FACULDADE DE CIÊNCIAS SOCIAIS E HUMANAS
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# From coastal defence to coastal adaptation. The role of coastal boundary lines in coastal management plans: a comparative study between Portugal and South Africa

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**Tese de Doutoramento em Geografia e Planeamento Territorial área de especialização em Detecção Remota e Sistemas de Informação Geográfica**

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# DECLARAÇÕES

Declaro que esta tese é o resultado da minha investigação pessoal e independente. O seu conteúdo é original e todas as fontes consultadas estão devidamente mencionadas no texto, nas notas e na bibliografia.

O candidato,

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Lisboa, 05 de Agosto de 2019

Declaro que esta tese se encontra em condições de ser apreciada pelo júri a designar.

O orientador,

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Lisboa, 05 de Agosto de 2019

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**FROM COASTAL DEFENCE TO COASTAL ADAPTATION. THE ROLE OF COASTAL BOUNDARY LINES IN COASTAL MANAGEMENT PLANS: A COMPARATIVE STUDY BETWEEN PORTUGAL AND SOUTH AFRICA**

**BRUNO MIGUEL ALMEIDA NEVES**

## ABSTRACT

The link between climate change and sea level rise has long been assumed by the scientific community. Climate change has been increasing sea levels and intensifying coastal extreme weather events in duration and frequency, aggravating flood risk, which may result in permanent submersion of coastal zones. Furthermore, the world's population has been growing, mostly in coastal zones, following a tendency that will continue in the coming decades. People and infrastructure are now more exposed and scenarios point to increasing exposure. In this regard, decision-making is now urged to respond to immediate constraints by implementing and reinforcing short- to medium-term responses through coastal defences whenever and wherever possible, while more proactive medium- to long-term coastal adaptation interventions are necessary to complement shorter-term measures. Therefore, many countries have been adopting coastal boundary lines, commonly referred to in the literature as setback lines, in their coastal management policies. Portugal referred to as a developed country, and South Africa as a developing country, both felt the need to adapt to these new challenges. Both countries have been subject to increasing coastal hazards and rising sea levels, while population in built-up areas along the coast has increased, exacerbating exposure, and consequently introduced significant changes to their coastal management policies, namely by incorporating setback lines. In order to acquire relevant information and views, semi-structured interviews were conducted with key-actors at National, Regional and Local Government levels, Academics, and Consultants, in both countries. Results suggest that different (political) backgrounds can lead to different outcomes. In Portugal, the implementation of Safeguard Lines is the responsibility of the Central Government, while in South Africa, Coastal Management Lines are a Provincial Government responsibility. Several constraints to the implementation of setback lines were identified by key-actors. In South Africa, more than in Portugal, the lack of a National Level methodological guidance raised some concerns related to the adoption of different methodologies by each Province, leading to increased implementation delays. In both countries, the national (mandatory) coverage of the lines was mentioned to be a major challenge due to restrictive and prohibitive regimes imposed by this type of lines, particularly in built-up environments. In the past, only the (few) most capacitated municipalities have adopted such coastal management measures. In both countries, key-actors have mentioned a general mistrust in Local Government due to the history of exceptions for development in restricted demarcated coastal areas. Both countries recognized the importance of public participation in the planning process through the policies in force. However, Portugal has grounded its methodology on the natural sciences and the contributions of stakeholders in this field of expertise have been reduced. South Africa had an equally solid natural science-based component, however, the social sciences component is crucial in the implementation of their lines. It should be noted, however, that both countries had limitations on the quality and availability of Geographic Information. Given this duality, it can be concluded that a "*one size fits all*" methodology does not apply to the implementation of setback lines in the case study countries.

KEYWORDS: Setback Lines, Coastal Management, Coastal Adaptation, Climate Change, Portugal, South Africa.

**FROM COASTAL DEFENCE TO COASTAL ADAPTATION. THE ROLE OF COASTAL BOUNDARY LINES IN COASTAL MANAGEMENT PLANS: A COMPARATIVE STUDY BETWEEN PORTUGAL AND SOUTH AFRICA**

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## RESUMO

A relação entre as alterações climáticas e a subida do nível do mar foi há muito tempo assumida pela comunidade científica. As alterações climáticas têm contribuído para a subida média do nível do mar e para a intensificação (duração e frequência) de eventos climáticos extremos costeiros, agravando o risco de inundação, o que poderá resultar na submersão permanente das zonas costeiras. Acresce que a população mundial tem vindo a aumentar, principalmente nas zonas costeiras, uma tendência que continuará nas próximas décadas. Pessoas e infraestruturas estão agora mais expostas e os cenários apontam para um agravamento. Neste sentido, há que tentar responder às limitações existentes, implementando e reforçando medidas de curto e médio prazo (defesas costeiras) e de médio e longo prazo (intervenções de adaptação costeiras). Assim, vários países têm adotado Faixas de Salvaguarda nas suas políticas de gestão costeira. Portugal referido como um país desenvolvido, e a África do Sul como país em desenvolvimento, sentiram a necessidade de se adaptar a estes novos desafios. Ambos estão sujeitos às vulnerabilidades costeiras e à subida do nível do mar, registando simultaneamente um aumento das áreas construídas e da população, exacerbando a exposição e originando mudanças significativas nas suas políticas de gestão costeira, nomeadamente incorporando Faixas de Salvaguarda. Com o objetivo de obter informações relevantes foram conduzidas entrevistas semiestruturadas a atores-chave aos níveis do Governo Central, Regional e Local, Académicos e Consultores, em ambos os países. Os resultados sugerem que diferentes circunstâncias (políticas) podem originar resultados distintos. Em Portugal, a implementação de Linhas de Salvaguarda é da responsabilidade do Governo Central, enquanto que na África do Sul, as *Coastal Management Lines* são implementadas ao nível da Província. Foram identificados vários constrangimentos à implementação das Faixas de Salvaguarda pelos atores-chave. Na África do Sul, mais do que em Portugal, a falta de uma orientação metodológica ao nível Nacional implicou a adoção de diferentes metodologias em cada Província, levando a sucessivos adiamentos na sua implementação. Em ambos os países, a cobertura nacional (obrigatória) das Faixas de Salvaguarda foi identificada como o grande desafio, particularmente em ambientes construídos, devido aos regimes restritivos e proibitivos impostos por estes instrumentos. No passado, apenas alguns municípios mais capacitados adotaram este tipo de medidas. É referida, em ambos os países, uma desconfiança generalizada relativamente ao Governo Local devido ao histórico de exceções permeáveis à construção em áreas costeiras demarcadas. Ambos os países demonstraram reconhecer a importância da participação pública nos processos de planeamento e políticas em vigor. No entanto, Portugal fundamentou a sua metodologia nas ciências naturais sendo as contribuições das partes interessadas particularmente reduzidas. A África do Sul teve igualmente uma componente sólida baseada nas ciências naturais, no entanto, a componente associada às ciências sociais demonstrou ser crucial para a implementação destas faixas. Deve-se notar, no entanto, que em ambos os casos houve limitações devido à qualidade e disponibilidade de Informação Geográfica. Dada essa dualidade de critérios, pode-se concluir que uma metodologia "*one size fits all*" não se adequa à implementação de Faixas de Salvaguarda nos países em estudo.

PALAVRAS-CHAVE: Faixas de Salvaguarda, Gestão Costeira, Adaptação Costeira, Alterações Climáticas, Portugal, África do Sul.

# INDEX

**ACCRONIMS AND ABREVIATIONS LIST**

AAER - Average Annual Erosion Rate

APA - Agência Portuguesa do Ambiente (Portuguese Environmental Agency)

ARH - Administração da Região Hidrográfica (Hydrographic Regional Administration)

CBO - Community-Based Organisation

CCDR - Comissão de Coordenação e Desenvolvimento Regional (Commission for Regional Coordination and Development)

CEDRU - Centro de Estudos e Desenvolvimento Regional e Urbano (Centre for Studies and Urban and Regional Development)

CHANGE project - Climate, Coastal and Social Changes (Mudanças Climáticas, Costeiras e Sociais)

CML - Coastal Management Line

CMPP - Coastal Management Policy Programme

CNADS - Conselho Nacional do Ambiente e do Desenvolvimento Sustentável (National Council for Environment and Sustainable Development)

CSIR- Council for Scientific and Industrial Research

DEA - Department of Environmental Affairs

DMSP-OLS - Defense Meteorological Satellites Program - Operational Linescan System

DSAS - Digital Shoreline Analysis System

ENAAC - Estratégia Nacional de Adaptação à Alterações Climáticas (National Strategy for Adaptation to Climate Change)

ENGIZC - Estratégia Nacional de Gestão Integrada das Zonas Costeiras (National Strategy for Integrated Coastal Zone Management)

EU - European Union

FAR - Fifth Assessment Report

FCUL - Faculdade de Ciências da Universidade de Lisboa (Faculty of Sciences of the University of Lisbon)

FEUP - Faculdade de Engenharia da Universidade do Porto (Faculty of Engineering of the University of Porto)

GDP - Gross Domestic Product

GHG - Greenhouse Gases

GIS - Geographic Information Systems

GIT - Geographic Information Technologies

GPS - Global Positioning System

HWL - High Water Line

HWM - High Water Mark

ICM Act - National Environment Management: Integrated Coastal Management Act

ICN - Instituto da Conservação da Natureza (Institute of Nature Conservation)

ICPD - International Conference on Population and Development

ICZM - Integrated Coastal Zone Management

IGOT - Instituto de Geografia e Ordenamento do Território da Universidade de Lisboa (Institute of Geography and Spatial Planning of the University of Lisbon)

INE - Instituto Nacional de Estatística (Statistics Portugal)

IPCC - Intergovernmental Panel on Climate Change

LiDAR - Light Detection And Ranging

LMA - Lisbon Metropolitan Area

LNEC - Laboratório Nacional de Engenharia Civil (National Civil Engineering Laboratory)

MASMA - Marine and Coastal Science for Management - Western Indian Ocean

MEC - Members of Executive Committees

MHWL - Mean High Water Line

MHWM - Mean High Water Mark

NEMA - National Environmental Management Act

NGO - Non-Governmental Organisations

NGVD - National Geodetic Vertical Datum

NHWL - Normal High Water Line

NOAA - National Oceanic and Atmospheric Administration

OCIMS - National Oceans and Coastal Information Management System

OHWL - Ordinary High Water Line

PDM - Municipal Master Plans

PMA - Porto Metropolitan Area

POC - Programa da Orla Costeira (Coastal Spatial Management Programme)

POOC - Plano de Ordenamento da Orla Costeira (Coastal Spatial Management Plan)

PPP - Purchasing Power Parities

PROT - Plano Regional de Ordenamento do Território (Regional Spatial Plan)

QEPiC - Quadro Estratégico para a Política Climática (Strategic Framework for Climate Policy)

RCM - Resolução do Conselho de Ministros (Council of Ministers Resolution)

RCP - Representative Concentration Pathways

REN - Reserva Ecológica Nacional (National Ecological Reserve)

RENCOASTAL - Regulations and Environmental Conflicts Due to Coastal Erosion

SHWL - Seasonal High Water Line

SPLUMA - Spatial Planning and Land Use Management Act

SPM - Shoreline Management Plan

SRES - Special Report on Emissions Scenarios

UAV - Unmanned Aerial Vehicle

UNEP - United Nations Environment Programme

US - United States

VHR - Very High Resolution

WOR - World Ocean Review

## INTRODUCTION

Coastal zones define the crossing point between the land and the sea, and are characterized by a diversity of ecosystems such as beach areas, cliffs, coral reefs, deltas, dunes, estuaries, mangroves, rocky shores, salt marshes, submerged vegetation and wetlands (AA.VV, 2010a; Benassai et al., 2015; Hansen & Fuglsang, 2014; IPCC, 2014b, p. 366). In the first volume of the World Ocean Review (WOR 1) (2010, p. 60) the definition of coastal zones emphasizes the influences that both can impose on each other and therefore *"the coastal zone can be considered more the sea, or more the land. Simply stated, the coastal zone encompasses that area where the land is significantly influenced by the sea, and the sea is notably influenced by the land".* The interdependencies that characterize this complex system require adding the notion of timescale to the definition in that *"the coastal zone, which represents the interface between the land and sea, is one of the most dynamic areas on Earth. Change is occurring at all time scales from hours (with storm impact) to decades and longer (due to sea-level rise)"* Encyclopedia of Coastal Science (2005, p. 21).

Such diversity is attractive for a wide range of leisure activities, making coastal zones privileged places for recreational and tourism activities, holiday and retirement homes. They are also amongst the most heavily industrialized areas, concentrating vital infrastructure, including crucial transport routes and interfaces, being often complex, dynamic, densely populated and economically important areas (AA.VV, 2010a; Alves et al., 2013; Balica et al., 2012; Flannery et al., 2015; Goble et al., 2014; Hinkel et al., 2012). Population densities in coastal zones are in general much higher than the global population average densities (AA.VV, 2010a; Bosello & De Cian, 2014).

The complexity underlying coastal zones management increases as consequences from climate change are being felt in these areas. Increasing temperatures, sea level rise and extreme weather events are now more frequent and intense leading to a vulnerability escalation in coastal areas (AA.VV, 2010a). A tendency aggravated by population migrations and tourism, which is expected to continue in the following decades (Balica et al., 2012; Berry & BenDor, 2015; Flannery et al., 2015; Gibbs, 2016; Hansen & Fuglsang, 2014).

Sea level rise is among one of the major concerns, playing a crucial role in shaping coastlines (Hinkel et al., 2013; Kay, 1990; Sanò et al., 2010). Its impacts on highly populated areas are aggravated by, particularly, extreme sea levels (Woodworth et al., 2011) and extreme weather events such as floods and storm surges (Balica et al., 2012; Gibbs, 2016).

As mentioned, natural and human pressures weaken the resilience of coastal systems. As a result, vulnerabilities increase and the risk to coastal inhabitants becomes higher (Benassai et al., 2015). Therefore, the need for efficient coastal management is urgent as land continues to lose territory to the sea.

This PhD project focuses on the role of coastal boundary demarcation lines for coastal management in a comparative study of policies and instruments between Portugal and South Africa.

South Africa, as opposed to Portugal, has a more recent history of coastal use. This issue is in part explained by the governmental regime in force in South Africa until 1994 that conditioned access to the coast. Consequently, coastal management laws for both countries have entered into force in different periods. Under this assumption, this PhD project proposes to contribute to the study of coastal management, specifically in the efficiency of using coastal boundary management lines in coastal adaptation to climate change.

## 1. PROBLEMATICS

Coastal boundary lines are management tools used to define areas vulnerable to coastal hazards such as storm surges, floods and erosion. They are meant to safeguard people, coastal infrastructures and resources from any type of coastal hazards, including those related to sea level rise and climate change. Despite their important role in reducing vulnerability and risk exposure, they are often seen as restrictive, a constraint on development and therefore have often become a problem rather than part of coastal management solutions.

The methodologies to define coastal boundary lines have, or should have, two essential components. One, linked to Natural Sciences, involves the use of mathematical modelling and Geographic Information Systems (GIS) and Remote Sensing, in order to predict whether, and to what extent, a coastline will move landwards or seawards, and to identify areas susceptible to coastal hazards and to sea level rise. The other component, more linked to Social Sciences, regards coastal actors and stakeholders involvement in the process of coastal boundary demarcation lines definition and implementation by inquiring how they perceive results or changes introduced, accept them, and how these are negotiated.

Both aspects are deeply relevant to this thesis, where Geography is the main area and planning can be described as the overall goal, in which this specialization (Remote Sensing and Geographic Information Systems) provides many and adequate tools to bring together both the modelling and the social components of coastal boundary lines.

## 2. RELEVANCE OF THE STUDY

The starting point of this thesis is the methodological misconception of coastal boundary demarcation lines presented in the above section, leading these to be rejected and negatively connoted. Therefore, it aims to expand the debate about coastal boundary demarcation lines, and contribute to their efficient use as coastal management tools and planning instruments.

This interest in studying and comparing these two different countries was initially set and later refined after a recent integration as a young researcher in the following projects: Knowledge production, communication and negotiation for coastal governance under climate change (KnowHow Marie Curie IRSES), and Emerging Knowledge for Local Adaptation – Modifying the symbiosis of knowledge and governance of the adaptation of Western Indian Ocean coastal communities at risk from global change (MASMA).

## 3. OBJECTIVES

The overall goal of this PhD thesis is to contribute to the study of coastal boundary management lines, within coastal management, in the adaptation of these highly dynamic coastal margins and within the context of multiple and changing ocean-climate vectors. Such goal considers the following objectives:

Objective 1. Assess coastal boundary lines, how they have been used in the past and are presently being used, identifying strengths and weaknesses, and possible room for methodological changes; evaluate the historical and contemporary use of coastal boundary demarcations, including main purpose, methodologies and modes of implementation in legislation, policy and management practices;

Objective 2. Analyse and evaluate coastal boundary demarcation legislation and policy in the two case study countries, including the extent to which they are explicitly used in climate change risk reduction and adaptation;

Objective 3. Undertake a critical assessment of the state of the art (strengths and weaknesses) of Geographic Information Technologies (GIT) (practices; techniques; methods) to render coastal demarcation for coastal management and planning purposes;

Objective 4. Discuss a framework for the appropriate use of coastal boundary demarcation lines in such dynamic coastal fringes subject to increasing impacts of climate change and make implementation recommendations.

## 4. METHODS

In the course of preparing each of the chapters, qualitative and quantitative methodological approaches are explored. Nevertheless, greater prominence is placed on qualitative methods, not neglecting quantitative methods, whenever necessary, in each of the different steps, being their strengths and limitations recognized.

Fonseca (2008) defines three different and important methodological stages in social sciences. Starting by defining the object to study and structuring the research;

followed by the research process; ending on the information analysis. In each of the mentioned steps, the author underlines the possibility of applying both methods, since both can contribute to build theories, to formulate hypothesis and tests, and to better contribute to creating new and real knowledge. Despite, a methodological approach based only on qualitative methods often replicates previous works results and information that is listed and observed through field works. Quantitative methods perform statistical analysis that allows finding patterns in information. Therefore, quantitative results must be properly explored in order to help to answer every question that arises along each step of the research. Lately, using both will contribute to extract meaning from the patterns found in quantitative methods.

The thesis is objectively structured (figure 01) in order to respond to each of its objectives so that assumptions resulting from the initial literature review leading to this project can be verified.

In the introductory section of the thesis, methods and links between chapters are outlined, considering the objectives presented above and their respective premises. These are later refined in the following chapters.

Chapter I incorporates exclusively qualitative analysis in the extensive literature review of key subjects in terms of coastal environments and related natural and human-induced pressures. It assesses the state of the art of Coastal Zones, highlighting relevant typologies and key concepts. It reviews how climate change is affecting and will affect coastal areas, considering sea level rise and coastal hazards scenarios. It also reviews the state of the art on coastal management including coastal defences and adaptation options. Lately, population dynamics are considered through an evolutionary analysis, particularly reflecting populations living in coastal areas.

Chapter II assesses how coastal boundary demarcation lines have been used in the past and how it is presently being used. It identifies the strengths and weaknesses of the used methodologies and seeks possible methodological changes through qualitative analysis. An extensive literature review on coastal boundary demarcation lines worldwide is initially done. Lately, information on coastal boundary lines regarding the used methods; reference features and distances; features considered worthy of protection; and, implementing authorities will help in the detection of changes in "discourse" and methods. Both the literature review and the coastal boundary lines analysis answer to the proposed objective 1. A set of case studies are presented to illustrate how such demarcations are implemented worldwide.

Chapter III introduces both case studies, recognising patterns in human occupation and land use changes through different qualitative and quantitative methodological approaches. It provides tools in order to track human-induced pressures identifying changes in occupation of the territory by residents, migrations and tourism through the use of free and open source statistical, vector and raster data. Trends resulting from the used methods supported by the literature review highlight the need to create effective short-, medium- and long-term measures to minimize risk, resulting from exposure to natural causes plus climate change.

Chapter IV undertakes a critical assessment of the state of the art in the use of coastal boundary demarcation lines in both Portugal and South Africa based on semi-structured interviews to key-actors of both the case study countries and supported by a literature review. It addresses legislation and policy instruments used in both countries, including the extent to which they are explicitly used in climate change risk reduction and adaptation, therefore responding to objective 2.

Chapter V focuses on the use of Geographic Information Technologies (GIT) in the development of coastal boundary demarcation lines, contributing to addressing objective 3. This evaluation is mainly based on the results obtained through the contribution of the key-actors during the semi-structured interviews, benefiting from a complementary analysis through a literature review. This qualitative analysis focuses on key-aspects, in particular, the adequacy of qualified staff to current needs; in the importance and role of GIT/GIS in the development of coastal boundary demarcation lines; the quality of the geographical information used to meet current needs, and; in possible alternatives to the currently used methods.

The thesis addresses objective 4 in the discussion of the results section, ending with the final remarks, followed by the references list section.

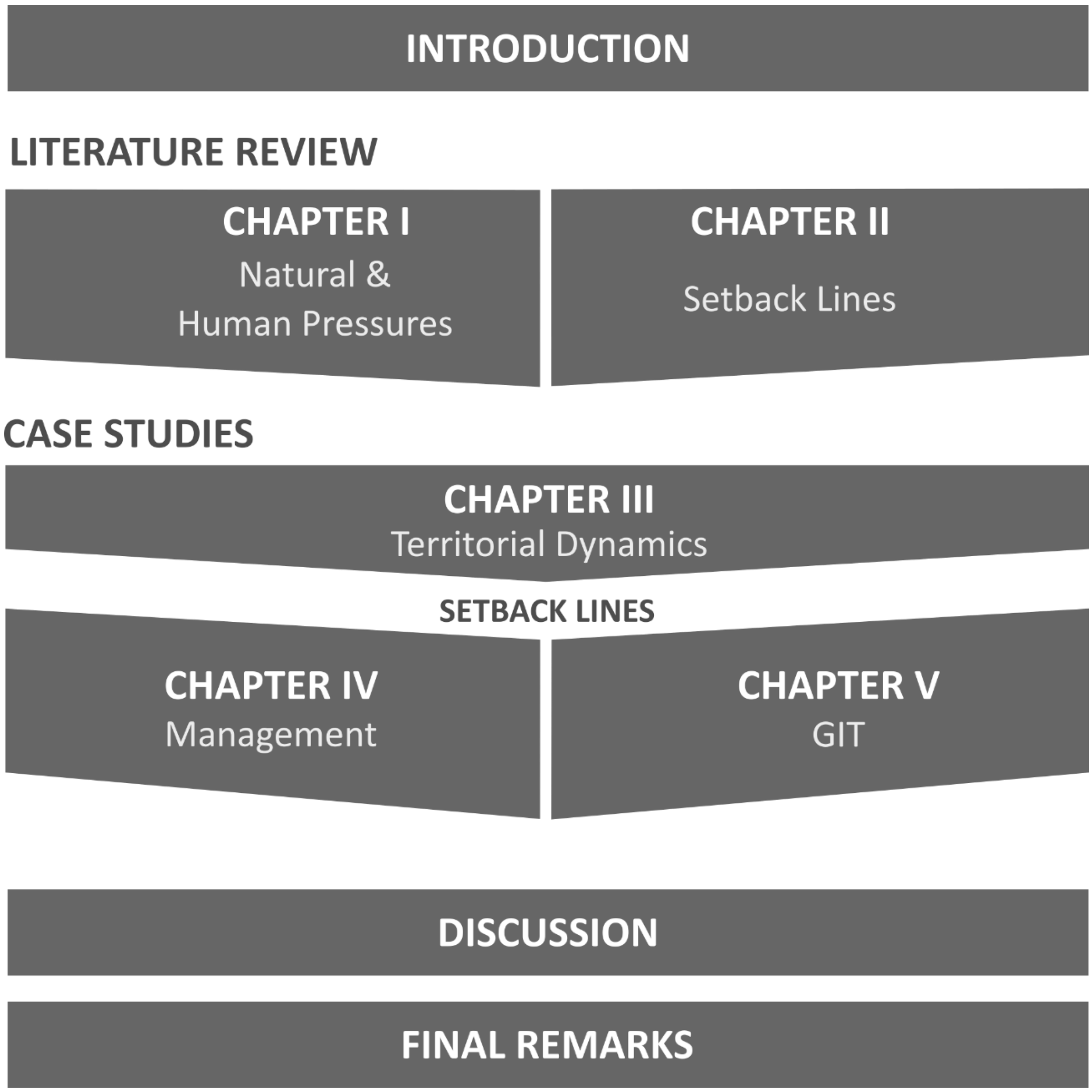


Figure 01. Thesis general structure.

# CHAPTER I. NATURAL AND HUMAN PRESSURES IN COASTAL ZONES

## Aim and scope

Chapter I provides the context to further explore the role of boundary lines in coastal management, with a focus on adaptation to climate change. It reviews coastal natural and human-induced pressures and provides a broad understanding on coastal management strategies, incorporating the concepts of coastal defences and adaptation, illustrated with a few international examples.

Firstly, the chapter introduces key concepts to enable a better understanding of processes arising from current and future coastal zone pressures, both natural and human-induced.

The chapter then reviews natural pressures considering climate change, referred to in the literature as an accelerator of coastline retreat, where sea level rise and increasing and intensifying extreme weather events are playing a crucial role.

It continues on to reviewing human-induced pressures, providing an overview of the current state and future trends regarding the world's population and migrations.

The review of natural and human-induced pressures provides the background to discuss the need for coastal management, including the various coastal management options available to policymakers, focusing on coastal defences and coastal adaptation as key policy options in the context of climate change.

The chapter concludes with a summary of key points.

## I.1. COASTAL ZONES

There is no common agreement defining coastal zones (Creel, 2003; Martínez et al., 2007). Literature often refers to Coastal Zones as the interface between land and sea. This definition has been largely adopted by different authors (AA.VV, 2010a, p. 60; Schwartz, 2005, p. 21) although it raises serious doubts about its geographical area.

The definition in the World Ocean Review (2010, p. 60) focuses on the influence that both land and sea may impose on each other. It accepts that *"the coastal zone can be considered more the sea, or more the land. Simply stated, the coastal zone encompasses that area where the land is significantly influenced by the sea, and the sea is notably influenced by the land".* The interdependence generated between both land and sea leads to the need to assign a timescale to the definition of coastal zone. Thus, the Encyclopedia of Coastal Science (2005, p. 21) highlights such dynamics in its definition: "*coastal zone, which represents the interface between the land and sea, is one of the most dynamic areas on Earth. Change is occurring at all time scales from hours (with storm impact) to decades and longer (due to sea-level rise)".*

In terms of planning, boundaries demarcations are essential in defining intervention areas, particularly in such dynamic and diverse spaces as coastal zones. Nevertheless, there are not universal geographical boundaries to define them, being much dependent of the scope of the project, and availability of data, and may vary depending on *"the nature of the environment and management needs"* (Lavalle et al., 2011, p. 15). According to the European Commission (1999, p. 11), *"the geographic scale and extent of a coastal zone management activity should be adapted to the issues under consideration. In practice, projects most commonly select the boundaries that are the simplest to manage – frequently administrative boundaries. However, administrative boundaries do not generally coincide with boundaries of natural or social systems. A 'systems' approach will normally require looking at driving forces or areas of impact located in other administrative units and possibly far from the coastline*".

Considering this broad scope, many countries have introduced spatial boundaries in their Coastal Zones. In its 1991 Planning Act, Denmark had defined as coastal zone, an area demarcated from the coastline, with a length of 3 km landwards.

Spain has adopted their Coastal Zone boundary from the exact reference point, although they consider an extension of 200 m landwards of that reference point in their Shores Act from 1988. In order to embrace both the geographical heterogeneity and the land use dynamics of the places, the European Commission proposed, in 2011, that the European Coastal Zone should encompass an area of 10 km from the coastline, and a 2 km wide buffer from the following Corine Land Cover classes: Coastal wetlands (salt marshes, salines, and intertidal flats); and Marine waters (coastal lagoons, estuaries). The intention of the first criterion was to encompass not only specific ecosystems but also urban areas that may be generating some kind of pressure over the coast. The second criterion intended to include inland areas under direct influence of maritime environments (Lavalle et al., 2011, pp. 15–16). In the AA.VV (2005, p. 516), Coastal Zone is defined as the 100 km distance landwards from the coastline, or the 50 m elevation contour line. Seawards, the distance set from the high water mark is 50 m depth.

This dynamism that characterizes coastal zones is, in turn, associated with the diversity of ecosystems in these areas, namely, beaches, cliffs, coral reefs, deltas, dune systems, estuaries, mangroves, rocky shores, salt marshes, submerged vegetation and wetlands (Benassai et al., 2015; Hansen & Fuglsang, 2014; IPCC, 2014, p. 366). This multiplicity of spaces with different characteristics eventually attracts a wide range of uses and activities related to housing, industry, services, and leisure activities (AA.VV, 2010a; Balica et al., 2012; Flannery et al., 2015; Goble et al., 2014; Hinkel et al., 2012).

The attractiveness of coastal zones associated with their high biodiversity and socioeconomic value makes them more densely populated compared to other inland regions, and, in turn also more vulnerable to the effects of climate change, namely, sea level rise and extreme weather events. This vulnerability results not only from exposure of people but also from infrastructure to climate hazards, which is defined in Flannery et al. (2015) as *"a function of the presence of human beings and their myriad activities in interaction with naturally occurring coastal processes"*, and therefore, it refers to their ability to anticipate their effects, but also to live with and resist them, and yet to recover from their effects (Vousdoukas et al., 2017).

## I.2. NATURAL PRESSURES

Coastlines have unique natural and human dynamics, their shape being in constant change (Ciampalini et al., 2015; Coelho et al., 2005; Coelho et al., 2006). Such dynamics have been enlarged by climate change, exacerbating vulnerability in coastal areas (Flannery et al., 2015; Leatherman et al., 2005; Ventura et al., 2017). Climate change has increased and intensified sea levels and coastal extreme weather events (Balica et al., 2012; Berry & BenDor, 2015; Coelho et al., 2006; Hansen & Fuglsang, 2014; McGranahan et al., 2013) and aggravated flood risk, which may result in permanent submersion of coastal areas, in particular low-lying coastal areas (Fernandes & Neves, 2017; Ventura et al., 2017; Neves, Fernandes et al, 2017; Neves, Pires, et al., 2018; Neves, Fernandes et al., 2018; Veloso-Gomes, 2007).

### I.2.1. CLIMATE CHANGE AND SEA LEVEL RISE

The link between climate change and sea level rise was long assumed by the scientific community. It acquired larger institutional recognition with the work carried out by the Intergovernmental Panel on Climate Change (IPCC), more precisely since the publication of the First Assessment Report (FAR), the first major report of global importance on the subject (IPCC, 1990). Successive IPCC reports further recognised this link along with its consequences (IPCC, 1996, 2001, 2007, 2014a).

Sea levels have changed over time with amplitudes around 100 m between cooler (Glacial ages) and warmer (Interglacial ages) periods (IPCC, 2007). However, since the last Glacial period, sea levels rose more than 120 m (Lambeck et al., 2004). A rise of 21 cm since 1880 was considered stable. This stability ended in the second half of the Twentieth century with an acceleration in sea levels (Church & White, 2011) associated with greenhouse gases (GHG) generated from human-related activities (IPCC, 2007).

According to the IPCC Fifth Assessment Report (AR5), it is very likely that between 1901 and 2010 sea level has risen globally at an annual average of 1.7 mm, with an increase to 2.0 mm between 1971 and 2010, and 3.2 mm between 1993 and 2010 (IPCC, 2014a, p. 11). Projections for this century continue to point to an increase in the annual global mean sea level rise in all scenarios. Major contributions are expected to be from thermal expansion between 30% and 55% and glaciers from 15% to 35%. The degree of confidence in the projections also increased in relation to previous IPCC reports due to improvements in the physical understanding of sea level components, validation, and inclusion of ice-sheets dynamical changes inclusion (IPCC, 2014a, p. 25).

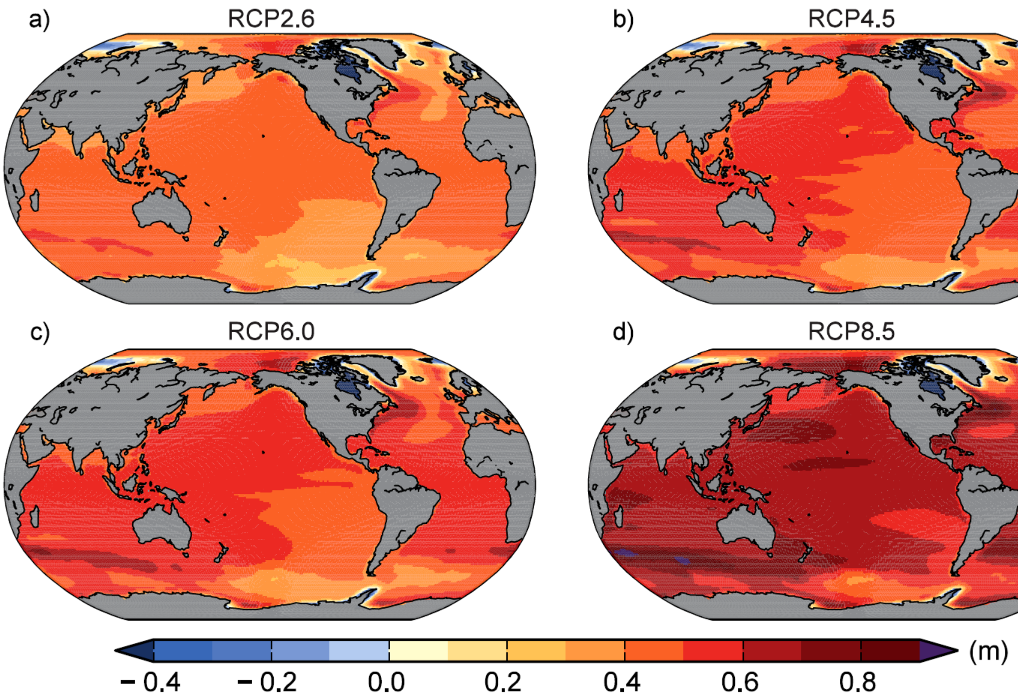


Figure I.2.1.02. Relative Sea Level Change 2081-2100 relative to 1986-2005 (metres). Source: Figure TS.23, IPCC, 2014a, p. 101.

Figure I.2.1.02 shows sea level rise projections published by IPCC for different scenarios. For the period 2081-2100, in relation to 1986-2005, the IPCC Fifth Assessment Report expects an increase in global mean sea level rise, likely to be from 0.37 to 0.69 m in the Special Report on Emission Scenarios (SRES) A1B scenario; 0.26 to 0.55 m in RCP2.6; 0.32 to 0.63 m in RCP4.5; 0.33 to 0.63 m in RCP6.0; and 0.45 to 0.82 m in RCP8.5 with medium confidence. According to this last scenario sea level will rise from 0.52 to 0.98 m in 2100, being the rate between 2081 and 2100 from 8 to 16 mm annum, with medium confidence (IPCC, 2014a, pp. 25, 98, 1140). Despite being lower than in the RCP8.5, all other scenarios are higher for 2100 comparatively to the period between

2081 and 2100. In SRES A1B the global rise in sea level is expected to be from 0.42 to 0.80; in RCP2.6 from 0.28 to 0.61; RCP4.5 from 0.36 to 0.71; RCP6.0 from 0.38 to 0.73; and in RCP8.5 0.52 to 0.98 m (IPCC, 2014a, p. 1182).

