

# **SOCIO-TERRITORIAL GIS AS A TOOL TO SUPPORT COASTAL MANAGEMENT**

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## **COASTAL CONFLICTS, COASTAL MANAGEMENT, COASTAL RISK, SOCIAL PERCEPTION, SOCIAL-TERRITORIAL GIS.**

### **ABSTRACT**

Nowadays, geographic information systems are an indispensable tool in land use management. Namely in coastal areas where population is and economic activities are concentrated, and where territorial conflict is common between the environmental, social and economical systems, this tool can be of great importance. On the other hand the climate change aggravation – increase of the frequency and intensity of extreme events – causing changes in coastal dynamics and intensifying coastal conflicts justify the use of this tool even more.

In this context, the design of a geographic information system with particular attention to coastal dynamics, coastal erosion and coastal risks, and integrating territorial and socio-economical data, can be decisive. The crossing of all this information, namely technical data, scientific data and social perception results, only in one tool should allow a more efficient coastal management policymaking thus allowing, in an *a priori* phase, the surveying of the populations' availability to accept the measures that governments or institutions intend to implement.

### **INTRODUCTION**

The coastal areas' diverse natural characteristics, favorable in terms of biodiversity, climate, fertility and accessibility, attract various activities: leisure, tourism, homes, commerce, and industry, among others. Consequently, there is an excessive occupation and use of this territory.

The affluence to coastal areas, whether temporary or permanent, has persisted throughout the years, leading to a high concentration in population and housing terms, provoking an incoherent urbanistic growth in relation to the principles and guidelines of sustainable development and integrated coastal zone management.

Confronted with this scenario, that characterizes many coastal Portuguese agglomerates, an urgent need arises in limiting this disorganized growth and inverting critical situations. It is therefore crucial that there is an effective integrated coastal zone management in which geographical information systems (GIS) may play a fundamental role as a tool to support the process.

This article is structured in six parts, the second refers to the current coastal area problems, the third concerning the involvement of the population in coastal management, the fourth contemplates the role of the GIS in coastal management, the fifth presents a geographical information systems model and the last, the conclusions reached.

## **PRESENT STATE OF COASTAL AREAS**

The coastal areas' present state, characterized by a disorganized and excessive human occupation, is, in itself a cause of countless difficulties for management to revert or, at least, minimize the current problems. It is important to refer that during the summer period this situation takes on critical proportions with the visiting population seeking beach tourism and sun, saturating the present beach infrastructures.

The Portuguese beaches were generally not planned for coastal tourism - neither for second home residents, tourists or daytime visitors. Furthermore, in the case of coastal places near cities, there is a significant occupation of these areas for lodging purposes. However, many of these urban agglomerates started off as small fishery centers that grew without any rules, very close to the sea, and that in the course of the years, were extended parallel to the sea or further into the interior.

This great attraction for coastal areas was not urbanistically foreseen, and the land use management system was incapable of managing this situation, nor was there an awareness of the need to protect the existent natural resources. The concept that the simple increase of the construction of buildings and of infrastructures means development is still very present in the mentality of local population and of local administration entities. "What is needed is a new way of thinking: humankind as a part of the system, not its master." (Beatley *et al.*, 2002).

The actual planning system broadly contributed to the unsustainable situation of coastal areas, in the sense that it did not supervise, nor advise on the correct form of development, safeguarding the protection of the natural resources and coherently planning urban growth.

Therefore, there is a large amount of buildings extremely close to the sea, too exposed to the consequences of its dynamics and cyclically influencing it. The harbour infrastructures also greatly influence coastal dynamics. In light of the changes to the natural systems originated by human deed, new interventions was required as an answer to critical situations, namely coastal defense interventions. These structures, namely groins, also significantly alter coastal dynamics, consequently aggravating some of the current situations of coastal risk and lead to new critical situations (Pinho *et al.*, 2006).

