AFTER THE 1972 STOCKHOLM CONFERENCE: 50 YEARS OF COASTAL MANAGEMENT IN PORTUGAL

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Stockholm Conference, held in 1972, represents the first United Nations Conference on the Human Environment. The declaration presented at the end of the conference considered the need for principles to inspire and guide in the preservation and enhancement of the human environment. Past 50 years over this event, some analyses are demanded. Thus, based on Stockholm Conference main proclamation, this work aimed to present an evaluation of what was the Portuguese coastal management over the last five decades, highlighting what was done and what is still missing. The Stockholm Conference outputs pointed out the importance to preserve the environment. The Portuguese coastal management along the last 50 years experienced different strategies. Presently, it is evident the importance of monitoring, integrated studies, combining social, economic and environmental aspects, stakeholder's involvement, education and dissemination. However, Portuguese coastal areas still face multiple environmental challenges and conflicts, which continuously demand for an adequate coastal management, looking for a sustainable future.

Keywords: coastal erosion; coastal interventions; monitoring; participatory approaches; cost-benefits assessment

INTRODUCTION

Stockholm Conference, held in 1972, represents the first United Nations Conference on the Human Environment. The declaration presented at the end of the conference considered the need for principles to inspire and guide in the preservation and enhancement of the human environment. Past 50 years over this event, some analyses are demanded. Thus, based on Stockholm Conference main proclamation, this work aims to present an evaluation of what was the Portuguese coastal management over the last five decades, highlighting what was done and what is still missing.

The work first presents what were the main principles proclaimed 50 years ago, at the first United Nations Conference on the Human Environment, at Stockholm, 1972. Than, a review of the main policies adopted in Portuguese coastal management along the last five decades is presented. Following the review, the actual trends are referred, considering monitoring, evaluation of alternative solutions, cost-benefit assessments and participatory approaches. Finally, the near future challenges are discussed in what concerns the need of improved capacity to model the coastal processes, define adequate climate change scenarios and the society response to those scenarios, including the uncertainties of the global economy.

STOCKHOLM CONFERENCE

The declaration of the United Nations (UN 1972) proclaimed that it is the duty of all Governments to protect and improve the human environment, as affects the well-being of peoples and economic development. UN (1972) stated 26 principles and 109 recommendations. No special attention was given to the littoral, but several management and planning policies are highly connected to coastal zones, mainly considering principles 2, 13, 15 and 19, among others. Reference to coast are only explicit when referring to pollution.

Principle 2 states that the natural resources of the earth, including water and land, must be safeguarded for the benefit of present and future generations through careful planning or management. Principle 13 considers that States should adopt an integrated and coordinated approach to their development planning so as to ensure that development is compatible with the need to protect and improve environment for the benefit of their population. Principle 15 refers that planning must be applied to human settlements and urbanization with a view to avoid adverse effects on the environment and obtaining maximum social, economic and environmental benefits for all. Principle 19 states that education in environmental matters, for the younger generation as well as adults, giving due consideration to the underprivileged, is essential in order to broaden the basis for an enlightened opinion and responsible conduct by individuals, enterprises and communities in protecting and improving the environment in its full human dimension. It is also essential that mass media of communications avoid contributing to the deterioration of the environment, but, on the contrary,

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disseminate information of an educational nature on the need to protect and improve the environment in order to enable man to develop in every respect.

In summary, transferring the UN (1972) to a littoral perspective, it can be understood that sediments are a limited natural resource at sandy beaches under erosion and that the adequate strategies to consider, to guaranty safeguard and careful planning and management, were not defined at the time. It is needed to include all the stakeholders in the decision-making processes to achieve a compatible development of the coastal zones. It is also highlighted that since 1972, "benefits" are referred in several principles. However, the way to quantify and compare social, environmental and economic benefits is not clear.