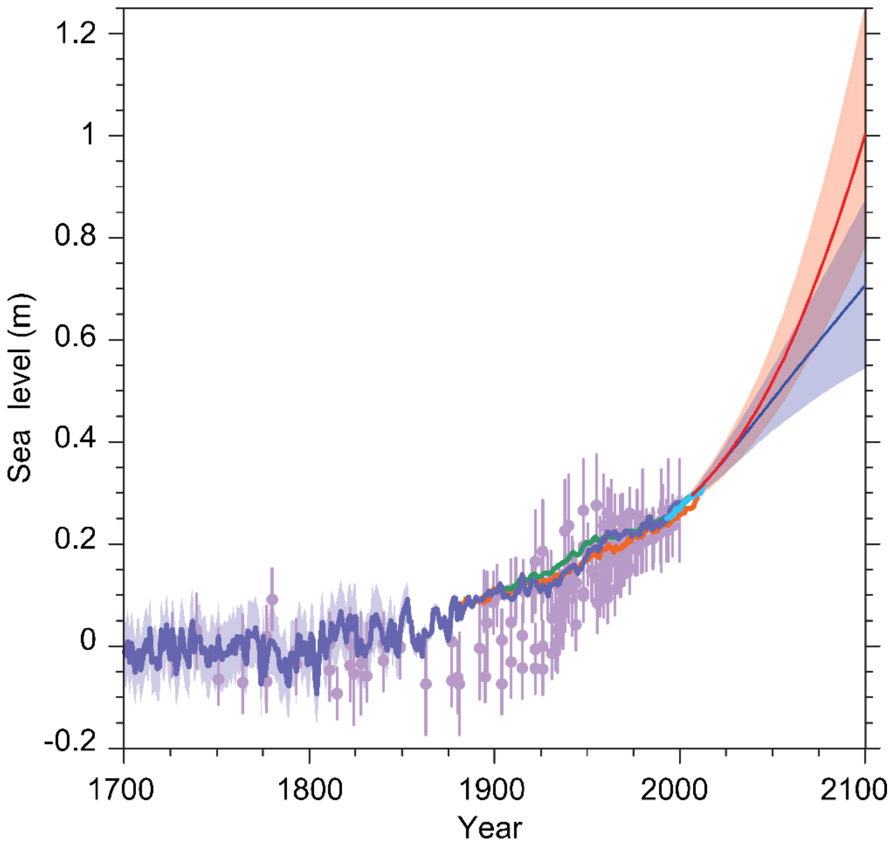


Figure I.2.1.03. Compilation of paleo sea level data (purple), tide gauge data (blue, orange and green), altimeter data (light blue) and central estimates and likely ranges for projections of global mean sea level rise from the combination of Coupled Model Intercomparison Project Phase CMIP) 5 and process-based models for Representative Concentration Pathways (RCP) 2.6 (blue) and RCP8.5 (red) scenarios, all relative to pre-industrial values. Source: Figure TFE.2, Figure 2 IPCC, 2014a, p. 49.

Semi-empirical scenarios project higher global sea level rise for this century (Neves et al., 2013), which can go up twice as the scenarios presented in the Fifth Assessment Report. However, because of insufficient evidence and consensus in the scientific community, these were not considered (IPCC, 2014a, pp. 26, 1140). Such differences can be related to an unidentified or underestimated contribution by the physical models or an overestimation of the semi-empirical models (IPCC, 2014a, pp. 99–100, 1140).

Other authors such as Vermeer & Rahmstorf (2009) reveal higher projections on sea level rise scenarios. The lowest scenario refers to a rise ranging from 0.81 to 1.31 m (1.04 m average) for the year 2100, having 1990 as the reference year. For the highest rise scenario values range from 1.13 to 1.79 m, with a 1.43 m average. In Pfeffer, Harper, & O'Neel (2008) the scenarios presented have similar values. The lowest projection refers to a rise in sea level of 0.80 m, while the highest projects a sea level rise of 2 m. The projections provided by Jevrejeva et al., (2010) for 2100 vary between 0.60 to 1.60 m. A semi-empirical study from Rahmstorf (2007) presents a scenario where sea level can rise between 0.55 and 1.25 m in 2100, in reference to 1900. This scenario can be extended from 0.50 to 1.40 m if statistical errors of the fit are included.

Despite some disagreements regardless amplitude, all estimates suggest that sea level will be higher by 2100. The various estimates are summarized in Figure I.2.1.04.

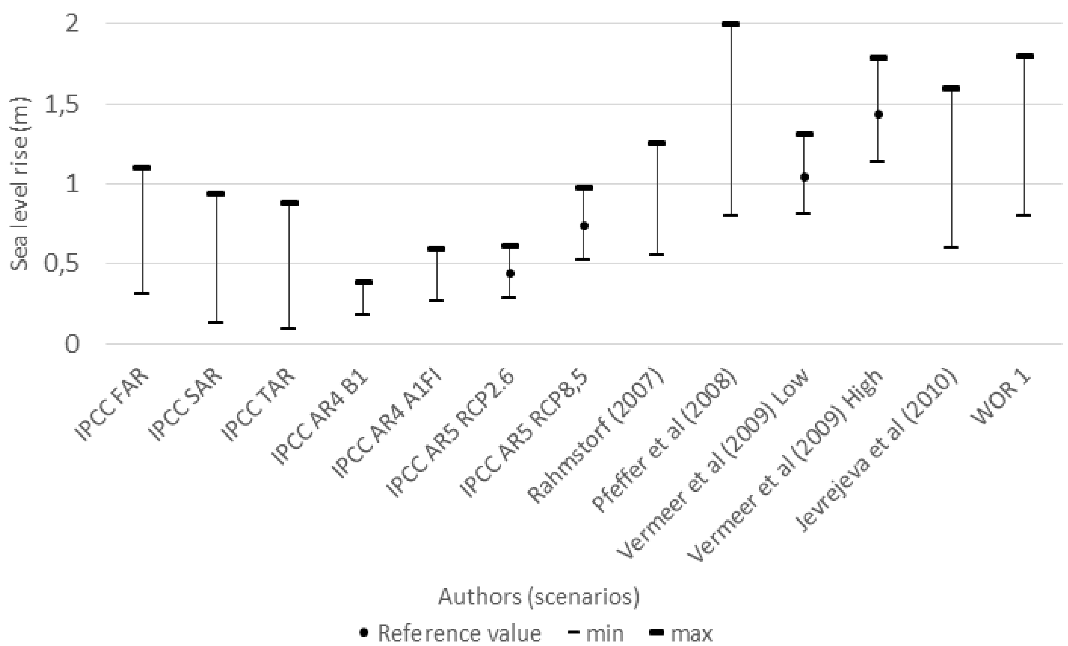


Figure I.2.1.04. Estimated sea level rise for 2100. Source: Author.

The Fifth Assessment Report refers as "virtually certain" a global sea level rise from 2100 afterwards (IPCC, 2014a, p. 100). Besides the previously mentioned scenarios, this report presents sea level rise scenarios for 2200, 2300, 2400 and for 2500, being for each year considered a low, medium and high scenarios (see Figure I.2.1.05 for an overview). For 2200 it is estimated for the lower scenario a rise in sea level from 0.35 to 0.72 m, and in the highest scenario a rise from 0.58 to 2.03 m, while in 2500 the lowest estimation is between 0.50 and 1.02 m, the highest is from 1.51 to 6.63 m (IPCC, 2014a, p. 1191).

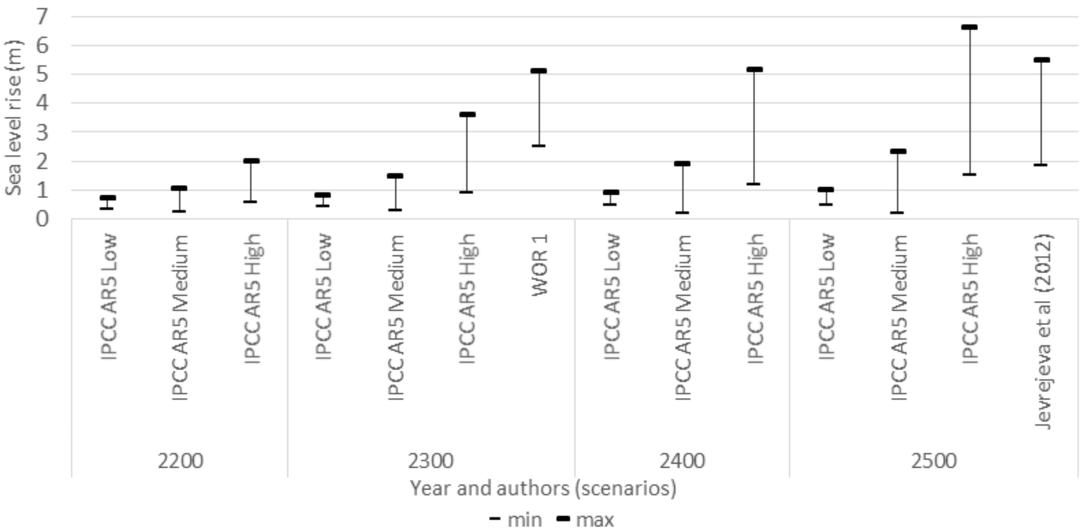


Figure I.2.1.05. Estimated sea level rise for 2200, 2300, 2400 and 2500. Source: Author.

Sea level rise scenarios are now more accurate than when IPCC, FAR was released in 1990. Such predictions became more robust as understanding of main contributors became more evident and methods were better refined, to which satellite observation data largely contributed, changing the scale of analysis and addressing the problems caused by storms to tide gauges which, left these inactive for long periods (Church et al., 2011; IPCC, 2014a, p. 1142; Meyssignac & Cazenave, 2012; Woodworth et al., 2011). Despite the lower uncertainties of today in modelling sea level rise, these are still present, in particular in the extent of each contributor, namely the ice sheet dynamics. There is no doubt of a rise in sea levels in the Nineteenth century and that this rise was larger in the Twentieth century, with higher rise expectations for this century and further rise for the centuries to come as it was presented above (AA.VV, 2010a; IPCC, 2014a, p. 1142).

### I.2.2. EXTREME WEATHER EVENTS

Climate change is affecting sea levels and oceans wave extremes mainly because of changes in duration, frequency, intensity and path of tropical and extratropical storms, which are considered as the main drivers of waves and sea level extremes (IPCC, 2012, 2014a). Because sea level is rising, the heights of these extreme events are increasing, and even if there were no changes in storms behaviour, such increases would exacerbate wave run-up resulting in coastal inundations in the form of storm surges and also in the form of tsunamis (IPCC, 2014a, p. 1200). Temperate and tropical regions are the regions where storms are expected to have the most increases (AA.VV, 2010b, p. 67).

The effects of storm floods have its peak related to spring tides. A storm can flood a coastal area for days if storm winds push the waters in the direction of the coast during spring tides, resulting in larger flooded areas for a longer period, which can last even during the ebb tide (AA.VV, 2010b, p. 67). Such increases in storm intensity will result in an acceleration of coastal erosion processes, bringing disruption to beaches and dunes systems. In many locations, artificially restocking these areas will be more difficult due to short supplies in nearby areas and the costs that are associated with beach and dunes nourishments which will reduce resilience in those territories (IPCC, 2014b, p. 376).

Floods can have huge impacts on livelihoods and business. They damage and destroy property and houses and kill people, livestock and wildlife. From all the natural hazards, floods are considered to be the most costly hazard and affecting the most people (National Research Council, 2015). The population exposed to 1 in a 100 year coastal flood in 2010 was about 270 million, a number that is expected to rise to 350 million in 2050, considering only socioeconomic development as the most relevant driver. But there are other drivers, including population growth, economic growth and urbanization (IPCC, 2014b, p. 381). In the United States of America (US), the flood disasters declaration rose from 5 in 1950s to 51 in 2008 and 2010. Such increase is in part caused by climate change but also because there are more people living in exposed areas (National Research Council, 2015). Asia and sub-Saharan Africa are the regions where such exposure is the most expected as result of socioeconomic development (IPCC, 2014b, p. 381).

In order to ease the impacts and damage of coastal floods affecting natural ecosystems and human settlements, coastal management has a crucial role to play, even more because increased exposure is expected for the decades and centuries to come. Therefore, proactive coastal management ensures better results than reactive responses to damage caused by extreme weather events and rising sea levels.

## I.3. HUMAN PRESSURES

As highlighted in the previous section, pressures resulting from natural factors are increasing coastal vulnerabilities. To add to the aforementioned, the world's population has been growing, particularly in coastal areas, following a tendency from the past that will continue in the coming decades (Flannery et al., 2015; Leatherman et al., 2005).

In 1994, by the time of the International Conference on Population and Development (ICPD) that took place in Cairo, Egypt (5–13 September), the world's population was estimated to be approximately 5.7 billion. In 2014 there were already more than 7.2 billion people living on the planet (table I.3.01), with the mark of 7 billion inhabitants reached in 2011 (United Nations, 2014b).

Table I.3.01. World's population by region.

*Population (millions of people/percentage)*

| *Region* | 1994 | | 2014 | | 2050 | |
|---|---|---|---|---|---|---|
| | Numb. | Percent. | Numb. | Percent. | Numb. | Percent. |
| *World* | 5 661 | 100 | 7 243 | 100 | 9 551 | 100 |
| *Africa* | 699 | 12,35 | 1 138 | 15,71 | 2 393 | 25,05 |
| *Asia* | 3 432 | 60,63 | 4 342 | 59,95 | 5 164 | 54,07 |
| *Europe* | 729 | 12,88 | 743 | 10,26 | 709 | 7,42 |
| *Latin America and the Caribbean* | 478 | 8,44 | 623 | 8,60 | 782 | 8,19 |
| *North America* | 294 | 5,19 | 358 | 4,94 | 446 | 4,67 |
| *Oceania* | 29 | 0,51 | 39 | 0,54 | 57 | 0,60 |

Source: Author. Adapted from United Nations, (2014, p. 3).

Despite a slightly lower growth rate (from 1.5% per year in 1994 to almost 1.2% per year in 2014), the world's population is expected to keep growing (table I.3.02). The United Nations predicts that global population will reach the 8.1 billion mark in 2025 and 9.6 billion in 2050 (table I.3.03) (United Nations, 2014b), which is 0.4 million more than what was expected in 2008, when the World Urbanization Report 2007 was released (United Nations, Department of Economic and Social Affairs, Population Division, 2008, p. 1). By 2050, the annual growth rate is expected to be 0.5%, which is significantly lower than the current rate. Nevertheless, world population will continue to grow (United Nations, 2014b).

Table I.3.02. World's population average annual growth rate by region.

*Average annual growth rate (percentage)*

| *Region* | 1990-1995 | 2010-2015 | 2045-2050 |
|---|---|---|---|
| *World* | 1,52 | 1,15 | 0,51 |
| *Africa* | 2,57 | 2,46 | 1,74 |
| *Asia* | 1,61 | 1,03 | 0,11 |
| *Europe* | 0,18 | 0,08 | -0,22 |
| *Latin America and the Caribbean* | 1,77 | 1,11 | 0,27 |
| *Northern America* | 1,05 | 0,83 | 0,45 |
| *Oceania* | 1,49 | 1,42 | 0,82 |

Source: Author. Adapted from United Nations (2014, p. 3).

Table I.3.03. World's population average annual increment by region.

*Average annual increment (millions of people/percentage)*

| *Region* | 1990-1995 | | 2010-2015 | | 2045-2050 | |
|---|---|---|---|---|---|---|
| | Numb. | Percent. | Numb. | Percent. | Numb. | Percent. |
| *World* | 84,2 | 100 | 81,7 | 100 | 48,5 | 100 |
| *Africa* | 17,3 | 20,55 | 27,0 | 33,05 | 39,9 | 82,27 |
| *Asia* | 53,9 | 64,01 | 43,9 | 53,73 | 5,7 | 11,75 |
| *Europe* | 1,3 | 1,54 | 0,6 | 0,73 | -1,6 | -3,30 |
| *Latin America and the Caribbean* | 8,2 | 9,74 | 6,8 | 8,32 | 2,1 | 4,33 |
| *Northern America* | 3,0 | 3,56 | 2,9 | 3,55 | 2,0 | 4,12 |
| *Oceania* | 0,4 | 0,48 | 0,5 | 0,61 | 0,5 | 1,03 |

Source: Adapted from United Nations (2014, p. 3).

Presently, Asia and Africa register the highest growth rates, with 54% and 33% respectively, of the 82 million people added every year (United Nations, 2014b). However, scenarios for 2050 predict that Africa will surpass Asia, adding more than 80% of the people in Africa and around 12% in Asia (Lee, 2015; United Nations, 2014b). These changes presented by the United Nations scenarios will bring a completely new dynamic in terms of population. By contrast, in Europe, population scenarios predict a decline in population just after 2020 (United Nations, 2014b).

With the majority of the population growth concentrated in Africa and Asia, it is not surprising that the countries responsible for the biggest increases in population are located there. What surprises the most is that only nine countries are expected to be responsible for more than half of the population increase for the period from 2014 to 2050. Of these, only one is not located in Africa or Asia. In this period, the Democratic Republic of the Congo, Ethiopia, India, Indonesia, Nigeria, Pakistan, the United Republic of Tanzania, the United States of America, and Uganda, will be responsible for more than the half of the population growth. In the meanwhile, India will overtake China, becoming the most densely inhabited country. Such shift is expected to take place in 2028 (United Nations, 2014b).

### I.3.1. URBAN POPULATION

Today more than the half of the total global population (54%) is living in urban areas[1] (see table I.3.1.04) (United Nations, Department of Economic and Social Affairs, Population Division, 2014a), a landmark that was reached in 2008 (United Nations, Department of Economic and Social Affairs, Population Division, 2008, p. 1).

Urban agglomerations are classified by the United Nations according to the number of inhabitants (see table I.3.1.05), from megacities (higher than 10 million inhabitants) to small cities and towns (lower than 500 thousand inhabitants). Today, megacities represent 12% of the total urban population with 453 million inhabitants distributed along 28 urban agglomerations. In 1990, the number of megacities was only 10, revealing a major increase in this type of cities, despite its present representation in the total of urban inhabitants. The so-called large cities (between 5 and 10 million

[1] The concept of Urban is a fuzzy concept and it is defined differently, according to several criteria. The International Organization for Migration, (2015, p. 201) defines Urban as varying *"from country to country, and, with periodic reclassification, can also vary within a country over time, making direct comparisons difficult. An urban area can be defined by one or more of the following: administrative criteria or political boundaries (e.g. area within the jurisdiction of a municipality or town committee); a threshold population size (where the minimum for an urban settlement is typically in the region of 2,000 people, although this varies globally between 200 and 50,000), population density; economic function (e.g. where a significant majority of the population is not primarily engaged in agriculture or where there is surplus employment), or the presence of urban characteristics (e.g. paved streets, electric lighting, sewerage)"*.

inhabitants) have a smaller representation, compared to the previous one. These account for 8% of the urban population, with more than 300 million inhabitants. In spite of its small representation, these city types are increasing. Medium-sized cities (between 1 and 5 million inhabitants) are growing as well. From 1990 to 2014, this typology doubled its cities number, representing today 20% of the total urban population with 827 million inhabitants. Expectations are that growth will be in the order of 36%, increasing the total population in these cities to 1.1 billion inhabitants by 2030. Cities with only 500 thousand inhabitants to 1 million are the second less representative cities, with only 10% of the total urban population. Small cities and towns with less than 500 thousand inhabitants, as a whole, represent 50% of the total urban population. However, these smaller cities and towns are expected to decline in population and represent, by 2030, around 45% of the total urban population (Lee, 2015).

Table I.3.1.04. World's urban and rural population by region in 2014.

| *Regions* | *Urban population* | *Rural population* | *Total* | *Percentage of urban population* |
|---|---|---|---|---|
| *World* | 3 880 128 | 3 363 656 | 7 243 784 | 53,6 |
| *Africa* | 455 345 | 682 885 | 1 138 229 | 40,0 |
| *Asia* | 2 064 211 | 2 278 044 | 4 342 255 | 47,5 |
| *Europe* | 545 382 | 197 431 | 742 813 | 73,4 |
| *Latin America and the Caribbean* | 495 857 | 127 565 | 623 422 | 79,5 |
| *Northern America* | 291 860 | 66 376 | 358 236 | 81,5 |
| *Oceania* | 27 473 | 11 356 | 38 829 | 70,8 |

Source: Author. Adapted from United Nations, Department of Economic and Social Affairs, Population Division (2014a).

As mentioned previously, Africa and Asia have the highest population growth rates. However, in both regions rural population still outgrows urban population (Lee, 2015; United Nations, Department of Economic and Social Affairs, Population Division, 2008, p. 1). Notwithstanding, urban areas in Africa have, in the last few decades, increased significantly (Lee, 2015). Urban growth therein is mainly centred in less developed cities and towns and the same pattern can be found in Asia (United Nations, Department of Economic and Social Affairs, Population Division, 2008, p. 1).

Table I.3.1.05. World's number of agglomerations, percentage and number of urban population by size class of urban settlement.

| | *2000* | | | *2015 (estimated)* | | | *2030 (estimated)* | | |
|---|---|---|---|---|---|---|---|---|---|
| *Size class* | N. aggl. | % urban pop. | Pop. | N. aggl. | % urban pop. | Pop. | N. aggl. | % urban pop. | Pop. |
| *10 million or more* | 17 | 9 | 255 132 | 29 | 12 | 471 314 | 41 | 14 | 729 916 |
| *5 to 10 million* | 30 | 7 | 209 696 | 44 | 8 | 306 864 | 63 | 9 | 433 898 |
| *1 to 5 million* | 314 | 21 | 600 433 | 428 | 21 | 847 201 | 558 | 22 | 1 127 875 |
| *500 000 to 1 million* | 385 | 9 | 261 530 | 538 | 9 | 370 964 | 731 | 10 | 509 412 |
| *300 000 to 500 000* | 501 | 7 | 190 194 | 690 | 7 | 261 772 | 832 | 6 | 318 917 |
| *Fewer than 300 000* | - | 47 | 1 339 147 | - | 43 | 1 699 170 | - | 38 | 1 938 140 |

Source: Author. Adapted from United Nations, Department of Economic and Social Affairs, Population Division (2014b).

The Sub-Saharan region of Africa is an example of this growth. In 1960, Johannesburg, in South Africa, was the only city with a total population of over one million inhabitants. Ten years passed, Cape Town (South Africa), Kinshasa (Congo), and Lagos (Nigeria) joined Johannesburg. In 2010, there were already 38 cities over one million inhabitants in the region (Lee, 2015) and scenarios point to 82 urban agglomerations in 2030, with total population higher than one million inhabitants (United Nations, Department of Economic and Social Affairs, Population Division, 2014c).

### I.3.2. INTERNATIONAL MIGRATIONS

International migrations in the last two decades have shown, on one hand, an increasing tendency and on the other, significant changes. Migration has increased from 154 million in 1990 to 232 million in 2013 (table I.3.2.06), corresponding to a 78 million increase of people travelling between countries (Lee, 2015, pp. 2–3; United Nations, 2014b). However, approximately 50% concentrate in only ten highly urbanised countries: Australia, Canada, France, Germany, Russia, Saudi Arabia, Spain, United Arab Emirates, United Kingdom, and the United States (Lee, 2015, pp. 2–3).

Comparatively, the number of internal migrants (travelling within the same country) is significantly higher, 740 million all over the world (Lee, 2015, pp. 2–3). In terms of share of international migrants in the world population, it represents an increase from 2.9% in 1990 to 3.2% in 2013. Such increase is not only in number but also in complexity. Many countries are now simultaneously countries of origin, transit and migrants destination (United Nations, 2014a).

North America added 1.1 million migrants per year from 1990 to 2013. It was the region with the biggest annual average increase of international migrants, followed by Europe, with 1 million, and Asia with nearly 1 million. However, a more recent tendency reveals that Asia is actually the region that is adding more international migrants. From 2000 to 2013, it gained, on an annual average, 1.6 million migrants totalling almost 21 million migrants in this period. Africa, Latin America and the Caribbean and Oceania were the regions with the least significant changes, adding 3 million, 2 million, and 3 million international migrants respectively from 1990 to 2013, changing from 16 million to 19 million, from 7 to 9 million, and 5 million to 8 million international migrants in this period (table I.3.2.06). Furthermore, in terms of international distribution of migrants worldwide, Europe and Asia combined hosted in 2013 approximately two-thirds of the world share (United Nations, 2014a).

In more developed regions, the positive net international migration[2] is presently the main source of population growth (table I.3.2.06). The share of international migrants in these regions rose from 53% in 1990 to 59% in 2013. Therefore, in the same period, less developed regions saw their share decrease from 47% to 41%. Comparatively, the more developed countries, more than doubled the number of international migrants in relation to less developed regions, being their increment of 53 million and 24 million people respectively, in the above mentioned period (United Nations, 2014a).

[2] Net International Migration results from the sum of immigrants, minus the sum of emigrants

Table I.3.2.06. World's population average annual increment by region.

| Region | International migrants (millions of people/percentage) 1990 | | 2000 | | 2013 | | Increment 1990-2013 |
|---|---|---|---|---|---|---|---|
| | Numb. | Percent. | Numb. | Percent. | Numb. | Percent. | Numb. |
| *World* | 154 | 100 | 175 | 100 | 232 | 100 | 78 |
| *Africa* | 16 | 10,39 | 16 | 9,14 | 19 | 8,19 | 3 |
| *Asia* | 50 | 32,47 | 50 | 28,57 | 71 | 30,60 | 21 |
| *Europe* | 49 | 31,82 | 56 | 32,00 | 72 | 31,03 | 23 |
| *Latin America and the Caribbean* | 7 | 4,55 | 7 | 4,00 | 9 | 3,88 | 2 |
| *Northern America* | 28 | 18,18 | 40 | 22,86 | 53 | 22,84 | 25 |
| *Oceania* | 5 | 3,25 | 5 | 2,86 | 8 | 3,45 | 3 |

Source: Author. Adapted from United Nations (2014a, p. 19).

One of the world's biggest shifts in international migration is in terms of region of origin and region of destination. In 1990, there were 40 million international migrants living in more developed regions that were born in less developed regions. In 2013, it doubled. In this same period, the number of people migrating between less developed regions grew from 59 million to slightly more than 82 million international migrants, significantly decreasing the existing difference at the beginning of the same period (United Nations, 2014a).

### I.3.3. URBAN MIGRATIONS

Migrants are responsible for the increasingly fast rate of urbanisation[3]. Every week three million migrants all over the world move to a city and with them opportunities and challenges for themselves, for local governments and to existing communities (Lee, 2015).

[3] Urbanization is here determined according to the presented definition in International Organization for Migration, (2015, p. 202) and it is defined as being *"mostly in demographic terms as the increasing proportion of a population that is living in urban areas. This increase can be attributed in general to three factors: natural population growth, net rural-to-urban migration, and also the progressive extensions of urban boundaries and creation of new urban centres. Urbanization frequently refers to a broad rural-to-urban transition involving changes in population, land use, economic activity and culture".*

In the Asia-Pacific region, about 120 000 people are migrating every day to a city, and rates are continuously increasing. Urban population in the region is keeping its growth rate steady since 1950. From 1950 to 1975 urban population more than doubled, and in the following 25 years, it was once again higher than 50%. Scenarios predict that between 2000 and 2025, urban population will almost duplicate, similarly to what occurred in the previous 50 years. By 2050, it is expected that the percentage of people living in urban areas in the region will be of 63% (Lee, 2015).

From the estimated 232 million international migrants in 2013, approximately 50% are living in only ten highly urbanised countries: Australia, Canada, France, Germany, Russia, Saudi Arabia, Spain, United Arab Emirates, United Kingdom, and the United States (Lee, 2015).

As mentioned in the beginning of this section, these high urbanisation rates are a challenge for planners and can better be mitigated by joining every actors and stakeholders such as its inhabitants, migrant groups, the private sector and local governments in order to optimise opportunities that current migrations can possibly bring to cities. Another solution being implemented and gaining popularity is through bilateral agreements between cities of origin and cities of destination, where employment and housing are facilitated, contributing to a more effective integration of the migrants in the local community (Lee, 2015).

### I.3.4. COASTAL POPULATION DYNAMICS

Coastal zones, in general, have suffered enormous transformation resulting from population dynamics, that must be read "*as the change in population size, distribution by age, spatial distribution (including urbanization), density, composition of households and family and the variables that generate these results: fertility, mortality, migration and marriage patterns*" (Martine & Schensul, 2013, p. 3). These developments occurred under unusual sea level stability, enhancing the recognized value and opportunities in these regions and consequently increasing migrations (AA.VV, 2010b, p. 60; Hansen & Sato, 2012; Neumann et al., 2015; Santana-Cordero et al., 2016). Today, the bulk of the largest cities are located in coastal zones (Neumann et al., 2015). In this sense, the

United Nations (2016), refers to eight out of ten largest cities in the world, to be designated as coastal cities: (1) Tokyo, Japan (coastal); (2) Mexico City, Mexico; (3) Mumbai, India (coastal); (4) São Paulo, Brazil; (5) New York City, US (coastal); (6) Shanghai, China (coastal); (7) Lagos, Nigeria (coastal); (8) Los Angeles, US (coastal); (9) Calcutta, India (coastal); (10) Buenos Aires, Argentina (coastal).

Although there are no global migration data for coastal zones, statistical data presented in the previous sections on population and migrations suggest that a higher population increase in these areas is in part due to migrations (Martínez et al., 2007). Furthermore, historically, people have shown preference to settle within a distance of 100 km of coasts or major rivers (McGranahan et al., 2007). To add to the aforementioned, 20% of the world population lives within a distance of 25 km from coastline (Williams et al., 2018), one-third now lives within a distance of 100 km from the coastline (Balk et al., 2013) and 44% lives within 150 km of the coast (United Nations, 2016). The WOR 1, (2010) report refers to coastal zones as the place where more than 45% of the world's population lives and works. In the beginning of this century, half of the population was already living 200 km from the coastline (Creel, 2003; United Nations, 2016).

In 2007, in the European Union (EU), there were 196 million people living in coastal zones within 50 km of the coastline, which corresponds to 43% living in the 22 coastal member countries (Lavalle et al., 2011, p. 49).

In some cities where planning is lacking or are unplanned at all, expanding rapidly leads to uncontrolled sprawl causing sustainability and environmental problems, on both land and sea, damaging relevant ecosystems, and causing enormous economic and ecological costs. (Santana-Cordero et al., 2016; United Nations, 2015, p. 3, 2016). Casablanca, Morocco, is one of these examples, with 600 inhabitants in 1839, it grew to 29 000 in 1900. Currently its population is around 5 million (United Nations, 2016). Nowadays, cities are expanding twice as fast as their population and projections are pointing to a relation where areas will almost triple their sizes in relation to their population by 2030 (United Nations, 2015, p. 3). Presently, population densities in coastal zones are about 100 people per Sq. km, which is three times higher than population densities in inland regions (AA.VV, 2005, p. 529). Furthermore, population in the former is growing much faster than in the latter (Creel, 2003).

In low-lying coastal areas, defined as the contiguous area along the coastline with less than 10 m altitude above sea level (McGranahan et al., 2007), population densities, in 2000, were already nearly five times higher than the global average. These were the places where more than 630 million people were living, with 360 million concentrated in urban areas. Lower income countries, despite having less urbanised coastal zones in low-lying areas, had actually more urban population living in these areas, with Asia being the bulk of such situation (McGranahan et al., 2013; Nicholls & Cazenave, 2010). Low-lying coastal areas are particularly vulnerable to coastal hazards and sea level rise due to their characteristics (McGranahan et al., 2013), with people and goods being highly exposed to climate change (Schensul & Dodman, 2013). The relevance of these impacts can be better understood when considering that, globally, estimates point to 200 million people living along coastlines less than 5 m above sea level, with an increase to 400 to 500 million by the end of the century (AA.VV, 2010b, p. 68).

Port cities are also particularly exposed to coastal hazards and climate change. In 2005, 13 of the 20 most populated cities were port cities. Such cities are vital links to national and international economies, particularly in developing countries (McGranahan et al., 2013).

A study by Hanson et al. (2011), considering 136 port cities worldwide with more than one million inhabitants, revealed that at present time there are 38.5 million people exposed to a 1 in 100 years coastal flood event, being Asia the most people exposed continent with 65% of the global exposed populations. By 2070, this number is expected to reach 150 million, due to sea level rise and increased storminess, subsidence, population growth and urbanisation. Scenarios predict that by 2070, Asia will still be the most exposed continent followed by Africa, surpassing Europe and the US. The same study estimates the impact of asset losses at US$3 000 billion, representing a loss of 5% in Gross Domestic Product (GDP), based on 2005 Purchasing Power Parities (PPP). Due to having higher GDP (PPP) than most of other port cities countries, North America is the region with the largest value of assets exposed. By 2070, it is expected that the value of assets exposed to be US$35 000 billion, corresponding to 9% of GDP in that same period. This scenario predicts that by this time Asia will surpass North America, having the highest value of assets at risk. The study of Hanson et al. (2011) concludes that in the 136 port cities studied, there is a probability of 74% of one or more of these cities being affected by a 100-year flood event every year. The probability rises to 99.9% when a city is affected at least once every five years by the same type of event. Flooding events will increase worldwide. Port cities are expected to be affected by 100 and 1 000-year flood events with a higher frequency, and therefore, the probability of people and asset exposure will equally increase, urging the need for adaptation and disaster management and planning strategies, and accurately predicting the risk involved.

The effectiveness of such measures will require proactive adaptation and governance, capable of involving government authorities, from national to local levels as well as other stakeholders and actors working towards making coastal urban environments safer from hazards. To date, this has been proven to being a major challenge. According to Creel (2003) "*the challenge for policymakers and coastal resource managers is to figure out how to reap the economic benefits of coastal resources while preserving them for future generations".*

## I.4. COASTAL MANAGEMENT

Coastal vulnerability in coastal zones associated with climate change and coastal hazards is increasing as populations and development in these areas are growing quicker than in anywhere else and coastal cities expanding accordingly (AA.VV, 2010b, p. 60; Flannery et al., 2015; Leatherman et al., 2005). As previously mentioned, such vulnerability is long proved to be exacerbated by climate change, resulting in the degradation of ecosystems, reducing resilience in beaches, coastal forests, dunes, wetlands and marine ecosystems, as coastal urbanized areas are expanding (Flannery et al., 2015; Santana-Cordero et al., 2016). This intensity in human activities in coastal zones is also raising questions regarding the capacity of these regions to retain their residential and economic value in the next decades and centuries or if, on the other hand, they are actually posing a threat to human lives (AA.VV, 2010b, p. 68; Rangel-Buitrago et al., 2018).

In coastal management, three broad practices are commonly referred to in the context of the increasing need to implement climate change measures, including: i) the use of soft or hard coastal defences; ii) retreat or relocation; and iii) adaptation (Fernandes et al., 2016), although these may vary in the literature (O'Donnell, 2019). Rangel-Buitrago et al. (2018) mention four coastal management strategies: i) protection: through hard and soft coastal defences; ii) accommodation: by accepting a higher risk of flooding, improving preparedness through land use changes and construction methods; iii) planned retreat: by relocating infrastructure and resettle people further away from the coastline; and iv) do nothing.

The WOR 1 mentions similar strategies. Nevertheless, the report refers to none of the presented to be successful in the long term (AA.VV, 2010b, p. 69):

1. Adaptation of buildings and settlements (artificial dwelling hills, farms built on earth mounds, pile houses and other measures);

2. Protection/defence by building dykes, flood barriers or seawalls;

3. Retreat by abandoning or relocating threatened settlements (migration);

4. "Wait and see", in the hope that the threat abates or shifts.

In England and Wales, coastal management uses four strategies under the so called system of Shoreline Management Plans (SPM) (Cooper & McKenna, 2008) that comply with the following principles: i) hold the line; ii) retreat the line; iii) advance the line, and; iv) do nothing.

The IPCC report on Impacts, Adaptation, and Vulnerability Part A (IPCC 2014b, p. 387) summarizes three categories of approaches to help coastal communities, such as the protection of people, properties, and infrastructures; accommodation, and; managed retreat:

1. Protection of people, property, and infrastructure is a typical first response. This includes “hard” measures such as building seawalls and other barriers, along with various measures to protect critical infrastructure. “Soft” protection measures are increasingly favoured. These include enhancing coastal vegetation and other coastal management programmes to reduce erosion and enhance the coast as a barrier to storm surges.

2. Accommodation is a more adaptive approach involving changes to human activities and infrastructure. These include retrofitting buildings to make them more resistant to the consequences of sea level rise, raising low-lying bridges, or increasing physical shelter capacity to handle needs caused by severe weather. Soft accommodation measures include adjustments to land use planning and insurance programmes.

3. Managed retreat involves moving away from the coast and may be the only viable option when nothing else is possible.

Hanson et al. (2011) remind that cities often emerge in safe places, within natural defences, in relatively high elevations, but it is when cities expand that the problems may arise. The tendency of cities to grow to coastal territories of lower altitudes is increasing its dependence on artificial defences. Such exposure does not necessarily mean immediate risk, although it is crucial to consider protection and adaptation strategies, which according to the authors must range from shorter and immediate responses to longer-term solutions, and should comprehend the following policy options:

- Early warning systems and evacuation;
- Upgraded protection;
- Managing subsidence (in susceptible cities);
- Building regulations (e.g., flood-proof buildings) and/or building retrofitting;
- Land use planning to reduce exposure, including focusing new development away from the floodplain, and preserving space for future infrastructure development;
- Selective relocation away from existing city areas to reduce exposure more rapidly than is possible by only focussing on new development;
- Risk sharing through insurance and reinsurance.