Furthermore, the recent aggravation of the intensity and frequency of extreme events, associated to the climate changes, increases the risk that populations are exposed to, as well as the difficulties of an effective coastal management, as global warming and the consequent sea level rise significantly contribute to erosion and shoreline retreat.

The coastal areas, due to all that was referred, especially the diversity of coastal area activities, excessive occupation, rich natural resource, as well as its dynamics, have a

propensity for conflicts. "...the more the spectrum of possible waterfront uses widens, the more the spectrum of potential conflicts between uses strengthens." (Vallega, 2001). These conflicts can be of different nature such as the incompatibility of localizing activities, lack of organization of different activities that can be harmful, environmental incompatibility and in maladjustments in the urban planning image (Vallega, 2001).

The referred conflicts lead to cyclical situations that become worse, in other words, for instance the degradation of environmental resources provokes social conflicts and these conflicts lead to greater environmental degradation. The degradation of resources lead to there shortage and, consequently, to worse standards of living, therefore provoking conflicts (Marone & Lana, 2003). To analyze the transformation throughout time of certain environmental and social parameters there are change indicators, which contribute to a better perception of the coastal territory and reveal the existing pressures (Trujillo *et al.*, 2003). The understanding of this feedback from the natural system, the social system and the social-environmental conflicts is the basis for the successful elaboration of new ways to manage and to solve the conflicts in a consensual manner (Marone & Lana, 2003), fostering social and environmental sustainability. To Kitsiou *et al.* (2002) "The strong interaction, therefore, between the human activities on the coastline and environmental quality has been the basis of seeking appropriate policies to ensure development opportunities and mitigate their impacts on the environment in the context of sustainable development." (Fig.1).

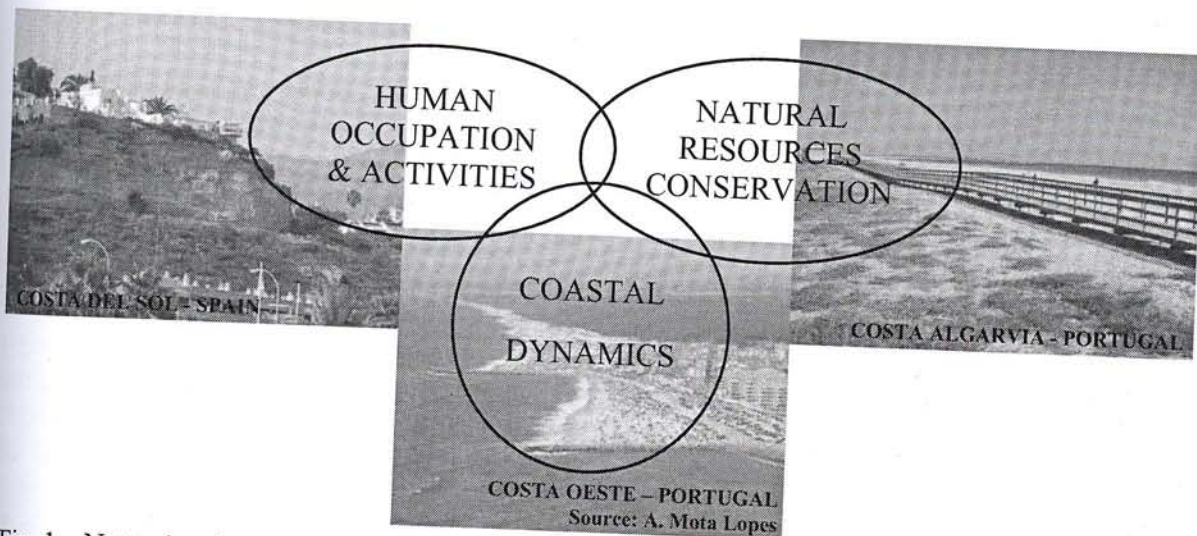


Fig. 1 – Natural and man-made issues integration

Sardá *et al.* (2005) consider that "The overall objective is to maintain and/ or to obtain a good ecological status of the coastal zone while keeping human activities on it.". Therefore, it is very important that land use management consider coastal area dynamics, as well as the aggravation of climatic change, in the planning proposals and in regulating the use and occupation of the land.

