2021. MSPs must take into account the particularities of maritime areas, existing and future activities and uses and their

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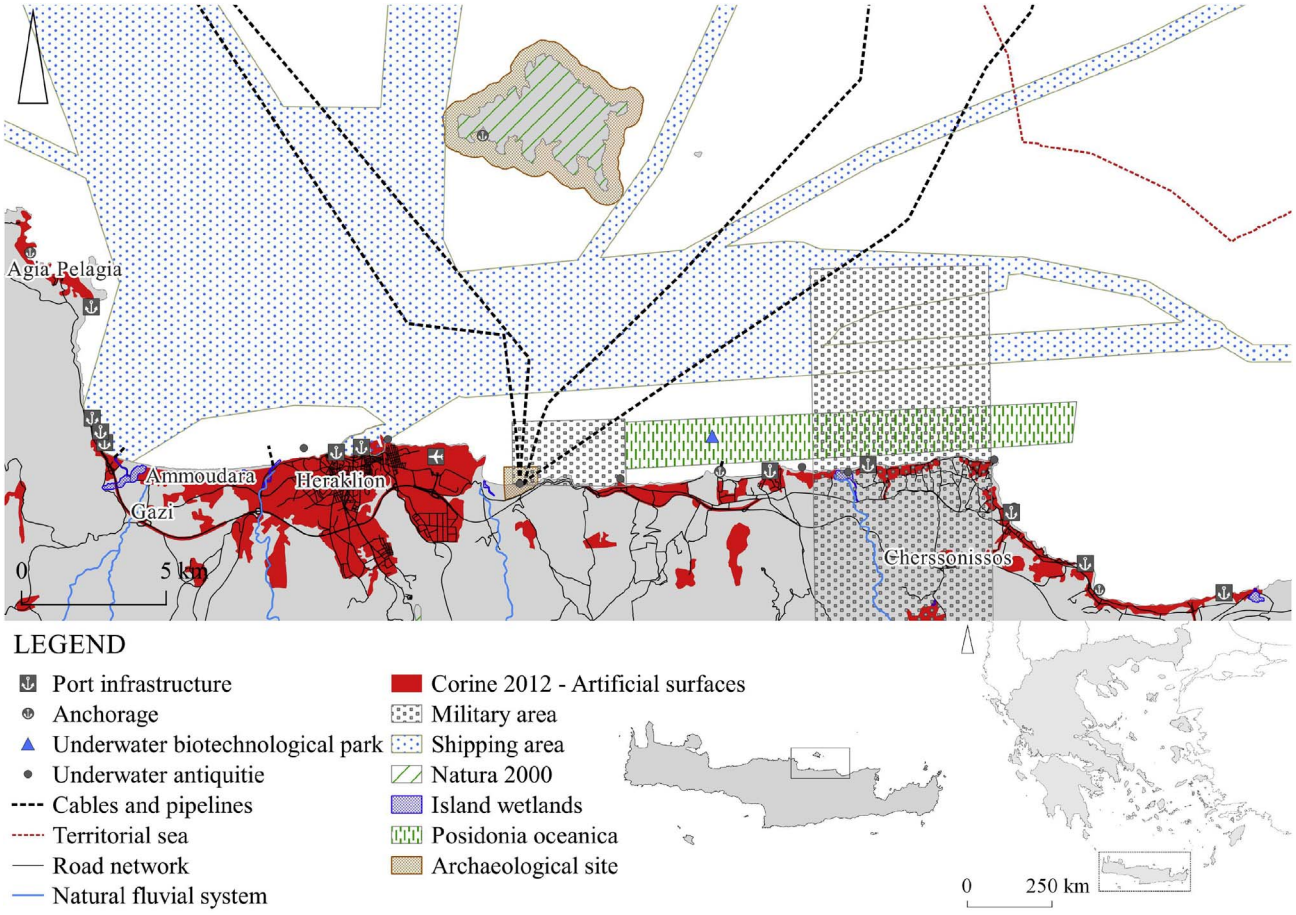

Fig. 1. Case study area.
Source: authors' own analysis

environmental impacts and also Land-Sea interactions. The increasing and uncoordinated activities and uses, in developed and further developing coastal zones, lead to uses competition and to an inefficient and unsustainable use of coastal and marine resources (EP&C, 2013). To that end, a key principle for an effective MSP, is to ensure coherence between terrestrial and marine planning, mainly for coastal zones (CEC, 2008; EP&C, 2014).

These increased pressures, lead coastal administrators and stakeholders in taking measures to address the negative man-made and climate impacts in order to sustain and further develop the coastal zones. Making a decision on implementing protection or development measures is a complex and multi-scale process, which in the process of solving a problem can cause new ones. The complex nature of the coastal zone makes each intervention unsustainable, if all the environmental, social and economic consequences are not explored.

In the past years the decision-making for coastal interventions did not follow well-structured procedures. Due to the lack of such structured processes, decision-making often was implemented without considering all aspects of a decision problem. As result, a group which was assigned to solve a problem, very often had the tendency to focus on a certain solution, which was accepted by the majority of stakeholders (Priem et al., 1995). In order to reduce the bias in decision making and to facilitate the implementation of the most suitable solution, decision making techniques that follow a structure based interaction within the decision-making group have been proposed (Priem et al., 1995). The resolution of a decision-problem implies the need to collect empirical or/and scientific knowledge from the stakeholders' (groups or individuals) that are affected by or/and can influence or/and contribute to the decision (Stratigea et al., 2017). Recently, the engagement of the public in the decision-making processes is noted more and more. Public participation in decision-making problems is crucial not only for data collection but also for setting objectives and priorities that serve stakeholders needs, as well as for responsibility sharing and decision strengthening (Somarakis and Stratigea, 2014).

Decision analysis is a set of techniques and models for analyzing management decisions under various conditions (Blomquist et al., 2010). This is a systematic procedure for transforming complex decision problems into clear decision problems by a sequence of steps (Howard, 1988). Towards this direction, Gregory et al. (2012) define Structured Decision-Making (SDM) "*as the collaborative and facilitated application of multiple objective decision making and group deliberation methods to environmental management and public policy problems*". This method, which is a codified process, can be used to reach a transparent decision when multiple conflicting objectives are present (Thorne et al., 2015; Dalyander et al., 2016).

The study aims to introduce a method to assess the interactions between future land and sea uses, identify the land and sea uses interactions and quantify the consequences arising by the implementation of a series of projects in coastal zone. As a case study area for the implementation, the central northern coast of Crete island was chosen.