In short, decision-making in coastal management can be resumed into to act or not to act. Not acting allows coastal processes to naturally evolve, shaping the coastline according to its characteristics, dynamics and driving forces independently of any decision-making or decision makers' awareness. This is where doing nothing differs from coastal adaptation. In coastal adaptation, allowing the coastline to naturally evolve is a process that was based on a decision taken by decision makers.

Coastal defence and coastal adaptation may differ on its characteristics, but both share also similarities. Dyke (2014), describes the act of defending as an immediate need to respond to a certain coastal constraint. Adaptation, on the other hand, tends to respond taking into consideration the medium and long term, which includes the relocation of key infrastructures or substituting existing structures such as a footpath for one with a more cost-effective material that can be easily replaced in case of an extreme weather event. Aside from presented differences, coastal defences and adaptation share the same purpose, since both search for suitable answers to coastal planning and management. In some cases, relocation is not the first option in the short to medium term for most people and infrastructure and therefore coastal defence structures are the means to gain more time to find more sustainable and long-term adaptation management options, being the most immediate answer before considering other adaptive strategies (Dyke, 2014; Hanson et al., 2011).

### I.4.1. COASTAL DEFENCES

A culture of risk associated with coastal zones, exists since the Middle Ages in particular in Europe and in the region of East Asia, namely in China and Japan. Although, by then, the order of how coastal strategies were occurring was the opposite as todays. Adaptation strategies such as retreat from vulnerable areas used to be the first option. Coastal defencing was adopted long after in more modern times in North America and then worldwide (AA.VV, 2010b, p. 70); and for the past two centuries, such strategy prevails worldwide in coastal zones that have their infrastructure affected by erosion (Cooper & McKenna, 2008). However, the costs associated to coastal defences are high and rising, often having complex technological processes associated, which makes the task of protecting every coastal area impossible. This leaves to decision makers the task of choosing which areas are considered to be a priority and the development of in-depth knowledge of coastal dynamics and characteristics of those specific territories (AA.VV, 2010a; Coelho et al., 2005, 2006; European Commission, 1999, p. 12). Territories that were subject to coastal defence interventions are likely to be less affected by coastal processes, although this depends on their effectiveness, and also on sea level rates and coastal extreme weather. In addition to the protective effect for which they were designed, these structures may become leisure areas (Coelho et al., 2006; Dyke, 2014).

#### I.4.1.1. HARD DEFENCES

To accurately know where and to what extent erosion will take place is considered to be crucial for coastal management (Kay, 1990; Woodworth et al., 2011), since coastal erosion processes are one of the main reasons for people and infrastructure endangerment, leading to considerable economic losses (Ciampalini et al., 2015). Coastal hard engineering defences are seen as the traditional approach in coastal defences, providing a solid barrier against the energy of waves and tides, breaking any interaction between both systems, land and sea (Linham & Nicholls, 2010, p. 21). These were for a long time, and still are, the solution to alleviate the consequences of such processes, whether they are armour units, breakwaters, gabions, groynes, revetments, sea dikes, and seawalls (figure I.4.1.1.06) (Benassai et al., 2015; Bosello & De Cian, 2014; Kay, 1990; Williams et al., 2018).

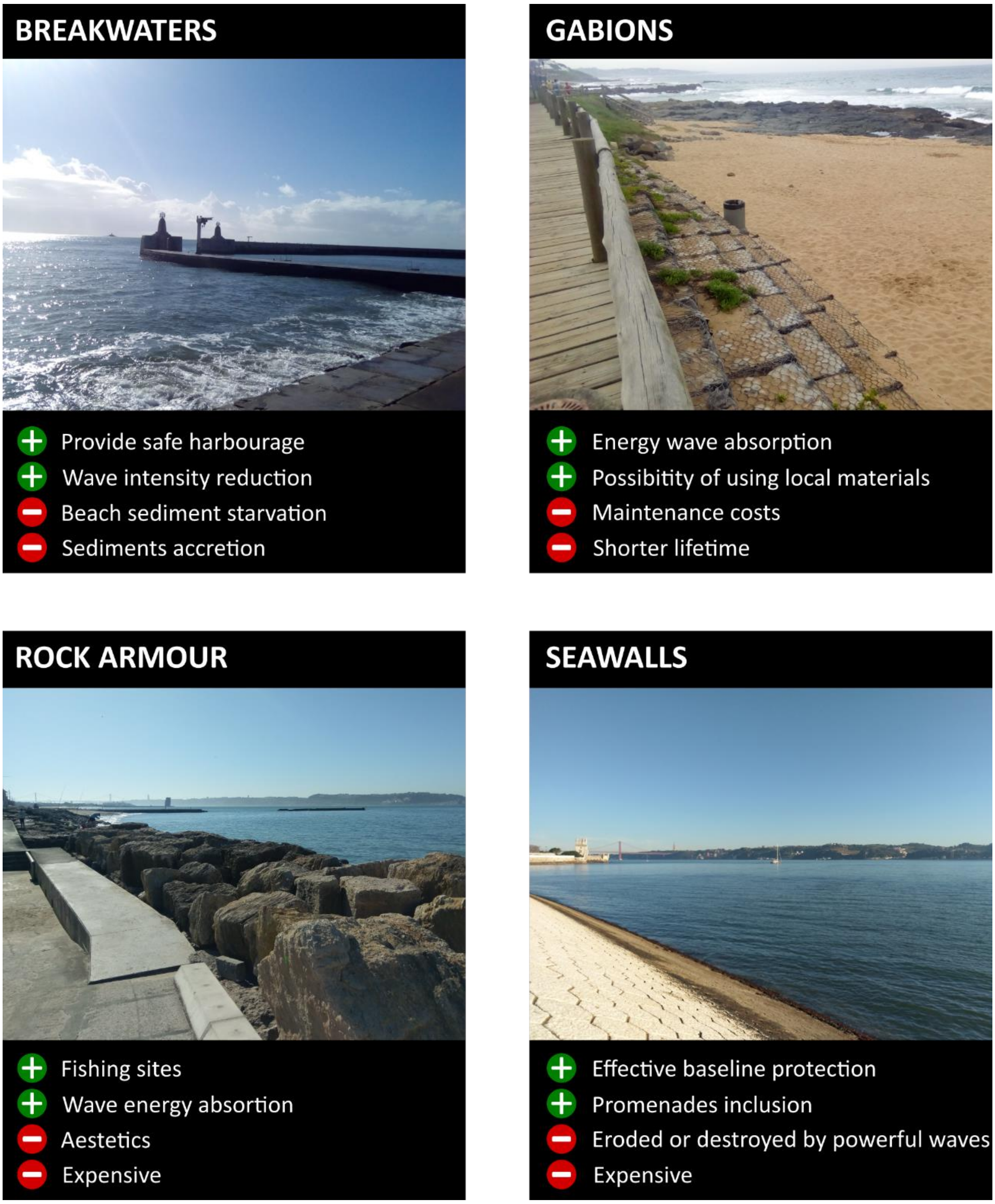


Figure I.4.1.1.06. Hard defence examples. Breakwaters: Oeiras, Portugal; Gabions: Ballito, South Africa; Rock Armour: Oeiras: Portugal; Seawalls: Lisbon, Portugal. Source: Author (Fieldwork 2015-2019, Portugal and South Africa).

These structures convey a great sense of security to the people who benefit from them. However, experience has proven that hard defences are also related to the loss of scenic landscape, to coastal access endangerment, and to the loss of resilience against coastal extreme weather events such as storms by reducing sediment deposition and exacerbating erosion especially in beach areas, which in some cases led to their disappearance. These structures have also consequences in neighbouring areas by reducing or interrupting sediment supplies, exacerbating erosion (Cooper & McKenna, 2008; Hinkel et al., 2013; Linham & Nicholls, 2010, p. 21; Liu et al., 2019; O'Donnell, 2019; Teodoro et al., 2009). Such situation can lately result in the total defence of a larger coastal area as the effects of these structures causes erosion to spread and being in some cases irrevocable (Kay, 1990).

The use of coastal hard defences is mostly used in highly developed coasts such as major cities. Decision-making in these areas considers essentially their economic value, using a cost-benefit approach. In highly developed coastal areas, this means that defending infrastructures is more valuable than the costs of not defending, with these cities being defended at all cost (Cooper & McKenna, 2008). Hard defences have also been used in less developed coasts, with presence of such structures causing an apparent feeling of safety, which in turn raises local coastal properties values leading to further development (O'Donnell, 2019). The induced development brought by this sense of safety will consequently require more coastal management measures to ease erosive processes which can be conditioned by cumulatively building coastal hard defences (Kay, 1990).

#### I.4.1.2. SOFT DEFENCES

The simplest way to understand the differences between hard defences and soft defences is that the former are intended to tackle coastal processes while the latter attempt to adapt and complement these natural processes (Linham & Nicholls, 2010, p. 21).


Figure I.4.1.2.07. Soft defence examples. Beach Nourishment: Durban, South Africa; Dune Nourishment: Durban, South Africa; Reprofiling: Oeiras: Portugal; Sandbags: Ballito, South Africa. Source: Author (Fieldwork 2014-2018, Portugal and South Africa).

Thus, soft defences are the result of the growing need to respond to the negative effects resulting from the application of hard engineering prevention measures. Moreover, this shift towards less evasive measures is reported to be a more holistic and proactive approach to coastal hazards (Linham & Nicholls, 2010, p. 21), and therefore a more natural and sustainable approach (Cooper & McKenna, 2008).

Soft defence measures are often related to beach and dune nourishment. Reprofiling, sandbags, and other geotextiles are also used (figure I.4.1.2.07). Compared to the former, soft defences have significantly less visual impact, than hard defences and from a cost perspective, are expressively cheaper (Cooper & McKenna, 2008).

Cases of beach nourishment are largely mentioned as a soft engineering example, being strongly recognised positive aspects. From a coastal management approach, this short-term measure does not have the erosive negative effects associated with hard defences. However, beach nourishment is referred to negatively impact the ecosystem reducing fauna and flora in the short to medium term (Cooper & McKenna, 2008). Furthermore, such measure, as other soft approaches, require the involvement of a broader range of actors, more monitoring and ongoing maintenance that must be considered from a cost-benefice analysis (Linham & Nicholls, 2010, p. 22).

In addition, dune nourishment may eventually fill some gap resulting from beach nourishment inefficiency or extreme weather, functioning as sand deposit. When accurately managed, dunes are highly effective against flooding and erosion, being valuable systems for flora and fauna. Nevertheless, there are some constraints to its implementation. These result from different points of view associated to each of the key-actors and stakeholders involved. Dune restoration may be conflicting with the interests of constructing in a privileged sea view area, may impact coastal access due to its restrictions, or may even lead to coastal squeeze due to the disappearance of a beach area due to erosion processes, impacting on tourism (Linham & Nicholls, 2010, pp. 31–36).

### I.4.2. COASTAL ADAPTATION

Adaptation in coastal areas includes all of the aforementioned measures. However, and while recognizing the advantages of using soft and hard defences in the short- to medium-term, it sees relocation as the safest solution in the medium- to long-term. However, moving back in coastal urban environments can be disturbing to society because these are spatially connected and interdependent spaces. Commerce, industry, services, residential and leisure areas are located and have been growing due to the influence of others. Besides the disturbance that such changes may cause, relocations are also costly decisions (McGranahan et al., 2007). However, precise interventions made today can result in major differences in future urban development, conditioning cities' size and spatial distributions (McGranahan et al., 2013).

For McGranahan et al. (2013) and Hanson et al. (2011), a problem of current and future urbanization, in a time where the climate is changing and sea levels are rising, relates to those places that can be, or are already, located in areas affected by coastal hazards, thus exacerbating their vulnerability (see figure I.4.2.08). For this reason, the authors state that the only obvious adaptive strategy is shifting further back urban development to areas where coastal hazards are not predicted to happen in the future, even if such predictions are yet difficult to accurately being made due to the range of sea level scenarios (graphics I.2.1.04 and I.2.1.05) and unpredictability of extreme weather events.

Such measures are currently being implemented on the 775 miles of United Kingdom coastline managed by the National Trust. By choosing the relocation of buildings and infrastructures, this adaptive strategy allows the coastline and habitats to naturally adapt, while at the same time reinsures coastal access and new homes for wildlife (The National Trust, 2017).

Low-lying coastal areas and port cities are expected to be the most affected all over the world, due to the rising of the seas and coastal hazards in the following centuries (AA.VV, 2010b, p. 55; McGranahan et al., 2013). Wealthy industrialised countries are expected to be able to defend themselves from such threats, although in the longer term these will also have to consider to withdraw from vulnerable areas or adapt to sea level rise and coastal related hazards (AA.VV, 2010b, p. 55). In this sense, adaptation options such as managed retreat or sacrifice of certain areas are generally being increasingly adopted in coastal management (Williams et al., 2018).

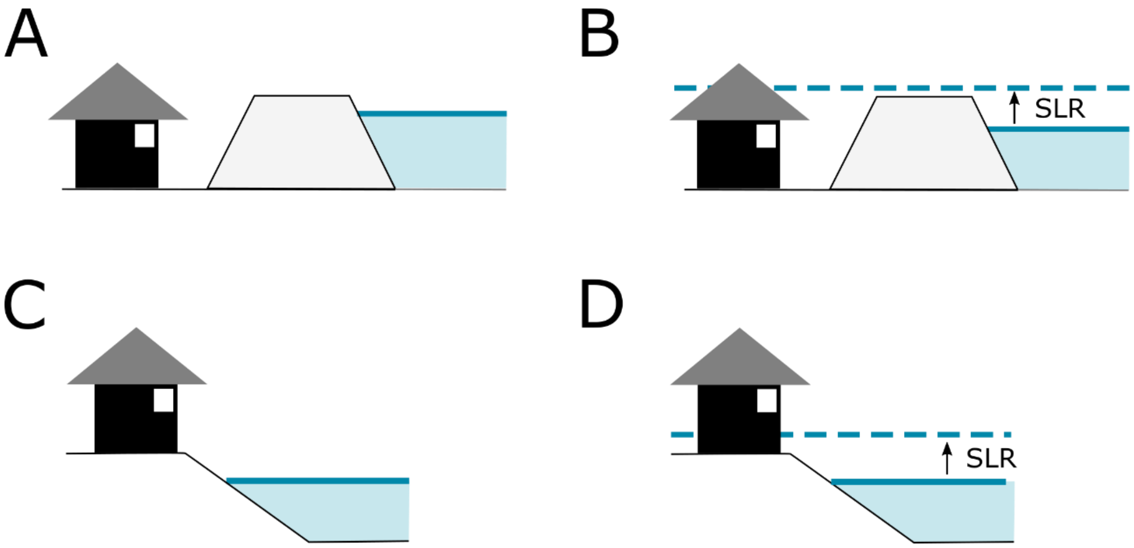


Figure I.4.2.08. Flood impacts after the failure of coastal defences and setback measures. Existing built-up areas below mean sea level are at a higher risk even with coastal defences in the event of SLR (A & B), when compared to areas built within a minimum elevation setback from mean sea level (C & D). Source: adapted from figure 4.31 in Linham & Nicholls (2010, p. 111).

**Summary of the chapter**

The literature review suggests that there is no agreed definition of coastal zone, and that this often varies between countries. What is considered the coastal zone results in part from the biophysical characteristics of each region as well as from the dynamics resulting from human occupation. However, there seems to be agreement that these areas are highly dynamic and subject to the influence of both land and sea, causing changes in the short-, medium- and long-term.

These dynamic spaces have been increasingly subject to natural pressures resulting from the increase in frequency and severity of extreme weather events and sea level rise, a consequence of climate change widely recognised in the literature.

If on the one hand there is great uncertainty about quantifying sea level rise, on the other hand, all scenarios presented in the literature, regardless of whether they are based on physical or empirical models, refer to this rise as certain, to a time horizon projected beyond the year 2100. In addition, changes in the duration, frequency, and intensity of extreme weather events are expected, exacerbating the effects of sea level rise, leading to intensification of coastal erosion processes.

Furthermore, over half of the population currently lives in urban areas, a trend that will keep pace with an overall increase in population, particularly in Africa and Asia in contrast to Europe, where a slight decline will occur from mid-century. Moreover, data suggest that, in coastal countries, a higher growth is expected, either through migratory or natural population balances. This, combined with climate change related pressures, will increase the vulnerability and exposure of these regions.

Thus, it is imperative to strengthen more short- and medium-term reactive measures, stemming from current risks, both through hard and soft defences; while also pursuing other types of medium- and long-term pro-active adaptation measures which are more complex, embracing a wider set of actors and stakeholders, and therefore more difficult to implement, such as relocation measures or setback lines, to which the next chapter is entirely dedicated.

# CHAPTER II. COASTAL BOUNDARY DEMARCATION LINES IN COASTAL ZONES

## Aim and scope

Acknowledging pressures affecting coasts and understanding their management needs, leads to one of the core parts of this thesis (the first objective). This is the analysis of coastal boundary demarcation lines in coastal management. The literature review aims to understand how coastal boundary lines have been used, what features are considered worth protecting, what methodologies have been used, who are the actors behind their implementation, and why are these being implemented. The literature review presents a clear perspective of coastal boundary demarcation lines and their role based on a set of international examples.

## II.1. THE NEED FOR COASTAL BOUNDARY DEMARCATION LINES IN COASTAL MANAGEMENT

Today, coastal fringes of a large number of countries are regulated by coastal planning and management laws such as the *Protocol on Integrated Coastal Zone Management in the Mediterranean* (European Commission, 2009b); the *Coastal Zone Management Act of 1972* at national level in the US, or the *Alabama Coastal Area Management Program of 1979* at regional (state) level (Neal et al., 2018); the *New Zealand Resource Management Act of 1991* (Williams et al., 2018); or the *Coastal Zone Management Plan for the State of Kerala* in India (National Centre for Earth Science Studies, 2018). They apply particularly to the first 500 m to 1 km from the shoreline towards the coastal hinterland. Although these regulations have proved not to be particularly effective in constraining coastal urban development (Neal et al., 2018). This is in part due to the existing intensive urban development that was already taking place before these coastal laws entered into force. Also because there was no clear definition and enforcement of measures to set back development from shorelines (Gibbs, 2016; Santana-Cordero et al., 2016). Furthermore, private property rights often prevail over coastal access (Donahue, 2016), erosion and inundation (Simpson et al., 2012) or coastal hazards in general (Neal et al., 2018) and climate change related threats, increasing a fear of liability in authorities responsible for implementation (O'Donnell, 2019), which end up armouring the coastline in order to protect private property (Abbott, 2013).

The identification and demarcation of zones that limit develop and use of the coastal zone is commonly referred to as setback lines (Kay, 1990). Sanò et al. (2011), refer to setback lines as "*a buffer space where permanent constructions are not allowed, defined by a specific distance from the shoreline's highest water mark*" (see section below for further definitions and deepening). Nevertheless, such "setbacks" serve many purposes including the preservation of aesthetic features, presence of coastal hazards, coastal natural resources, promote and secure public access to beach areas, govern the physical height of buildings, or even to prevent strategic economic sectors from disruptions, and strategic places such as military facilities (Celliers et al., 2009; Fenster, 2005; Gallop et al., 2015; Horne, 1969; Kay, 1990; Sanò et al., 2010).

In terms of coastal hazards such as floods or erosion, setback lines are regarded as buffer areas that separate coastal development (public infrastructure and privately-owned buildings and property) from potential hazards such as wave inundation, to avoid future erosion damage and coastal protection measures and to minimise damage to property and people (Fenster, 2005; Williams et al., 2018). Not all coastal areas are developed and remains completely or partly natural ecosystems such as beaches, dunes, wetlands, amongst others that deserve to be protected for their biodiversity, and ecosystem functions minerals and other resources (AA.VV, 2010a; Hansen & Fuglsang, 2014). Therefore, establishing setback lines can provide protection to coastal ecosystems and maintain the natural dynamics of the coast (Fenster, 2005; Linham & Nicholls, 2010; NOAA, 2012).

### II.2. DEFINITION OF SETBACK LINES

Fenster (2005) defines setback lines as *"a type of regulatory restriction that require coastal construction projects to "set back" a landward distance from a predetermined reference feature on the beach. This arrangement provides a buffer between a hazard area or natural area and coastal development"* being described as *"…one type of regulatory method used by all levels of government to mitigate risks to coastal structures and to protect coastal resources".* Sanò et al. (2010), describes setback lines "*as the width of a buffer zone behind the shoreline, being the so-called setback-line its landward limit".* In their view, a setback line *"should include the protection of the coastal zone from unwise coastal uses and development, the most important sources of coastal degradation. These sources include housing and tourism developments, heavy infrastructures for coastal accessibility or coastal defence, wastewater discharges and solid wastes dumping on the shore"*.

In this regard, Kastrisios & Tsoulos (2016), refers to the delimitation of setback lines for several aspects, whether is coastal management, sea protection, maritime trade, or even the utilisation of living and non-living resources. Nevertheless, the use of such type of measures have been described in literature as controversial (Sanò et al., 2011). Neal et al. (2018), refers to such (controversial) measures, in the US, as "backroom politics" and "midnight calls" by influential wealthy stakeholders, that often finds the governor's office getting permit-denials overturned. In turn, in Italy, due to the implementation of regulations failure, illegal development has been spreading along the coast, whether is due to residential development, second homes, and holiday homes, or the tourism industry (Falco, 2017).

## II.3. SETBACK LINES COMPONENTS

Fenster (2005), refers to coastal boundary demarcation such as setback lines to be determined based on three main components:

i) A reference feature, being stationary or dynamic;

ii) A feature considered relevant to be protected, which can be a natural environment, built-up environment and;

iii) a method for determining such line designated as fixed, floating, and combined fixed and floating methods.

### II.3.1. REFERENCE FEATURES

A reference feature is the starting point of any setback line and it establishes a setback distance from that point landwards (or seawards). There are two types of reference features: i) stationary, which means it is relatively stable, and; ii) dynamic reference features (Fenster, 2005).

A *stationary* reference feature can be any specific elevation value selected as reference, but also a natural feature such as a vegetation line or even the top or the bottom of a dune formation. Built-up environments are equally valid and used as reference features and these can be an existing road or even a coastal feature such as a lighthouse (Fenster, 2005).

*Dynamic* reference features are normally associated with the coastline since it represents the connection between land and sea (Fenster, 2005). Such connection assumes various representations, which vary according to the entities in charge of setting such setback (Fenster, 2005; Linham & Nicholls, 2010; NOAA, 2012). Reference features are normally named as lines or marks and these are the proxy for the coastline and can assume several designations: High Water Line (HWL); Mean High Water Line (MHWL); Normal High Water Line (NHWL); Ordinary High Water Line (OHWL); Seasonal High Water Line (SHWL). In the case of high-slope coastal areas, cliff edges are the proxy for the coastline, and therefore, the reference feature for the setback line (Fenster, 2005; NOAA, 2012).

According to Linham & Nicholls (2010), a problem of establishing a setback line based on a dynamic reference feature such as a water line limit, is that it changes on a daily basis and consequently it may give rise to different interpretations concerning the extent of the setback line.

### II.3.2. FEATURES CONSIDERED WORTHY OF PROTECTION

Coastal habitats and ecosystems such as beaches, dunes, estuaries, uplands and wetlands, sand and gravel are natural resources in the coastal zone that are worthy of protection (Fenster, 2005). In built-up environments, structures in a coastline nearby area are also considered worthy of protection (NOAA, 2012).

### II.3.3. SETBACK LINES METHODS

There are several methods for determining coastal boundary lines (Fenster, 2005; Kay, 1990; NOAA, 2012), and the choice of a particular method is often dependent on the institution in charge of such task. In most cases, setback lines are set parallel to a reference feature that represents the coastline, establishing a horizontal distance and creating a buffer area between the reference feature and the setback line. Setting this distance is considered crucial since, once in practice, the setback may impose limitations to coastal development inland. Setback lines have implications for actors and stakeholders of the coastal area, which can range from central to local governments, coastal planners and managers, and citizens (Fenster, 2005).

In Fenster (2005) setback lines methods for the US are described to be: i) fixed methods; ii) floating methods, and; iii) combined fixed and floating methods. For Europe, two different methods are mentioned regarding coastal boundaries: i) shore-parallel linear and; ii) contour.

The designation of fixed setback lines in Fenster (2005) are equivalent to arbitrary setback lines in Kay (1990) and in NOAA (2012). The same is noticeable in relation to the combined setback lines referred in Fenster (2005), which in NOAA (2012) are referred to as hybrid setback lines and illustrated in their work with some examples in the US.

Linham and Nicholls (2010) distinguishes two distinctive types differentiating between elevation setback lines and lateral setback lines (figure II.3.3.09). The first is meant to adapt to coastal flooding and the second to coastal erosion.

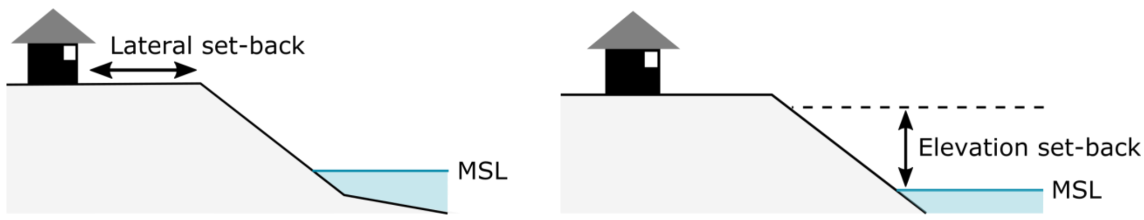


Figure II.3.3.09. Types of coastal setback lines. Source: adapted from Linham & Nicholls (2010, p. 110).

### II.3.3.1. FIXED SETBACK LINES

Fixed, shore-parallel or arbitrary setback lines are rigid constructs (Fenster, 2005). These are outlined based on a slow changing or static reference feature and a constant distance landwards (Fenster, 2005; NOAA, 2012). One example is given by Fenster (2005) for Poland in the designated "Technical Belt" where the Maritime Administration applied fixed setback line methods. In cliff areas, a setback line of 100 m inland was set from the reference line, which was the upper edge of the cliff. In dune areas, a 200 m setback line was referenced from the dune ridge. Sanò et al. (2010), refers to a similar situation for the Mediterranean region, where a setback line of 100 m from the Highest Winter Waterline prohibits new constructions.

The shore parallel or fixed setback line often do not reflect the real needs or changes taking place at the coast, which may not accurately represent erosion or coastal flooding as opposed to floating setback lines (Fenster, 2005; Kay, 1990; Linham & Nicholls, 2010; NOAA, 2012). In this regard, flooded hazard studies have referred to the

30 m fixed setback line, for Jamaica, to be insufficient for the provision of flood protection (Linham & Nicholls, 2010).

A setback line can also be referenced to an elevation contour line (Fenster, 2005).

#### II.3.3.2. FLOATING SETBACK LINES

Floating setback lines methods differ from fixed, shore-parallel or arbitrary setback lines methods. Floating setback lines take into account dynamic natural phenomena of the coast which may include elevation and topography, and extreme tidal fluctuations (Fenster, 2005).

Erodibility and erosion rate play a key role in the determination of floating setback lines, which are often based on average annual erosion rate (AAER) for a period of time. In practice, this method requires temporal and spatial data on the dynamic movement (accretion and erosion) of the shoreline. This means that accurate data on coastal erosion rates must exist, even if through averaging or by grouping it in blocks of similar erosion rates, enabling the segmentation of the coast. The AAER is then multiplied by a time period of choice (e.g. 30 or 50 years) to determine the possible location of the shoreline at the end of that period. It represents, on one hand, the duration of the setback protection, and on the other hand, the yearly migration landwards over time according to the specified methods. Since coastlines are dynamic, floating methods are required to periodically update coastal changes by taking into consideration their actual and past conditions (Fenster, 2005). According to NOAA (2012), in South Carolina, US, such updates in setback lines erosion rates occur every eight to ten years.

Monitoring of shoreline movement remains important to verify and validate erosion rates because changes in the coastline are often affected by cyclical or stochastic and extreme climate and weather phenomena (e.g. intense precipitation and floods, and wind storms). Nevertheless, the models used to predict coastal fluctuations are mostly linear, assuming constant changes over time, that might be, or not, in accordance with real changes occurring at the coastline. For Fenster (2005) the simplicity of such linear models implies the assumption that all processes are equal and thus dismissing, for instance, knowledge referring to sand transportation rates, occurring differently in the various stretches along the coast.

### II.3.3.3. COMBINED FIXED AND FLOATING SETBACK LINES

As it was previously mentioned, in some cases, setback lines are implemented using a combination of both fixed and floating methods (Fenster, 2005; NOAA, 2012). The mixture of methods may mitigate situations as the one mentioned in the floating setback lines section, related to the gaps that may exist in erosion rates data (NOAA, 2012) and also in situations where there are vulnerable features worthy of protection. In these cases, the fixed setback line reinforces the distances determined by the erosion rates used in floating methods (Fenster, 2005).

In other cases, setback lines may be implemented considering the lot's average depth and buildings footprint. These setback methods are based on the lot's average depth to which is added a fixed distance. The bigger the lot's average depth, the bigger the distance from a reference feature. When reaching the maximum established for lot's average depth, the setback is then based on the buildings footprint plus a fixed distance, times the annual erosion rate. This type of setback lines methods are used in the US, Kauai County (NOAA, 2012). Such setbacks are a combination of fixed and floating methods where properties and buildings are the core and main focus in its establishment.

## II.4. SETBACK LINES IMPLEMENTATION WORLDWIDE

The implementation of setback lines varies in type and function from country to country, or even between states, regions or other administrative regions (see table II.4.6.07 and annex 1 for further details). They vary in the way they are administrated and according to who is responsible for its administration. As discussed in the section above, its methods are as diverse as the supporting requirements. There are cases where setback lines may apply only to new constructions, others, to existing and new constructions. Diversity in the standards may also consider classes of buildings. These variations can range from single-family dwellings, multi-family buildings, or commercial and industrial facilities (Fenster, 2005).

Implementing setback lines also differ in its administrative programmes, being these mandatory or voluntary, which are normally applied by Local Government level, nevertheless, it can also be implemented at Regional and National levels (Fenster, 2005; NOAA, 2012). In Barbados, Caribbean Islands, setback lines have been implemented for over 30 years and are supported by different levels of government policies such as the Town and Country Planning Act, the Coastal Zone Management Act, and the Integrated Coastal Management Plan (Linham & Nicholls, 2010). The sections below overview the implementation of coastal boundary lines across different countries, and whenever possible, between states and other administrative regions within that country.

### II.4.1. SETBACK LINES IN AFRICA

For its coastal zone, Egypt has implemented a fixed setback line of 200 m. The purpose of this line is to prohibiting new development and construction. However, private interests often prevail coastal management. Despite being actively retreating, a new hotel was built in the nearby coastline of Obayed Beach, Marsa Matrouh, in 2006 (Sanò et al., 2010). Situations as this are recurrent and encourage built-up areas to grow seawards and shore-parallel in coastal zones increasing its vulnerability to coastal hazards.

In Kenya, a fixed setback line 100 ft (37.7 m) having the highest watermark as reference feature was set and is mandatory by law. This "imaginary line" has in fact physical markers in the territory. It had been marked with beacons, although reported to be hard to find. Nevertheless, some concerns have been raised regarding used methodology. The methodology did not consider erosion rates, coastal geology, sea level rise and risk analysis. Furthermore, there have been occasional constructions of local land owners in the setback line demarcated area, which tend to occur because of inadequate marking of the boundary line. Additionally, erosion in shrinking the area between the public beach and private properties (Ballot et al., 2006, p. 27).

The Ghana coastal zone is experiencing chronic erosion threatening public infrastructure and private property, especially in the Accra region (Appeaning Addo & Appeaning Addo, 2016). AAER is approximately 1.5 m per year over the last two decades. In this sense, Government has been implementing reactive measures, whether these are in the form of hard or soft defences, or sanction measures. Despite, applied measures have proven to be insufficient to address the current issues addressing this region. Thus, it is understood that one should consider an integrated coastal management approach, which according to the authors, will compulsorily include more proactive adaptation measures, comprising the implementation of setback lines, and considering the contributions of stakeholders and local actors. At the same time, initiatives should be developed in order to raise awareness and educate coastal communities about the causes and effects that contribute to the erosive processes of these territories.

### II.4.2. SETBACK LINES IN ASIA

In light of fast and vast land use transformations occurring in the coastal zone of Kerala, Ernakulam District, in India, the Government of Kerala recognized the urgency in protecting coastal environment and local communities from coastal hazards in consequence of these modifications (Ramachandran et al., 2005). In this sense, the Coastal Zone Regulation Notification (CRZ) was introduced to facilitate the adoption of measures, under the umbrella of the Coastal Zone Management Plan for the State of

Kerala, to control development through the implementation of fixed setback lines to which strongly restrictive measures are associated (National Centre for Earth Science Studies, 2018, pp. 1–2).

Coastal Zone Management Plans provide for setback lines implementation, both landwards and seawards under the framework of CRZ. The first are set from the High Tide Line (HTL), comprising a distance of 100, 200 and 500 m from this reference feature, landwards. The latter have the Low Tide Line (LTL) as reference feature and extend within a distance of 12 nautical miles, corresponding to the territorial water boundary (National Centre for Earth Science Studies, 2018, p. 3).

According to the authors, an important and perhaps the most relevant and difficult aspect is the accurate definition of the reference features, since they are highly dynamic. Once these are set, setback lines can be demarcated and the methodology easily replicated without any ambiguities (National Centre for Earth Science Studies, 2018, p. 4; Thomas, 2010).

### II.4.3. SETBACK LINES IN EUROPE

In Europe, Denmark, Finland, Germany, Norway, Poland, Spain, Sweden, and Turkey, all implemented fixed setback lines, with buffer areas ranging from 5 m to 3 km (Fenster, 2005). Denmark has established a 3 km coastal strip that restricts development from the coastline, while securing coastal access within 300 m from that exact same reference feature. In Finland, development is restricted 100 m from the coastline (Sas et al., 2010).

In the Russian area of the Baltic Sea coast, a 1 km setback line was applied due to the economic and military strategic importance that the Kaliningrad region represents (Fenster, 2005).

The Protocol on Integrated Coastal Zone Management in the Mediterranean (UNEP, 2008) from the United Nations Environment Programme (UNEP) intends to establish a common setback line of not less than 100 m in the Mediterranean Region where construction will not be permitted (UNEP, 2008, p. 16). Such measure is known to be hard to implement due to the diversity of countries that integrate the region, namely in terms of coastal characteristics, people, and national and regional planning instruments. Therefore, this intention has been questioned regarding its efficiency (Sanò et al., 2010). These setback lines have the purpose of safeguarding areas directly and negatively affected by climate change and natural risks. Nevertheless, there are exceptions to be contemplated. Such exceptions are related to projects of national interests, geographical constraints, or people related constraints, such as population densities and social needs (European Commission, 2009b).

In this regard, Santana-Cordero et al. (2016), point some constraints relative to past coastal management practices in Spanish country's coastal governance framework, namely the "…*lack of a clear and sound coastal management policy, inadequate definition of regulations and responsibilities, lack of proper institutional setting and strategies, need to educate administrators, and insufficient real time information on the status of the socio-ecological system, as well as inexistent public participation processes*".

**II.4.4. SETBACK LINES IN LATIN AMERICA AND THE CARIBBEAN**

Barbados, in the Caribbean Islands, have been using fixed setback lines for more than 30 years. These were enforced with the support of the Town and Country Planning Act, the Coastal Zone Management Act, and the Integrated Coastal Management Plan. These fixed setbacks have in consideration two different types of features, and therefore, using two different methods, both prohibiting coastal development. One of the methods applies to sandy beach coastal zones, considering as a reference feature the MHWM to limit a setback of 30 m landwards. The other situation refers to cliff coastal zones. Here the distance set is 10 m from the cliff edge landwards (figure II.4.4.10), however, if the base is under erosive processes, then the distance is set considering the base of the cliff, as it is the most landwards part of the cliff (Linham & Nicholls, 2010, p. 114).