## SOCIAL PERCEPTION ROLE IN COASTAL MANAGEMENT

Nowadays, the development of land use and risk management plans are finally starting to be conceived with the involvement of the population, especially because, in one way or another, everyone should contribute to sustainable development. Any strategy that seeks to contribute to sustainable development should conquer, in an initial phase, the active involvement of all citizens. This involvement is fundamental as it is an easy way to reach a consensus and brings benefits to the proposals in development.

If the need to protect the natural resources is not always a good enough reason for a change in mentality and attitude, it is expected that the coastal risks that the coastal populations are exposed to, will have a greater weight in determining their social habits.

In spite of this, the most acceptable and desirable direction for the population to follow in light of this problem, is in coastal protection engineering intervention and not in preventive management. An important issue is the false sensation of safety that the structures of coastal defense can transmit to the populations and even to the local management entities. This perspective of protection can lead to increases of beach front occupation, allowing new buildings and consequently increasing the exposure to coastal risks.

Furthermore, the significant shoreline retreats occur "... during more energetic episodes (storms) (...) with long periods of time in which, seemingly, nothing special happens" (Dias, 2005). This sporadic occurrences factor weakens the perception of the risk in light of the real and continuous shoreline retreat.

However, the population is aware of the shoreline retreat, but its importance has been minimized - "...there is some evidence to suggest people try to deny the significance of the risk for personal and financial reasons." (Richardson *et al.*, 2003). The implications on having to leave ones home, considering the sentimental connection with the sea, to ones home, to the place as a whole, to the community that they are part of, financial issues, or other factors, make the population partly deny the risk factors.

In this context, some reluctance and lack of information and awareness is verified amongst the coastal populations, to the risks they are exposed to. To Richardson *et al.* (2003) "If the public are made aware of the risk then it can be more proactively and effectively managed.". It is, therefore, necessary to facilitate the access to information through a process of interactive communication that allows a consensus to be reached between managers and population, as communication is crucial in decision making. The public participation will smooth the risk mitigation measures and the public risk sharing.

In the light of the information exposed, it is important to refer that coastal management implies the participation of local populations in the entire process. "The implementation of sustainable development requires new strategies of public relation and conflict management to integrate different ecological, economical and social interests." (Kaiser & Alder, 2004). Participative planning enriches decision making, in the measure in that it supplies more information and more points of view in the discussion of problems and in the definition of the solutions. "The involvement of stakeholders is essential in all steps of the ICZM process." (Douven *et al.*, 2003).

Public consultation and studies of social perception are methods that allow the involvement of the population in the process of land use management. Both are important, more greatly valued when joined. It is important to refer that the questionnaire method is of a more random and broader nature, supplying a greater array of opinions (Lima, 2000), facilitating the participation in decision-making, and promoting the transparency of the whole process (Upton, 2003).

In this context, the use of social sciences positively contributes to the quality of technical analyses, as a platform for the elaboration of strategies that respond to the expectations and needs of the population, as well as for the reinforcement of the legitimacy and acceptance of the strategies, on the populations part.

## **GIS ROLE IN COASTAL MANAGEMENT**

The attractiveness of coastal areas implicates, as was already referred, the excessive occupation and use of these areas. The great affluence of activities and population, with the consequent excessive construction, provoke constant changes to land use, namely in the environmental functions of the land. Besides this direct influence of territorial occupation, the referred alterations are due to the influence of several factors, namely geomorphology, the occurrence of extreme events, natural risks, population dynamics, cultural models, industrialization and political-administrative regulations, among others.