2. Materials and method

2.1. Case study

Crete Island is one of the four exclusive insular Regions of Greece. Heraklion city, which is the capital and the larger urban center of the island, is located in the case study. The area of Heraklion presents an

intensive urbanization, which is directed principally along the coast (Tsilimigkas and Rempis, 2017a). Tourism is the pillar of the local economy while the presence of the secondary sector is also important, mainly in proximity with the urban center (EP&C, 2014). Important infrastructures in the coastal zone of Heraklion include the port of Heraklion, which has the third largest passenger traffic, after Piraeus and Rafina, in Greece, with very important commercial activity and the international airport of Heraklion which has very high passenger traffic, especially during the summer. In coastal zone, there is accumulation of uses, with a lot of other port facilities, military areas and protected areas (Fig. 1). Also, Heraklion's coastal zone is a place of cultural heritage, as the Venetian City walls and the Venetian fortress (Koules) are located there, along with historical shipwrecks.

The study area also includes some other urban clusters that receive a particularly large number of visitors during the summer period, such as the areas of Agia Pelagia and Ammoudara and Cherssonissos, in the neighbouring municipalities of Malevizi and Cherssonissos, respectively. These areas are particularly tourism developed and they receive significant man-made pressures. During the winter period, these areas support their economic viability from the agricultural sector, which is highly developed inland.

In previous years, development projects have been carried out in the area, such as (a) restoration of the Koules Venetian fortress, (b) partial restoration of the coastal walls, (c) squares, playgrounds and bike paths for public use. These projects have made the area even more attractive, for residents and visitors, increasing tourism. However, the coastal zone remains saturated, due to the uncontrolled urban sprawl (Tsilimigkas et al., 2016a), but also due to the effects of climate change and coastal erosion. The northern coast of Crete (65.8%) receives intense erosion pressures threatening both the natural environment and the tourism (Alexandrakis et al., 2013a,b; Alexandrakis et al., 2015). More specifically the erosion phenomena cause significant reduction of the width of the coast and also stability problems on the Venetian walls.

2.2. Coastal development interventions

In order to further support the development of the coastal zone, local authorities and stakeholders have proposed several development interventions. In the area under study local authorities have already carried out a series of studies that include technical, feasibility, architectural, coastal engineering and environmental impact studies that where related to (a) coastal protection, (b) urban regeneration and (c) coastal tourism. During the public announcements of each project its official justification was presented. Although, each one of this project studies that proposed a certain intervention does not take into account the other proposals made by different stakeholder. A brief overview of the responsible authority, the feasibility and proposed interventions of each proposed project is presented below based on the contents of the relevant studies, as they are:

(a) The Municipality of Malevizi in order to restore and protect the coastline along the waterfront in Agia Pelagia which receive a significant large number of visitors during the summer period has proposed a beach nourishment project with of a total length of 450 m as well as the construction of breakwater (70 m) (Pr1 – Named as 'Study of Agia Pelagia coast protection project') ['Meléti érgon prostasías tis aktogrammís Agías Pelagías', in Greek].
(b) The Municipality of Heraklion in order to protect the Venetian walls and the restore beach areas in the vicinity which are degraded due to coastal erosion, has proposed beach nourishment projects (180 m and 190 m), as well as the construction of breakwaters of a total length of 700 m (Pr2– Named as 'Study of the preservation of the Venetian walls by waves action') ['Meléti proastasías ton enetikón teichón apó ti drási ton kymáton', in Greek].
(c) The Municipality of Malevizi in order to upgrade the coastal front of its most popular beach, which receive a significant number of visitors during the summer period has proposed the regeneration of the Ammoudara area with a total length of intervention 3.7 Km (Pr3 – Named as 'Study of Amoudaras coastal front regeneration') ['Meléti ergon anaplasis paraliakou metopou Ammoudaras', in Greek].
(d) The Ministry of Tourism, in cooperation with the Heraklion Port Authority, in order to upgrade the port infrastructure of the wider region and enhance maritime tourism has proposed the creation of a tourism marina (capacity of 400 berths) in the bay of Dermatas, within the Venetian walls (Pr4– Named as 'Study of Heraklion tourist port development in the bay of Dermatas') ['Meléti anáptyxis touristikoú liména irakleíou ston órmo Dermata', in Greek]. This project has spatial overlap with Pr2 in the bay of Dermata.
(e) The Heraklion Chamber of Commerce in order to enrich tourism product and enhance tourism revenues has proposed the creation of a diving park in two potential locations, Agia Pelagia or Cherssonissos (Pr5 and Pr5′ - Named as 'Study on the creation of a diving park on the northern coast of Heraklion') '['Meléti gia ti dimiourgía katadytikoú párkou sta vóreia parália tou Irakleíou', in Greek].

The locations of all these projects are shown in Figs. 2 and 3.

2.3. Spatial, development and sectoral policies

In the National Spatial Planning and Sustainable Development Framework (NSPSDF) it is noted that the coastal and insular areas are under high pressure due to accumulation of uses, making the implementation of an integrated spatial planning framework necessary for the sustainable management and the spatial organization of these areas. In the Region of Crete, the dipole Heraklion – Chania, as it is defined in NFSPSD, is considered as a primary development pole at a national level. In this direction, a further enhancement of the dipole in the fields of higher education, research-technology, sport and health, holds. While by developing a wider dynamic dipole the prefectures of Rethymno and Lassithi will be influenced. Development targets include (a) tourism, combined with the promotion of important local, natural and cultural resources, (b) primary sector, (c) processing activity and distribution of products, (d) transport, with the development of airport and port infrastructures of national or transnational importance, in Heraklion and Chania, (e) enhancement of the interconnection of Heraklion and Chania with the metropolitan center of Athens and other city centres (OGG, 2008a).

The Special Framework for Spatial Planning and Sustainable Development (SFSPSD) for Aquaculture (OGG, 2011) does not permit large concentrations and organized massive zones of aquacultures around Crete. While for the wider area of Heraklion, the establishment of an aquaculture hatchery, packaging and production facilities for unprocessed fishery products are proposed. The SFSPSD for Renewable Energy Sources (RES) (OGG, 2008b) does not included Crete in Wind Priority Areas. Regarding the exploitable hydroelectric potential, the water district of Crete has a limited potential. The SFSPSD for Tourism (OGG, 2009a), beyond the directions for the tourism development model in the coastal zone, promotes the development of marine tourism (cruise, yachting, diving, fishing) as alternative form, aiming in tourism season extension and competitiveness improvement. The SFSPSD for Industry (OGG, 2009b) considers Heraklion as an area, where industry can be developed, complementary to other activities. While it discourages industrial units in a zone closer to 350 m from the shoreline, The Regional Framework for Spatial Planning and Sustainable Development (RFSPSD) of Crete (OGG, 2003a) ranks Heraklion as 1st level residential center and the administrative capital of the Region. Regarding the residential development, this framework aims to limit the expansion of residential uses, which function against agricultural, forest or other protected areas. To this end, regulations that favors the