As in many other situations, there is always an exception, and in Barbados exceptions go both ways, meaning that these setback lines can be increased or decreased. Increasing situations may occur in cases related to the need of additional protection for important ecosystems, historical or archaeological sites. The opposite may happen in cases where development already exists seawards from the established setback (Linham & Nicholls, 2010, p. 115).

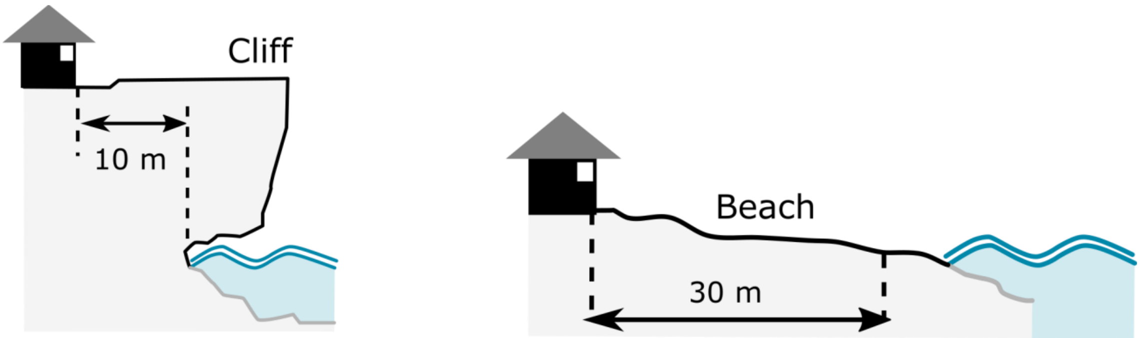


Figure II.4.4.10. Barbados setback lines in cliff and beach coastal zones. Source: adapted from Linham & Nicholls (2010, p. 115).

### II.4.5. SETBACK LINES IN NORTHERN AMERICA

In the United States of America (US) the differences in methods and in the implementation of setback lines are noticeable between States. Such differences can be related, for instance, to the methods applied to determine erosion floating setback lines. In North Carolina, the coastal erosion rate is calculated based on an average coastal regression rate for coastal sectors with nearby similar characteristics. In Massachusetts, the coastal erosion rate is measured with a transect interval of 100 m (Fenster, 2005).

The same applies to the selection of a reference feature. In Florida, the SHWL is used for coastal permitting as a reference feature for the implementation of a setback line, while in Wisconsin the reference feature is the OHWL for the establishment of a fixed setback line of 75 ft (22.9 m) landwards, set state-wide. This same distance is applied from cliff edge areas where existing structures in that area are considered worthy of protection from cliff erosion. In Delaware, both the reference feature and the applied distances differ from Wisconsin. Here, the National Geodetic Vertical Datum (NGVD) is used as the reference feature to set a fixed setback line of 100 ft (30.5 m), which starts 7 ft (2.1 m) landwards from the NGVD (Fenster, 2005).

The States of New Jersey and North Carolina, in the US Atlantic coast, are considered prone to severe erosion rates. As such, these States implemented combined fixed and floating methods in their setback lines, with the objective of increasing the distance landwards from the given erosion rate (Fenster, 2005). A more contemporary source refers to the States of Florida and North Carolina having adopted a new methodology for the establishment of floating setback lines based on erosion rates. Since 2009 that North Carolina is adopting such methodology. The North Carolina's Administrative Code for Ocean Hazard Areas sets a setback line 30 times the long-term average annual erosion rate, measured from the first line of stable and natural vegetation for structures less than 5 000 Sq. ft (1 524 Sq. m); 60 times for structures between 5 000 Sq. ft and 9 999 Sq. ft (3 047.7 Sq. m); structures 10 000 Sq. ft (3 048 Sq. m) or greater have incremental setback lines sizes, reaching a maximum of 90 times for structures with 100 000 Sq. ft (30 480 Sq. m) or larger (NOAA, 2012).

In the County of Kauai, the State of Hawaii, two different setback line methods are applied. One combines the lot’s average depth for cases with less than 160 ft (48.8 m) and a fixed distance from a reference feature; the other combines the building’s footprint, with a fixed distance plus a number of times the annual erosion rate, depending on the footprint of the building. In the first case, for lots of an average depth of 100 ft or less, a setback of a minimum of 40 ft (12.2 m) is applied, increasing 10 ft (3 m) for each 20 ft (6.1 m) increase in the average lot depth. The shift for the second situation happens when the lot’s average depth reaches 160 ft. In this situation, the setback line is no longer based on the lot’s average, but based on the building’s footprint, which includes all types of existing buildings and is grouped into two classes: i) less or equal to 5 000 ft, where a setback of 40 ft is applied plus 70 times the annual erosion rate, or; ii) 40 ft plus 100 times the annual erosion rate for the cases where the footprint is higher than 5 000 ft (Abbott, 2013; NOAA, 2012).

Joint methods were also used in the Great Lake of Michigan where fixed and floating setback lines were used to protect from cliff erosion (Fenster, 2005). Both methods also applied to the North Shore of Lake Superior, Minnesota, with the intention to overcome gaps in erosion rate data. A floating setback 50 times the annual erosion rate was established, plus a 25 ft (7.6 m) fixed setback line. However, and because data on erosion rates did not cover the entire territory a fixed setback line of 125 ft (38.1 m) was applied in these areas (NOAA, 2012).

As the examples above have shown, setback lines components may differ from State to State or even between Counties, depending on the administrative scale that such setback lines are applied. In 2005, ten coastal States (43.5%) and all five territories (American Samoa, Guam, Marianas Islands, Puerto Rico, and the Virgin Islands) in the US used fixed methods; floating methods were used in five States (21.8%), and; four States (17.4%) were using a combination of both fixed and floating. All setback lines were controlled at State level, except in the States of California and Washington, where setback lines were implemented at the local level (Fenster, 2005).

### II.4.6. SETBACK LINES IN OCEANIA

With regard to coastal management, Australia has no national setback lines policy, being these applied at regional level (Williams et al., 2018). Furthermore, it is important to note two measures identified in the country, which make a clear distinction between the use of setback lines and retreat measures. When mentioned, setback lines apply only to new infrastructure, that have to be developed at a distance from the coastline determined by that same line, preventing new infrastructure to be erected in a designated hazard area. Retreat requires existing infrastructure in hazard areas to be removed or relocated to areas considered more stable, further back from the coast. Although, there is great resistance in the application of both measures, the latter is the one that generates greater controversy (O'Donnell, 2019).

Despite of the above mentioned, setback lines have been enforced in the country. New South Wales, have been using fixed setback lines since the approval of the State Environmental Planning Policy 71 – Coastal Protection 2002, using the Mean High-Water Mark (MHWM), a bay or an estuary as reference features to set a 100 m landwards area where development is subject to restrictions, requiring the approval from the Minister of Planning and Infrastructure. In 2010, with the New South Wales Sea Level Rise Policy Statement entering into force, new development in high-risk areas from sea level rise were required to raise ground level to 1 m from MHWM (O'Donnell, 2019).

In Western Australia, floating methods are used to define a setback line. These include the inputs from i) 1 in 100 year storm surge (3 consecutive storms); ii) 100 times the annual erosion average rate, calculated from a minimum period of 40 years data, and; iii) sea level rise multiplied by 100, applying the Brunn Rule (Smith, 2010, pp. 19–20; Williams et al., 2018).

New Zealand is being implementing coastal restrictions using fixed setback lines for more than two decades. The New Zealand Resource Management Act of 1991, sets a minimum setback line distance of 20 m. This distance then varies regionally. In the Rodney District Council a setback line of 50 m is applied in rural areas, while in urban areas this distance is set to 23 m (Williams et al., 2018). The New Zealand Government, (2010) recognizes the importance of setting back development in order to protect the natural characteristics of coastal environments, by keeping the open space, public access and amenity values of the coastal environment, as well as establishing buffer areas in significant indigenous biological diversity and historic heritage sites.

Table II.4.6.07. Setback lines implementation examples worldwide. Methods and purposes.

| COUNTRY/ REGION | METHOD | REFERENCE FEATURE | SETBACK LINE DISTANCE | FEATURES WORTHY OF PROTECTION/ OBJECTIVE | TERRITORIAL MANAGEMENT INSTRUMENTS | SOURCE |
|---|---|---|---|---|---|---|
| **Barbados, Caribbean Islands** | Fixed | Mean High Water Mark (MHWM) | 30m from the MHWM (sandy beaches) | Development, ecosystems, important historical or archaeological sites (i.e. mangroves or turtle nesting sites) | Town and Country Planning Act; Coastal Zone Management Act; Integrated Coastal Management Plan | (Linham & Nicholls, 2010) |
| | | | 10m from the cliff edges | | | |
| | Fixed | High water mark | 30m | Unique features can expand this limit, existing buildings can reduce it | - | (Simpson et al., 2012) |
| | | | 10m cliff top | | - | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Denmark** | Fixed | Shoreline | 3km | Restricts development | - | (Sas et al., 2010) |
| | | | 300m | Secure public access | - | |
| **Egypt** | Fixed | - | 200m | Prohibits new development and constructions | - | (Sanò et al., 2010) |
| **Finland** | Fixed | Shoreline | 100m | Restricts development | - | (Sas et al., 2010) |
| **Israel** | Fixed | 0.75m above current sea level | 100m | Prohibits development | Coastal Environmental Protection Law of 2004 | (Sas et al., 2010) |
| **Kerala, India** | Fixed | High Tide Line (HTL) | 100, 200 and 500m | Protect coastal environment and local communities from coastal hazards | Coastal Zone Management Plan for the State of Kerala; Coastal Zone Regulation Notification (CRZ) | (National Centre for Earth Science Studies, 2018) |
| **Medit. Countries** | Fixed | Highest Winter Waterline | Not less than 100m | Areas directly and negatively affected by climate change and natural risks | PROTOCOL on Integrated Coastal Zone Management in the Mediterranean | (European Commissio n, 2009a) |

Source: Author. Adapted from (Simpson et al., 2012, pp. 143–146).

**Summary of the chapter**

Coastal boundary demarcation lines, commonly referred to in literature as setback lines, have many purposes such as to prevent exposure to potential coastal hazards. These have been implemented through coastal management programmes with the purpose of control, restrain or prohibit various types of uses or activities that can harm people and damage infrastructure and ecosystems as a result of natural and human pressures in coastal zones.

In order to determine a setback line there are three essential components: i) a reference feature; ii) a feature worthy of protection, and; iii) a method to determine a setback line.

i) Reference features can be: stationary or slow changing natural features such as the bottom of a dune formation or part of a built-up environment, such as a road, and; dynamic, assuming the High Water Mark/Line or a cliff edge the proxy for the coastline;

ii) Setback lines may consider features worthy of protection landwards or seawards of that imaginary line. Both, natural ecosystems, and infrastructure in the nearby coastal area maybe be considered important features;

iii) Methods are mostly described as fixed, when a prescribed distance is set landwards (500 m) or seawards (12 nm) of that reference; floating, have into account erosion rates, sea level rise and extreme weather events, and; combined fixed and floating setback lines, resulting from the aggregation of the previous methods.

Regarding methodology, fixed setback lines have been implemented for longer time in many countries, being its methodology significantly easier, comparatively to floating methods. Nevertheless, fixed methods within coastal management programmes, whether at national, regional or local levels, have been pointed in literature as somehow ineffective in controlling urban development in sensitive coastal zones and in the avoidance of coastal ecosystems degradation. In this sense, exceptions to the so-called urban development in restrictive coastal areas are often found in many countries encouraging the consolidation and expansion of urban fabric, increasing the need to coastal defences' implementation and exacerbating erosion in the nearby coastal areas.

Floating setback lines are more complex in its methods, and yet, significantly more accurate in their relation between exposure and coastal hazards. In consequence, applied regimes are tendentiously more restrictive and goal-oriented. Therefore, its implementation ends up facing greater opposition due to controversy generated by these measures. Particularly from private property owners who put their interests above risks arising from the current and expected exposure to coastal hazards.

# CHAPTER III. TERRITORIAL DYNAMICS: INTRODUCING THE CASE STUDIES

## Aim and scope

The chapter introduces both case studies, Portugal and South Africa (figure III.11). It describes and tracks the evolution of human induced pressures, and provides an overview of future scenarios and tendencies, particularly those affecting the coastal zone. The chapter is subdivided into two main sections being referred initially to the Portuguese case study and after to the South African case study. In both, different methodologies are used, referring in both cases to the pressures arising from human occupation in coastal zones.

With regard to the Portuguese case, a first analysis is made for the evolution of the population in the last 100 years, based on statistical information referring to the national census data, from 1911 to 2011.

In a second approach, spatial information from the US Air Force Defense Meteorological Satellite Program (DMSP-OLS) is used to measure the growth of urbanized areas in coastal zones for a period of just over 20 years, concluding with the presentation and evolutionary scenarios regarding population growth and urban areas in coastal environments.

For the South African case study, the DMSP-OLS data was also used for a buffer area of 50 km from the coastline inland, to measure the growth of built-up areas in coastal zones for a similar period, in order to assess how changes could impact risk arising from increased exposure to coastal hazards.

In this sense, a general analysis was carried out, first at the National level. This was followed by regional analysis. This analysis includes a comparison between the DMSP-OLS information and land cover maps. Finally, a local scale analysis was carried out and four coastal cities were selected: Durban, East London, Port Elizabeth and Cape Town. In this last analysis, the correlation between the growth in area and population is verified in these four selected cities.

Results are presented in the following sections. For both case studies, published and unpublished papers and materials, by the author in co-authorship with supervisors and with other co-authors, were used in the chapter.


Figure III.11. Location of the case study countries.

## III.1. TERRITORIAL DYNAMICS IN PORTUGAL

### III.1.1. THE PORTUGUESE POPULATION CENSUS DATA

According to the Portuguese population census data (Direcção Geral da Estatística, 1913, 1933; Fundação Francisco Manuel dos Santos, n.d.; INE, 1945, 1952, 1964, 1973), in the last century, the country has been increasing its population (figure III.1.1.12 and annex 2). A growth that has a higher expression in littoral areas, particularly in the Lisbon Metropolitan Area (LMA) and the Porto Metropolitan Area (PMA), rather than in the inner territories (figures III.1.1.13 and III.1.1.14).

This increase in population is characterized by periods of instability, which result, mostly, from migrations. From the 1950s and until the fall of the old regime a significant number of people migrated from the inner regions to the urban areas in the coast and particularly to the LMA. In turn, the 1960s and 1970s registered an outflow of population, in particular to France, Belgium, the Netherlands, Luxembourg and Germany.

With the fall of the authoritarian regime in 1974 and subsequent decolonization, the migratory flow reversed its tendency, and a large number of people that were living in the ex-colonies returned to Portugal. To add to the aforementioned, the middle of the 1970s were passing through an international economic crisis, which in terms of population has reverted in a favourable migratory balance for the country.

In the 1980s, population growth was largely influenced by natural growth rather than by migratory flows. Nevertheless, migrants were still arriving at the country. The 1990s there were more migrants arriving than leaving the country and thus, Portugal clearly became a country of immigration, and therefore, contributing to fast growth in population, more expressive in the LMA (DGOTDU, 2007, p. 53).

From the 1990s onwards, particularly in the last two census decades (1991; 2001; 2011) positive variation rates in Portugal were more expressive in the littoral areas of LMA and also in the region of Algarve (figure III.1.1.13). Regardless of its lower rates, the PMA has also enlarged its population. In the last hundred years, these are the regions with the higher positive rates of population growth.

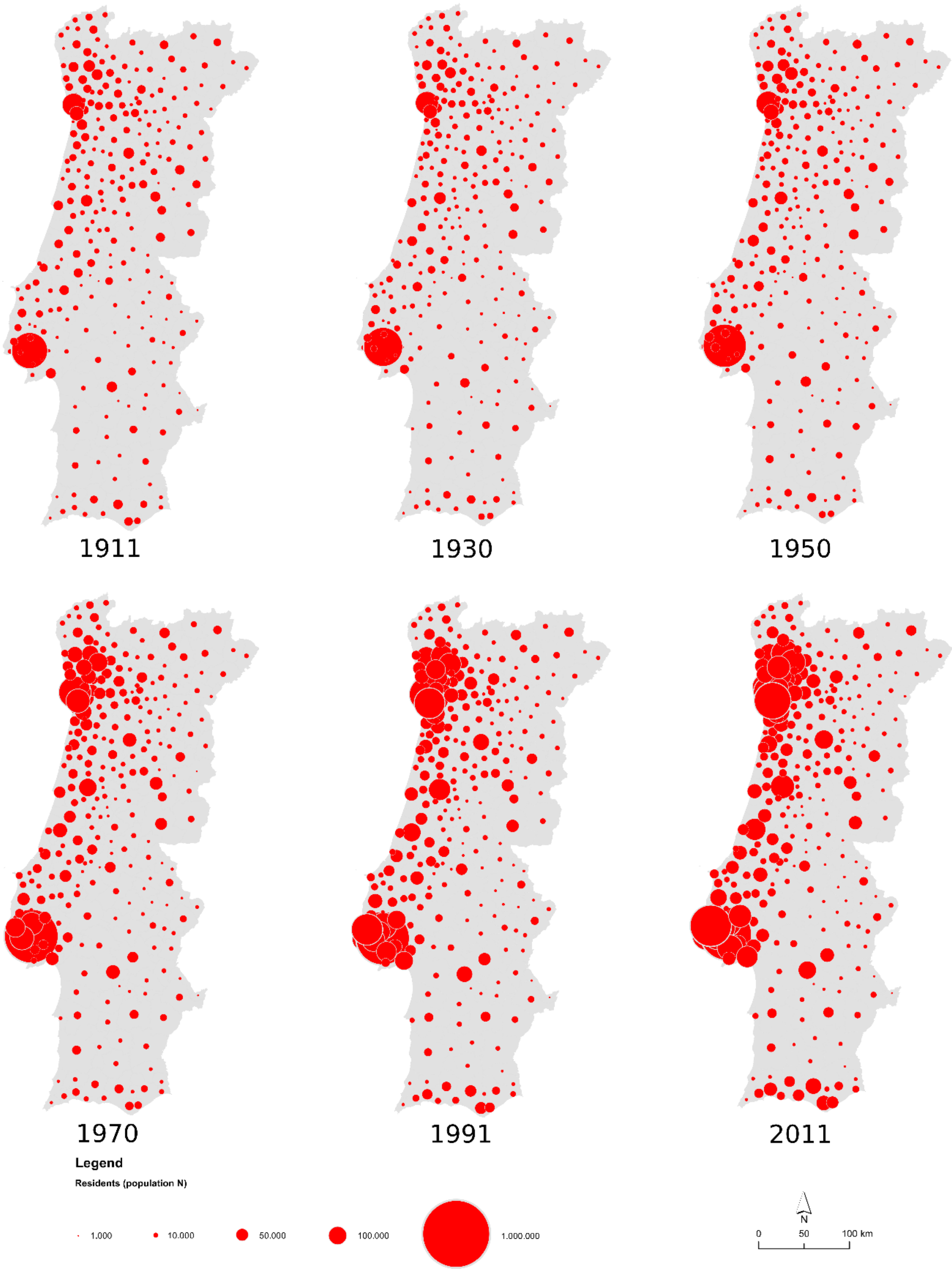


Figure III.1.1.12. Population number (residents) according to the census data (Statistics Portugal), by municipality.

Orlando Ribeiro used to refer to this type of population distribution as uneven, where the littoral areas were the most preferable for the population to settle. In particular the littoral areas north from the Tagus river and the region of Algarve, rather than the remaining inner regions, either north or south (Arroteia, 1985, p. 11).

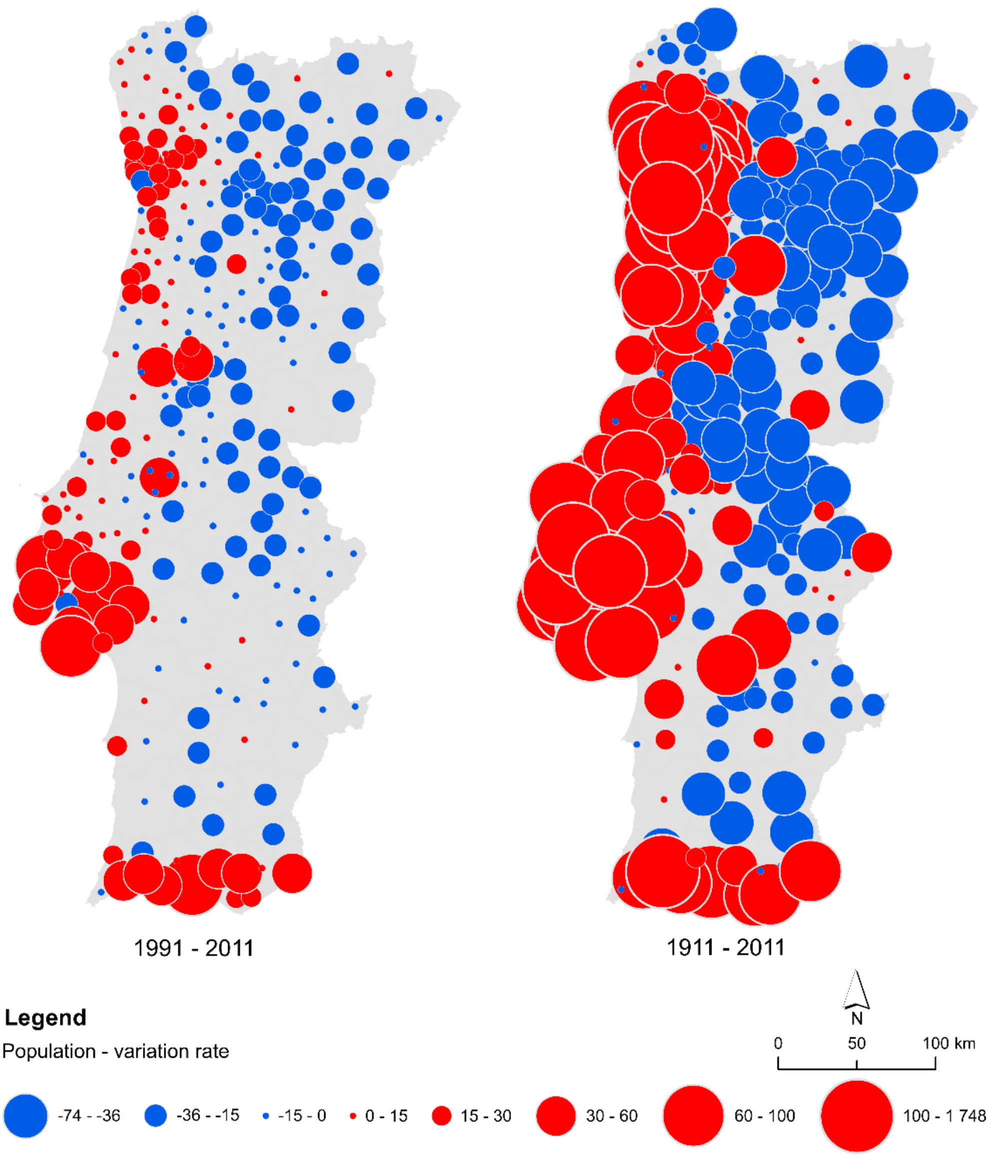


Figure III.1.1.13. Population variation rate in Portugal (Continental), from 1991 to 2011 and from 1911 to 2011, according to the census data (Statistics Portugal), by municipality.

Such inequalities have become exacerbated, and currently, municipalities with a coastline have generally increased population, unlike inner municipalities. Actually, there is a higher number of inner municipalities losing population at a lower rate and a smaller number of municipalities increasing the population at a higher rate, particularly the inner municipalities bordering Spain, which have registered the highest rates of population loss (figure III.1.1.14).

Despite this general increase, since 2010, Portugal shifted to a negative tendency and population is declining until present days. Either the natural population growth rate and the net migration rate have been registering negative values and therefore justifying this negative tendency (Neves & Rodrigues, 2015).

According to Statistics Portugal (INE), this decreasing tendency in population will remain. The population scenarios presented by INE for 2060 are in line with the current trend (INE, 2014a). The exception is the most optimist scenario, where a population increase is assured by migratory fluxes of international migrants (INE, 2014b). Nevertheless, population will continue to register the growth tendency verified in figures III.1.1.12, III.1.1.13 and III.1.1.14, which in the cases of the LMA and PMA, the conductivity to employment is referred to as one of the major contributing factors (INE, 2013).

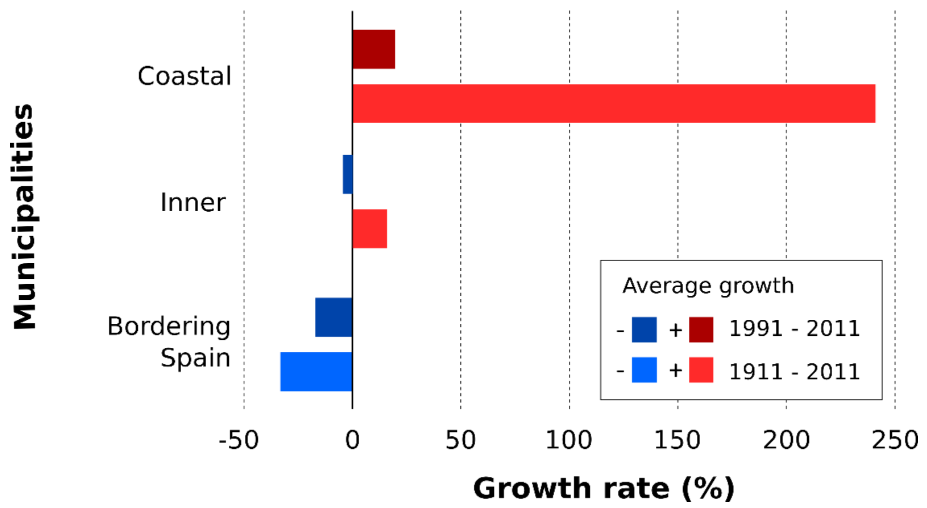


Figure III.1.1.14. Growth rate in the Portuguese Municipalities (Continental) classified as Coastal Municipalities, Inner Municipalities and Municipalities Bordering Spain, from 1991 to 2011 and from 1911 to 2011, according to the census data (Statistics Portugal).

### III.1.2. TERRITORIAL DYNAMICS AND THE USE OF DMSP-OLS

To add to the aforementioned, urban environments are expanding. In the work of Neves & Rodrigues (2015)[4], the U.S Air Force Defense Meteorological Satellite Program - Operational Linescan System (DMSP-OLS)[5] data was used as a proxy to urban development, particularly to assess the growth of built-up areas in coastal territories.

The DMSP-OLS datasets are freely available on an annual frequency since 1992 onwards, on a global scale. Such periodicity and coverage encourage comparisons to be made between regions and countries, being this methodology easily replicated (AA.VV, 2005, p. 529). One must remember that this spatial information does not replace the Land Use and Land Cover data. However, its coverage and periodicity are considered an added-value in terms of tracking changes on an annual basis, with global scale coverage (McGranahan et al., 2007). The dataset here used covers a total of 22 years' time, from 1992 to 2013 (figure III.1.2.15), including data from sensors: F10, F12, F14, F15, F16 and F18, comprising the administrative area of Continental Portugal (Neves & Rodrigues, 2015).

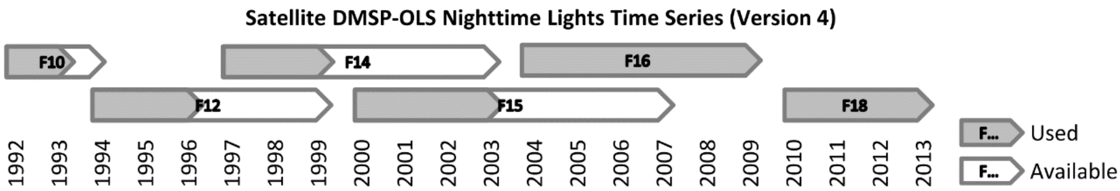


Figure III.1.2.15. Used and available data of the DMSP-OLS Nighttime Lights Time Series, version 4, for the case study of Portugal.

[4] Section is greatly based on published paper from the author in co-authorship: Neves, B., & Rodrigues, A. M. (2015). Identificação e análise de dinâmicas populacionais em Portugal Continental com recurso a imagens de satélite DMSP/OLS. In Maria José Roxo, Rui Pedro Julião, Margarida Pereira, & Daniel Gil (Eds.), Os Valores da Geografia. Atas do X Congresso da Geografia Portuguesa (pp. 389–394). Lisbon, Portugal: Associação Portuguesa de Geógrafos.

[5] The nightlights dataset from the U.S Air Force Defense Meteorological Satellites Program/Operational Linescan System (DMSP/OLS) freely available for download at the NOAA website: http://ngdc.noaa.gov/eog/dmsp/downloadV4composites.html

The DMSP-OLS had its beginning in 1972, collecting at that time images of the aurora. The use of this data soon evolved, and scientists and researchers have been using these data on a diversity of matters, from cloud distribution and its temperatures to manmade and natural fires, natural gas flaring and city lights (NOAA, n.d.-b). Since 1992 this satellite information is being kept digitally on a dataset freely available at global scale spanning -180 to 180 degrees longitude and -65 to 75 degrees latitude (NOAA, n.d.-a). In practice, the DMSP-OLS has the ability to detect artificial lights at night, even without moonlight, and it does it in a 3 000 km land surface within one pass. (NOAA, n.d.-b; Zhang & Seto, 2011).

In version 4 of the Nighttime Lights (DMSP-OLS), light detection ranges from values between 1 (minimum light detection areas) to 63 (maximum light detection areas). To the absence of light, the value 0 (zero) is given in every dataset. Cells have a spatial resolution of 1 Sq. km (Neves & Rodrigues, 2015).

In figure III.1.2.16, the cells represented in black are those whose intensity and the intensity of neighbouring cells is above the 95% percentile, resulting in spatial significant clusters and were designated as urban areas. The colour ramp represents the full range of light intensities. In the 22 years in analysis, it is possible to confirm that there was a clear increase of the spots and that this respected the existing tendencies. This means that the growth occurred in the existing spots, corresponding to the spatial significant clusters, and along existing corridors.

With regard to the so-called borderline areas (figure III.1.2.17), and although the general pattern has remained unchanged, there are important changes to detail as well as the order of magnitude, which are worth mention. With the growth of urban areas, there is a corresponding spreading of nearby areas more prone to change (Neves & Rodrigues, 2015).

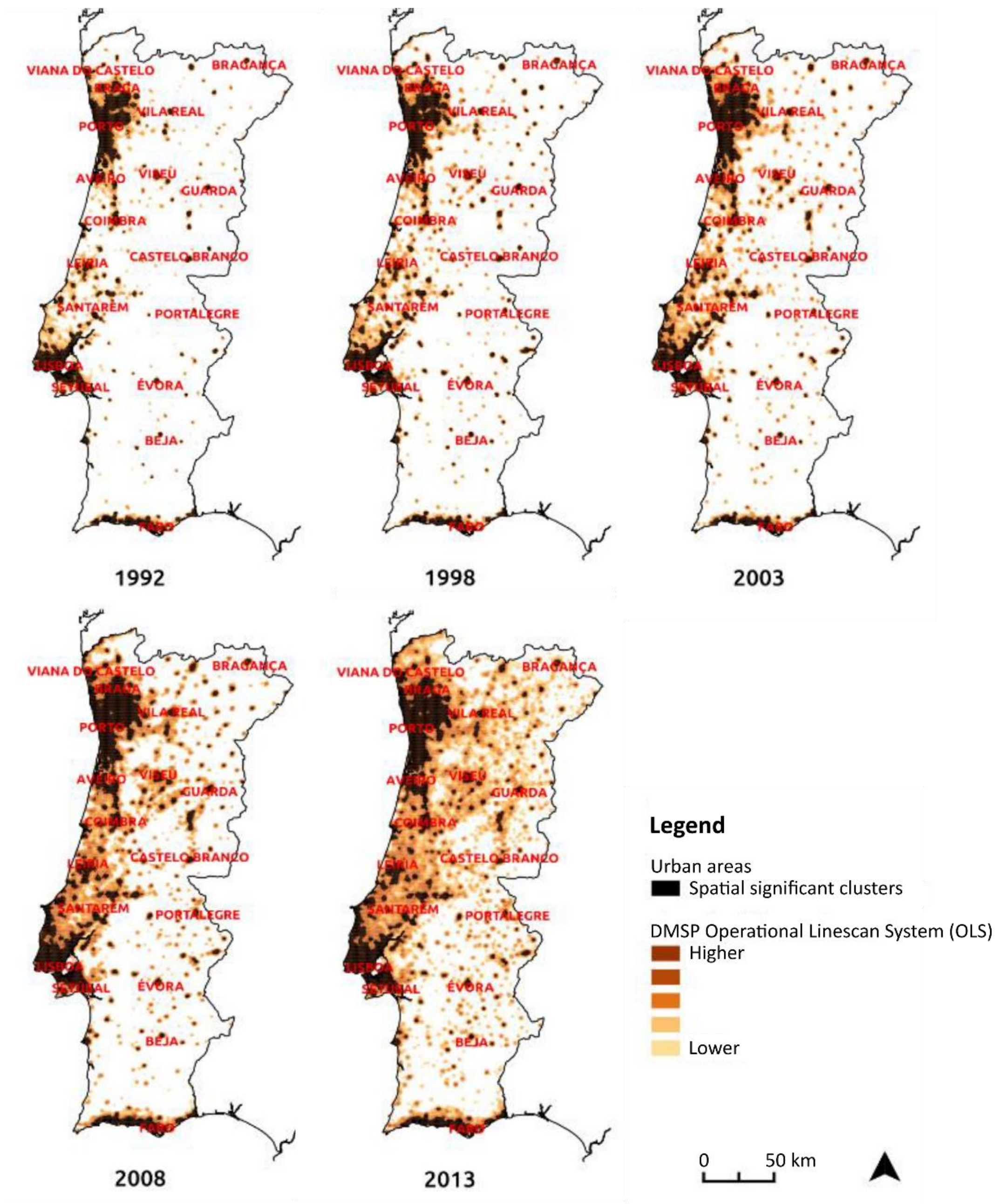


Figure III.1.2.16. Variation of emitted light intensity with the identification of spatial significant clusters. Source: adapted from figure 1 in Neves & Rodrigues, 2015, p. 392.

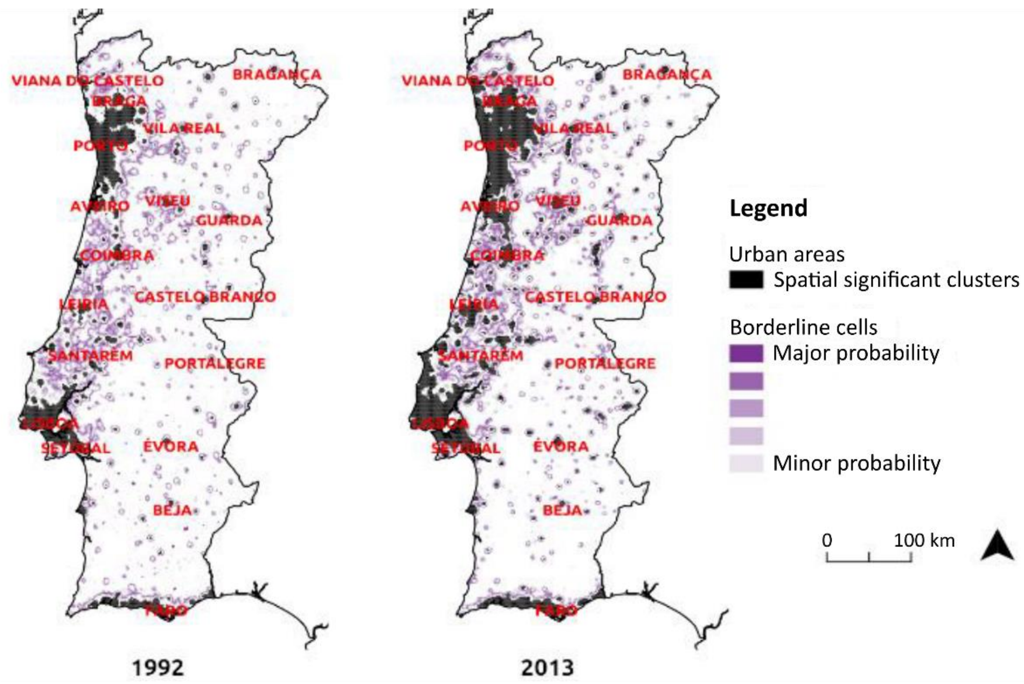


Figure III.1.2.17. Borderline regions and its susceptibility to change. Source: adapted from figure 2 in Neves & Rodrigues, 2015, p. 393.