Therefore, there is a great human influence in the processes of global change and in coastal areas in particular due the excessive presence and consequent changes on the land. In light of this, the human element should have a crucial role in integrated coastal zone management. The physical, environmental and social factors will have to be integrated for management to be successful. In this context it is important to refer the GIS, that is a great advantage in the capacity to store and to process great amounts of spatial information and can integrate different types of information, namely graphic and alphanumeric. Allen *et al.* (1999) consider that "...GIS has advantages over conventional methods in integrating various data sources, performing spatial analysis, modelling spatial process, and mapping the results in land-use change studies.". GIS are already used in several areas of territorial management as they easily integrate different information and allows efficient spatial analyses. It is a tool that presently has become indispensable and has already been integrated in curricular programs in the planning area.

In this sense, GIS play a vital role in coastal management as well as they allow the integration, analysis and handling of physical, environmental and social-economical characteristics of a certain area, whose crossed analysis allows a greater understanding of territorial dynamics instead of the treatment of data per sector. In addition, another advantage of this tool is the possibility of integrating new information, or even carrying out different analyses, varying the elements to be used in the analysis. "We can conclude that the benefit from GIS for coastal zone management lies in the fact that GIS can process large amounts of (spatial) data and can integrate different types and sources of data using the location as a common identifier." (Douven *et al.*, 2003).

This tool can be useful in the different phases of a coastal management process. "The development of a GIS database is therefore an integral activity supporting all policy analysis phases." (Douven *et al.*, 2003). The utility of the tool can have several simultaneous purposes, from the characterization and analysis of the territory, to its technical use for daily territorial management, as well as a platform for policy-making, even to communicate with the population on the political and technical decisions taken in management terms, and also to make the population aware of coastal area conservation and coastal risks.

## GIS PATTERN

In light of the diversified use of the GIS in coastal management support, with several foreseen users, for several objectives and different needs, the development of this tool must be user friendly (Douven *et al.*, 2003).

The proposal that will be presented in this article is still in a development phase, research is to be done at the University of Aveiro on the role of social perception of coastal dynamics and coastal risks in the process of coastal management, and the perception data considered one of the crucial elements to integrate in the system thought for the Portuguese context.

The proposal, still in development and for validation (Fig. 2), intends on combining social-economical, territorial and environmental indicators to evaluate pressure and impact caused by human activity in coastal areas, to identify vulnerable areas and of coastal risk, as well as identify social-environmental conflicts. Its ultimate objective is to contribute to an environmentally sustainable coastal management. "The integrative capabilities of geo-information technologies make them very useful to support ICZM." (Douven *et al.*, 2003).

In this sense, several sources of information will be collected and several are the origins of the indicators, namely central, regional and local administration that intervene in coastal areas (in a broad sense), entities owning cartography (litology, hidrography, topography, coastal dynamics, land use, buildings and infrastructures, etc.), entities holders of statistical social-economical information, harbour administrations, the research in course and other already developed in the extent of this theme, among other sources.

In this way, and to the similarity of any SIG, the tool will be constituted by the interface, for different types of users, and for the following components: data integration consulting and analysis of data, visualization and data printing, data administration and storage of data. The interface will be used for technical, decision-making, and support purposes to define policies and strategies, and to provide information and foster citizen awareness. The data will be alphanumeric, graphic and images.

But several aspects should be taken into account in the design of a SIG model, namely: the need for flexibility in the crossing of indicators depending on the area analyzed. Elements that are important, for example, in a dune area, won't be the same as those considered in a cliff area. Other two very important aspects are the spatial and temporal scales to use, which should also be adapted to the indicators in use, and that will vary depending on the extent of the area studied, or for instance, depending on the time that a certain process takes to elapse. Yet another element to bear in mind is the fact that the needed information isn't always

available, particularly in evolution terms, which would allow the analysis of evolutionary tendencies.

