Chapter 13
Impact of Sea Level Rise on Coastal Regions and Strategic Responses

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ABSTRACT

This chapter includes an assessment of physical vulnerability of the coast, including a coastal vulnerability index composed of 9 physical variables—elevation, distance to shore, tide amplitude, significant wave weight, erosion/accretion rates, geology, geomorphology, ground cover vegetation, and anthropogenic actions—followed by a quantification of coastal recession and the data of special report on emissions scenarios (SRES) developed by the Intergovernmental Panel on Climate Change (IPCC) on the rise in average sea level. It includes an estimate of the economic value of an area of recreation based on the travel cost method. Finally, a bibliographic review is made to assess strategies and responses to the impacts of sea level rise in order to make comparisons and to develop a road map of interventions for shoreline protection. The proposed methodology was applied to a case study on the Portuguese coast corresponding to the beaches of Costa de Caparica, Almada.

INTRODUCTION

The rise in mean sea level is considered one of the most significant results of global warming (Gilman, 2005). To date, few studies have been conducted that considered damage from sea level rises, and those who did so have been exposed to potential damage, such as reductions in the area of coastal habitats (Nicholls, 2006 in Anthoff, 2001). Throughout the geological history, changes in sea level have resulted in a rise of about three hundred meters due to changes in the shape and size of ocean basins, the amount of water in the oceans and the average density of seawater. Studies conducted since 1993 based on satellite altimetry indicate that the rate of sea level rise at the global level has been higher in the last decade,

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with a rise of more than 3 mm per year (Church et al., 2001 in Holgate & Woodworth, 2004). In the last century, sea level rose about 20 cm, to an average of 1 to 2 mm per year (Nerem & Mitchum, 2001; Leuliette et al., 2004 in Antonov et al, 2005).

Coastal areas are an unstable system conditioned by processes, such as the balance between the accretion and erosion of sediments, which will influence the formation of different types of coasts (Gomes, 2009). The natural processes create a normal sediment migration due to wind, tides and storms, but the anthropic actions can accelerate these processes at the long term, while may reduce it at short term.

Vulnerability is a fundamental concept in the investigation of the human environment. It is the potential for loss and can be defined as the social and ecological context that adjusts the capacity to ensure well-being when confronting a population with situations of variability (Downing & Patwardhan, 2003). Its assessment to coastal systems becomes necessary in the sense that from an ecosystem point of view is not a problem but a natural response to a new equilibrium created by Earth's biogeochemical mechanisms. However, Man is embedded in the various ecosystems and derives benefits such as housing, food and raw materials for economic activities; therefore, it is justified by the possibility of identifying areas with high potential for loss.

In industrialized countries, most populations are protected from flooding by building structural coastal protection measures such as the United Kingdom, the Netherlands and Japan. In developing countries, defenses are less developed and populations are more often subject to floods, economic losses and in the worst cases, loss of life. Among the potential impacts of sea level rise are erosion, coastal recession, increased severe flooding, and contamination of groundwater by seawater intrusion (Small & Nicholls, 2003).

There are many stakeholders in coastal areas that have different preferences for actions to be adopted, including economic and social partners, organizations representing coastal residents, NGOs and the business sector. This shock of preferences are often seen among those whose interests lie in maintaining natural values and progressing towards sustained development and those whose interests are purely economic (McFadden & Green, 2007).

BACKGROUND

It is estimated that 1.2 billion people, approximately 23% of the world's population, live 100 km from a coastline (Nicholls & Small, 2002; Nicholls, 2003). The population density in coastal regions is about three times the world average (Nicholls, 2003). Coastal areas are of great economic value (Schernewski & Loser, 2004) nonetheless, they are susceptible to hazards such as sea level rise.

Rising sea levels will have significant impacts on a range of marine and terrestrial ecosystems, many of which are already threatened by human activities (Feagin, 2005). Even small saline intrusions in coastal lagoons may cause disruption of the zooplankton community regarding its structure and abundance (Schallenberg et al., 2003).

In Portugal, 28.5% of coastal areas were at risk of erosion (Costa, 2007). Coastal shoreline intensification has coincided with the development of several interventions in the catchment and coastal areas, including sand extraction, construction in sensitive areas and the construction of more than 100 large dams in the national territory (Costa, 2007). As a consequence, sediment transport from the mainland to the coast decreased by about 90%. The construction of infrastructures to protect the coastline, such as spurs, consolidation of cliffs and artificial feeding of beaches altered the coastal dynamics (Crooks, 2004).