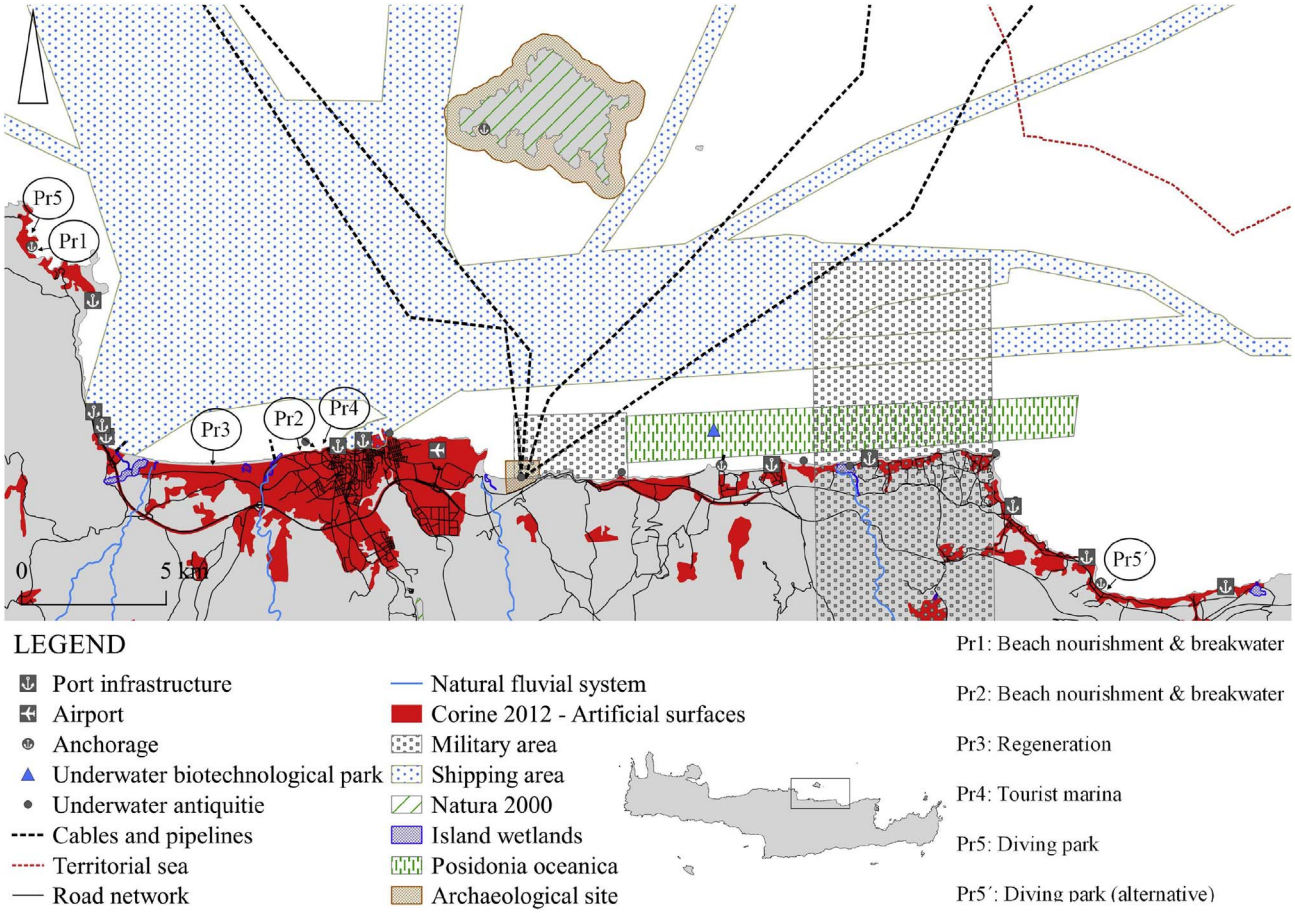

Fig. 2. Coastal development interventions in the central northern coast of Crete.
Source: authors' own analysis

construction outside the urban planning zones should be suspended as a priority in coastal zones, while at the same time initiatives should be taken to improve the living quality in urban and peri-urban areas.

Regarding the economic development, the RFSPSD proposes the development of alternative forms of tourism, such as marine tourism. Also, to balance the distribution on the island of the quality tourism, in order to extend the tourism season and reduce the pressures on the high developed areas. Concerning the maritime transports system, guidelines for functional and aesthetic improvement of the main ports gateways of the island are proposed.

The General Urban Plan of Heraklion characterizes the region of the Venetian walls as protected zone of sites of historical archaeological interest. Also, the coastal area of Ammoudara is characterized as an area to be protected and promoted area (OGG, 2003b).

In the Partnership Agreement for the Development Framework (PA) 2014–2020 (MDC, 2014), which is the main strategic plan for the growth in Greece, it is noted that the opportunities arising from the maritime activities are of strategic importance for the economy. Maritime and coastal tourism, fishery and aquaculture, wind energy are already sectors with significant contribution to economy. However, more opportunities are identified in further developing (a) blue energy infrastructures and use, (b) marine ecosystems protection, (c) fish shelters development and (d) regeneration of fish population. Additionally, fishing areas can be used by marine tourism activities, promotion of the Navy culture and marine natural resources.

Especially for the coastal zones, the objectives are: (a) the focus of tourism on high-quality demand, (b) the link of new forms of tourism to the dominant model, (c) the mitigation of seasonality and the link to cultural and environmental resources, (d) the assurance of resources efficiency and (e) the prevention of risks from climate change. In order to manage the increasing number of marine and coastal activities, to protect the marine environment, to avoid conflicts of use, the implementation of Marine Spatial Planning and Integrated Coastal Zone Management (ICZM) is a prerequisite (MDC, 2014).

PA 2014–2020 comprises 20 Operational Programmes (OP), 7 Sectoral and 13 Regional. The OPs contain thematic objectives, investment priorities and specific objectives which aim to (a) upgrade the urban environment, to (b) protect the natural and cultural environment, to (c) prevent and treat the effects of climate change and natural disasters, to (d) upgrade and develop the transport infrastructure and to (e) develop tourism with a focus on alternative forms of tourism. All the above are included, specified and quantified in the Regional OP of Crete (MDC, 2014).