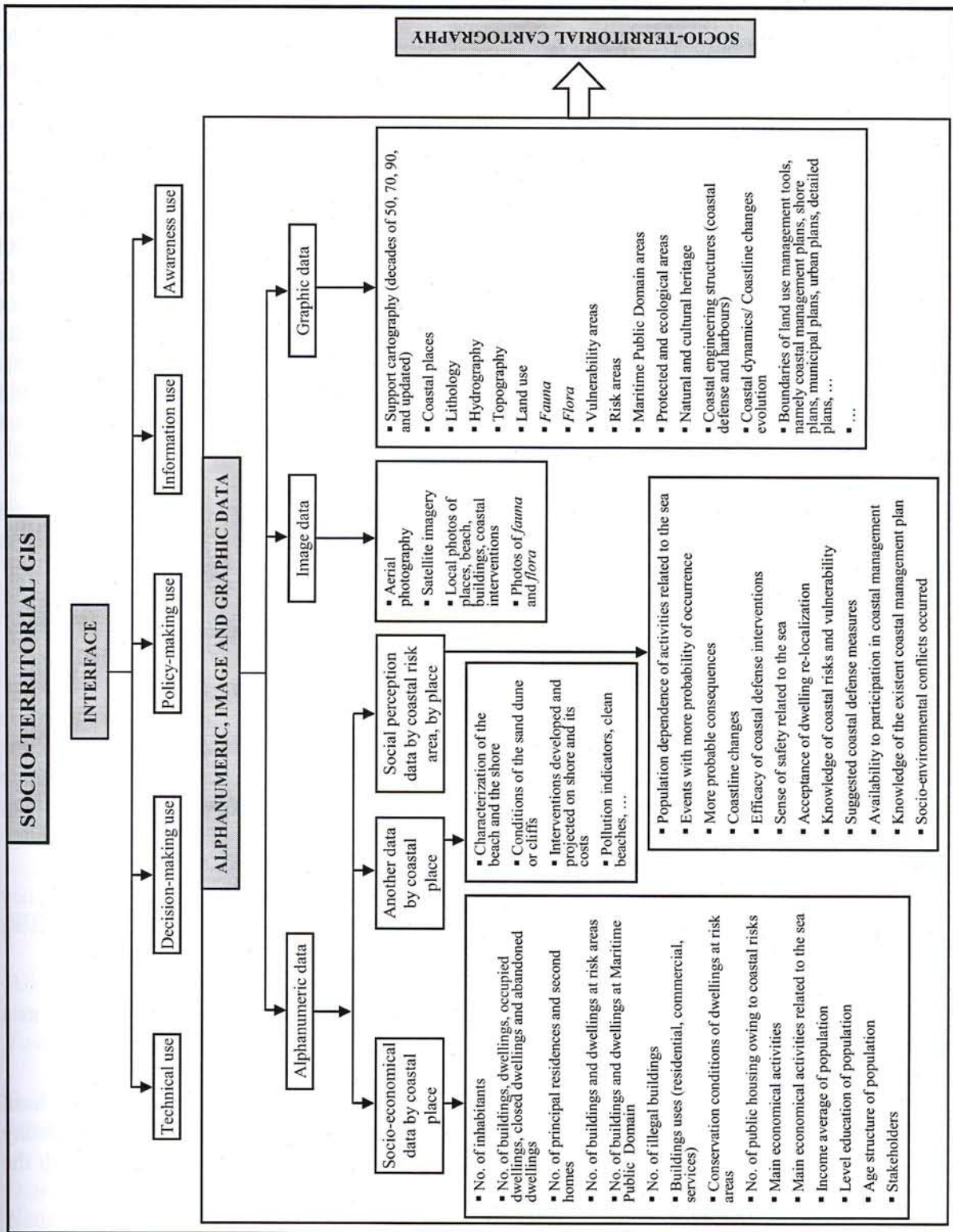


Fig. 2 – Socio-territorial GIS

It is important to collect all the possible information, although in a proper manner. In other words, the multiplicity of obtained indicators can complicate and hinder GIS use, as well as give repeated unnecessary information. Therefore, a careful analysis of the elements to integrate should be made before the GIS is used. For instance, for alphanumeric information that can be statistically treated, through a principal component analysis, interesting results may be reached in the simplification and reduction of indicators to consider, without discarding information. Standardizing data of a different scale system may also be required, if there is an interest in establishing a comparisons between them, or even to integrate them in the principal component analysis referred above.