The analysis of the empirical density function of the series referring to the borderline zones allows the identification of some non-obvious facts presented in the figure above. In figure III.1.2.18, three series corresponding to three years are presented (1992; 1998; and 2013). In 1992, the changing pressure was considerably larger, a fact that can be induced through the figure, as the number of cells with a higher likelihood of change was greater. The decrease in flattening and transport of the central tendency measures to the left indicates that there was a tendency of compaction of the energy emission centres. It is not possible to directly induce that this means greater compaction of the urban areas, although the analysed data clearly point to confirm such deduction (Neves & Rodrigues, 2015).

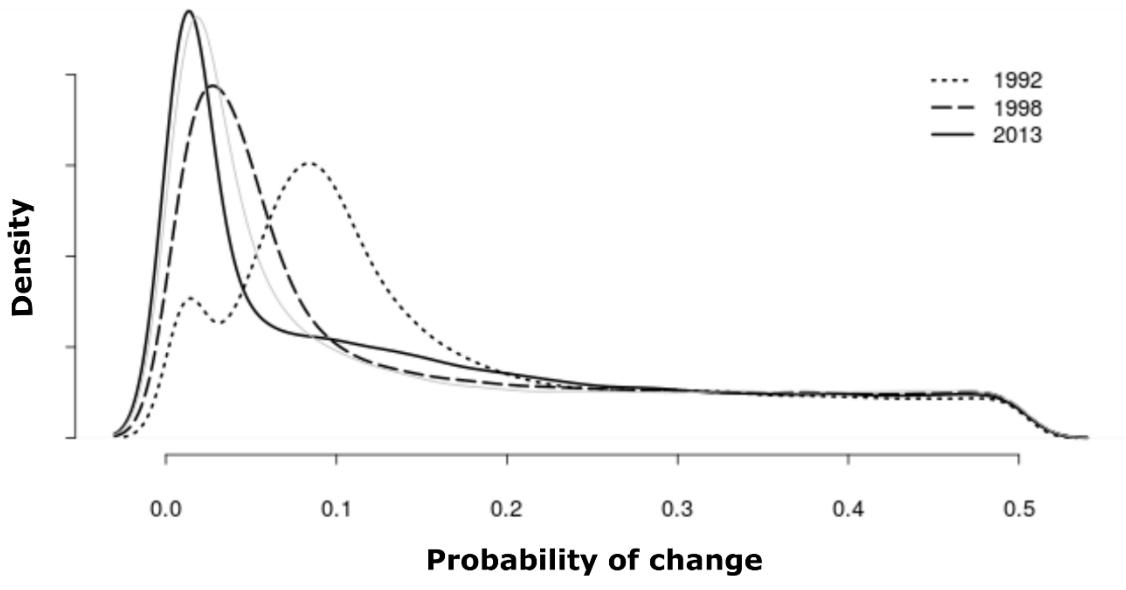


Figure III.1.2.18. Empirical density functions of the time series. Source: adapted from figure 3 in Neves & Rodrigues, 2015, p. 393.

The tendency of littoralisation of the population began to occur from an early age (Schmidt, Gomes, et al., 2013) and nowadays coastal areas concentrate 2/3 of the population (Craveiro, 2013b). In result of this tendency, the need to implement measures within territorial management instruments with a particular focus on coastal zones is emphasized, especially those aimed at reducing the vulnerability of these populations to the risks associated to SLR and the occurrence of extreme climatic events (Fernandes & Neves, 2017; IPCC, 2012; Neves, Fernandes et al, 2018).

To add to the aforementioned, in a study published by the European Commission (Lavalle et al., 2011), encompassing the whole territory, on land use change scenarios, results refer to the increase of built-up areas for 2050 (year of reference 2000). In coastal zones, the increase in built-up environments is expected to be even higher. The presented scenarios in this study are designated as reference scenario, and policy alternatives scenarios. The last consider two different situations. In one situation, changes occur under a sustainable policy scenario. The second considers that changes are occurring under uncontrolled policies.

Bearing in mind these assumptions, results point to the increase in built-up environments in the European Union (EU) countries, from 2000 to 2050. Europe (EU27) is expected to have a share of 4.7% in the reference scenario. For sustainable policy, the share is 4.56%, and 4.87% for uncontrolled policy. For the strip of 30 km considered to coastal zones, the reference scenario is set on 8.6%, being higher on uncontrolled policy (8.75%) and lower on the sustainable policy with 8.16%.

In Portugal, built-up environments are expected to increase along the coast. Even though there are no individual shares for the Portuguese territory available in the report, presented scenarios point to an increase in built-up environments of 27.4% under uncontrolled development and 18.15% under sustainable policy (Lavalle et al., 2011, pp. 28–48), reinforcing the presented results on population and by DMSP-OLS leading to increasing exposure resulting from coastal hazards.

In line with these results, Gibbs (2016) stresses that people and infrastructure are increasingly exposed to coastal risks as a result of global population growth and international migrations, particularly from rural areas to larger cities, namely coastal cities. These scenarios apply to this case study and thus reinforce the need for effective adaptation measures.

## III.2. TERRITORIAL DYNAMICS IN SOUTH AFRICA

With a coastline length of nearly 2 800 km, the continental coast of South Africa is economically and socially resourceful. It ranks third place in coastal and marine biodiversity, which needs to be carefully managed in order to meet the necessities of its population to coastal access and marine resources. Nevertheless, strong concerns have been rising in the country in relation to the migration tendency of population to the coast, endangering the relationship between coastal and urban environments (Goble et al., 2014).

In result, the coastal zone of South Africa is highly populated and concentrate port areas, tourism, industrial activities, trade and residential development. Such human activities have been causing substantial pressures on coastal productive ecosystems particularly in the last four decades (Cilliers & Adams, 2016).

At the same time, the increase in storms in the region has also increased the vulnerability of those living in such areas (Theron et al., 2014, pp. 6–7). In the KwaZulu-Natal province, for instance, fast growing rates were actually a big concern. The coastal belt of the province went through significant changes, detected by analysing differences based on the South African National Land-Cover from 1994/95 and 2000. Such transformations up-scaled concern regarding coastal management and conservation and urged the need for a new land cover map, considered essential by the province for the development of a strategy, allowing proper coastal management and conservation of biodiversity of the coast. Such land cover information was produced for the whole province and designated as KZN Land-Cover Mapping 2005 (GEOTERRAIMAGE, 2008, p. 3).

### III.2.1. USING DMSP-OLS TO TRACK COASTAL TERRITORIAL DYNAMICS

In order to assess coastal development in South Africa, version 4 of the DMSP-OLS nightlights multi-temporal dataset was used once again. Similar to what happened in the study of Neves & Rodrigues (2015) for Portugal and for the Western Indian Ocean region (Neves & Celliers, 2015a, 2015b), data from F10, F12, F14, F15, F16 and F18 sensors was used comprehending a period ranging from 1992 to 2012 (figure III.2.1.19)[6]. Such data enable the identification of urban dynamics in the coastal zone of South Africa. The case study area was set to a buffer of 50 km inland from the coastline (an area of approximately 150 000 Sq. km), and therefore analyse coastal changes resulting from urban dynamics.

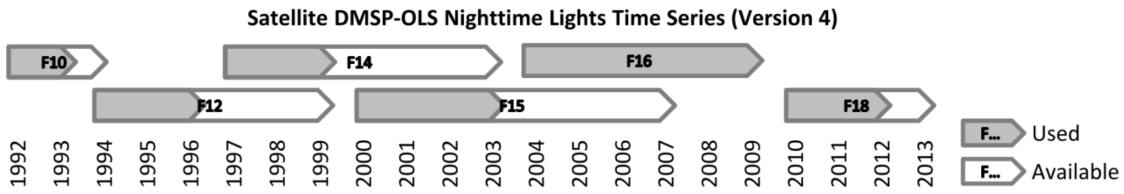


Figure III.2.1.19. Used and available data of the DMSP-OLS Nighttime Lights Time Series, version 4, for the case study of South Africa.

The official polygon file (*shapefile)* of South Africa with the administrative provincial boundaries was also acquired for further delimitation of the case study area. The official Land Cover maps were used for comparative analysis and suitability validation of DMSP-OLS satellite data.

In order to perform local analysis, open and free information was once again downloaded, concerning first, the representation of cities in the case study area (point vector *shapefile*) from the Baruch Geoportal (2013)[7] and second, information that could match the initial DMSP-OLS multi-temporal dataset in order to establish a correlation between both information types. This information was found in a table format in the

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[6] Section is greatly based on unpublished paper from the author in co-authorship with supervisors and in the already published works: Neves, B., & Celliers, L. (2015). The utility of DMSP/OLS Night Lights satellite imagery to track the evolution of urban dynamics in the Western Indian Ocean. *Western Indian Ocean Marine Science Association Scientific Symposium*, 151. Eastern Cape, South Africa; and Neves, B., & Celliers, L. (2015, October). *The utility of DMSP/OLS Night Lights satellite imagery to track the evolution of urban dynamics in the Western Indian Ocean*. Poster presented at the 9th Western Indian Ocean Marine Science Association Scientific Symposium, Eastern Cape, South Africa.

[7] Webpage https://www.baruch.cuny.edu/confluence/display/geoportal/

United Nations (2014)[8] website. This webpage has the "*World Urbanization Prospects, the 2014 revision*" publication data freely available for download. The dataset contains population data from 1950 until today, with scenarios until 2030 for cities worldwide making it suitable for cross-countries analysis.

Here, the limit to the analysis of coastline areas and the urban dynamics therein, is set to a 50 km area from the South African coastline inland. Such area is suitable for the identification of changes regarding the built-up environment, and the identification of expected coastal hazards and possible conflicts. From these, coastal management and intervention priority areas are identified.

The coastline was extracted from the official South Africa polygon file and converted to a new polyline *shapefile*. Two buffer analysis were performed: i) defined by a boundary region of 50 km inland from the coastline, giving place to a new polygon *shapefile* representing the study area, and; ii) defined by multi buffer zones of 10 km interval inside the 50 km limit. This last layer was created for a closer analysis regarding changes closer or further away from the coastline.

Next, the two shapefiles with buffer zones were overlaid with the boundaries of the four South African coastal provinces, namely, Kwazulu-Natal, Eastern Cape, Western Cape and Northern Cape.

Consequently, the following information was confined to the 50km case study buffer area from the coastline:

- DMSP-OLS night lights satellite data from 1992 to 2012;
- Official Land Cover available maps;
- Major coastal cities.

This set of information aims at analysing the suitability of the NOAA DMSP-OLS data to track urban dynamics in coastal zones, here understood as corresponding to the built-up environment where human and economic activities take place. The identification of these coastal urban dynamics allows understanding and classifying

[8] Webpage https://www.eea.europa.eu/data-and-maps/data/external/world-urbanization-prospects-the-2012-2

priority areas at the coast, which are vulnerable, or at risk concerning coastal hazards so the ability to adapt in these areas can be assessed.

The results presented in the sections below were separated in three different scales of analysis: i) general results at the national level; ii) regional results for the four coastal provinces, and; iii) local results for selected coastal cities.

### III.2.2. DMSP-OLS NATIONAL SCALE RESULTS

A first analysis to the DMSP-OLS dataset for the case study area shows an increase in nightlights covered area from 1992 to 2012 in the South African coastal selected buffer, representing an increase in built-up and artificial areas (figure III.2.2.20).

This tendency is found also for the two inter-period dates: 1992 to 2002 and 2002 to 2012. In 1992 the area covered by nightlights represented nearly 32% of the total area (150 000 Sq. Km) increasing to more than 35% in 2002, reaching almost 39% in 2012 representing an increase from 3 to 4 percentage points from the first to the second inter-period (figure III.2.2.20).

A closer look to its distributions, when crossed with the buffer stripes parallel to the coastline (figure III.2.2.20 - B), reveals that nightlights intensity is higher closer to the coastline and gradually decreases towards inland. In 1992, South Africa had 44.24% of its area in the 0 to 10 km distance stripe from the coastline covered by nightlights, gradually decreasing to 18.59% in the stripe from 40 to 50 km. The reality in 2012 was much different with percentages of 50.18 and 29.91 in the abovementioned stripes, corresponding to a growth of nearly 6%, and more than 11% respectively (figure III.2.2.20 - B).

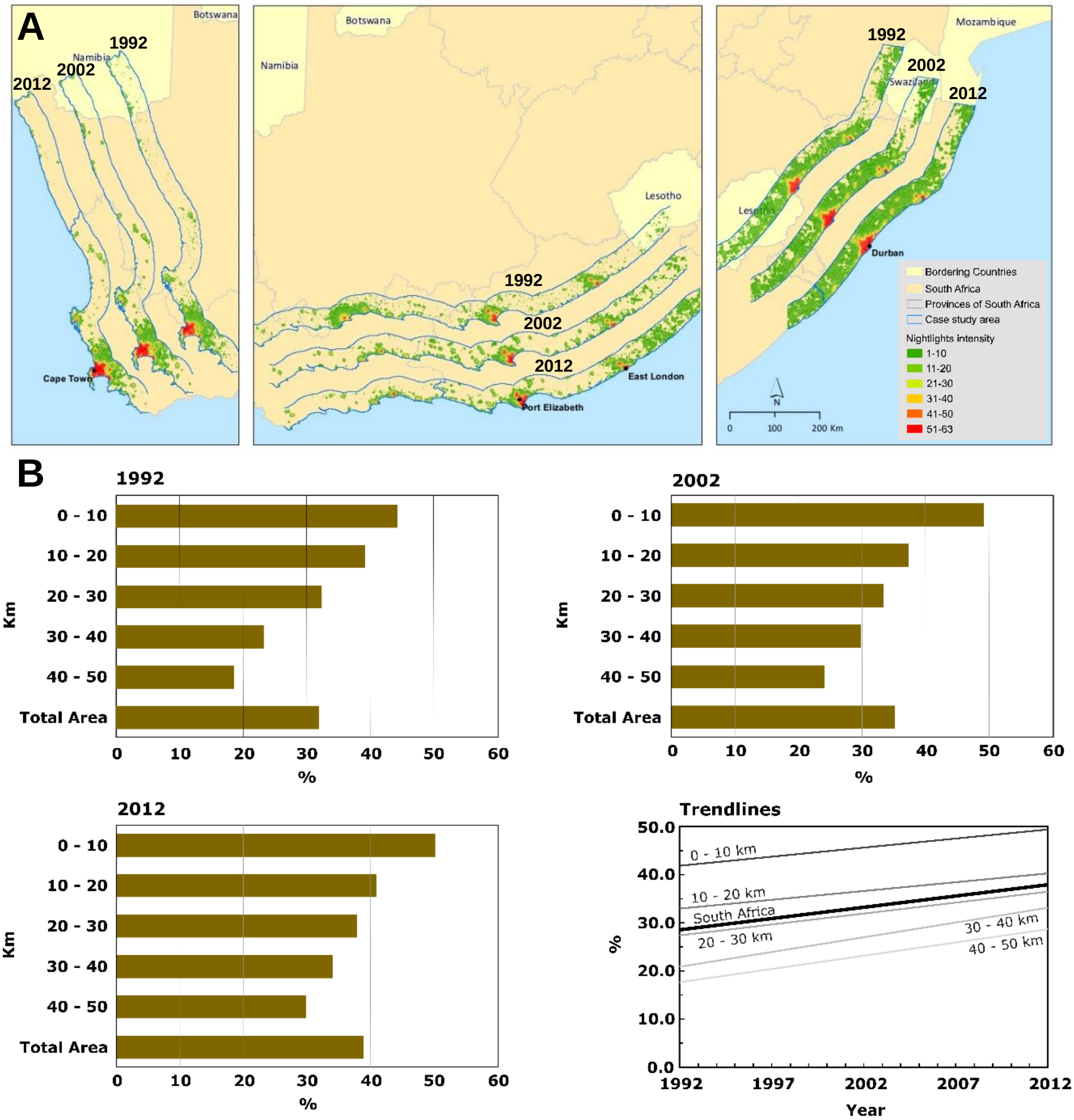


Figure III.2.2.20. A - Spatial distribution of nightlights intensity in South Africa for 1992, 2002 and 2012. B - Percentage of area occupied by nightlights for the 10 km buffer zones in each year and linear fit trendlines of nightlights yearly percentages by distance zones, for 1992 to 2012.

### III.2.3. DMSP-OLS REGIONAL SCALE RESULTS

In the regional analysis, results refer to the percentage of the area that is covered by nightlights referring to the same three years and both periods. These results are illustrated in figure III.2.3.21 and systematized in figure III.2.3.22. It considers the 50 km stretch from the coastline for the four coastal provinces, which totalises an area of approximately 150 000 Sq. km. The KwaZulu-Natal province totalises an area of 30 689

Sq. km; Eastern Cape 45 464 Sq. km; Western Cape 55 359 Sq. km; and the province of Northern Cape, an area of 17 762 Sq. km.

The furthermost eastern coastal province of South Africa is by far the one that has the highest percentage of area covered by nightlights. KwaZulu-Natal has grown from 61% in 1992 to 67.50% in 2002, reaching nearly 77% of covered area in 2012. Although the highest value is registered in the coastal strip from 0 to 10 km from the coastline with 85% in 2012, the highest change was in the farther couple of strips in analysis. The strip within a distance from 40 to 50 km from the coastline grew from 36% in 1992 to nearly 51% in 2002 and 69% in 2012 corresponding to growths of 15% and 18%, while the nearest strip grew slightly more than 5% for the total period in analysis (figure III.2.3.21).

Results suggest that the KwaZulu-Natal coastal area is highly developed and artificialized, in particular in the surroundings of the coastline, where the metropolitan area of Durban plays the main role, both in area and in lights intensity, followed by Richards Bay. The values obtained for these 21 years also suggest a tendency of continuous growth although less evident in the near coastline due to its already high development. Growth in nightlights covered areas, particularly from the 20 km from the coastline inland are comparatively high regarding not only KwaZulu-Natal in general but also the coastal provinces in analysis, exception must be made to the province of Eastern Cape as it can be seen below and in figure III.2.3.21.

In Eastern Cape the nightlights covered areas are not as intensive as in the KwaZulu-Natal province. Nevertheless, results reveal an increasing tendency in the last period comparatively to the previous province, although smother. In 1992, 24% of the Eastern Cape study area was covered by nightlights, growing to 34% in 2002 and 42% in 2012. Contrarily to KwaZulu-Natal, growth was more evident in the nearby coastal areas of Eastern Cape. The coastal strip from 0 to 10 km from the coastline registered in 1992 a nightlight covered area of 32%, growing to 47% in 2002 and nearly 54% in 2012. The changes in nightlights area of almost 22%, contrasts with the growth in the farther strip in analysis where changes for the same periods are in the order of 14%. The highest growth was again in the first period in analysis, from 14.50% in 1992 to 23% in 2002. In 2012 the nightlights covered area was slightly more than 28%.

Regarding the present tendency, it is expected that in maximum of 20 years (from 2012), Eastern Cape will reach 50% of its area covered by nightlights in its 50 km coastal strip. In what concerns to nightlights intensity Port Elizabeth is the most expressive city followed by East London. The northeast coastal area next to the KwaZulu-Natal border is the one revelling more contiguity, which ends right before the near East London city area with nightlights intensity values generally below 10 from a maximum of 63, similar to what happens in KwaZulu-Natal, with the exception of the already mentioned two largest cities areas of that province.

In general terms, the Western Cape province shows a relatively stability during the period of 21 years in analysis. In 2012, the province had slightly more than 24% of its area covered by nightlights, the same value was registered in 2002, which is the average for the total period in analysis. However, in 1992 the province had more than 28% of its area covered by nightlights, a value that drops down to almost 24% in the following year. Such situation is common for all coastal provinces and then for the whole coastal case study strip, leading to conclude that the year of 1992 may be an outlier. Yet, a spatial analysis of the whole data reveals evident changes in nightlights intensity, in particular a continuous decrease for the first period in the suburbs of Mossel Bay and George, which was gradually compensated by the growth of Saldanha and Vredenburg, and by the expansion of the metropolitan area of Cape Town.

The strip from 0 to 10 km from the coastline is the only one that kept the average value of 40% of nightlights coverage, all the other strips registered a decrease in coverage values from 1992 to 2012 (figure III.2.3.21). Nevertheless, despite this decrease in the strips from 10 to 50 km from the coastline, the second period in analysis, in relation to the first, registers an increase in general average values for all strips.

Western Cape is the only coastal province that kept the overall average coverage area from 1992 until 2012, in contrast with the growth of 15% in KwaZulu-Natal and 18% in the Eastern Cape province.

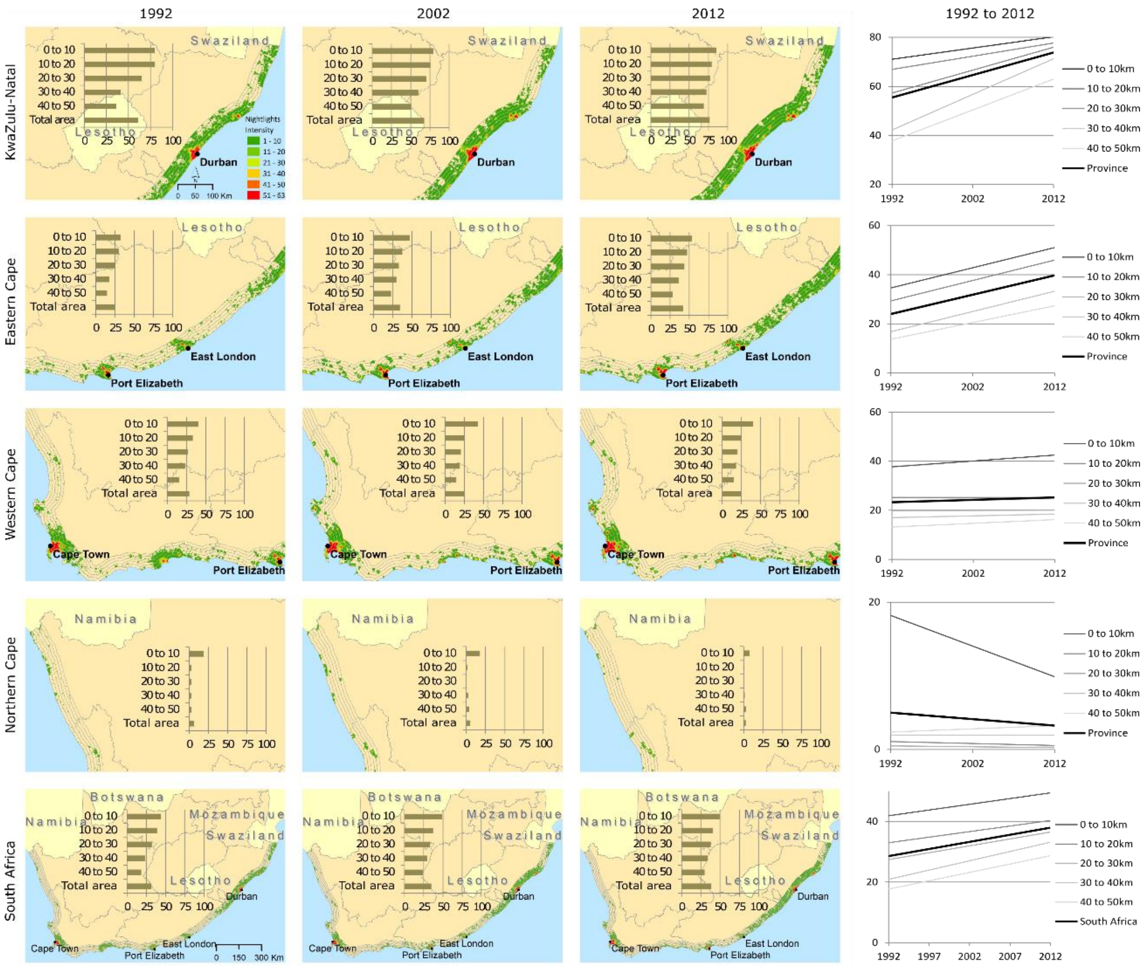

Figure III.2.3.21. Nightlights covered area by region and for South Africa in the delimited 50 km stretch from the coastline.

The Northern Cape is the most western coastal province and the only one in analysis that registered a decrease in nightlights covered area. It is also the province that revealed being the most heterogeneous in what concerns to spatial nightlights coverage. The coastal strip from 0 to 10km from the coastline had in 1992 a coverage area of nearly 19%, with the following strips values in the order of 3% of coverage area. This sharp decline contrasts with all the other provinces where the nightlights area gradually decreases as the distance from the coastline increases.

With the exception of the strip within a distance from 40 to 50 km from the coastline that kept its coverage values on an average of 3%, all the other strips decreased. The highest decrease was from the strip from 0 to 10 km in the second period, from nearly 18% in 2002 to almost 8% in 2012. The following couple of strips have coverage values around 1% and nearly 0% and the strip from 30 to 40 km from the coastline decreased from slightly more than 2% to nearly 1.5% in 2012.

Comparatively to the other provinces, in the 50 km strip areas in analysis, the Northern Cape has no urban settlements with a significant dimension worthy of being mentioned. The significant loss of coverage area in the most coastal strip can be explained in part by the changes in the mining sector, with the closure of inshore mines, moving offshore.

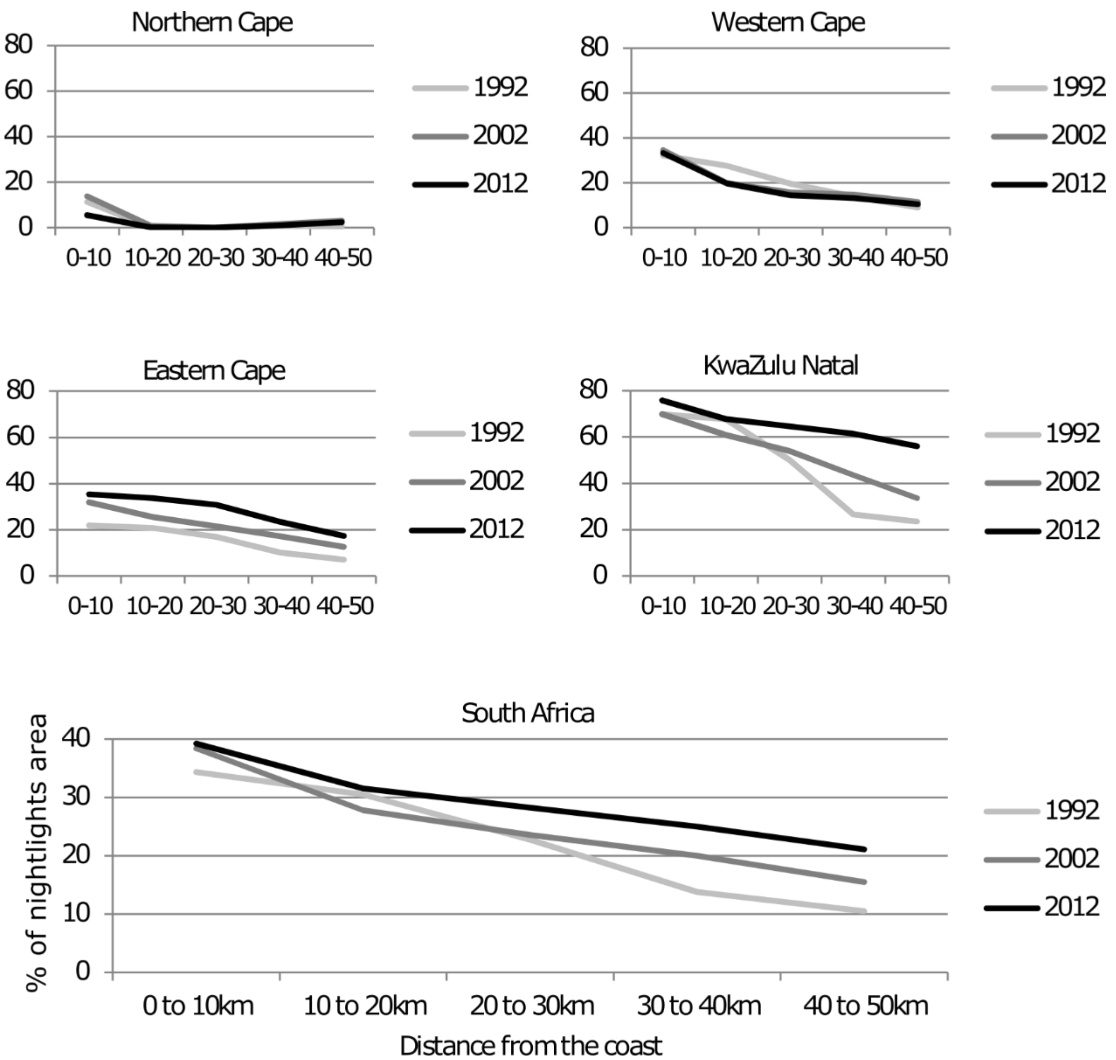


Figure III.2.3.22. Percentage of area occupied by nightlights for the 10 km buffer zones in each year, aggregated by coastal province, and South Africa.

The accuracy of light emissions from the DMSP-OLS in identifying built-up areas was tested against land cover maps and specifically to urban classes. The KwaZulu-Natal province was selected due to the availability of land cover maps for four different periods, designated as: 1994/95; 2000; 2005 and 2013/14 (figure III.2.3.23).

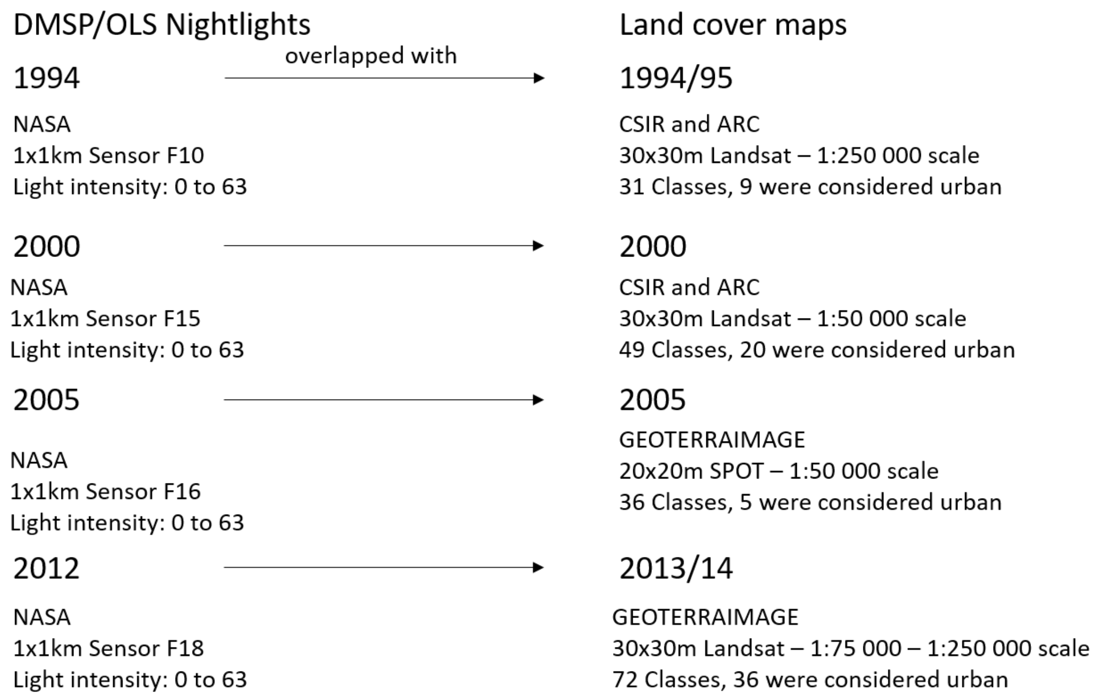


Figure III.2.3.23. DMSP-OLS and land cover datasets used for the KwaZulu-Natal province comparative analysis.

Such comparison was done through a clustering analysis with the objective of separating the urban areas from the most natural areas. The nightlights data was grouped after multiple tests from two to seven clusters, and with the exception of the cluster two, all the other clustered files were regrouped in two clusters, separating the areas with the lightest from the areas with low light emission values. These clusters were then overlapped with the land cover maps and for each cluster, the percentages were calculated in order to assess the relation of both data types, the built-up environment with the high light emissions from the non-built-up environment with very low light emissions.

Results revealed that only the most consolidated urban areas produce the higher values of light and therefore were grouped in the urban cluster. These urban classes fell almost completely in the urban cluster, with more than 90% of its total areas. The exception occurred in the land cover dataset from 2005, where a maximum of 76% was registered for the most consolidated urban class, falling in the urban nightlights cluster (figure III.2.3.24).

Less consolidated areas fell more on the non-urban cluster once their light values are more similar to the natural areas. It became more evident since 2000, where, in that year, in the most favourable case, only 24% of the urban class “Urban/built-up rural cluster” fell on the urban cluster. The three “Urban/built-up smallholdings” classes also registered low overlapping values for the urban cluster, between 2% and 47%. In 2005, the “Rural dwellings” class was the urban class less represented with only 28% falling in the urban cluster. For the last year in analysis, the new “Urban village” classes (four) were the most critical, with only 13% to 37% of its total falling on the urban cluster. Such disparities can be related with the different methodologies used on the four different land cover maps. These were done by different entities and technicians, which used different satellite images from different sources with scales of analysis and minimum mapping unit areas. Lately and again, different number of classes were set for the land cover maps, some of them were more class-detailed than others, in particular to what concerns to the considered urban classes (CSIR & ARC, n.d.; GEOTERRAIMAGE, 2008, 2015, n.d.; Thompson, 1999; Thompson et al., 2001).

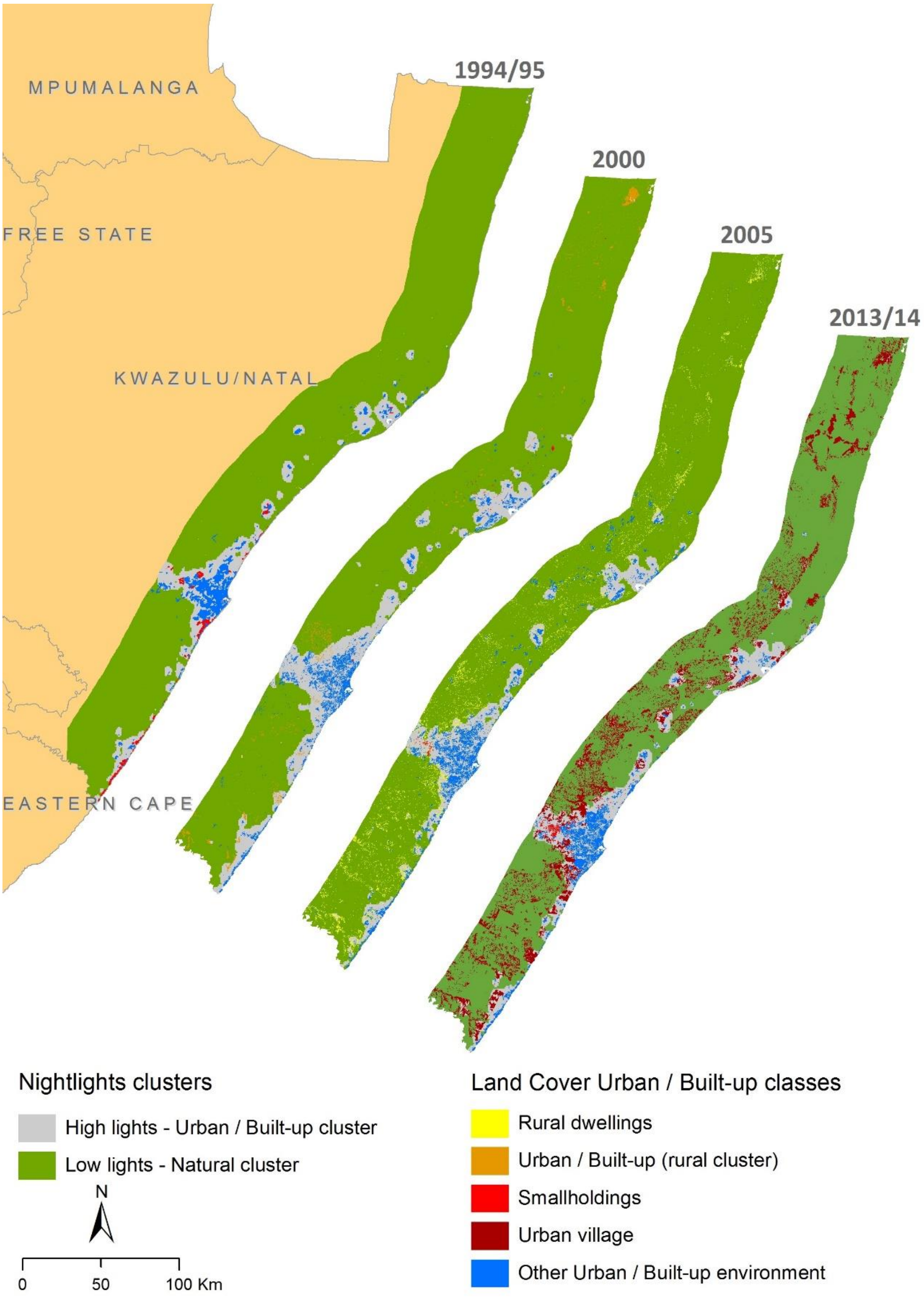


Figure III.2.3.24. Nightlights clustering representation and land cover grouped classes overlapping analysis for the periods: 1994/95; 2000; 2005 and 2014/2015 in the Province of Kwazulu-Natal.