PAST PORTUGUESE COASTAL MANAGEMENT

Portugal is bordered by the Atlantic Ocean along an estimated length of 987 km, being part of one of the most affected coastlines worldwide by the erosion phenomenon. Presently, shoreline evolution is mainly conditioned by the energetic wave climate, the presence of numerous manmade structures and the progressive weakening of the alluvial sources, nowadays responsible for the retention of approximately 80% of the sediments that could be potentially transported in natural conditions (GTL 2014). According to Marinho et al. (2019), during the past few decades, the difficulty of reconciling the safety of people and assets with the benefits offered by natural coastal resources has been exacerbated. Part of this situation is mainly attributed to the growing population density near the coast (with 75% of the inhabitants living in coastal municipalities), increasing capital investments (in coastal defense) and the previously referred failing in river sediment discharges (EUrosion 2006; APA 2016). Thus, considering the previous, the cost of coastal erosion mitigation actions has been increasing. Between 1995 and 2014, public expenditures dedicated to coastline protection against the risk of erosion and flooding have reached an estimated amount of 196 million euros (M€), whereas the cost of repairing the damage caused by the major storms from January to March of 2014 has totalized approximately 23 M€ (Figure 1).

Figure 1 - Example of coastal damages registered at Furadouro beach, NW Portugal, during the 2014 storms.

Presently, 14% of the Portuguese shoreline is protected by artificial structures, including groins, longitudinal revetments, breakwaters and harbor infrastructures, which adds up to around 140 km of the coast. These coastal defense structures were mostly implemented since the 1970's and were essentially focused on maintaining the shoreline position. However, it is observed a recent paradigm shift, with the artificial nourishments becoming a favorite mean to mitigate erosion and maintain the coastline (Pinto et al. 2018). In fact, mainly during the last decade it was observed a general increasing tendency to favor environmentally friendly coastal protection solutions through sand nourishments and reinforcement of dune systems. Artificial nourishments have arisen as a high potential alternative,

passive to be applied in some locations, although their potential effects have not been well quantified yet.

PORTUGUESE POLICIES ACTUAL TRENDS

From economic, cultural and environmental point of views, Portuguese coastal areas still face multiple challenges and conflicts which demand a deep restructuration interfering with the coastal management policy, the functionality of the governmental services and the responses to the society/affected citizens. Any action affecting coastal areas should look for a balance between enhancement of the land use and preservation of the environmental values. This implies necessarily some qualitative and quantitative understanding of the coastal morphological processes, as a precondition for a successful coastal management project, so all the parties concerned can be in position to understand not only the past, but also how the present situation has developed and how to anticipate future evolution tendencies. Thus, increased knowledge about Portuguese coast (monitoring and the development of advanced studies), involving stakeholders in the decision processes (participatory approaches), also supported by cost benefit assessment studies are recent trends in Portuguese coastal policies.

Monitoring

Continuous monitoring was achieved with COSMO (2022) programme, which includes topographic and hydrographic surveys applied to previously selected sites, presenting great vulnerability and exposure of people and assets to hazard. COSMO, "Coastal Monitoring Programme of Continental Portugal" is a programme designed and developed by the Portuguese Environment Agency (APA) and consists of collection, processing and analysis of information on the evolution of beaches, dunes, nearshore seabed and sea cliffs along the Continental Portuguese coastline. Systematic and identical, standardized surveys, are used for data collection, processing and analysis applied to the coastline. The COSMO results are essential for timely and informed decision making on the coast, contributing to the optimization of coastal management and planning (COSMO 2022).

Monitoring is particularly relevant for the characterization and establishment of a baseline and future evolutionary trend for sandy and cliffed coasts. A continued monitoring programme allows understanding the impacts of climate change on the coastal system, helping on defining adaptation strategies and in the definition of coastal planning strategies in the medium and long-term perspectives. It is also particularly relevant for the assessment of the effects/impacts of coastal engineering works already in place, letting evaluate their degree of success. These should be considered when programming and defining future new coastal protection/defense interventions. Finally, monitoring permits an increased ability for projection of future scenarios and an optimization of risk mitigation strategies (i.e. erosion, instability of cliffs, damage to coastal protection structures) (COSMO 2022).