2.4. Methodology

Although the proposed interventions did not considered the other projects, a holistic approach, in assessing their relation and effects, is adapted, as all the coastal development projects are included into a single functional coastal zone. In this study, the interaction between current state and future land and sea is evaluated under a Structured Decision-Making. The steps for applying a SDM in a collaborative context are (a) identification of the Problem, (b) clarification of the Objectives, (c) creation of Alternative management actions, (d) estimation of the Consequences and (e) implementation of Trade-offs. Based on the trade-offs new alternatives arise and are examined again in steps (d) and (e). The final decision is taken step 6, as the product of all trade-offs. The flow chart of the SDM is presented schematically in

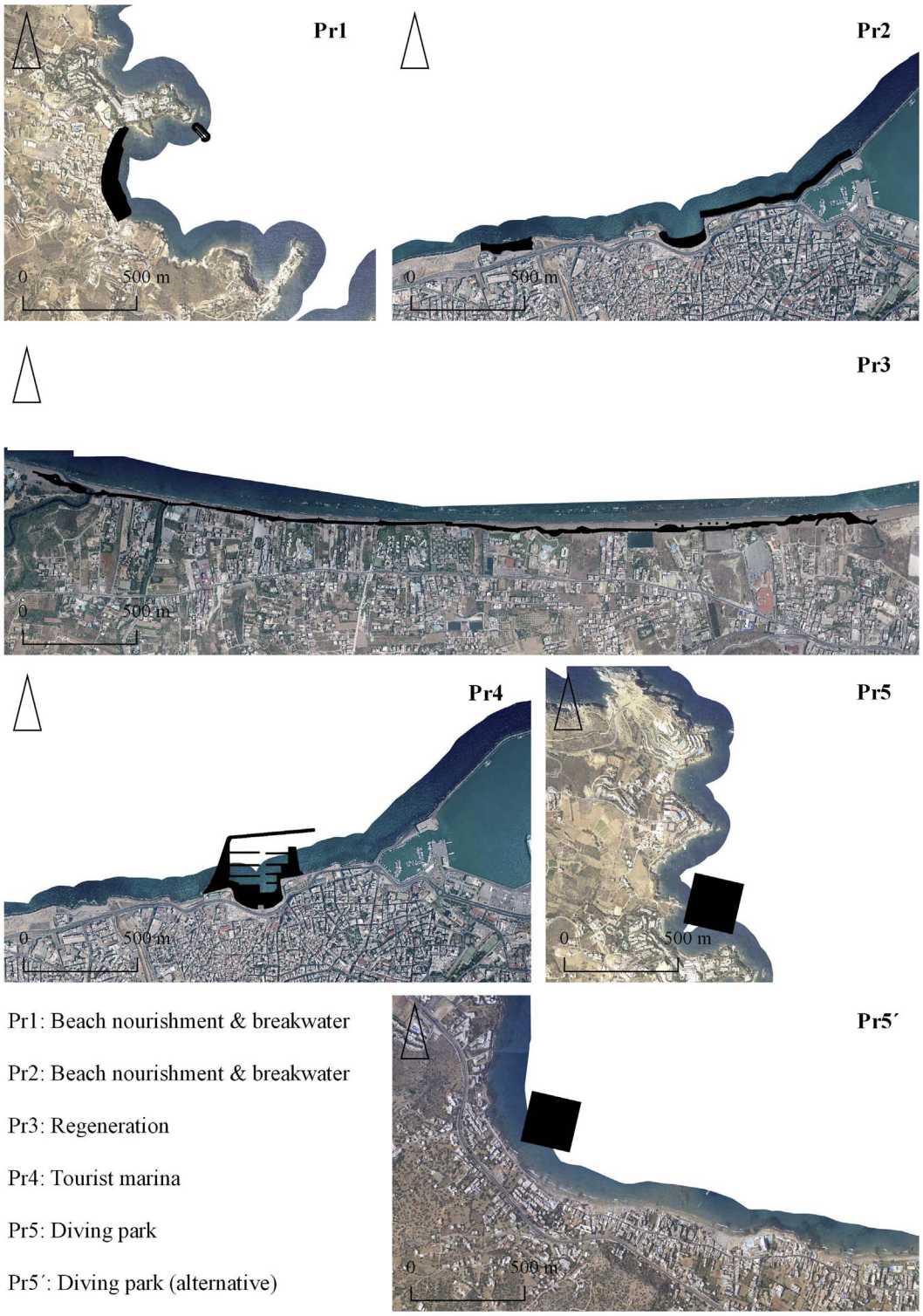

Fig. 3. Proposed projects.
Source: authors' own analysis

Fig. 4. This formal process is known as PrOACT (Hammond et al., 1999).

This study is a proposal for adopting a methodology as part of participation procedures in decision making in order to assess the interactions between future land and sea uses, identify the land and sea uses interactions and quantify the consequences arising by the implementation of projects in coastal zone. In order to have real data that are related to actual problems and stakeholder needs, predefined and already studied interventions where considered. The aim was to indicate what could be done differently if a holistic approach was followed. For this reason only the authors of this paper participated in the process of applying the method. More specifically, four people participated and worked as a group. These are two researchers specialized in spatial planning issues and two researchers specialized in coastal management and coastal erosion issues. The group analysed all related studies that were already implemented for each project in order to

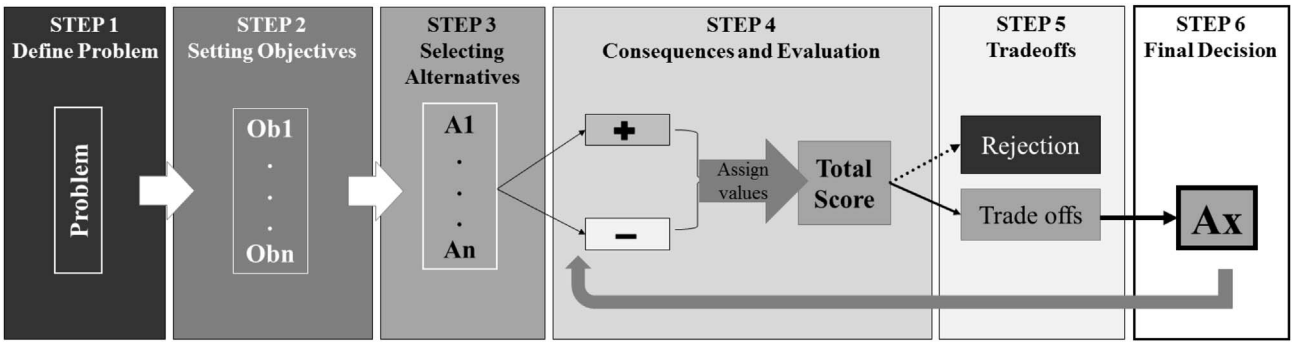

Fig. 4. Schematic representation of the methodological approach.
Source: authors' own analysis

identify and supplement the consequences tables.

2.4.1. Problem definition

The first step facilitates the definition of the problem. Formulation of a question, which reflect the key elements of the decision, is the foundation of a SDM (Thorne et al., 2015). The documentation of each project feasibility, according to the relevant studies, indicated that common goal of the all proposals was to upgrade the coastal zone. What was deferent in each study was the reasons and the approach, in order to achieve the environmental, economic and social benefits. Based on the justification of each intervention, the question that arises and is include in all feasibility studies (P) is: "Can the proposed intervention projects of the wider coastal area of Heraklion contribute to the achievement of environmental, economic and social goals?".