The results on the used methodology suggest that its reproduction on other areas similar to the coastal areas of South Africa may misrepresent the above mentioned transitional urban areas between the consolidated areas, and the most natural areas from forest or grassland areas to cultivated fields, where light emissions are much lower and closer to these transitional urban classes. However, consolidated areas will be well represented as results demonstrate.

The process of validating the nightlights with the reference data, in this case, the land cover datasets, results were most suitable when using a total of four or five clusters. On average, the percentage of noise resulting from the most natural classes is lower than 10%. For a higher number of classes, the non-urban classes in the urban clusters are higher than 10%. With less clusters, the noise in the urban clusters are lower, however its urban representativeness its equally lower leaving much of the urban areas of low light emissions misrepresented by the cluster (figure III.2.3.25).

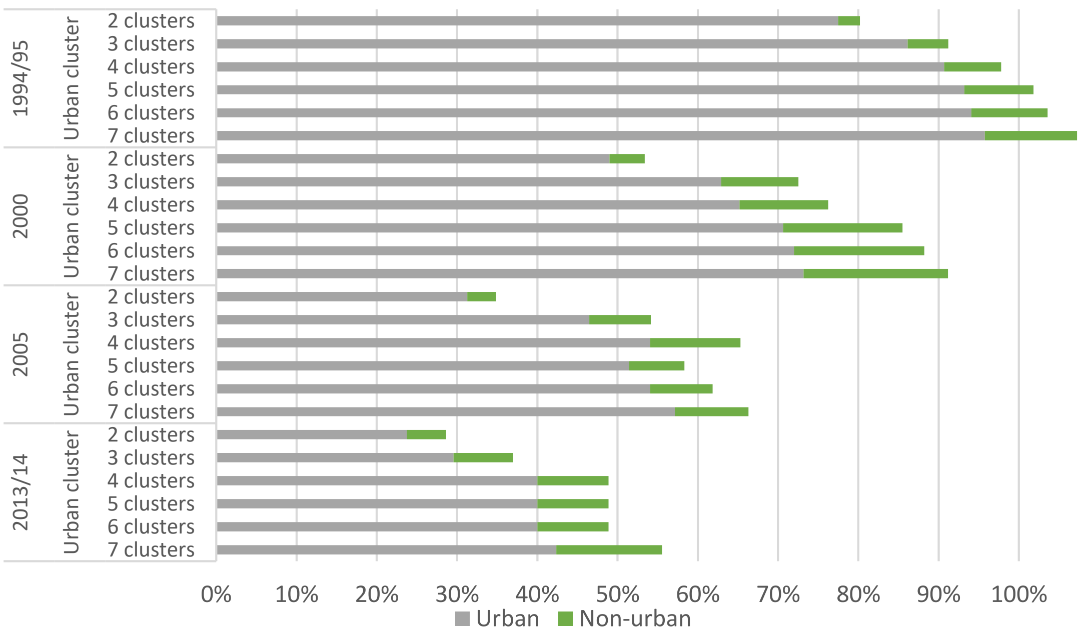


Figure III.2.3.25. Total percentage area of land cover urban and non-urban classes that fall on the nightlights urban cluster.

### III.2.4. DMSP-OLS LOCAL SCALE RESULTS

Set as one of the objectives, the use of the nightlights at local scale to assess to what extent it can be used in the identification of coastal dynamics changes regarding built-up environments, considering that this raster information has a spatial resolution of 1 Sq. km.

At the local level several analyses were performed. In a first stage nightlights covered area were submitted to a hot spot analysis (and a degree of confidence of 99% of clustering) and the four case study coastal cities and nearby cities selected. The centres of the cities polygons were calculated based on its area and after, in order to understand trends and shifts, the weighted centres were calculated based on nightlights intensity, revealing not only its centre but also the direction in which changes are occurring. The cities analysis ends with a comparison of the changes in cities areas with the changes in the population number by using the Pearson correlation coefficient, being the objective to comprehend how much of the city expansion in area can possibly be explained by the growth of the population.

Durban is one of the case study cities that most grown along the coastline, only Cape Town presented similar coastal expansion. In the presented period it reached Tongaat and Ballito, and according to its current expansion trend, Stanger will soon be aggregated to the Durban city hot spot urban area. Despite being in a completely different direction from the current expansion trend, and regardless of its slower expansion rate, with the growth of both Mpumalanga and Inchanga, these are the hot spots that will sooner join Durban. Umkomaas in SSW, is the hot spot that according to the present tendencies will take longer to be part of the Durban's hot spot area once both Umkomaas and Kingsburgh have presented low signs of expansion along these two decades (figure III.2.4.26).

Such levels of coastal development generate concern not only for the city of Durban but for the Province of KwaZulu-Natal in general (Theron et al., 2014). In March 2007 the surrounding area of Durban was affected by run-up levels higher than 8.5 m above Mean Sea Level and the reason why it was so impacted by these storms is its high level of coastal development near the coastline (Theron et al., 2014, p. 77).

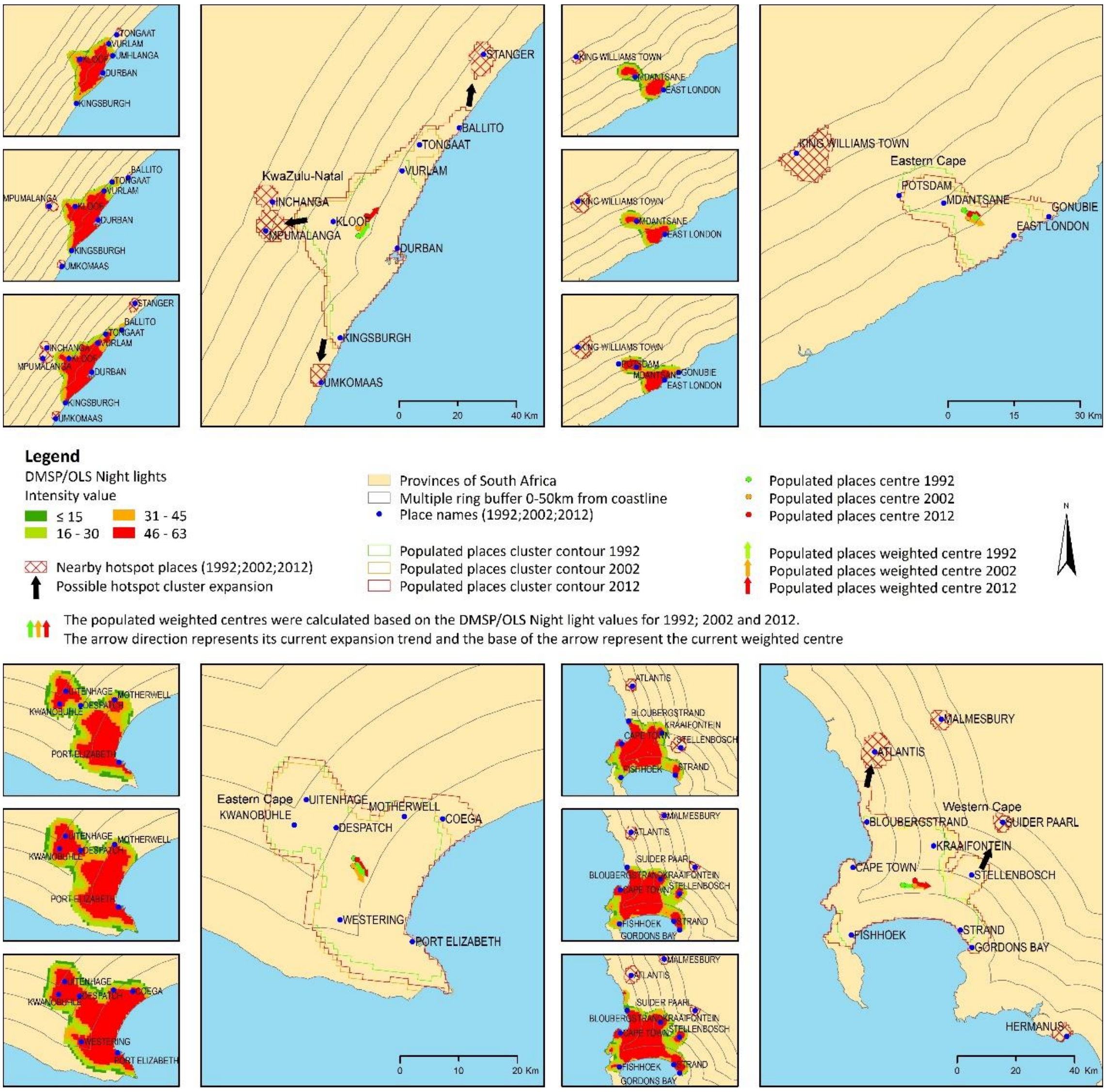


Figure III.2.4.26. Nightlights local analysis for the cities of Durban, East London, Port Elizabeth and Cape Town considering the periods of 1992, 2002 and 2012.

Despite its slower expansion pace, East London, like Durban, is expanding and consolidating closer to the coastline as nightlights intensity values demonstrate. Due to the aggregation and consolidation of Potsdam with Mdantsane, both the centre and the weighted centre moved slightly backwords from the coastline in the last year here presented. However, its directional trend is still the waterline with the aggregation of Gonubie, an urban agglomeration in the coastline, NE from East London. Similar situation is presented in the results of the Port Elizabeth hot spot area, where the aggregation of Coega moved the weighed centre in its direction, however, its tendency did not change for the whole period in analysis, indicating a consolidation of the Port Elizabeth urban area (figure III.2.4.26).

Cape Town as revealed great expansion along the coastline for the period in analysis with the consolidation of Fishhoek and Blouberstrand, and the aggregation of Gordons Bay, close to Strand, to the Cape Town hot spot area. Contrarily to all the previous situations and due the physical constraints imposed by the relief of the coastal area and to the strong consolidation of cities like Stellenbosh and Kraaifontein in this hot spot area, the trend of expansion directional is not the coast and both areas will, probably, in the future, join with Suider Paarl, a hot spot that, like Stellenbosh, has been growing in this period. Another possible expansion may happen north from Cape Town. The fast development registered in the last period in analysis, north of the Blouberstrand area, to Melkbosstrand, together with the growth of Atalantis may result in the aggregation of the last one mentioned (figure III.2.4.26).

Population in the four case study cities has been growing uninterruptedly since 1950 according to the United Nations population database, and it is projected that such tendency will continue at least until 2030, last date presented in the United Nations used dataset for population projections (figure III.2.4.27). Cape Town is the most populated case study city with an estimated population of 3 666 000 inhabitants in 2015, followed Durban with 2 901 000 inhabitants, Port Elizabeth with 1 179 000 inhabitants and East London with 319 000 inhabitants. According to the United Nations projections, Durban will add to its current population 15% more inhabitants. East London will be the city with the highest growth, with 24% of population growth. Port Elizabeth and Cape Town will register a growth of 18% in number of inhabitants by 2030 (United Nations, 2014c).

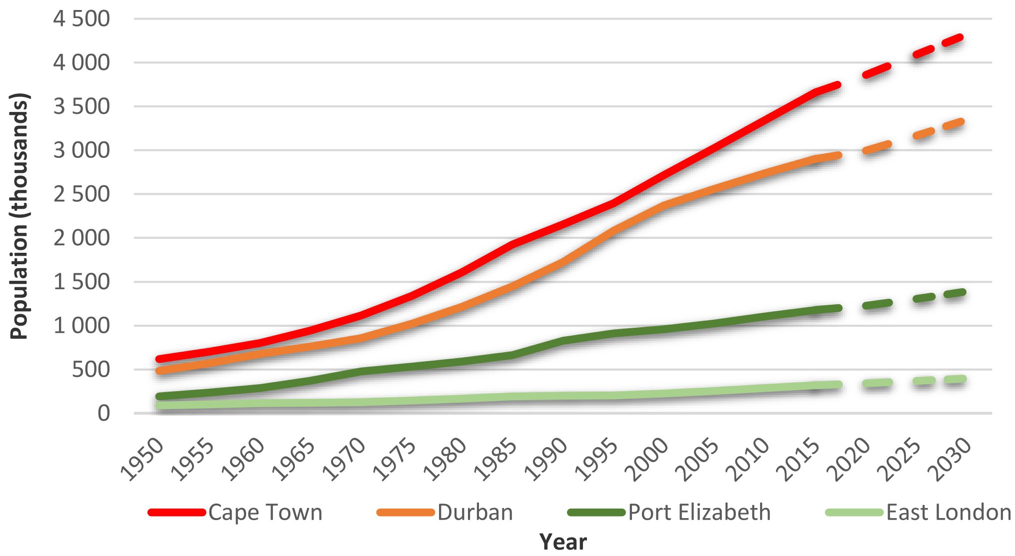


Figure III.2.4.27. Population trends in the four case study cities between 1950 and 2030.

The Land cover and the nightlights datasets have already demonstrated that the built-up environment has been expanding along with population growth increasing coastal pressures and exposure to current and future threats related to coastal extreme weather events and climate change. In this section, the Pearson product-moment correlation coefficient (Pearson's r) was used in order to identify a possible correlation between the growth of both, the cities area and the city's population. It was expected that with this correlation a possible positive correlation between both variables would be found. The Hot Spot Analysis was used to outline solid contiguous areas based on the nightlights in order to define the city's boundaries for each year in analysis and correlate these areas with the United Nations population database.

Results for these correlations based on the used methodologies demonstrate a substantial positive high correlation between both the used variables. Durban and East London have a correlation value of 0.72, while Cape Town and Port Elizabeth present the highest correlation values for the cities in analysis, with 0.86 and 0.89 respectively (figure III.2.4.28).

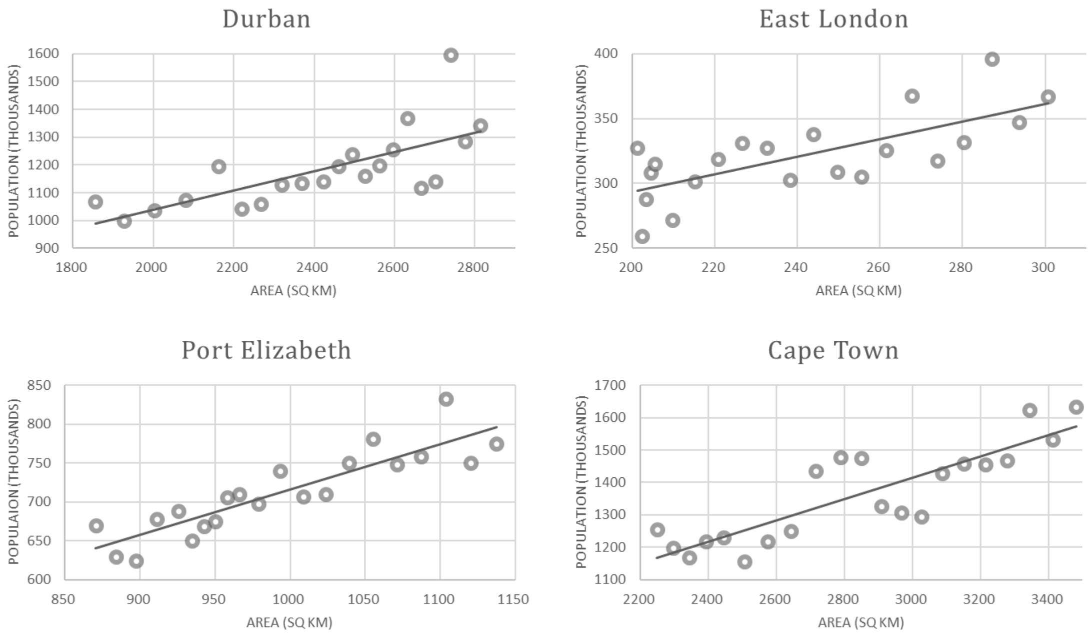


Figure III.2.4.28. Correlation between Population (UN) and city's area (nightlights) from 1992 to 2012 for Durban, East London, Port Elizabeth and Cape Town.

**Summary of the chapter**

Territorial dynamics resulting from the analysis for both case studies show, in relation to current population trends and projections, that both countries follow the general tendency of population increase in coastal zones verified in Chapter I.

Portugal is currently increasing population in coastal areas, with emphasis on the two great metropolitan areas, Lisbon and Porto and also in the Algarve region. However, since 2010, the country has been losing population and according to Statistics Portugal, this trend will hardly change in the coming decades.

In addition, according to the analysis carried out through the DMSP-OLS, coastal zones have also increased their built-up areas, particularly near the coastline. Thus, the trend observed in the period under analysis points to its consolidation.

Also in South Africa, results from the use of DMSP-OLS data, reveal that there has been a tendency of increase in built-up areas, particularly nearby the coastline, which results in increased pressures for coastal ecosystems as well as for infrastructure and people to coastal hazards.

Results at the regional level (Province) revealed that Kwazulu-Natal is the most heavily occupied province in the study area, followed by the Eastern Cape, the Western Cape and finally, the Northern Cape. In this sense, the comparative regional analysis between Nightlights and Land Cover maps for the province of Kwazulu-Natal allowed the assessment and confirm this same growth, in particular, in the larger urban perimeters. In addition to these results, it was still possible to verify that there is a change in typology, and areas previously considered as rural, have now acquired an urban character, confirming the consolidation of these areas in this coastal zone.

The analysis at local scale in the four selected cities reveals a tendency of increase and consolidation towards the coastline. At the same time, there has been a growth of urban areas around these larger four urban areas, suggesting the results further consolidation in these areas. These results are in line with the population scenarios referred to by the United Nations, pointing to population growth for these cities. Thus, the correlation between population and the expansion of built-up areas along the coastline is considerably positive, particularly in the cities of Cape Town and Port Elizabeth.

Furthermore, it is important to remember results obtained in Chapter I regarding the tendency towards an increase in the population in coastal areas, and that is confirmed in both case studies, Portugal and South Africa. It is also expected, and it has already been mentioned, that coastal zones are and will be subject to an increase in frequency and severity of extreme weather events and sea level rise. In this sense, the reinforcement and implementation of reactive and proactive measures acquires an increasingly significant role. However, in relation to the last type of measures, results from chapter II suggest that the use of coastal boundary demarcation lines has not produced the desired results. In consequence, there has been an increase in urban perimeters in areas where they are applied resulting from high contestation from stakeholders and actors involved in the process, and thus increasing their exposure to coastal hazards. In this sense, the following chapters are entirely dedicated to the use of coastal boundary demarcation lines in both case studies, where it is important to understand what results these entail.

# CHAPTER IV. THE USE OF COASTAL BOUNDARY DEMARCATION LINES IN PORTUGAL AND SOUTH AFRICA

## Aim and scope

Chapter IV seeks to respond to the premises presented in the second objective of the third point in the introductory section, by evaluating coastal boundary demarcation legislation and policy in the two case study countries, which includes the extent to which they are explicitly used in climate change risk reduction and adaptation.

The chapter begins with an introduction to the methodology used in conducting and analysing the semi-structured interviews applied in both case studies. The semi-structured interviews focus on the use and implementation of coastal boundaries lines to demarcate vulnerable or areas at risk, or that somehow need to be restricted in terms of use, in Portugal and South Africa. Whenever necessary, semi-structured interviews are supported in the literature for both the case studies.[9]

Following the methodology, the results are then presented initially for both case studies in a general manner, and after, separately. The results for Portugal appear first, followed by results for South Africa. Separate results presented in this chapter were aggregated in eight major groups of questions and are designated as: i) past practices; ii) actual practices; iii) climate change; iv) review process; v) institutional involvement; vi) stakeholders involvement; vii) implementations challenges, and; viii) policy risk alternatives.

[9] The chapter includes published and unpublished works by the author in co-authorship with supervisors and with other co-authors.

**METHODOLOGY**

The chapter presents part of the results from the semi-structured interviews conducted as part of this study. The script of the semi-structured interview was divided into three distinct parts (see annex 3 for details). In total, the script had 28 questions for Portugal and 30 questions for South Africa. A difference explained due to different policy contexts.

The first part is brief and mainly aims to introduce the interviewees in order to understand their role in their institutions and, how these roles contribute, and to what extent, to the development of setback lines (tables IV.08 and IV.09).

The second and third parts of the interview are extensive. The second part is fully dedicated to planning-related issues and policies around setback lines, and its results are reported in this chapter. The third part explores more technical issues, namely those associated with the use of Geographic Information Technologies and with Remote Sensing. The results of this part of the interview script are reported in Chapter V. The themes of the planning and technical parts of the interview script are summarized in figure IV.29.

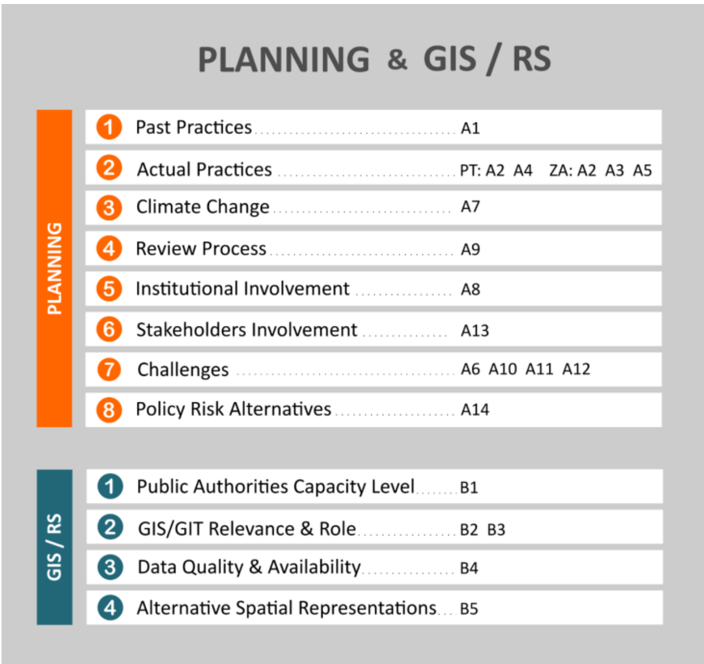


Figure IV.29. Aggregated structure of interviews for both case studies according to questions number and country code (ISO 3166 alpha-2 code).

A total of nine interviews, to key-actors, were completed in South Africa, between November 27, and December 07, 2017. In Portugal, ten interviews were undertaken between March 09, and June 19, 2018. The interviews were organised according to the availability and constraints of the PhD candidate, interviewees and supervisors. The interviewees were selected based on their role in their institutions and how it relates to current and past setback lines delineation and implementation processes. Tables IV.08 and IV.09 provide details on the interviews.

Table IV.08. Interviewed key-actors in South Africa.

| *No.* | *Name* | *Institution* | *Level* | *Place* | *Date* |
|---|---|---|---|---|---|
| *1* | Dr Niel Malan | Department of Environmental Affairs | National | Cape Town | 27-11-2017 15h00 |
| *2* | Mrs Lauren Williams | Department of Environmental Affairs | National | Cape Town | 28-11-2017 09h00 |
| *3* | Mr Darryl Colenbrander | City of Cape Town | Municipal | Cape Town | 28-11-2017 12h00 |
| *4* | Mr Gregg Oelofse | City of Cape Town | Municipal | Cape Town | 30-11-2017 13h00 |
| *5* | Mrs Ieptieshaam Bekko | Department of Economic Development and Environmental Affairs (Western Cape) | Provincial | Cape Town | 01-12-2017 14h00 |
| *6* | Dr Andrew Mather | eThekwini Municipality | Municipal | Durban | 04-12-2017 14h00 |
| *7* | Mr Omar Parak | KwaZulu-Natal Department: Economic Development, Tourism and Environmental Affairs | Provincial | Durban | 07-12-2017 08h30 |
| *8* | Mr Alfred Matsheke | KwaZulu-Natal Department: Economic Development, Tourism and Environmental Affairs | Provincial | Durban | 07-12-2017 08h30 |
| *9* | Mrs Tandi Breetzke | Coastwise | Consultancy | Durban | 07-12-2017 12h00 |

Table IV.09. Interviewed key-actors in Portugal.

| *No.* | *Name* | *Institution* | *Level* | *Place* | *Date* |
|---|---|---|---|---|---|
| *10* | Mrs Maria João Pinto | Agência Portuguesa do Ambiente (APA) | National | Lisbon | 09-03-2018 15h00 |
| *11* | Mr António Rodrigues | Agência Portuguesa do Ambiente (APA) | National | Lisbon | 09-03-2018 15h00 |
| *12* | Mrs Teresa Alvares | Agência Portuguesa do Ambiente (APA) | National | Lisbon | 09-03-2018 15h00 |
| *13* | Mr Sérgio Barroso | Centro de Estudos e Desenvolvimento Regional e Urbano (CEDRU) | Consultancy | Lisbon | 16-03-2018 15h00 |
| *14* | Dr José Luís Zêzere | Instituto de Geografia e Ordenamento do Território (IGOT) | Academy | Lisbon | 26-03-2018 15h00 |
| *15* | Mrs Maria João Pinto | Agência Portuguesa do Ambiente (APA) | National | Lisbon | 19-04-2018 15h00 |
| *16* | Mrs Teresa Alvares | Agência Portuguesa do Ambiente (APA) | National | Lisbon | 19-04-2018 15h00 |
| *17* | Mr Celso Pinto | Agência Portuguesa do Ambiente (APA) | National | Lisbon | 19-04-2018 15h00 |
| *18* | Dr César Andrade | Faculdade de Ciências da Universidade de Lisboa (FCUL) | Academy | Lisbon | 16-05-2018 16h30 |
| *19* | Dr Fernando Marques | Faculdade de Ciências da Universidade de Lisboa (FCUL) | Academy | Lisbon | 19-06-2018 14h30 |

The interviewees were first informed of the content and purpose of the interviews. All interviewees were asked permission to record the content of the interviews in audio format, thus avoiding the loss of relevant information for further analysis. The interviews were then recorded using an audio recorder.

Interviews were after integrally transcribed using the oTranscribe[10] software. This open source tool, under the MIT license, enables (not only) audio files to be played while transcribing the text, which is very practical and user-friendly. Despite being a time-consuming process, this allows a first reflection on the content. The resulting information was treated using content analysis techniques, used to analyse qualitative data, in this case as interview transcripts (Bardin, 2004; Bernard, 2018).

The interviews were subsequently categorized and, whenever necessary, changes were made or categories were added in order to allow for a better and clearer analysis. Such processes are commonly used in content analysis (Bengtsson, 2016; Saldaña, 2015) and previously used in coastal hazards related issues (Domingues et al., 2017). This task was performed using MAXQDA[11] (proprietary software), version 11, described as a professional software for qualitative and mixed methods research, developed by and for researchers, and made available by the Research Centre (CICS.NOVA) for the time necessary to perform the task.

The coding of interviews resulted in twelve major topics. Eight topics belonging to the planning group of the interviews, corresponding to 82% of the coded segments, and four topics belonging to the more technical group of the interviews with 18% of coded segments (figure IV.30).

This discrepancy is largely due to the fact that there were more questions related to planning issues compared to technology issues. A total of 23 questions on planning subjects were prepared for interviewees in Portugal, and 25 for South Africa. In contrast, 5 questions were prepared to explore technology issues, in both countries.

[10] oTranscribe is available at: https://otranscribe.com/

[11] MAXQDA is available at: https://www.maxqda.com/

The topics that generated the largest proportion of coded segments were mostly related to the planning issues, reflecting both the larger number of questions on these topics as well as a greater interest from interviewees in talking about these. In the planning topics, implementation challenges (P7) and actual practices (P2) generated the largest proportion of coded segments, 18.8 and 17.3 %, respectively. In the technical domain, the topics generating the largest proportion of coded segments were the data quality and availability (G3) and the relevance and role of Geographic Information Systems and Technologies (G2) with 8% and 5% respectively (figure IV.30).

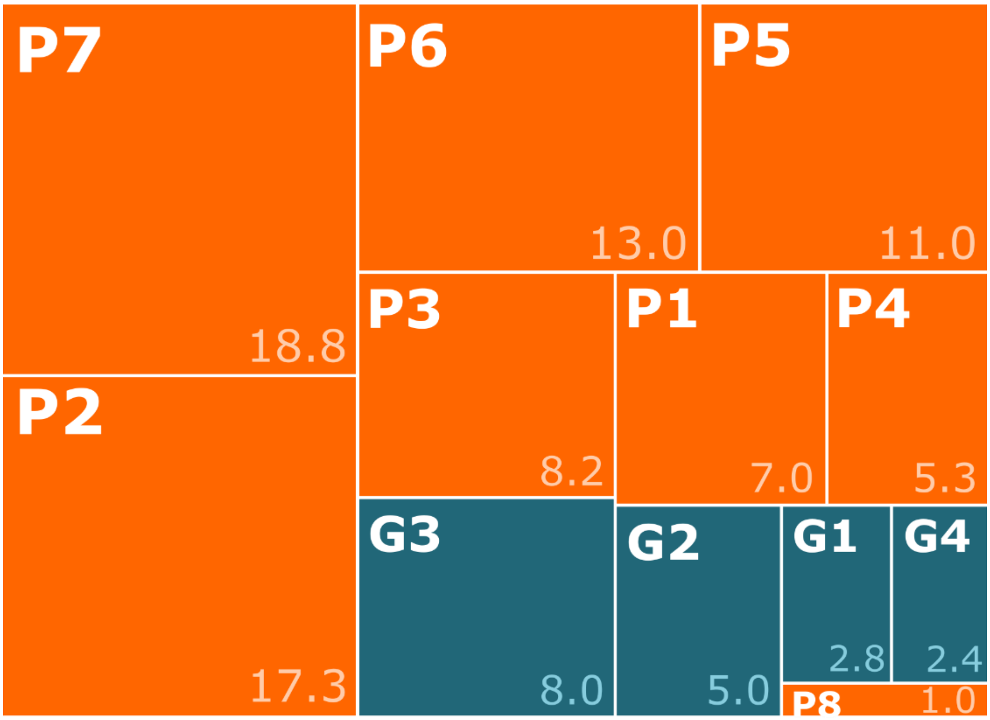


Figure IV.30. Share of responses' segments by topic.

There were also disparities between responses within countries since key-actors did not give equal importance to the same issues. In general, more segments were coded in the interviews that took place in South Africa (83%, against 80% in Portugal), for topics associated with the first group (figure IV.30). The second group registered more coded segments in Portugal (20%, against 17% in South Africa).

Although these differences are not generally significant, individually there are considerable differences (figure IV.31). For example, in key issues related to current practices, key-actors gave greater emphasis to the changes introduced by the emergence of the Integrated Coastal Management Act (ICM Act) in South Africa and the introduction of Coastal Management Lines (23%) in Portugal with the entry into force of Decree-Law 159/2012 and the transition from the Coastal Spatial Management Plans (POOC) to Coastal Spatial Management Programmes (POC) and their transition from Risk Lines to Safeguard Lines (12%). This is equally true for the various types of interviewees. In South Africa, interviewees from the various Spheres of Government and consultants gave greater relevance to issues associated with actual practices (figure IV.04). In Portugal, challenges on the implementation of Safeguard Lines was the most generally approached issue (figure IV.03).

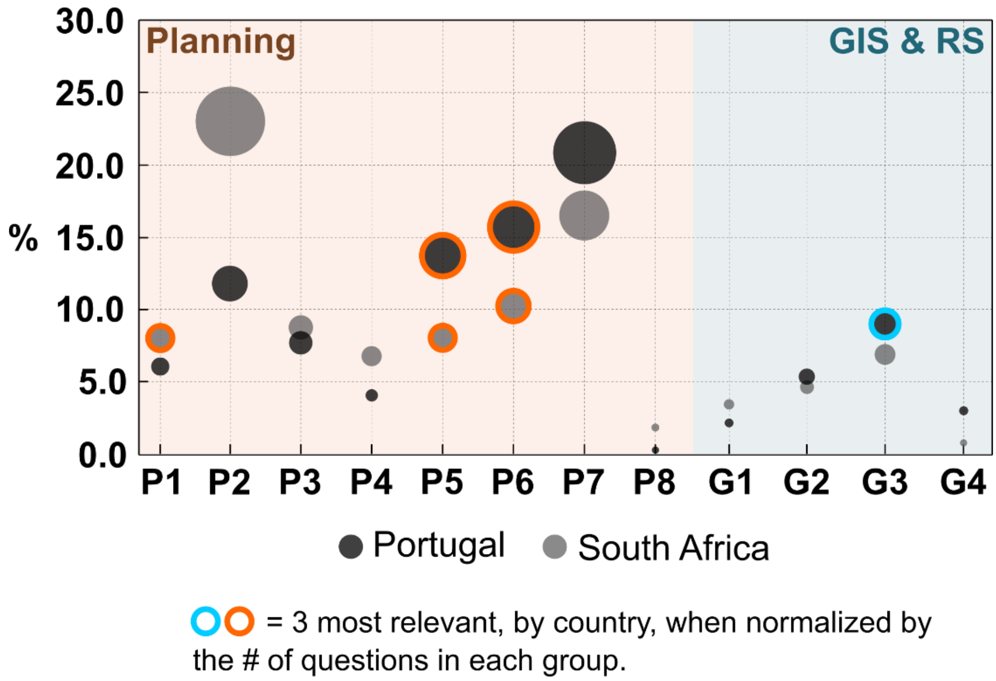


Figure IV.31. Question groups on total answers of each case study (%).

After normalization, according to the criteria presented in figure IV.31, it appears that issues related to institutional and stakeholders' involvement were highlighted in both case studies. In Portugal, the quality and availability of information was also widely reported. In South Africa, all the work done on setback lines was widely covered, in particular, the path leading to the approval of the ICM Act where the Green and White Papers in general; and some good practices for implementing setback lines particularly in Durban and Cape Town were also widely mentioned. All these subjects are broadly mentioned in the following sections and Chapter V, and subsequently discussed.