Evaluation of alternative solutions and cost-benefit assessments

Very recently, Portuguese Environmental Agency asked for studies on alternative solutions for the Atlantic coast (bypassing systems and detached breakwaters), discussing the costs and benefits of their implementation in a medium to long-term perspective. The feasibility study of sand by-passing at Aveiro and Figueira da Foz tidal inlets aimed to evaluate a sediment by-passing system (Figure 2), discussing the technical solution and the economic impacts, including a cost-benefit assessment. The study included a historical analysis of the evolution of the shoreline and nearshore morphology, before and after interventions, and provided elements that have contributed to decision-making on the sediments by-passing at the Aveiro and Figueira da Foz tidal inlets. The study has also presented a discussion on the volume of sediments to be transposed and their place of deposition. As referred, the definition and comparison of technical solutions for sediments transposition included cost estimates and a cost-benefit analysis (Coelho et al. 2021).

Other recent study demanded by the Portuguese Environmental Agency corresponds to the feasibility study of a detached multifunctional breakwater in front of Praia da Vagueira, at the Northwest coast of Portugal (Sancho et al. 2022). This project main objective was the characterization and definition of parameters of sizing and location of a detached breakwater, in front of Praia da Vagueira (Figure 3). It was intended that this breakwater should be multifunctional, fulfilling the following objectives in order of priorities: i) to reduce the risk of coastal overwashes in the urban front of Praia da Vagueira; ii) to promote the possible increase of the beach in front of the rocky revetment, reinforcing the natural defense against the erosion and coastal flood and increasing its greater recreational use by the population and bathing security; iii) create physical conditions to promote

reference surf waves, boosting the economy associated with this activity. The study aimed to present alternatives and solutions for a detached breakwater, a preliminary solution scheme and its location, the indication of the main conditions and information on the possible need to obtain additional elements for the execution of the project.

Figure 2 – Example of a sediments by-passing system at Golden Coast, Australia.

Figure 3 – Praia da Vagueira, NW Portugal, where the construction of a new detached breakwater was evaluated.

It is highlighted that both studies included a cost-benefit assessment, considering the definition of economic values to the interventions and to the land/services/ecosystems, weighting environmental, cultural, social and historical aspects. In fact, to choose the better intervention solution is a complex decision and the cost-benefit assessment revealed the importance of defining the main goal of the intervention. To develop the cost-benefit assessment it is also required to define the time horizon of the analyze and always combine the physical, economic, social, cultural, environmental, etc. factors (Roebeling et al. 2011; Lima et al. 2020; Coelho et al. 2022).

Participatory approaches

Finally, participatory approaches are being adopted in innovative projects that involve stakeholders, who assess different options and create meaningful debates over important assumptions (INCCA 2023; COAST4US 2023). This represents more knowledge among the stakeholders, serving on the management of the littoral.

INCCA - INtegrated Coastal Climate Change Adaptation for Resilient Communities aims to reduce the vulnerability of coastal territories and increase the resilience of local communities, defining a Coastal Adaptation Action Plan to the case of the pilot study, on the coast of the municipality of Ovar, NW Portugal. Adaptation approaches that integrates short (2030), medium (2050) and long-term (2100) perspectives, considering the social, environmental, economic and engineering dimensions are still scarce. Decision-making entities should devise action plans for implementing sustainable and long-lasting strategies. Thus, the main objectives of this project are to conduct a cost-benefit analysis of intervention strategies for the Portuguese coast in those different time horizon perspectives, assessing social and environmental impacts at the local level of the Adaptation to Climate Change options and involving local populations and stakeholders through workshops in order to develop a participatory and economic model (Figure 4).

Figure 4 – Participatory workshop developed in the aim of the INCCA project (INCCA 2023).

COAST4US – Application of the COAST tool to the Portuguese coast, aims to develop a study about the technical and economic potential of the application of the COAST tool – a software to perform cost-benefit analyses. This tool contributes to a more efficient coastal planning, helping public and private entities (Coelho et al. 2020). The project discusses several different intervention scenarios to be tested at three coastal stretches highly vulnerable to erosion: 1) São Jacinto - Gafanha da Boa Hora; 2) Cabo Mondego - Cova Gala; and 3) Cova do Vapor - Cornélia, in Costa de Caparica. The intervention scenarios are being discussed with the central government and the local authorities, representing another example that combines a participatory approach and a cost-benefit assessment in a medium-term perspective (20 years).