2.4.2. Objectives

Clarification of the objectives is another fundamental step for making decisions. The objectives must answer questions such as "what I want to achieve?"; "what are the problems to be addressed?"; "what is the vision?". The main objectives can be summarized as: the protection of the Venetian walls (Ob1), the aesthetic improvement of coastal zone (Ob2) and tourism development (Ob3). Those were derived by analysing all relevant studies of each intervention. These three objectives answer the above questions for each project and from which objectives and feasibility are highlighted and represent the vision for the study area. Any proposed intervention, based on its feasibility documentation, seeks at least one of the above objectives. More specifically (a) Pr1 pursues Ob2 and Ob3, (b) Pr2 pursues all objectives, (c) Pr3 pursues Ob2 and Ob3, (d) Pr4 pursues Ob3 and (e) Pr5 or Pr5′ pursues Ob3.

2.4.3. Alternatives

The third step is to identify alternative actions for the achievement of the objectives. In this study, the five interventions are considered in a unified manner, even though they have been proposed as individual solutions by different stakeholders, as is apparent from the relevant studies of each intervention. The "No action" (A1) alternative is examinated in order to understand the consequences of maintaining the status quo. The second alternative (A2) is the implementation all projects without Pr4, which has a spatial overlap with the Pr2 in the area of Dermata bay. The third alternative (A3) differs in relation to A2 at the location of the diving park. The fourth (A4) and fifth (A5) alternatives include the implementation of all projects. The location of the diving park is also their unique difference. The projects with no spatial overlap (Pr1, Pr3 and Pr5 or Pr5′) are consider in all alternatives.

2.4.4. Consequences

The consequences used are the results of the Environmental Impact Studies of each project and are analysed in the next step. In order make the analysis, it is necessary an influence diagram for each alternative to be created, aiming in exploring their impact on the objectives. The influence diagram, is used to link the problem, the objectives and the alternatives and also contributes to the visualization of the results. The quantification of the consequences is implemented by an expert qualitative technique, by assigning values for the likelihood and severity of each consequence, with the use of a qualitative environmental risk assessment matrix. This technique is used to estimate the sustainability of various project forms (Azapagic et al., 2006; Liu et al., 2017). As positive consequences are considered those that serve the objectives of the project, while those which have a negative impact are considered negative (Table 1). The consequence score is the sum of Likelihood and Severity (SC = L+S). The overall score of each alternative is the sum of the values from each consequence (Equation (1))

$$SC_{Ai} = \sum_{0}^{n} C_n \quad (1)$$

with SC the score of the alternative; Ai: the alterative; Cn the consequence score; n: the number of consequences.

Due to the small number of participants in the application of the proposed method, the quantification of each consequences is the result of a group discussion and decision making. In assessing and expressing opinions, the contributors were based on all the studies that have been carried out for each project. In other cases, where the number of parties involved are larger or rating is more difficult, the use of a questionnaire can be considered.

2.4.5. Trade-offs

Adding weight and priority to the objectives is crucial for reaching the final decision (Thorne et al., 2015; Converse et al., 2013). In the trade-off step, modifications of the alternatives are made in order to minimize the negative consequences. When there is more than one proposal from different parts for interventions in an area, conflicts are expected to emerge. In this work the priorities have been defined based not only on the objectives of each proposal but also on their social, environmental and economic impacts. In this step, new alternatives are arising. The new alternatives, in their turn, follow again the procedure of steps 4 and 5, in order to evaluate their consciences. This loop in the procedure can repeat until there are no more alternatives that can serve

Table 1
Consequence likelihood and severity matrix.

		Severity		
		1	2	3
Likelihood	1	2	3	4
	2	3	4	5
	3	4	5	6

Fig. 5. Coastal erosion in Dermata bay.
Source: authors' photo

Table 2
A1 consequences score.

Consequence		A1		
		L	S	T
Environment	Non altering the physiogeografic of the coastal zone	3	3	**6**
	Aesthetic degradation	-2	-3	**-5**
	Coastal erosion	-3	-3	**-6**
	Subtotal 1	**-2**	**-3**	**-5**
Economy	Infrastructures degradation	**-2**	**-3**	**-5**
	Reduction of visitors	-2	-3	**-5**
	Loss of income	-2	-3	**-5**
	Loss of jobs	-2	-1	**-3**
	High costs to repair damage (recurrent)	-3	-3	**-6**
	Subtotal 2	**-11**	**-13**	**-24**
Society	Erosion of Venetian walls (cultural heritage degradation)	-3	-3	**-6**
	Subtotal 3	**-3**	**-3**	**-6**
TOTAL		**-16**	**-19**	**-35**

the objectives to be considered.

3. Results

All alternatives were analysed based on the above methodology in order to estimate the likelihood and severity of each consequence. A1 alternative, which is implemented by maintaining the status quo was analysed, this also provided information for the current state of the study area. A1 alternative, presents a positive consequence which can be described as the non-change of the natural and urban environment, by minimizing interventions. Although, it presents a significant number of negative consequences. There is an increased likelihood for the wave induced erosion phenomena to continue, while the wave impact of the coastal zone of the Heraklion will result in structural instability of the Venetian walls and coastal infrastructure (Fig. 5). As the Venetian walls are the city's landmark, with high historical and tourism value, their degradation will result to significant negative socioeconomic effects. Over the years, this will lead to a reduction of tourism attractiveness, loss of income, loss of jobs and additional costs in damages repairs. All of the above will contribute to the overall aesthetic and functional degradation of the coastal urban landscape of Heraklion.

Moreover, the “Do nothing” scenario will have significant negative social, economic and environmental impacts to Malevizi and Cherssonissos. In Agia Pelagia, the social and economic prosperity are based on the exploitation of bathing beaches. The reduction of the width of the beach, due to erosion, except the land loss, reduces the beach capacity and therefore loss of income from tourism. In Ammoudara area (Malevizi), the unregulated urban sprawl has created a significant aesthetic degradation of coastal zone degrading the offered tourism product (Alexandrakis et al., 2013a,b). Finally, in Chersso-nissos, the current state of development has reach the upper limit in natural resources exploitation and infrastructure development and cannot contribute to further growth. Therefore, this alternative does not contribute in to achieving the objectives. Instead, A1 alternative, as it corresponds also to the current state of the area, highlights the need for interventions. The quantitate representation of the consciences like-lihood and severity of A1 alternative is presented in Table 2.