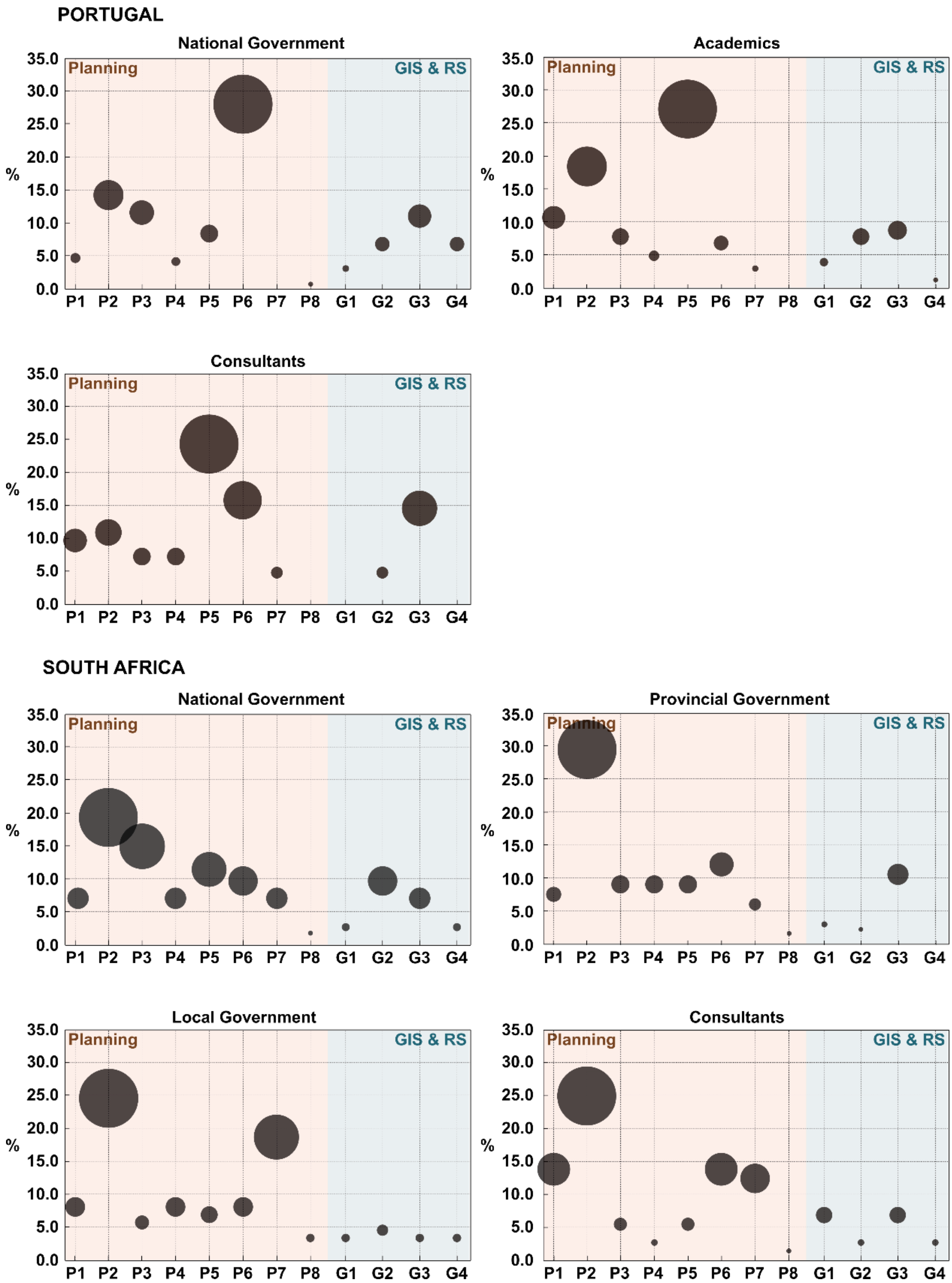


Figure IV.32. Question groups on total answers of each type of interviewee, by case study (%).

## IV.1. PAST PRACTICES

### IV.1.1. PAST PRACTICES IN PORTUGAL

When referring to the first management related question on past practices, in Portugal, three main topics were highlighted by interviewed key-actors: i) the Maritime Public Domain (*Domínio Público Marítimo*); ii) the Coastal Zone Spatial Plans (*Planos de Ordenamento da Orla Costeira – POOC*), and; iii) a clear distinction between low-lying and cliff coastal areas.

Concerning the subject of Maritime Public Domain, Portugal soon started to demonstrate concerns about the use and occupation of the territory in coastal zones (Neves, Pires, et al., 2018). The country became a pioneer when it established the Maritime Public Domain, in 1864, determining a strip area in terrestrial coastal areas owned by the State and on which private use is restricted (Dias et al., 2013). Areas falling inside these strips cannot be acquired (Schmidt, Gomes, et al., 2013) but owners or inheritors can provide documentary proof of pre-existing rights to a property falling within the designated areas (Decree-Law no.468/71, November 5).

Despite the concerns expressed early on by the Portuguese Government, the population also showed a fixation for areas along the coastline since early ages. Therefore, dominant public policies for coastal areas have been prioritizing coastal engineering interventions in order to maintain the coastline (Carmo, 2017; Veloso-Gomes et al., 2004). Such interventions have been almost entirely funded by the Portuguese Government. Therefore, due to the lack or ineffective policies in terms of planning and monitoring in coastal areas, and also because of the attractiveness factors characteristic of these areas, these are currently the most densely populated and inhabited areas (Schmidt, Gomes, et al., 2013).

Pressures along coastal areas increased, even more in the 1970s, which, among other factors, are a result of the large exodus from rural areas to major coastal cities (Schmidt, Gomes, et al., 2013).

In 1983, with the establishment of the National Ecological Reserve (*Reserva Ecológica Nacional – REN)*, new stricter measures emerged in coastal planning. As a result, demolitions started to occur in some protected areas along coastal areas.

However, and although there were some expectations of change to coastal planning policies in coastal areas, this turned out to be not entirely true. Coastal defences have a long history of use along the coastline. Even after the introduction of these measures through REN, coastal defences were kept and have been maintained mostly by means of heavy engineering works, the so-called hard defences, as briefly highlighted in figure I.4.1.1.06, Chapter I (Schmidt, Gomes, et al., 2013; Veloso-Gomes et al., 2004).

In the late 1990s, with the emergence of a new figure in terms of land management in coastal zones, the Coastal Zone Spatial Plan (POOC), new approaches emerged. Setback lines (“Risk Lines”) to inform risk areas were introduced in some POOCs, and according to key-actors, beyond what was in the legislation. This generation of POOCs was much geared towards spatial planning and few referred to the issues associated with risks. Notwithstanding, key-actors referred some POOCs that included these Risk Lines, namely, the two POOCs in the region of Algarve: Burgau – Vilamoura and Vilamoura – Vila Real de Santo António; the POOC Sines - Burgau. However, these lines were a “bonus”. The technical teams that were working on these POOC realized that there was already some information that could and should be incorporated into these plans in terms of designing what was then called Risk Lines, and which would be incorporated in the above-mentioned plans.

As mitigation measures, the POOC, they foresee the demolition of built-up environments in areas at risk, just like the REN. However, because these measures were still not socially well-accepted and created situations of conflict, they soon began to lose strength. As a consequence, these measures started to give rise to lengthy legal proceedings (Schmidt, Gomes, et al., 2013).

To add to the aforementioned, fragmentation of competencies is also frequently associated with the critical situation that described coastal management at the beginning of the new century in Portugal (Marinho et al., 2019). To illustrate, and according to the view of the National Council for Environment and Sustainable Development (*Conselho Nacional do Ambiente e Desenvolvimento Sustentável – CNADS*), the defragmentation of competencies is due to the fact that there are numerous legislative instruments (more than 250 in 2001) and dozens of institutions with competencies associated to coastal zones.

Therefore, answers were still needed in order to effectively manage the coast. One of the measures would arise just before the adoption of the Decree-Law no.159/2012 of July 24, which would introduce changes in coastal management. Key-actors mentioned that, in 2011, the Portuguese Environmental Agency (*Agência Portuguesa do Ambiente – APA*) promoted a project in association with the Faculty of Sciences of the University of Lisbon (*Faculdade de Ciências da Universidade de Lisboa – FCUL*) and the National Laboratory of Civil Engineering (*Laboratório Nacional de Engenharia Civil – LNEC*) designated as the Creation and Implementation of a Coastal Monitoring System Covered by the Area of Jurisdiction of the Administration of the Tagus Hydrographic Region (*Criação e Implementação de um Sistema de Monitorização no Litoral Abrangido pela Área de Jurisdição da Administração da Região Hidrográfica do Tejo*). This project ended in 2013 (APA, 2013). It aimed to provide objective answers, crucial to coastal management, in order to safeguard people and property, to prevent the occurrence of natural disasters, to conserve the natural environment, to improve social welfare and to develop compatible economic activities with a context of sustainability. To add to the aforementioned, the project aimed to support the processes of implementation and revision of the POOCs, as well as the management of the territory under the jurisdiction of APA within the Tagus and Oeste Hydrographic Region (Andrade et al., 2013).

As can be read in the summary of the abovementioned report (Andrade et al., 2013, pp. 7–8), the project has three distinctive parts:

In part one, designated as the "*Study of the coast in the area of intervention of the APA, I.P./ARH of Tejo*"[12], results were meant to contribute to define procedures in order to implement a coastal monitoring system, mainly focused on the evolution and dynamics of coastal systems, necessary to the management and planning needs of the coastal zone under governmental responsibilities, including the assessment of hazards and the prevention of risk. It also provided updated information, decisive for the revision of the POOC/POC providing technical elements in terms of High Water Mark (spring

[12] APA, I.P./ARH Tejo – Agência Portuguesa do Ambiente / Administração da Região Hidrográfica do Tejo.

tide), characterization of the evolution of the coastline in the last 50 to 100 years in sandy and cliff areas, beach erosion, dune cord retreat, coastal overtopping and coastal flood, and, when applicable, redefinition of the already existing Risk / Safeguard Lines[13] in the POOC in force.

Part two of the study was focused on the Costa da Caparica area. The evolution of the beach was monitored between June 2010 and June 2013, realizing periodic surveys to the beach profiles, in order to quantify the morphological and volumetric variations.

The results from the third part of the project, designated as the "*Study of the Albufeira Lagoon*", contributed to characterization, diagnosis and monitoring of the tidal dynamics, the water quality in the lagoon, the support capacity of the lagoon in relation to the activity of mytiliculture and definition of the areas to be dredged and their respective dredging places. These contributed to the accomplishment of part of the objectives inherent and foreseen in the POOC Sintra – Sado. This study was largely mentioned in one of the interviews, which highlighted the work done in FCUL, involving all the above-mentioned entities plus Hidroprojeto.

During the interviews, key-actors frequently systematize the approach to coastal risk lines within the POOC in a very simple and clear way, highlighting two distinct situations: low-lying coastal areas and cliff coastal areas, which generally cover the entire 1 000 km of continental coastline. Pinto & Martins (2013), go a little further in this classification and divide the low-lying areas in i) sandy shores, and; ii) low-lying rocky shores. In what concerns the above mentioned project: Creation and Implementation of a Coastal Monitoring System Covered by the Area of Jurisdiction of the Administration of the Tagus Hydrographic Region, many key-actors referred to the coordination for the delimitation of the risk lines in low-lying and sandy coastal areas to be in the person of Prof. Dr César Andrade. While the validation of the Risk Lines in coastal cliff areas was given the coordination of Prof. Dr Fernando Marques.

[13] The term Risk Line was used in the POOC. Safeguard Lines Is the term used with the introduction of the new POC.

Actually, this was an interesting aspect that stood out in almost all interviews, the clear distinction between low-lying areas and cliff areas. Under the first generation of POOCs, the development of Risk Lines in cliff coastal areas was perceived to be in a more advanced stage than in low-lying coastal areas despite the vast work already developed by both the abovementioned researchers.

Another aspect that emerged from the interviews was the state of the art in terms of setback lines development and knowledge for the Portuguese coast, in specific for cliff areas. In the south region of Algarve, that work was already solid, namely by Sebastião Teixeira. Therefore, further work involved mostly validating existing knowledge.

In cliff areas, the concern was, on one hand, if these Risk Lines could absorb the phenomena of retreat, or the instabilities in the cliffs; and on the other hand, if the safeguard and protection regimes were accurate. In what regards to the regimes, there were different situations throughout the country. For example, in the Algarve, it was possible in a certain demarcated risk area to allow the construction of a building if a study guaranteed its safety conditions. In contrast, in a POOC under the tutelage of the former Institute for Nature Conservation (ICN) occupation in zones delimited by setback lines was always interdicted, regardless of any study. Therefore, there were differences from the point of view of the regimes, depending on the responsibility under each POOC, from the APA or the ICN.

From the technical point of view, the concern was to ensure that in a given time, these erosive processes were absorbed and stayed in these lines and obviously limit the occupation in the areas lying within them. Therefore, the concern in cliff areas was always to monitor and evaluate their evolution to check if movements exceeded the width of the demarcated areas. Experience has shown that, although the methodology used is not as robust as the current one, in 97% to 98% of cases, the movements that took place were contained within the risk areas. The size of the risk lines was accurate with the process itself, both the retreats at the ridge and the projection of materials to the beaches. Such robustness is based on the monitoring of these areas, with over 500 observations made in the field. This included more than 300 observations in the Algarve region and more than 200 observations in the Lisbon area.

In the low-lying and sandy coasts, the situation is completely different. In these areas, Risk Lines did not exist. Foremost, one must keep in mind all the advances that were occurring through time. The first POOCs had their beginning in 1998, while, the last POOC of the first generation entered into force in 2005, in the region of Algarve and in 2007, in the North region. During these years, there were significant changes and advances in technology and therefore, there was more information available to support coastal management, whether in the cliff or low-lying coastal areas.

### IV.1.2. PAST PRACTICES IN SOUTH AFRICA

Interviewed key-actors refer to a series of coastal measures in force in the past. Some of these measures are National, others were regionally applied, but all relied, firstly, on an environmental centred approach, and later, in the need to change to participatory driven processes.

Coastal management in the 1970s was very much sectoral (Glavovic, 2006; Taljaard et al., 2012). There were a large number of agencies operating in coastal related issues, each one focusing on very specific issues without any relationship or joint decision-making initiatives, resulting in overlapping competencies and unclear responsibilities (Colenbrander & Sowman, 2015). In 1973, the Department of Planning and Environment established the Coastal Management Division, due to the need for cooperative actions on coastal management (Glavovic, 2006).

In the 1980s, the need to regulate activities in the coastal zone was very clear. Constructions were being developed without any control or planning initiatives, increasing the pressures in these areas, which were negatively impacting coastal ecosystems, the major concern at the time. In this sense, coastal regulations ended up being implemented in South Africa around 1986. Key-actors referred to these as the "Wiley Regulations" which were meant to control development. Issuing permits became mandatory for approval of new developments in the 1 000 m wide strip from the coastline (High Water Mark). Despite the efforts, these measures ended up being withdrawn and uncontrolled development continued to increase (Glavovic, 2006).

There were other regulations in force during this period, as referred by key-actors. This included Sensitive Coastal Areas, which were introduced for the Garden Route, Cape Town, Port Elizabeth and KwaZulu-Natal. In these coastal areas considered sensitive, a permit was required even for earthworks or clearing of vegetation. By then, all measures in place were concerned with controlling development and people.

Concerning developments in setback lines, key-actors referred to the Durban case. In the 1980s, Coastal Risk Lines were developed by the Council for Scientific and Industrial Research (CSIR). At that time, those lines were described as Potential Erosion Lines and Building Setback Lines. They modelled the Potential Erosion and then added a buffer to create a Building Setback Line. In that sense, this was expected to guide development and warn people that beyond that line, they would be putting infrastructure and themselves at risk.

Again, this decade did not bring much progress. Urban development was still evolving with little control, increasing pressures on the coast and endangering ecosystems. Efforts were still being made by the Government and external entities but still very much driven by the natural sciences and little concern for politic or socioeconomic aspects of coastal management. As a response, a Committee for Coastal and Marine Systems of the Council for the Environment was established in 1982, formed by members from the Government and academics. Its objective was to develop recommendations for a comprehensive coastal management policy to be put in place (Glavovic, 2006).

The 1990s brought significant changes to coastal management. Coastal development was still a threat urging for new and more effective coastal management approaches. Previous approaches did not encourage people to actively participate in decision-making processes, promote sustainable economic development or even equitable access to coastal resources. In this sense, the apartheid regime impacted coastal management options that were being made (Glavovic, 2006).

With the South African Government negotiation for the transition for a new and democratic regime, new approaches to coastal management emerged. Efforts were now concentrated on bringing public opinion to the process of formulating a policy for coastal management. People with a wide range of backgrounds that were not previously included in these processes were now included. Coastal management was shifting to a more inclusive and holistic approach set on a sustainable development view (Taljaard et al., 2012). If the conversations took long to achieve the desired effect at the beginning, the need and commitment of the stakeholders involved in this process began to result in some promising dialogue. This process of building trust took five years (from 1992 to 1997) and led to what was later called as the Coastal Management Policy Programme (CMPP) involving participants from *"all levels of Government, liberation organisations, trade unions, the South African National Civics Organisation on behalf of black community-based organisations (CBOs), organised business, parastatal organisations and environmental non-governmental organisations (NGOs)"* (Glavovic, 2006).

After five years of conversations, consultation, workshops and international coastal management experts advisory, the CMPP was still only in its inception phase. The start-up was given in May 1997, and it would take another three years for it to be implemented. During the interviews process, key-actors emphasised the importance that the Green Paper had to the whole process. The Coastal Policy Green Paper was brought to light in the middle of 1998 and considered inputs from the public and experts. The document assumed such great importance than it was considered not only a draft for a policy document but was also conceptualised as a capacity-building tool. Its acceptance urged the preparation of a Draft White Paper. By the end of February 1999, the Draft White Paper was completed and copies of the document distributed to who directly participated. Sessions were held between regional managers and stakeholders and feedback from those sessions was collected. Recommendations were made and the White Paper was completed in April 1999. It was later approved, on the 1st day of December, supported by all spheres of Government and a wide range of stakeholders from all regions. This policy was officially released on June 6, 2000 (Glavovic, 2006). Interviewees underlined four aspects in this policy: awareness, education and training; monitoring research; institutional and legal development; and projects. The White Paper preceded the ICM Act.

In short, the 1990s brought a democratic regime with a CMPP which also relied on social sciences to build measures and policies that were described as more inclusive and encouraging stakeholders participation. This contrasts with the old regime, more conservative, elitist in the preparation of policies and much centred in the biophysical aspects of the coast (Glavovic, 2006).

## IV.2. ACTUAL PRACTICES

### IV.2.1. ACTUAL PRACTICES IN PORTUGAL. WHAT HAS CHANGED?

One of the most obvious changes was the change in the number of POC, which are now six, compared to the existing nine in the previous generation of POOC (tables IV.2.1.10 and IV.2.1.11). Some of the previous Plans are now contained in the current Programmes, therefore increasing their spatial scope as demonstrated in the IV.2.1.33. Curiously, none of the interviewees recognised this as a major change.

Interviewed key-actors highlighted some changes that are worth mentioning, namely: a) the concept of setback lines was highlighted as a key change; b) the methodologies to define these lines where a clear distinction was made between low-lying coastal areas and cliff coastal areas; c) the mandatory implementation the new setback lines that raised doubts in some key-actors and; d) the rationale for Safeguard Lines implementation.

Table IV.2.1.10. The second generation of Coastal Zone Spatial Programmes (POC) by Hydrographic Region and status.

| ***Hydrographic Region*** | ***Coastal Zone Spatial Programmes (POC)*** | ***Status*** |
|---|---|---|
| *Norte* | Caminha – Espinho | Approval |
| *Centro* | Ovar – Marinha Grande | In force (August 10, 2017) |
| *Tejo e Oeste* | Alcobaça – Cabo Espichel | In force (April 11, 2019) |
| *Alentejo* | Espichel – Odeceixe | Elaboration |
| *Algarve* | Odeceixe – Vilamoura | Elaboration |
| | Vilamoura – Vila Real de Santo António | No information |

Source: Adapted from: APA, Programas da Orla Costeira.

Table IV.2.1.11. The first generation of Coastal Zone Spatial Plans (POOC) by Hydrographic Region and status.

| ***Hydrographic Region*** | ***Coastal Zone Spatial Plans (POOC)*** | ***Status*** |
|---|---|---|
| *Norte* | Caminha – Espinho | October 02, 2007 |
| *Centro* | Ovar – Marinha Grande | October 20, 2000 |
| *Tejo* | Ovar – Marinha Grande | October 20, 2000 |
| | Alcobaça – Mafra | January 17, 2002 |
| | Citadela – Forte de São Julião da Barra | October 19, 1998 |
| | Sintra – Sado | June 25, 2003 |
| *Alentejo* | Sintra – Sado | June 25, 2003 |
| | Sado – Sines | October 29, 1999 |
| | Sines – Burgau | December 30, 1998 |
| *Algarve* | Sines – Burgau | December 30, 1998 |
| | Burgau – Vilamoura | April 27, 1999 |
| | Vilamoura – Vila Real de Santo António | June 27, 2005 |

Source: Adapted from: APA, Planos de Ordenamento da Orla Costeira.

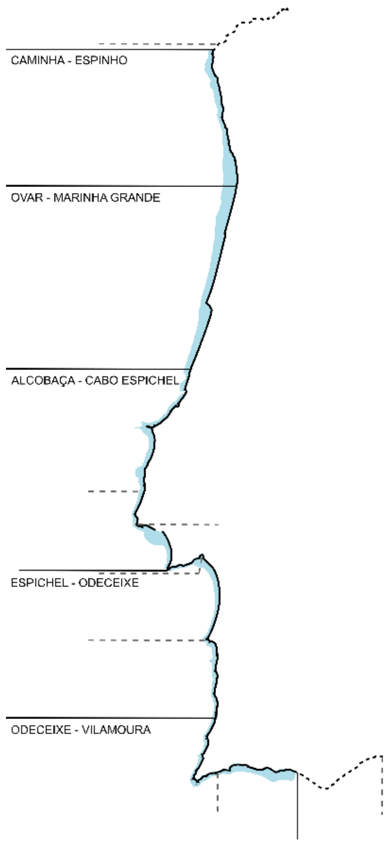


Figure IV.2.1.33. Spatial distribution of the second generation of POC in relation to the first generation. Source: Author. Adapted from: (APA, Programas da Orla Costeira; Planos da Orla Costeira).

a) For interviewees, one of the key changes that has occurred is an improved conceptualization of the concept, to Safeguard Lines. The new terminology is undoubtedly more adequate and adjusted to what is intended with these lines and associated regimes.

In the view of interviewees, risk is something that has a conceptual framework. Defining a zone where the coastline is expected to be in 50 or 100 years from today and call it a risk line is a mistake. From the point of view of scientific terminology is a setback line, not a Risk Line. The concept of risk is broader. The fact that the coastline is retreating does not mean that it is creating risk. The concept of risk implies that something is at stake, that something is threatened by the retreat of a particular area of coast. The existence and level of risk depends on context. There may be a high level of risk with a low retreat rate if there is an urban cluster with thousands of people in a specific coastal area. In contrast, in another area there may be a faster retreat rate but nothing of value is exposed, for example infrastructure or habitats of importance.

Regarding the abovementioned, a key-actor supported his view by giving the example of a typical situation in low-lying and sandy areas, the type of coastal areas that usually retreat. The key-actor mentioned the POC Ovar - Marinha Grande, widely reported by the key-actors for being the only one in force at the time of the interviews. The previous POOC Ovar - Marinha Grande were more in-line with what is meant by setback lines, where the coastline will lie within a time horizon of, for example, 50 or 100 years. Essentially, this told decision makers that coastal area with higher rates of retreat should receive more attention. This view, grounded on the basis of two premises, was seen as potentially misleading.

First, it sees the coastline has having the same characteristics, namely being a natural area with its natural tendency to retreat. However, this is not true. There are stretches along the coast that are built-up, where there is no beach. This means that, adopting a methodology based on where the coastline was a number of years ago may introduce gross error from the point of view of identifying areas at risk. The example of Cortegaça clearly illustrates this. It retreats around it but not in this settlement, because there are hard coastal defences in place. So, the coastline does not move inland. In Vagueira or Furadouro, the same applies. It does not retreat because it has already been walled. It may retreat some years from now, but it will not retreat until coastal defences give way to the advancement of the sea. Therefore, when one analyses the territory without considering details such as the existence of urban areas by the coast where the risk is greater and the retreat rate is smaller, disparities may arise from the point of view of spatial planning. In any of the given examples within this POC the retreat rate is zero due to the existence of coastal defences.

In short, this view of the territory would be effective if the coast was completely natural, without coastal defence interventions, without any interference in the transit and transportation of sediments that interferes with erosion or accretion (figures I.4.1.1.06 and I.4.1.2.07). If this type of situations did not exist along the whole coastline, then one could look at what comprises a setback line with more confidence.

The second condition relates to exposure (i.e. the distribution of the exposed elements: people; houses; roads; factories; restaurants; hotels, etc.), if everything were to be homogeneous along the whole coast. Neither is. In some places, there are exposed elements, in other places there are not. Therefore, from the point of view of risk and spatial planning, it is clear that attention should focus on coastal areas with greater numbers of people and assets exposed, as is the case of coastal urban areas.

b) Regarding the methodologies, key-actors introduced some general comments regarding relevant changes. One change mentioned by interviewed key-actors was that in previous POOCs there were no Risk Lines within the urban perimeters. In the current POC, the Safeguard Lines were included within the urban perimeters and their respective regimes were associated. This is considered a major change since in some urban areas the lines contain the whole territory. Another change, referred to as an improvement, relates to the fact that the new POCs are no longer just an instrument to regulate the Beach Plans, mentioning what can and cannot be done; where sewers must be placed; where beach supports should be located; what is the typology of beaches, etc. It became an instrument in which the entire coastal zone is seen as a dynamic entity and where there is an understanding of how it can evolve considering scenarios over an extended time horizon. This is a completely different view.

The adopted methodology for establishing Safeguard Lines would eventually be developed by the APA, that is, at the National level. This methodology was developed based on a number of contributions, including the Faculty of Sciences of the University of Lisbon (FCUL); a published work in co-authorship by Dr. Óscar Ferreira, Professor in the University of Algarve, proposing a methodology for low-lying and sandy coastal zones (Ferreira et al., 2006); international methodologies for the delineation of setback lines; and some inputs introduced by the APA itself.

The methodology for Safeguard Lines in low-lying and sandy coasts focuses effectively on three fundamental components, namely historical retreat, retreat associated with sea-level rise, and retreat related to extreme weather events. The historical retreat underpinned the methodology previously used, (i.e. if a stretch of coastline retreated by 1 m per year, and a setback line for 100 years is required, 1x100 = 100 m setback line). According to the key-actors interviewed, this methodology was manifestly insufficient and responded poorly to actual needs. Thus, in addition to a finer comparison of the evolution of the coastline, the retreat associated to the rise of the mean sea level was added to improve it, applying the Brunn Rule, which was considered a simple way to include this factor. The instantaneous retreat associated with extreme weather events was also taken into account to further improve the methodology.

On cliff coastal areas, the methodologies that came from the previous POOC were already considered much more robust, having consistency in its application, in general, for the entire territory, and therefore, there was no particular reference that should be highlighted, except one, the associated regimes. In the new POC, for the same line, restrictions are now higher. Despite, from the technical point of view, there are more data.

The new POC makes a clear distinction for methodologies regarding land-use management and the other to beach management.

Land-use management incorporates issues as such as interdiction, or not, of use and occupation in areas of risk and, therefore, where people and property may be at risk if nothing is set to be done. One may be transferring the burden of retreat to future generations. Therefore, in a logic sense of sustainable territorial management one should not impose this burden on future generations.

The issue related to beach management concerns regulations to the occupation and use of beach and cliffs areas at risk. From the moment this problem was regulated it created huge pressure on the State. In essence, regulating these transferred responsibilities to the State to ensure that the measures taken not only reduce but eliminate risk. For example, if there is a landslide or blocks falling from the cliff onto the beach, questions are asked whether the measures taken were correct or sufficient, even if risk areas were clearly identified (figure IV.2.1.34).


Figure IV.2.1.34. Signalling preventing the occupation of areas at risk in cliff and beach areas, and cliffs’ instability. Locations: A and B – Cabo da Roca; C – Praia Formosa, Santa Cruz; D – Praia do Abano, Guincho. Source: Author. Fieldwork April – July 2018.

Therefore, only two conditions are expected: either people are prevented from occupying risk areas, or conditions are created so that there is no risk. From the moment that this type of situations became a recognized problem from the State, an obsession of cliffs' artificialization at the beach areas arose. The point is, either it is guaranteed that people do not go to these areas or it is prevented, and this is almost impossible. Many are the situations where signs have been put up to warn of the hazards and risks in these areas and people just ignore them. In these situations, the State is safeguarded, did its part by intervening and signalling these zones in a precautionary sense (figure IV.2.1.34).

c) Regarding the implementation of the current Safeguard Lines established by Decree-Law 159/2012, there are divergent views regarding their obligatoriness. For the Central Government their implementation is mandatory. However, this view is not shared by all actors. Several interviewees argued that there is no explicit indication regarding its obligation even though this policy instrument refers to areas at risk.

As for risk, in the new POC this dimension is now clearer and more unambiguous. Three risk-associated concepts now appear systematically within the POC framework: erosion, flood and overtopping. This means that regardless of which team is in charge of the elaboration of a certain POC, all have to consider these three key natural phenomena. In addition, the new legislation of REN uses the exact same three concepts, therefore reinforcing the message implicit in the POC.

REN, in a succinct way, intended to limit the use of the territory, in this case the coastal territory, by attempting to preserve environmental values as much as possible. The new legislation maintains this intention but adds to the dimension of risk. Thus, there are two territorial management instruments that basically consider the coastal strip, and which are convergent but also overlapping. In the POC they appear on the designation of Safeguard Lines, and in the REN with the designation of zones threatened by the sea.

d) Regarding the rationale for implementation, interviewees argued that Safeguard Lines are (absolutely) required. Whatever the names given to these lines, they generally argued, it is important to have an instrument to define a zone near the coastline where one should not build; where the type of intervention should be very limited for a number of reasons. Furthermore, they considered that it was time to tell people that they may not be safe, that there are certain risks they are exposed to. Interviewees felt that this was an important message that needed to be passed on.

Interviewees also argued that climate change is a further rationale for the implementation of safeguard lines. It creates additional problems, adding to existing pressures such as the disruption to sediment traffic because of dams, dredging, particularly in the main estuaries areas. Sand in the estuaries has high economic value and is often referred as to “cash in the box”.

Key-actors consider essential to make people understand the challenges posed by climate change, and some already recognize it. Therefore, it is necessary to value the idea of a Safeguard Line and give it a weight as a regulation on occupation of the coastal space with regards to risk, which to date practically did not exist. Few people are now beginning to realize that risk exists and will worsen in the years to come. In this sense, either proactive coastal management interventions are done now or reactive management interventions may take place in cases of emergency situations. Key-actors consider that acting now is a better approach.

Hence, as it was already mentioned, the rationale behind these lines is essentially related to the need to protect people and property. This is a concern that has been reinforced in the new programmes. The lines have now much more severe restrictions from the point of view of occupation. The point is trying to prevent or condition new occupations on the coast and to avoid repeating some of the mistakes of the past. These lines reinforce the component of the REN, a free zone, a buffer zone. The main objective is to diminish future exposure and ensure that whoever is in such areas obviously needs to have a different view at the territory.

### IV.2.2. ACTUAL PRACTICES IN SOUTH AFRICA. WHAT HAS CHANGED?

In South Africa the most commonly spoken topics concerned moving towards the National Environment Management: Integrated Coastal Management Act (ICM Act No. 24 of 2009) and the rationale behind it.

South Africa went through great changes regarding coastal management, adopting principles more oriented to integrated coastal management, which are now grounded on the Integrated Coastal Management Act, commonly designated as ICM Act. It is a specific environmental management Act, and it was first published on February

11, 2009 in the Government Gazette and later amended by the Act No. 36 of 2014, and structured according to the guidelines presented by the National Environmental Management Act (Act No. 107 of 1998) (NEMA) (ICM Act No. 24 of 2009; ICM Amendment Act No. 36 of 2014).

The ICM Act follows the 1998 Coastal Policy Green Paper and the 2000 White Paper for Sustainable Coastal Development in South Africa, both authored by the extinct Department of Environmental Affairs and Tourism (Celliers et al., p. 3).

The ICM Act breaks with the existing top-down management approach and launches an integrated coastal and estuarine zone management system, establishing norms, standards and policies to promote the conservation of coastal environments, in order to preserve the natural attributes of coastal and maritime landscapes. It also aims to ensure an adequate and equitable use and sustainable development from an economic, social and ecological perspectives (ICM Act No. 24 of 2009).

In order to guarantee an integrated coastal zone management (hereafter referred to as ICZM), the ICM Act is based on five main objectives i) to determine an official national coastal zone, thus avoiding misunderstandings regarding its area of coverage; ii) to promote the coordination in every level of government and following the principles of cooperative governance; iii) to preserve, protect, extend and improve the quality of coastal public property, so present and future generations can benefit from it; iv) to ensure equitable access to the opportunities and benefits that coastal public property provides and to which access cannot be restricted, under no circumstances, and finally; v) comply with the obligations of the country in terms of international legislation applied to coastal and maritime management (Celliers et al., 2009, pp. 14–15; ICM Act No. 24 of 2009).

According to the Western Cape Government (2016) a key factor for a successful ICZM relies on the establishment of operative institutional measures seeking cooperative government and governance, by allowing governments and civil society to contribute towards coastal management objectives. However, these goals can only be achieved with a well-organized and wide representation of coastal stakeholders.

The ICM Act, through the establishment of Coastal Committees, provides the necessary institutional arrangements to put forward an effective a cooperative coastal management in the country at all levels of government (National, Provincial and Municipal). Municipal Coastal Committees are established by the ICM Act, while at National and Provincial levels, the Coastal Committees' establishment are the concern of the Minister and Members of Executive Committees (MEC) respectively, which amongst other coastal matters are responsible for setting up coastal boundary demarcation lines (Western Cape Government, 2016).

In the first version of the ICM Act, the concept of Coastal Setback Lines grounded the way risk lines were understood. Currently, the amended Act uses, instead, the concept of Coastal Management Lines (CML). For key-actors, both share the same purpose but differ in an important detail. The former was a much more technical concept based on physical analysis to determine Building Setback and Potential Erosion Lines, whereas the latter includes not only the physical analysis but also socio-economic issues. In this regard, South Africa changed its approach to coastal management, from an almost exclusive technical process to another regarded as more inclusive.

The interviewed key-actors did not state more than a few reasons that could explain the above shift in coastal management. In spite of all changes of the last decades on how coastal management is understood, one of the main reasons is still valid and actual: the need to control development along the coast. In this sense, the ICM Act symbolizes the value that the coastline provides to South Africa and the significance given to the management of its 3 000 km, in favour of present and future generations. Thus, CML implementation is established at Provincial Level and therefore has a provincial spatial representation. In this regard, each coastal Province must implement their CMLs (figure IV.2.2.35).

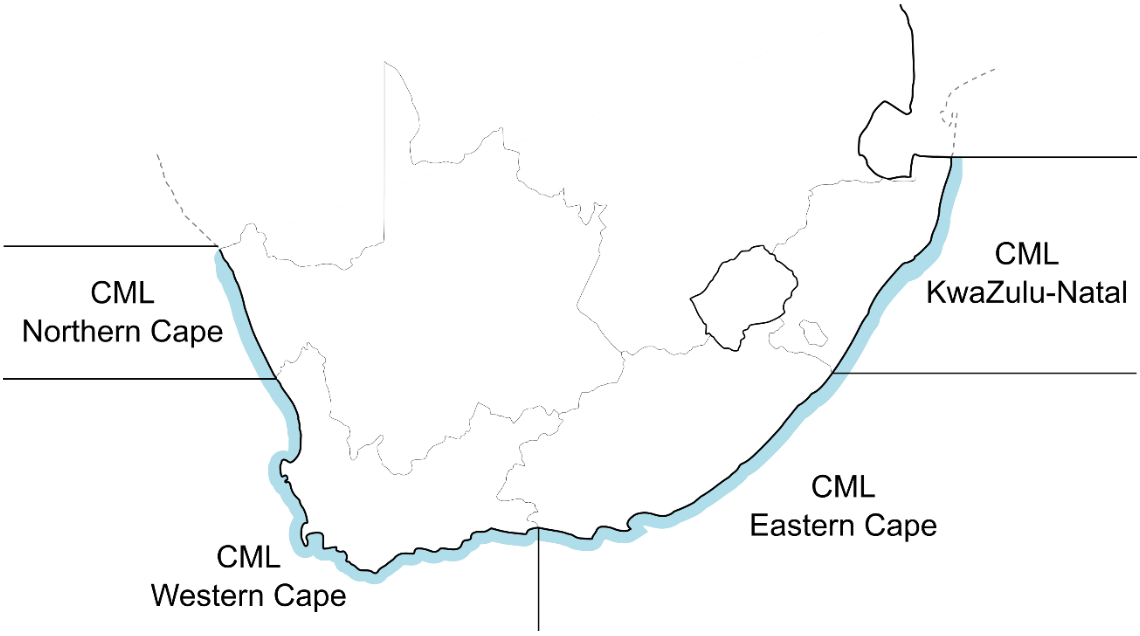


Figure IV.2.2.35. Spatial representation of the Coastal Management Lines boundaries' intervention area in South Africa by Province. Source: Author, based on figure IV.2.1.33.