NEAR FUTURE CHALLENGES

Projecting the future to assess different measures for mitigating coastal erosion and adapting to climate change requires the adoption of assumptions, that represent the most relevant near future challenges for the scientific, engineers and managers coastal community. Some of them are briefly referred in this section and are related with the ability of models to adequately reproduce hydrodynamic, sedimentary dynamics and morphodynamic processes, as well as the impacts of adopted measures, over extended time horizons. On modelling projections, the adoption of wave climate and sea level scenarios need to be discussed, representing the forcing agents of the models. However, the social response over time to the adopted measures is also fundamental, depending on the various actors on the coast (political agents, economic interests, social groups) and their perspectives, conditioning what the projection of benefits over time may be. This needs to be combined with economic scenarios based on

global conditions (pandemics, wars, energy crises, etc.) and local conditions (distances, available materials, access to equipment, appreciation of the territory, etc.).

Improved capacity to model the coastal processes

Hydrodynamics, sediments dynamics and morphodynamics processes are being reproduced by numerical models, with different levels of detail. Usually, climate complex models, requiring big computational efforts, are applied for short term predictions, while simplified models are considered for long-term simulations, also allowing easier sensibility tests to different scenarios. When looking to medium to long-term coastal management and planning, simplified models are the most common, but managers and planners need to be aware of the assumptions and simplifications made by the model, to understand the range of potential results.

Coastal intervention impacts also need to be better understood, to be represented by the models. Due to the complexity of the coastal systems, the impact of an intervention changes the place from place, under different conditions (forcing agents, sediments characteristics, etc.). For instance, where to nourish a beach profile with sediments (dune, berm, submerged bar) and how is the beach profile response to this intervention still represents a challenging topic for coastal researchers (Dingler 2005; Ferreira and Coelho 2021).

Climate change scenarios

The shoreline retreat drives to conflicts between shoreline evolution and human activities, and is expected to be aggravated by the climate change effects (Nicholls et al. 2007; Vousdoukas et al. 2020). Thus, the definition of the forcing agents of the numerical models' simulations for future projections require assumptions on the climate change scenarios. It is important to keep in mind when planning integrated adaptation to climate change in coastal areas that the probability of occurrence of the various International Panel for Climate Change climate scenarios varies over time. In other words, there are scenarios whose probability of happening is decreasing and others whose probability is increasing. Global emissions of carbon dioxide (CO_2), the Green House Gas that most contributes to the radiative forcing that causes climate change, continue to increase rather than rapidly decrease as is necessary to halt climate change. If the trend of maintaining high annual global emissions persists, the increase in global average temperature will exceed the Paris Agreement temperature targets. These facts indicate that the probability of the SSP1-RCP2.6 scenario being fulfilled is decreasing sharply (SSP - Shared Socioeconomic Pathways; RCP - Representative Concentration Pathways). Currently, the most likely scenario, bearing in mind the pace at which the energy transition is taking place on a global scale, is SSP2-RCP4.5, but these is not completely consensual over the scientific community, representing different possible results for the future projections (Tollefson 2022).

Society response scenarios

Coastal management policies have impact on society reactions. When a coastal stretch is protected by coastal defense structures, it can be observed an urban pressure because the place is protected and there is a safety sensation, or in other way, people may move to other places, where there are natural conditions (Figure 5). When planning future conditions and the land use value of the coastal areas, this kind of discussion is needed, which means to integrate social sciences, engineering, physics and economics in the projection of future uses of the littoral.

Figure 5 – Society response to coastal planning. Left: protected coast, without beach; and right: natural beach, without adequate infrastructures.

Coastal ecosystems are diverse, productive, ecologically important and valuable for the wide range of services they provide to humans. These include provision services (such as fisheries production, firewood and energy resources), regulatory and habitat services (such as coastal stabilization, nutrient regulation, waste disposal, genetic heritage and species nursery) and cultural services (such as tourism and recreation). These services are of high value to local communities living in these coastal zones, as well as to national economies and global trade (TEEB, 2010). An important way to investigate human vulnerability and dependence on coastal ecosystem services is to examine their estimated values, paying attention to their variation (decrease/increase) over time. Estimating its value provides information about the elements (such as characteristics of the place and context) that determine its high and low values, and at the same time informs policy makers (Rao et al. 2015; Su and Peng 2021).