A2 alternative is represented by the implementation of Pr1, Pr2, Pr3 and Pr5. A2. This alternative presents many positive consequences re-lated to the natural and human environment. By implementing this alternative, the likelihood of protecting of the Venetian walls and of the coastal infrastructures is increasing. Also, the restoration of the coast, through the creation of bathing beaches, increases the aesthetic value of the coastal area, resulting an increased potential in attracting visitors and further development of the tertiary sector. This increase will by create new jobs, which is a significant concern of stakeholders. Job creation and increase of income will have a short time effect also during the construction phase. Although, A2 alternative has also negative consequences. Projects implementation entails environmental de-gradation for the construction period. Moreover, the creation of bathing

Table 3
Consequences score of A2-A5.

Consequence		A2			A3			A4			A5		
		L	S	T	L	S	T	L	S	T	L	S	T
Environment	Aesthetic upgrade	3	2	**5**	3	2	**5**	3	1	**4**	3	1	**4**
	Environmental degradation during the construction	-2	-1	**-3**	-2	-1	**-3**	-3	-2	**-5**	-3	-2	**-5**
	Erosion of Ammoudara coast	-3	-3	**-6**	-3	-3	**-6**	-3	-3	**-6**	-3	-3	**-6**
	New projects to address Ammoudara erosion	-3	-3	**-6**	-3	-3	**-6**	-3	-3	**-6**	-3	-3	**-6**
	Degradation of seawater (marine traffic, bathers wastes)	-2	-1	**-3**	-2	-1	**-3**	-2	-3	**-5**	-2	-3	**-5**
	Subtotal 1	**-7**	**-6**	**-13**	**-7**	**-6**	**-13**	**-8**	**-10**	**-18**	**-8**	**-10**	**-18**
Economy	Protection of coastal infrastructures	3	3	**6**	3	3	**6**	3	3	**6**	3	3	**6**
	Upgrade of port infrastructures	0	0	**0**	0	0	**0**	3	2	**5**	3	2	**5**
	Tourist product enhancement	3	2	**5**	3	2	**5**	3	2	**5**	3	2	**5**
	Increase in visitors	3	3	**6**	3	3	**6**	3	3	**6**	3	3	**6**
	Increase of income (during the construction)	2	2	**4**	2	2	**4**	2	3	**5**	2	3	**5**
	Job creation (during the construction)	2	2	**4**	2	2	**4**	2	2	**4**	2	2	**4**
	Increase of income (after the construction)	2	3	**5**	2	3	**5**	2	3	**5**	2	3	**5**
	Job creation (after the construction)	2	3	**5**	2	3	**5**	2	3	**5**	2	3	**5**
	Costs of interventions	-3	-2	**-5**	-3	-2	**-5**	-3	-3	**-6**	-3	-3	**-6**
	New needs for infrastructures (eg. parking, transport connections)	-3	-2	**-5**	-2	-2	**-4**	-3	-3	**-6**	-3	-2	**-5**
	Supplementary costs for new infrastructures	-3	-3	**-6**	-3	-3	**-6**	-3	-3	**-6**	-3	-3	**-6**
	Supplementary costs to address Ammoudara erosion	-3	-3	**-6**	-3	-3	**-6**	-3	-3	**-6**	-3	-3	**-6**
	Tourist flows change between antagonizing areas	-2	-2	**-4**	-1	-1	**-2**	-2	-2	**-4**	-2	-1	**-3**
	Subtotal 2	**3**	**6**	**9**	**5**	**7**	**12**	**6**	**7**	**13**	**6**	**9**	**15**
Society	Protection of Venetian walls (erosion)	3	3	**6**	3	3	**6**	3	3	**6**	3	3	**6**
	Degradation of cultural heritage (construction of the marina)	0	0	**0**	0	0	**0**	-3	-3	**-6**	-3	-3	**-6**
	Increase in car traffic	-3	-2	**-5**	-3	-2	**-5**	-3	-2	**-5**	-3	-2	**-5**
	Subtotal 3	**0**	**1**	**1**	**0**	**1**	**1**	**-3**	**-2**	**-5**	**-3**	**-2**	**-5**
TOTAL		**-4**	**1**	**-3**	**-2**	**2**	**0**	**-5**	**-5**	**-10**	**-5**	**-3**	**-8**

beaches will result in traffic increase and generally higher services requirements to address the users' needs. Also, the establishment of the diving park close to Agia Pelagia (Municipality of Malevizi) will increase traffic and needs in an already saturated area. This implies the need for new traffic regulations and new infrastructures in the near coastal urban environment. Also, the creation of bathing beaches entails seasonal degradation of seawater by bather's wastes, but it this can be considered as minimum impact. The regeneration of Ammoudara (Municipality of Malevizi), as has been suggested, contributes to the aesthetic improvement of the urban landscape. While the planed constructions are expected to cause urbanization as well as erosion of the beach, there is hence increased liability of additional negative environmental and economic effects. Moreover, the high costs for the implementation of the interventions, added by the extra costs to address coastal erosion in Ammoudara, reduce the sustainability of the alternative. Even though this alternative, has a number of positive effects and contributes into achieving the overall objectives of the projects. The Venetian walls will be protected, the coastal zone will be aesthetically upgraded and the tertiary sector, particularly tourism, will be generally enhanced. The quantitate representation of the consciences likelihood and severity of A2 alternative is presented in Table 3.

A3 alternative is almost the same with A2. Their difference lays in the location of the diving park (Cherssonissos). This location is in an area with less pressures in the near coastal zone. The quantitate representation of the consciences likelihood and severity of A3 alternative is presented in Table 3.

A4 and A5 alternatives include the implementation of all projects, and their difference lays in the location of the diving park. These alternatives have similar consequences with A2 and A3. The Venetian walls and the coastal infrastructures will be protected from the erosion. Also, the port infrastructures will be upgraded. In addition, the restoration of the coast through the creation bathing beaches will contribute to aesthetic improvement. All these are expected to contribute to the upgrading of the coastal area of the wider Heraklion area. Thus, the attractiveness will be increased, contributing to the further