This tool aims, on the one hand to analyse land uses and occupation changes, particularly, to analyse coastal places changes since the 50's, to compare the changes of coastal places with coastal engineering interventions, to compare coastal places changes with defined coastal risk areas, to compare land use with protected and ecological areas, to suggest corrections of defined coastal risk areas, to identify buildings at risk areas, to connect coastal dynamics with coastal engineering interventions and with coastal places changes. On the other hand, it aims to identify conflicts between coastal dynamics and land occupation, namely to figure land occupation, risks and perceptions in cartography and to try to detect conflicts between coastal dynamics and land occupations.

The GIS intends to improve the coastal management, giving particular attention to the coastal dynamics, erosion and risks, and integrating spatial and socio-economic analyses, as a tool to support the coastal management, with socio-territorial synthesis maps.

## CONCLUSION

Nowadays, geographic information systems are already an indispensable tool in land use management. Particularly in the case of the Portuguese coastal areas, where 75% of the country's population is concentrated, and due to that reason there is a massive economic activity concentration and conflicts, both between socio-economic systems, and these systems and natural ecosystems, this tool, therefore, assumes an even bigger importance.

Climate change aggravation, mean sea level rise and increase of extreme events in frequency and intensity, namely storminess, and consequent aggravation of coastal erosion, causing coastal dynamics changes, intensifying the socio-environmental conflicts even more.

The defence coastal engineering structures have been carried out many times as well as a response to emergency situations, aggravating this problematic situation even more.

Therefore, in presence of the excessive human occupation of coastal areas, coastal local populations are more affected by this set of factors, depending on the territorial vulnerability where they live. The high number of buildings on sand-dunes and cliffs together with the coastal dynamics place people and goods at risk.

Aiming at contributing to a better management of the coastal areas and taking into account all of the mentioned issues, research is planned that achieves mechanisms to minimize the



conflicts between coastal dynamics and the land use. It must integrate the social component in the land use management and it be seen as a contribution to the integrated coastal zone management.

Although public involvement in land use management is not yet a customary practice, the process of Integrated Coastal Zone Management needs to develop and implement a coordinated strategy to manage environmental, socio-cultural and institutional resources, aiming to reach the conservation and the sustainable multiple use of the coastal zone.

It is very important to integrate technician and scientific knowledge, with the local knowledge, considering the population's know-how about the coastal areas evolution processes and to use this information in a context of a participatory planning and management, in order to make possible the mitigation of conflicts and the development of consensus (integration of the opinions and perspectives of all stakeholders). It is important to bring near quantitative risk analysis and assessments and the public perception, in order to overcome a social rejection of the sustainable mitigation measures and to improve the dialogue between the experts and the stakeholders.

In this context, the above-mentioned SIG with special attention to coastal dynamics, coastal erosion and coastal risks, integrating territorial and socio-economical data, intends on facilitating coastal area management.

The crossing of all the information only in one tool should encourage a more efficient coastal area management, because it allows the integrated analysis of the physical and socio-economic data and also because social perception will be taken into account, surveying, in *a priori* phase, the population's availability to accept the measures that governments or institutions intend to implement.

The involvement of the population will determine coastal management success, necessary to promote the legitimacy of the decisions, as well as the acceptance of its implementation by local population. This should, therefore, be taken into account in the support tools used in land use management.

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