Economic scenarios

The adoption of economic scenarios based on global conditions (pandemics, wars, energy crises, etc.) and local conditions (distances, available materials, access to equipment, appreciation of the territory, etc.) is required to quantify the costs of different measures. However, local conditions are site specific and thus, when a new location is studied, the related data are usually scarce. These local conditions justify why several times are coastal management options adequate to one place, that does not work well in other place. In a global perspective, the recent COVID-19 pandemic situation and the war in Ukraine are examples of the difficulties in project economic scenarios for the future. In fact, a jigsaw of factors associated with economics, technology, infrastructure and social and political aspects play a leading role in defining development paths.

CONCLUSIONS

In 1972, Stockholm Conference outputs pointed out the importance to preserve the environment. The Portuguese coastal management along the last 50 years experienced different strategies to achieve that goal. Presently, it is evident the importance of monitoring, integrated studies, combining social, economic and environmental aspects, stakeholder's involvement, education and dissemination. All these approaches were already mentioned in 1972, in an avant-garde and more or less explicit way, highlighting the importance of the United Nations Declaration.

Despite the positive evolution that has been registered, the Portuguese coastal zones still face multiple challenges and environmental conflicts, which continuously demand for an adequate coastal management, looking for a sustainable future. Sediments deficit continues to increase the exposure of coastal waterfronts and the climate change anticipates the problem over time. Coastal protection costs continue to increase over time and thus, prevention and planning elaborated with project horizons of a few decades, should represent technical, social and political concerns.

Information, a participatory society, coastal interventions, improved future projections and continuous monitoring are some of the main topics in future coastal management (INCCA 2023; Coelho et al. 2023). It is necessary to expand and make accessible databases referring to dates of overtopping/flooding events and related damages, as well as data regarding the implementation and maintenance of protection works. These historical and present data are crucial for public, technical and scientific communities, in the debate about the most viable coastal planning and adaptation for each location. The involvement of diverse groups of stakeholders in participatory processes and decision-making is essential for the delineation of the coastal management policies with the greater acceptance and collective benefit. Integrating academy members, local administration, institutions, NGOs, and interested citizens, it is possible to merge scientific and empirical knowledge, reconciling tradition with development, obtain a multidisciplinary view of the system, and reach equitable solutions. The decision on the most relevant coastal interventions to adopt should be weighed, keeping in mind the potential for the complementarity of solutions. Protect urbanized areas and, at the same time, maintain the socioeconomic value of beaches through combining artificial nourishments and reconfiguration of existing protection works should be evaluated in deeper studies. It is necessary to continue investing in local knowledge, in particular with regard to the social potential and economic benefits of beaches and urban areas, but also the value of coastlines ecosystems in each region. Additionally, intervention costs should be defined in such a way as to allow rigorous cost-benefit analyzes and real representativeness, adequate to the specificity of each location. Finally, it is reinforced the idea of the need to monitor the progress and effectiveness of the measures adopted on an ongoing basis, considering all the effects that may result of its realization. Observing coastline erosion patterns and sea level rise rates, the performance of both coastal protection structures and artificial nourishments have to be studied year by

year, adjusting and, if necessary, adopting different adaptation paths (INCCA 2023; Coelho et al. 2023).

Given the uncertainty, volatility, complexity and ambiguity of the collective future, whether from the perspective of the climate, the economy or the socio-political (dis)balances factors, it becomes increasingly urgent and important to design and develop appropriate land management models. Participatory governance models, dynamic, iterative, flexible and transparent will be a growing need and are already replacing traditional models, bringing new technologies, new knowledge, and, above all, new processes that promote the involvement of all stakeholders in the various stages of thinking, reflecting, planning, implementing and assess strategies and measures to mitigate and adapt coastal zones (INCCA 2023; Coelho et al. 2023).

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