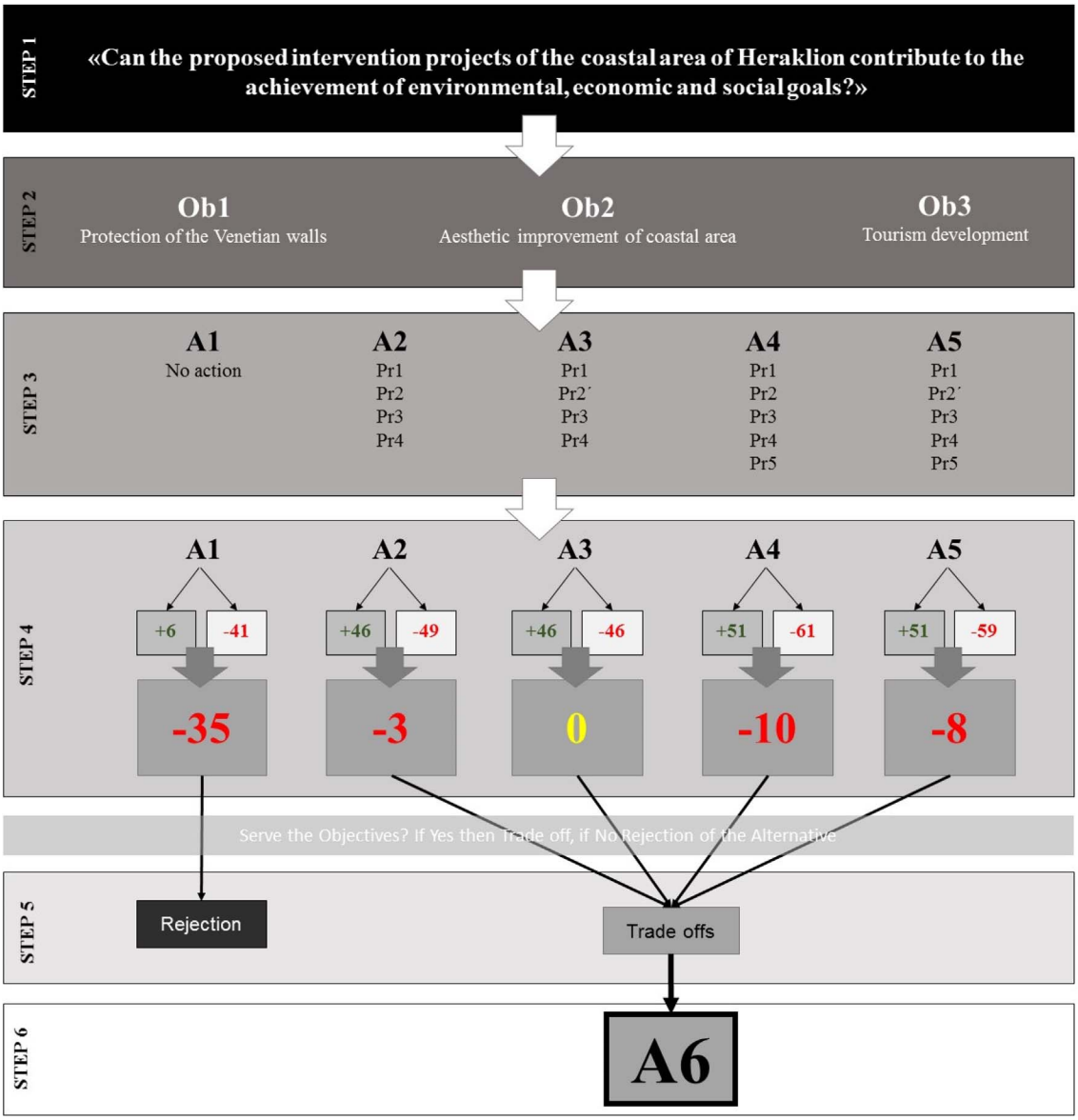

Fig. 6. Alternatives influence diagram.
Source: authors' own analysis

development of the tertiary sector. However, these alternatives have some additional negative impacts in relation to A2 and A3, since they are related to a different project, the Dermata Marina. The implementation of these projects entails greater and longer environmental degradation during the construction period. Moreover, the new marina and bathing beach create larger needs for new infrastructures (e.g. parking, transport connections), which imply an extra costs. The marina will also have a negative effect on the cultural heritage, due to the fact that it is planned to cover a part of the Venetian walls. Also, as in alternatives A2 and A3, the urban regeneration of Ammoudara is expected to cause coastal erosion, creating further needs and further environmental and economic demands. Finally, as negative effects the very high interventions costs and the increased seawater degradation due to increased marine traffic are stated. A4 and A5 although they have negative consequences, also contribute in achieving the objectives. The Venetian walls will be protected, the coastal area will be aesthetically upgraded and the tertiary sector, will be enhanced. The quantitate representation of the consciences likelihood and severity of A3 and A5 alternatives is presented in Table 3.

The difference between the scores does not automatically means that one alternative is better than the others (Fig. 6). A determining factor in the configuration of the total score have the negative effects of Ammoudara project, as well as the negative effect on the cultural heritage. For the final decision, trade-offs have a key role.

Although the aim of this study is to propose a methodological approach and not the proposing a final decision, another alternative (A6) is examined which is the outcome of the trade-off stage. Recognizing that all proposed interventions serve the objectives, from the SMD it was stated that this cannot be done by adopting the proposed projects as they stand, since they do not completely address the defined problem (P). Based on the objectives of each proposed intervention, but also on their social, environmental and economic impacts the following trade-offs were decided:

(a) The first trade-off concerns Ammoudara project (Pr3) which has an increased negative impact due to coastal erosion. Therefore, the modification of this intervention is necessary.
(b) The second trade-off concerns the conflicts arising from the implementation of Pr2 and Pr4. Taken into consideration that protection and preservation of cultural heritage is of high importance,

Table 4
Trade-off Alternative (A6) consequences score.

Consequence		A6		
		L	S	T
Environment	Aesthetic upgrade	3	2	**5**
	Environmental degradation during the construction	-3	-2	**-5**
	Erosion of Ammoudara coast	-1	-1	**-2**
	New projects to address Ammoudara erosion	-1	-3	**-4**
	Degradation of seawater (marine traffic, bathers wastes)	-2	-3	**-5**
	Subtotal 1	**-4**	**-7**	**-11**
Economy	Protection of coastal infrastructures	3	3	**6**
	Upgrade of port infrastructures	3	2	**5**
	Tourist product enhancement	3	3	**6**
	Increase in visitors	2	3	**5**
	Increase of income (during the construction)	2	3	**5**
	Job creation (during the construction)	2	2	**4**
	Increase of income (after the construction)	3	3	**6**
	Job creation (after the construction)	3	3	**6**
	Costs of interventions	-3	-3	**-6**
	New needs for infrastructures (eg. parking, transport connections)	-3	-2	**-5**
	Supplementary costs for new infrastructures	-3	-3	**-6**
	Supplementary costs to address Ammoudara erosion	-1	-3	**-4**
	Tourist flows change between antagonizing areas	-2	-2	**-4**
	Subtotal 2	**9**	**9**	**18**
Society	Protection of Venetian walls (erosion)	3	3	**6**
	Increase in car traffic	-3	-2	**-5**
	Subtotal 3	**0**	**1**	**1**
TOTAL		**5**	**3**	**8**

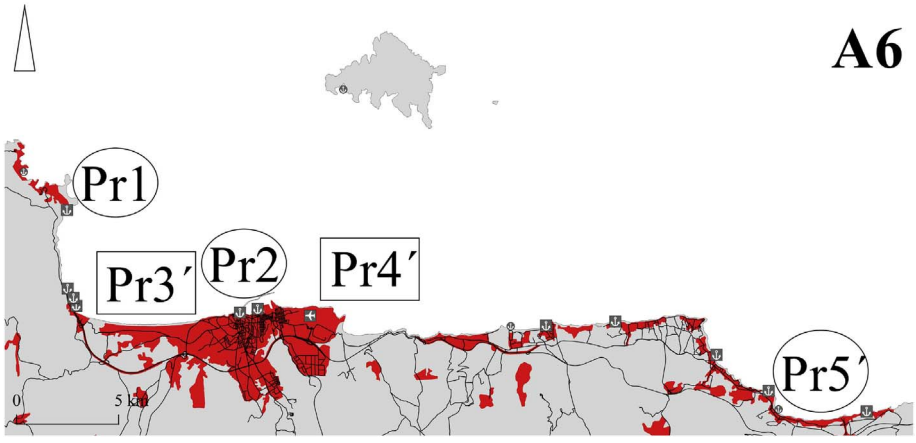

Fig. 7. Trade-off Alternative (A6).
Source: authors' own analysis

as the Venetian walls are a valuable, sensitive and non-renewable resource for the local society (Panagiotopoulou et al., 2017), it is accepted that Pr2 and Pr4 should not be overlapping. More specific, Pr4, "Dermatas marina", should be modified in order to not to conflict with the preservation of the Venetian walls.

(c) Finally, the third trade-off concerns the location of the diving park. Modification of the diving park implementation, are be based on reducing coastal pressures and enrichment of the tourism product in areas that can hold additional tourism development.

Trade-off outcome, alternative (A6), focus on the reduction of the size of interventions in Ammoudara beach, in order to minimize coastal erosion probability. Moreover, in A6 the new marina is relocated in an area that currently has less urban pressures (e.g. east of the Heraklion city). The area proposed in A6 has no conflicts with cultural heritage monuments and additional can create development prospects, in a less

develop area. Moreover, in A6 the diving park is located in the area which has less pressures (Cherssonissos), as tourism development is expanded in a wider area, while the target group for such activity is larger. In Table 4 the quantitate representation of the consequences of the trade-off alternative A6, is presented. In relation with the other alternatives, the total score has increased. Thus, A6 alternative, as a product of the trade-off stage, can contribute to the overall objectives of set by the stakeholders and minimize negative effects. The spatial distribution of the projects under alternative A6 are presented in Fig. 7.

4. Conclusions

The need to address the negative man-made or/and natural changes in the coastal zone added by the need for further social and economic development, leads coastal administrators to implement new interventions in coastal zones. However, the implementation of a development or protection project in the coastal zone and especially in the sea-land limit is a complex process. Interventions frequently trigger a series of reactions due to the sensitive and often changing nature of the coastal zone. Moreover, in Greece this complexity also enhanced by the absence of a detailed integrated legal framework for coastal zone management. Spatial planning framework provides tools that can cover part of the gap even though it characterized by fragmentation, inconsistency and absence of strong links between (a) the planning levels, the (b) sectoral policies and (c) the development policies (Tsilimigkas et al., 2016b, Tsilimigkas and Rempis, 2017a,b).

This study has attempted, through a case study, to propose a methodological road map in order to investigate the interactions between future land and sea uses and quantify the consequences arising by the implementation of a series of projects in coastal zone. The results show that through the implementation of the proposed interventions the uses as well as the users of the central northern coastline of Crete are expected to increase along with their conflicts.

More specifically, the new proposed uses, which will aim in enhancing the coastal zone and enrich the tourism product, are expected to attract new users. However, the attraction of new users requires the need for new interventions in the near coastal zone, in order to ensure the harmonious integration and function of the new uses. The analysis shows that all proposed interventions and in particular those that are expected to attract specific users, such as large number of swimmers at bathing beaches, divers in the diving park and sailors in the marina, need to be supported by a set of complementary projects in order to be sustainable. These projects, have not been taken into account in decision making by the managers, involve traffic connections, parking lots, and new recreation areas. This cascade effect is a strong indicator of the land – sea interaction.

The proposed SMD method, in which all stakeholders' objectives and planed actions, as they result from the studies of each project, are considered in a holistic approach, highlights the consequences of each intervention, in relation to the other interventions, environment, society and economy, and also the conflicts between each of them. The ‘do nothing’ scenario evaluation highlights the need for interventions in the coastal zone in the study area.

More specific through this method a significant number of negative environmental, societal and economic impacts that may affect the viability and feasibility of any intervention have emerged during the holistic evaluation step. Moreover, the significance of some areas of the coastal zone is also highlighted by the arising conflict between projects, in the bay of Dermata, where the same area is claimed by two different stakeholders for two different uses that serve the same objective, tourism enhancement. Also, reveals a fragmented decision-making process, as negative issues that are associated to the implementation of the proposed interventions are emerged. This fragmented procedure concerns both the investigation of the impacts of each proposed project within a single stakeholder (e.g. Ammoudara erosion, the additional needs of each proposal that emerge, etc.), as well as the investigation of conflicts or/and synergies between different stakeholders (Dermata bay case).

By quantifying the consequences of each intervention, managers and decision makers can have a clearer view of the relation between interventions and provide information about the strengths and weakness of each intervention. Analysing the alternatives in the trade-off stage a new alternative can be developed that will minimize impacts, better serve objectives and answers the initial problem.

All of the above highlight even more the need for integrated approaches that are supported by holistic decision-making method, in order to estimate the interactions between terrestrial and maritime space. These methods should ensure the participation of a large number of experts and stakeholders from various disciplines (state, local authorities, institutions, citizens, etc.) that are affected by or/and can influence or/and contribute to the decision (Stratigea et al., 2018). The public participation in decision-making is necessary to collect citizens and stakeholders' empirical or/and scientific knowledge and integrated it in decision process (Stratigea et al., 2017). In this way strengths and weakness of projects can be identified and the long-term sustainability can be further improved.

For the effective implementation of a plan or a project its acceptance from the users in necessary. In a small spatial scale decision-problems, the adoption of participatory processes by involving the local users and stakeholders, is a key factor the implementation and acceptance of such a decision. In a larger spatial scale decision-problems, can be resolved in the decision making procedures by the consultation between political governance and administration bodies (Tsilimigkas and Rempis, 2017b). Decision making and a methodological holistic approach that will ensure public participation, in the coastal zone can contribute to reduction of negative interactions, both between land and sea and between the development projects. Moreover, through an integrated approach of coastal zone synergies between land and sea and between uses and activities can be achieved.

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