The recognition to control development along the coast was clear in the ICM Act. Despite of the Coastal Management Lines, the ICM Act refers to other types of management lines, although these were not cited by key-actors (see Chapter II in Celliers et al., 2009), except the Coastal Public Property, which is the area below the High Water Mark (HWM) and certain parts of land on the coast, and the Coastal Protection Zone, which in urban areas is a 100 m zone and 1 000 m in rural areas. However, it is not as straightforward. More than the 100 and 1 000 m, the ICM Act determines that for any coastal protected area, the entire protected area is included. It does not matter if it extends 50 km inland. Any private land under the HWM is included as well. If a property, a farm, even if a small piece of that farm is within those 1 000 m in a rural area, then the entire farm is included. In practice, what the Act says is that there is a starting point set at the 100 m for urban areas and 1 000 m for rural areas, but then the Act says that boundary can be adjusted (figure IV.2.2.36). It can be either narrower or wider. Therefore, controlling development is well present in the objectives of the ICM Act, as it is meant to safeguard people and property.

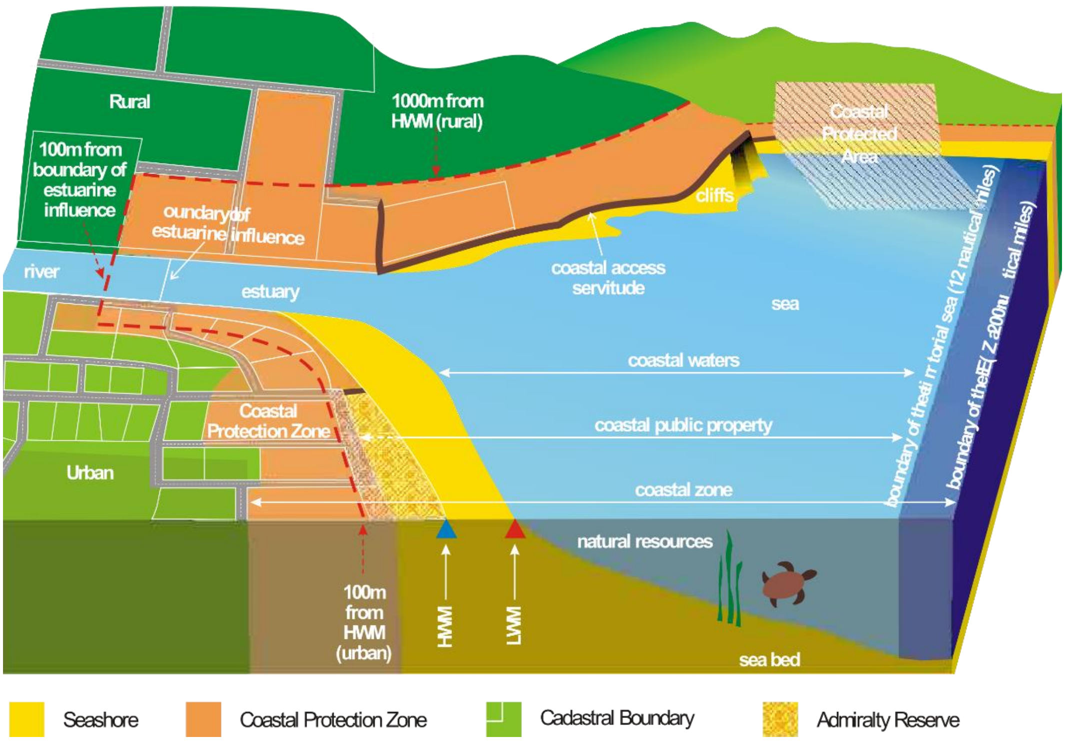


Figure IV.2.2.36. Representation of the coastal zone of South Africa. Source: Figure 2.1. in Celliers et al. (2009, p. 19).

For key-actors, the reasons behind the ICM Act may be wider considering all the different spheres of Government. At the National perspective, it is to protect the coastal environment and to protect private infrastructure. To make sure that private property owners do not develop in the wrong areas and lose their investment because of it. It is also to protect the natural environment by preventing the development of infrastructures in sensitive coastal systems.

These general reasons appointed at the national level are also present at the local level but municipalities go further in the details. Municipalities do not want to expose more beach infrastructures to, for example, storm surges and then manage the issues that may arise from that exposure such as leaking sewer lines, or rubble on the beach. These issues impact not only on property value but also on public space (here, beach) value. These somehow converging views were particular underlined by local level key-actors.

Despite the overall view of local authorities, some key-actors argue that there are different points of view and mistrust between the spheres of government. One respects to the responsibility, in terms of the Act, of implementing CML. Some argued that the National and the Provincial Governments does not trust Municipal Governments, although there is capacity at the local level. Durban, for instance, has been enforcing setback lines since the 1980s, and Cape Town has been developing their own lines. However, past mistakes eventually withdrew trust in local governments today. The explanation is simple, all Municipalities in South Africa rely on property rates. Mistrust arises from the "feeling" that municipalities would only create lines that suite development, meaning that more development on the coast would increases property values and enable municipalities to earn more from rates. The mistrust is that municipalities will not look after the people, for future generations. Instead, they will be driven by rates, or the money. In this sense, municipalities would allow for more development on the coast and that is not in line with the other spheres of government. There is no agreement on that and this is why key-actors believe that the responsibility for CML, at the provincial level, now lies on the MEC.

Other key-actors grounded their views in the need to formalise CML within the integrated coastal management approach brought by the ICM Act, being more inclusive at the same time recognizing that one needs to plan for current as well as future generations. To add to the latter, a high extent of the South African coast is eroding, which reinforces even more the need to implement CML. Furthermore, it is thought that the storm of 2007 may have exacerbated this need.

In an interview, one of the key-actors states that the 2007 storm in the KwaZulu-Natal Province had a major impact on the coastline, causing significant damage across the entire coast. This event proved in people's mind that a single event can significantly damage the Provincial coast (as it was indeed the case). At the same time, it created a sense of urgency to act and go forward, keeping in mind such events are likely to occur with increasing frequency and intensity. This recognition did not exist before, not with that impact and damage. The 2007 event was seen as an important landmark for the relevant authorities to start planning development taking into consideration the associated risks. That is part of the challenge, whether it is in KwaZulu-Natal or in any other Province. There is a lot of coastal development already in risk areas, so one must manage development already in these risky areas and in the sections of the coast that have not been developed yet, those are the ones where one must ensure that new developments are planned and located outside risk areas. Therefore, the CML as recommended by the ICM Act are an opportunity to deal with current as well as future development. The government has been involved in these issues from a more reactive point of view with an emergency and a disaster response perspective. Nevertheless, it is also in the best interests of the Government to start planning for these events more proactively, rather then, when these events happen, repeatedly reacting without changing the status quo.

## IV.3. CLIMATE CHANGE

### IV.3.1. SAFEGUARD LINES AND CLIMATE CHANGE IN PORTUGAL

Despite being one of the European countries most vulnerable to the effects of climate change, only recently Portugal started to design climate change policies to mitigate risks in coastal areas (Schmidt, Gomes, et al., 2013).

In terms of land use and occupation, the situation in Portugal reflects an imbalance in favour of coastal areas (Neves & Rodrigues, 2015; Veloso-Gomes et al., 2004). Currently, 2/3 of the population living in Portugal is distributed along the coastline (Craveiro, Antunes, et al., 2012). In the mainland region of Portugal, the metropolitan areas of Lisbon and Porto concentrate the majority of the population. Although, more dispersed throughout smaller agglomerations from north to south, the coastal zone has significantly more population than the inland regions (figures III.1.1.12, III.1.1.13 and III.1.1.14) (Craveiro et al., 2012a; Neves & Rodrigues, 2015). This trend, which intensified during the last decades, reinforces the urgency and the necessity of effective adaptation measures for land management, especially those more directly related to coastal zones (Fernandes & Neves, 2017), due to the increasing exposure of populations living in these territories (Domingues et al., 2018) to coastal climatic phenomena (IPCC, 2012, 2014a).

However, it was only in 2009, with the publication of the National Strategy for Integrated Coastal Zone Management (Estratégia Nacional para a Gestão Integrada da Zona Costeira – ENGIZC) (RCM no.82/2009, of September 8), that climate change starts to be part of the set of issues associated with coastal zones in Portugal. This national strategy emphasizes the need to create measures to anticipate, prevent and manage situations of risk and of environmental, social and economic impacts. Amongst these measures are buffer zones that should identify and contain the occupation in vulnerable territories, based on the principle of precautionary measures (Fernandes & Neves, 2017; Schmidt, Gomes, et al., 2013).

More recently, the Strategic Framework for Climate Policy (Quadro Estratégico para a Política Climática – QEPiC), approved by the RCM no.56/2015, of July 30, has framed the national climate policies and reiterates the need for articulation of land management instruments and institutions in the integration of the above mentioned climate policies concerns within sectoral policies to reinforce the resilience and adaptive capacities of these territories (Fernandes & Neves, 2017).

The National Strategy for Adaptation to Climate Change (Estratégia Nacional de Adaptação às Alterações Climáticas – ENAAC), which was approved by the same policy (RCM no.56/2015, of July 30), pointed to the urgent need for a higher integration of climate change adaptation measures in land management instruments at the local level, analysing the problems of each territory in particular and involving all interested parties (Fernandes & Neves, 2017).

This urgency and the requirement of effective adaptation measures in the scope of coastal management, which derives in part from European policies, also benefit from an increase in the number of scientific studies directly related to coastal risk issues such as flooding and overtopping.

From a technical point of view, the new generation of POCs, benefit from a higher level of data and information cohesiveness, and concomitantly, from scenarios with higher accuracy. However, this increase in quality is still not homogeneous throughout the country. Therefore, the degree of precision differs along the coast.

These scenarios clearly point to the high levels of risk in coastal urban areas associated with coastal flooding and overtopping and to the necessity of coastal retreat measures. At the same time, these scenarios also show that the implementation of such measures can be hampered by constraints emerging in some areas with high levels of urbanization.

In one of the interviews, António Mota Lopes[14] (APA) was pointed as one of the key-actors in terms of scenarios concerning coastal retreat related to coastal flooding and overtopping. This reference arose while mentioning the Safeguard Lines within the new POC generation. According to the interviewed key-actor, scenarios elaborated by António Mota Lopes in terms of the so-called Safeguard Lines considered a higher upper bound than the one measured and adopted in terms of coastal flooding and overtopping

[14] António Mota Lopes has recently joined the Litoral Working Group (*Grupo de Trabalho do Litoral*).

for the POC Ovar – Marinha Grande. From an academic point of view, this work is given no faults. However, an interviewed key-actor points out that in some areas, like many others along the Portuguese coast, there were no constraints in terms of occupation. In what regards to coastal management, in political and social terms, it is a great change to move from a situation where there were no restraints, to a situation where there are areas demarcated with some restrictions on construction and others where construction is totally prohibited. Again, from an academic point of view, the work that is currently being developed is great, but the problem resides in the regimes that have to be associated to areas at risk.

In this regard, one of the interviewees states the implementation of restrictions resulting from coastal exposure are more easily accepted by society if enclosed by a discourse based on climate change issues, then by arguments only regarding coastal exposure. This is much linked to a culture of fear. Speaking about coastal issues and highlighting the effects of climate change increases in people the fear of exposure and consequently, the fear associated with potential damages.

Climate change issues are in fact one of the biggest differences between the first POOCs and the new POCs. Technically, this type of approach was already possible before the first POOC but it was, simply, not politically well accepted. It was also necessary to realize that things were new and the issues related to coastal risk only gained more strength since the ENGIZC. This happens for two reasons, because damages have increased greatly since 2000, and this was accompanied by an inability to respond to damage. The volume of investment is very small compared to what the needs are. Therefore, the response was given through coastal protection, an essentially reactive approach that only responds to emergency situations. On the positive side, this has contributed to an increased perception that a problem does exist. This discourse was later reinforced by the Integrated Coastal Zone Management Strategy (imposed by the European Commission) that brings this precautionary principle to coastal zones.

As it was mentioned already, key-authors highlighted the differences between low-lying and cliff areas. For the first, sea level rise scenarios were incorporated. The most unfavourable scenarios were worked in-line with those of the IPCC and the most recent scenarios of the FCUL, namely from Prof. Dr. Carlos Antunes, where values pointed to sea-level rise in the order of 35 cm by 2050 and a scenario of of 1.5 m to 2100. The National Laboratory of Civil Engineering (LNEC) also recommended more preventive scenarios, above those published by the IPCC. Despite its controversy, the Brunn Rule was also applied incorporating sea level rise into coastal retreat.

It is also known that there will be an increase in the frequency and intensity of storms, as evidenced by the SIAM project. In this sense, scenarios referring to extreme weather events were also incorporated based also on recently occurred events. The case of the storm Hercules has helped to work with the most pessimistic scenarios. From the point of view of the low-lying and sandy coastal areas, the Safeguard Lines are extremely conservative, adopting a more prudent scenario, pessimistic enough to face the current uncertainties. There are not enough studies developed at the local scale considering the effects of climate change. Thus, methodologically, this justifies the conservative strategy that was adopted.

On the cliff coast areas, the issue of climate change does not occur. Two studies were done by the geology group that worked with Prof. Dr. Filipe Duarte Santos in the SIAM reports. In what regards the future in cliff areas, there will be changes in precipitation and an increase in the frequency of storms, although there is no clear relation between the evolution of cliffs and climate change. In the opinion of the key-actors, what controls cliffs is the local geology. Thus, the Safeguard Lines on cliffs have not incorporated the effects of climate change.

### IV.3.2. COASTAL MANAGEMENT LINES AND CLIMATE CHANGE IN SOUTH AFRICA

In South Africa, Climate Change issues are now an integral part of coastal management and hence a relevant component for the implementation process of Coastal Management Lines (CML). In this process, social, economic and environmental issues are included together with technical information and their conjunction to the final decision may either push the line further inland or pull it forward.

Technical information includes results and data from the modelling process, on sea level rise, storm surge and wave run-up. However, the implementation of CML surpasses the technical dimension in that a balance must be achieved between relevant key-actors that do not want to be neglected. Thus, CML implementation is, as such, a political process that tries to balance technical and social inputs, and so decisions are made weighting some kind of political acceptance.

But, and according to one of the interviewees, there is also a lack of consensus within the technical dimension in that different consultants use different methodologies to draw those lines, and as a country, key-actors would like that the same assumptions were used nationally.

In this sense, key-actors usually refer to the methodologies and results used by the Western Cape Province, and particularly by the City of Cape Town, as the most advanced. They have been using hydrodynamic modelling to assess wave run-up lines, with projections for 20 and 50 years and also sediment dynamics to determine erosion lines. Despite the advances that have and are being made, the coast is still seen as a complex space where human, terrestrial, atmospheric and sea interactions take place. All these aspects converge at the coast and there is an increasing need to positively respond to all these physical processes and social and economic interactions. Furthermore, the CML are also seen as a planning tool and as such, they must provide responses for present and future constraints posed by climate change.

In South Africa, spatial data acquired particular relevance in the subject of climate change. It may be obtained from distinct providers, which is widely common amongst several other countries. Nevertheless, this diversity of information sources often means different scales of information, which, in itself, can be a constraint. A key-actor referred to the example of the National Vulnerability Assessment done by the CSIR for the entire South African coast, in which data were collected every 500 m. Having this study done for the whole coast is seen as a great effort and accomplishment. But, in a key-actors' perspective, and from a storm surge point of view, this data may be too coarse to define a CML. Thus, and although the issue of scale can be a problem, particularly when working with climate change variables, it is worse not to have any kind of data, as it is the case for certain areas in the country.

Regardless of these shortcomings, spatial data is available from different governmental entities (e.g., bathymetric data are available from the Navy or from the Council for Geoscience; weather data from the South African Weather Services) and can be freely accessed through web portals or acquired upon request. There are other entities producing and providing spatial information, whether they are Research Centres, parastatal institutions such as the CSIR, or private institutions, but the information provided by these may be charged.

## IV.4. THE REVIEW PROCESS

### IV.4.1. THE REVIEW PROCESS IN PORTUGAL

The key-actors interviewed agree that Portugal has no legal deadline for reviewing Safeguard Lines under the POC. However, opinions start to diverge about the need to adjust the Programme, with dissimilar stated reviewing periods that range from 5 to 10 or even 12 years after the implementation of the Safeguard Lines within the POC.

Nevertheless, opinions also converge to a common understanding that there are different timescales involved in coastal management. The implementation of Safeguard Lines as a response to, for example, coastal erosion is a medium- to the long-term response. When establishing a Safeguard Line, one is not protecting people and property at the present time, but rather creating protection conditions for the medium- and long-term, i.e. by preventing new constructions along the coast. By contrast, coastal defences are reactive solutions to problems that already exist. These are two completely different timescales. The POC as a model and instrument of coastal management emphasizes a medium- and long-term vision. Therefore, one must monitor the evolution of coastal phenomena but the response must be adequate for the next decade(s). This model of coastal management is considered to be correctly conceived.

Within this line of thinking, a completely different thing is the program of works to be done over the lifetime of the POC. Assuming that the lifetime of a POC is 10 to 12 years, it is risky to define an entire agenda of works to be executed since the initial stage of the Programme. The occurrence of an extreme weather event can impact all the planning, expected for the duration of the POC, whether it may be in terms of artificial beach feeding or the durability/suitability of a coastal defence work. A program of works to execute in short cycles and establish in detail the set of works, following a continuous monitoring plan in order to make re-evaluations and thus anticipate situations that were not foreseen in the initial phase of the Programme.

### IV.4.2. THE REVIEW PROCESS IN SOUTH AFRICA

Similarly to the Portuguese case, South Africa does not have any timeline for the Coastal Management Lines review process, and key-actors' opinions on time horizons also differ among them. Some advocate for a five year review period, while others agree on a 10 year period after implementation.

By the time interviews were being done in South Africa, the National Guideline Towards the Establishment of Coastal Management Lines had been drafted by the Department of Environmental Affairs (DEA) and waited approval. This guideline recommended that the CML should be reviewed every five years. Their argument is based on the need to align with other spatial planning tools such as the Spatial Development Frameworks and Land Use Management System in terms of the Spatial Planning and Land Use Management Act – SPLUMA (Department of Environmental Affairs, 2017, p. 32).

Yet, from the planning perspective, experience as proof that all these processes in terms of implementation need time, and five years is not practical. A line has to be designed based on solid foundations in order to remain valid and viable for a period that allows for some stability and updating of relevant information. In this sense, the framework provides for this process to consider only stretches of the line that really need adjustment, instead of being entirely reviewed.

Key-actors agree that there will be instances where one needs to relook at the lines sooner, in situations of massive storm surges with heavy losses of coastline in one event. In such situations, one should start the review process immediately. However, the reality is that the currently legislated framework does not allow fast modifications to occur. They describe the process as being very long, very tedious and very complaisant. The fact is that all the changes would have to follow the implementation procedures, including the consultation with interested and affected parties and later, all relevant land management instruments would have to incorporate those changes (Department of Environmental Affairs, 2017, p. 32).

Some of the interviewed key-actors were more pragmatic on this issue. In urban areas, there is few on nothing that actually needs to change, to be reviewed. There are so little unoccupied portions of the coastline that the line is set by development that exists already. One has the sea, followed by a small beach or sandy area and then there is the hard infrastructure. It is nothing there to change. CML may not work in an urban context. Many coastal areas are already beyond the point one would consider acceptable from a coastal edge point of view. In a rural environment, it is completely different and one can certainly make the necessary adjustments according to the occurring modifications along the coastline.

Despite the times and reasons for the review process, key-actors expect that by the time CML will be reviewed, the Government may have already agreed to use the same assumptions and methodologies to refine the lines so it can be uniform along the entire coast. Thus, the expectations are that the contributions brought by the framework can introduce significant improvements in this regard. Nevertheless, the biggest concern, at the moment of the interviews, was to have the CML approved.

## IV.5. INSTITUTIONAL INVOLVEMENT

### IV.5.1. INSTITUTIONAL INVOLVEMENT IN PORTUGAL

It is the Portuguese Environmental Agency (APA) that has jurisdiction over the coastal zone. It is therefore up to the APA to define and implement the Safeguard Lines within the POC. In practice, what has been happening is the opening of tenders to external entities, whether these are companies, consortiums of companies, or universities, to which the responsibility for designing the POC and respective Safeguard Lines is attributed. For example, in the case of POC Ovar - Marinha Grande, CEDRU and the University of Aveiro were deeply involved.

Depending on the geographical area of the country and its proximity to the area of involvement of the POC and the knowledge generated in this region, several external entities associated with the development of the POC and Safeguard Lines, and with these some reference authors, associated with their development, which are closely linked to Research Centres within, essentially, Universities.

In the North region, the Faculty of Engineering of the University of Porto (FEUP) ends up being a reference much associated with the involvement of Fernando Veloso-Gomes. At the University of Aveiro, Carlos Coelho and Fátima Alves are prominent references. In the University of Coimbra, the contributions of José Carmo are highlighted. In Lisbon, the work carried out in the Faculty of Sciences of the University of Lisbon (FCUL), in IGOT, and in the NOVA University of Lisbon highlights the work of José Carlos Ferreira on the left bank of the Tagus River. In the southern region, Óscar Ferreira is associated with the work developed by the University of Algarve.

In summary, the main entity is the APA, alone or through the ARH (Hydrographic Regional Administrations). This is the entity with the competence to define the structure and the contents of the new POC, which can then contract other external entities, such as Universities and Research Centres, for information production, empirical support, the definition of these Programmes and Safeguard Lines. These are the ones who, in fact, are in charge of elaborating the POC, teams of external consultants associated with the most diverse entities. The APA gives support and validates the results but does not have the human or technical means to do these Programmes and therefore the execution is done externally. The implementation phase is carried out by APA and thereafter, it is the APA and its decentralized agencies, in this case, the ARH, who regularly monitor and now more due to the extreme weather events, where damage surveys, surveys of flooded areas, etc. are undertaken.

### IV.5.2. INSTITUTIONAL INVOLVEMENT IN SOUTH AFRICA

All spheres of Government are involved in the process, but according to the Integrated Coastal Management Act, Coastal Management Lines are a Provincial responsibility. South Africa has four Provinces with coastline: Northern Cape, Western Cape, Eastern Cape, and KwaZulu-Natal. Provinces determine the lines and municipalities and interested and affected parties are consulted after. Following this there is consultation with the Minister, and finally the Member of Executive Committee (MEC) promulgates the CML, which will after be included in the Municipal Zoning Schemes. The line will only have an actual meaning after being included in the Municipal Zoning Schemes (Celliers et al., 2009, p. 26).

In short, the responsibility to define and implement the CML lies with the Provinces. However, and according to the interviewed key-actors, they do not have the human and technical capacity and often have to appoint consultants, normally engineers. Hence, the main players involved in the implementation of coastal boundary lines are the Provincial Authorities and the consultant engineering industry.

Even though this is a Provincial responsibility, Municipalities have been building their own lines. Durban has been demarcating setback lines since the 1980s with their Potential Erosion Lines and Building Setback Lines. Cape Town has been developing their lines even before the ICM Act entered into force. Because of this, Municipalities have been trying to negotiate with Provinces because the latter will have to promulgate the lines.

Durban and Cape Town have been developing quite a lot of work on the issue of Setback Lines. Now that it became a Provincial responsibility, the work that has been developed must not be ignored and dismissed. Therefore, Provinces need to ensure that there is a consistent methodology for CML demarcation for the entire coastline and this must include the municipalities. In this regard, Provinces would need to go through what cities have been done and check if it is still part or entirely, up to date in order to be integrated into the methodology. The Western Cape Provincial Government and the City of Cape Town are working quite closely to ensure that the work being done by the City of Cape Town converges from a Provincial perspective. In KwaZulu-Natal, the province and the City of Durban are joining efforts to consolidate the work that has been developed by both local and provincial Governments.

Nevertheless, these situations were not the rule. There are the Local Municipalities, the District Municipalities and then the Metropolitan Municipalities and the last are the bigger and normally the ones with the human resources, know-how and methods to go forward with these coastal management requirements.

Furthermore, it is the responsibility of the National Department to ensure the alignment of CML between Provinces. To add to that, in National Protected Areas, the National Department is also responsible for the development of those management lines. This is the case of the iSimangaliso Wetland Park, a World Heritage Site in the KwaZulu-Natal. The mandate of the Province for the development of the management lines is only up to the boundaries of the World Heritage Site and then the management line for this protected area would need to be developed by the World Heritage Site authority in conjunction with the National Department of Environmental Affairs. For key-actors, this is one of the reasons behind the need to develop the National Guideline Towards the Establishment of Coastal Management Lines. This is actually one of the biggest challenges, because one must keep in mind that different Provinces are appointing different service providers to assist with the development of the management lines. Consequently, provinces would end up with different methodologies. Therefore, the last thing authorities want is that for a similar type of development, different Provinces undertake different measures. Therefore, if one decision was made in the City of Cape Town, Western Cape Province, regarding a certain type of development in a specific type of coastal area, in the City of Durban in the Province of KwaZulu-Natal that same decision must be made. Otherwise one can argue what was the reason why one is being so harsh and the other softer for the same issue in different locations, and it will cause instability between coastal actors.

### IV.6. STAKEHOLDERS INVOLVEMENT

### IV.6.1. STAKEHOLDERS INVOLVEMENT IN PORTUGAL

One of the views stated by National Strategy for Adaptation to Climate Change (ENAAC) is that the impacts of climate change may enhance the involvement of stakeholders, including local communities through training and awareness-raising or through other participatory mechanisms (RCM no.56/2015, of July 30). Involvement of all parties is thus seen as relevant, making public participation a key component in planning and adaptation processes for coastal areas (Schmidt, Gomes, et al., 2013).

Currently, one of the criticisms being made to land management in coastal zones is related to the excessive significance given to the scientific knowledge produced by academics in the formalization of policies related to the risks inherent in these territories and the reduced importance given to public participation processes (Neves, Fernandes et al., 2018; Neves, Pires, et al., 2018). This imbalance attributed to the value of knowledge and perceptions among different stakeholders in the decision-making processes tends to weaken the adaptive capacity, reducing the effectiveness and response of these policies and, consequently, generating situations of conflict (Pires et al., 2012; Veloso-Gomes et al., 2004).

The recognition of this type of fragilities related to participatory processes became more relevant with the publication of Decree-Law no.159/2012 of July 24, which regulated the preparation and implementation of the Coastal Zone Management Plans (POOC). Thus, it can be read in Article 5 of the aforementioned Decree-Law that public participation is one of the principles that should be considered in these plans, to promote the active involvement of the public, institutions and local agents, through access to information and intervention in the elaboration, execution, evaluation and review processes.

The Law on Public Policy Soil, Territorial Planning and Urbanism (*Lei de Bases Gerais da Política Pública de Solos, de Ordenamento do Território e de Urbanismo*) (Law no. 31/2014 of May 30) further reinforced the principle of participation in land management instruments. It should be noted that one of the general principles of this diploma refers to citizen participation. It underpins the relevance of access to information and intervention in all the procedures inherent to land management, namely drafting; implementation, evaluation and review of territorial programmes and plans. It also notes that all have the right to effective participation in procedures that affect the land use, occupation, and transformation of soils through the presentation of proposals, suggestions and complaints, as well as the right to obtain a reasoned response from the administration under the law.

By entering into force, the Law no.31/2014 of May 30 urged for complementary legal instruments to be reviewed under Article 81. Therefore, the approval of Decree-Law no.80/2015, in May 14, 2015, lead to the review of the Legal Regime of the Territorial Management Instruments (*Regime Jurídico dos Instrumentos de Gestão Territorial*). In turn, with this new legal framework, all Special Plans are now designated as Special Programmes, and therefore, Coastal Zone Spatial Plans (POOC) are now referred to as Coastal Zone Spatial Programmes (*Programas da Orla Costeira – POC*). In line with the aforementioned, this Decree-Law recognized the weaknesses inherent in existing participatory processes, associated with an increasing need to restructure procedures at the administrative level, reinforcing participation in planning processes, in particular through the use of electronic platforms (Decree-Law no.80/2015 of May 14). It is thus expected that, through changes introduced by different legal instruments, participatory processes can be more effective, involving all stakeholders, including the different scales of governance, academia and local communities (Schmidt, Gomes, et al., 2013).

Reviewed literature reveals that the problem can go deeper than the opportunity of participation through participatory measures itself. It is also related with the perceptions of coastal communities in relation to their exposure and risk (Neves, Pires, et al., 2018). Several studies highlight the fact that coastal communities may even be aware of their exposure to the most diverse climatic events and the risks associated with it. However, such communities do not consider to relocate to safer areas (Craveiro, 2013a; Domingues et al., 2018; Pires et al., 2012). This is not uncommon, as illustrated below.

In the RENCOASTAL Project (Regulations and Environmental Conflicts Due to Coastal Erosion - Regulações e Conflitos Ambientais Devido à Erosão Costeira), exploratory interviews were carried out in a coastal community in the Lisbon Metropolitan Area (LMA), specifically at the Costa da Caparica, municipality of Almada. Here, representatives of the fishing community expressed the will to remain near the coastline and have no intention of moving. The testimonials also suggested that this fishing community has insufficient knowledge regarding the physical causes associated with coastal erosion. They place high levels of confidence in the hard coastal defences that have been built in order to respond to the extreme climatic events that have been affecting this area (Pires et al., 2012). This view was corroborated by semi-structured interviews carried out with key-actors in the coastal and spatial planning field. Key-actors pointed out that these defences end up creating a false sense of security, which can definitely minimize a risk situation but does not entirely avoid it.

The perceptions regarding coastal vulnerabilities are diverse among different groups of stakeholders that interact with the coast. Nevertheless, these views are not entirely divergent (Craveiro, 2013a). On the one hand, fisherfolk favour a more natural coastal environment, despite existing coastal hard defences. On the other hand, interviewed restaurant owners look at the coastal hard defences as an opportunity to value the land and, consequently, to artificialize these coastal areas.

Despite of the different views expressed by the two different groups regarding the coastal environment, both groups agree on the need of artificial feeding of the beaches. This understanding stems from the limitations to which each type of activity has been subject. Fishing activities have been limited by the insufficient availability of sand, conditioning the use of agricultural vehicles or animals to pull the nets to land. For restaurant owners, it is imperative that there is sand on the beaches in favour of tourism and the benefits associated with it (Craveiro, 2013a).

It is also important to stress that not all the interviewed groups share the same opinion about the effectiveness of coastal defences. Such divergences may fall on past lived experiences (Neves, Pires, et al., 2018). Contrary to other opinions, a camping site administrator expressed his concern regarding the state of conservation and resistance of the coastal defences to coastal climate events. To illustrate his concern, this interviewee referred to an episode in which the sea broke through the concrete wall and invaded part of the camping site area (Pires et al., 2012).

In Lugar da Praia, in Paramos (Espinho), the fishing community also seems to have a poor understanding on the causes associated with coastal climatic events that take affect the area. Similarly to the Costa da Caparica communities, fishers attribute the climatic occurrences to natural causes, mostly, in the periods associated with spring tides (Craveiro, 2013a). These assumptions are the result of a survey to the fishing community with a mean age of around 60 years old, in which the vast majority (80%) does not have more than four years of schooling (Craveiro, 2013b).

In an interview to one of the key-actors, Paramos was once again mentioned in a situation that somehow complements the above findings. This key-actor refers to a festive tradition in which this community used to go in a parade, out of the so-called Paramos Chapel, heading down the beach towards the sea, covering a distance of around 120 m and then turning back. This situation goes back some 60 years. Currently, the sea stands much closer to the Chapel and the houses that were being built along this period. Due to these new constructions, the need to protect them with coastal defences has been rising, and today, in situations of extreme climatic events, there are situations of overtopping, showing that these coastal (hard) defences are manifestly insufficient. Therefore, it must be noted that this community should have a better understanding of problems taking place in this area, even more due to the fact that they went through most of the changes occurring in the coast.

In the Algarve, in a study published by Domingues et al. (2018) on the perception of local communities about coastal hazards and risks, in the Ria Formosa barrier island system, in particular on Faro Beach, local communities claim to be aware of the dangers and risks arising from their exposure to coastal hazards (85.7%). Nevertheless, they do not show any intention to relocate to a safer place. The argument given is that they feel relatively safe in the place where they live. In fact, approximately 25% of the surveyed population believes they are not yet at risk. While nearly 20% of the surveyed population admits to be already in a situation of risk.

This will to stay may be associated with the fact that the surveyed population has already experienced situations of risk (1/3) that did not result in any fatality. Yet, only 1/3 of the population admits being minimally prepared for a situation where they have to face an extreme weather event.

According to Domingues et al. (2018), life experience is the main source of information (73%) concerning coastal issues, followed by information obtained by the media and family (49%), friends and neighbours (43%), while the information obtained from environmental education campaigns, education, and through public participation processes registered a comparatively smaller percentage (21%). Another factor that may contribute to the sense of security in these coastal communities is related to their characteristics. The area comprised by the Faro Beach has an extension of three kilometres along the coastline. The dune cord that existed here has given way, in almost all its extension, to built-up areas for different uses, ranging from habitation, to tourism and recreational activities. Consequently, the need to protect them led to the constructions of hard coastal defences. Despite these defences, strong wave events associated with storms on spring tides have led to situations of overtopping of the defences and consequent deposition of materials and sediments (Ferreira et al., 2006).

In another study, in the scope of the CHANGE project - Changing Climate, Changing Coasts, Changing Communities (*Mudanças Climáticas, Costeiras e Sociais*), surveys were carried out regarding public participation in coastal zones (Schmidt, Delicado, et al., 2013a). The case study areas were: Vagueira (Aveiro), Quarteira (Loulé) and Costa da Caparica (Almada). The results showed a very small involvement (4%) in participatory processes associated with coastal zone management plans and decisions affecting coastal zones. In addition, the low participation of the population is associated with their perception of the small or no value and weight of their contributions. They consider that decision makers involved in coastal zone management are not predisposed to consider integrating their contributions, and so, knowledge resulting from public participation processes has no effect on coastal zone management decisions (Schmidt, Gomes, et al., 2013).

The literature, in general, suggests a poor understanding of the risk in relation to current exposure, namely in the local communities. These seem to accept the diverse climatic events that tend to modify the coastline while overly relying in coastal defences exposing the vulnerabilities to which these communities are subject to (Neves, Pires, et al., 2018).

Both the Costa da Caparica and Faro Beach have revealed fragilities for the populations resulting from flooding situations in areas already subject to coastal defences (Ferreira et al., 2006; Pires et al., 2012). The land use and occupation changes that took place in Espinho and Costa da Caparica can be summarised in an increase of the built-up areas near the coastline, which exacerbate their vulnerability. Thus, it is important to implement policies that result in less costly preventive and mitigation measures, avoiding situations that call for reactive measures (Craveiro et al., 2012).

The literature has reinforced the need to involve stakeholders, in particular local communities, which have been increasingly highlighted by the current legislative framework (APA, 2015), and transposed into land management instruments, particularly, those with direct impact on coastal zones, namely the second generation of Coastal Zone Spatial Programmes (POC). However, their actual involvement in participatory processes is still insignificant. Public participation processes are fraught with an apparent fragility due to the low importance that land management instruments have been given. Consequently, the low participation that is still occurring in these processes is often associated with evident economic interests.

It should be noted that only 4% of the surveyed population under the CHANGE Project had participated in participatory processes. The information that reaches these communities from public participation processes is reduced, accentuating the apparent weakness that is attributed to them. According to Domingues et al. (2018) the information resulted from public participation processes reached less than 10% of the participants in this study. Such results show the need to foster the active involvement of the public, institutions and local agents, through access to information and intervention in the processes of elaboration, execution, evaluation and review, as has been demonstrated in the Decree-Law no. 159/2012 of July 24. Despite the actual low levels of participation, more than 78% of the interviewees showed interest in contributing actively in these processes (Domingues et al., 2018).

For Craveiro (2013a), one possible solution that reduce this lack of information and involvement in participatory processes, could eventually be through the development of citizenship and environmental education programs and thus sensitize local communities to the current problems that occur in coastal areas. According to the author, it could also contribute to raising awareness to the importance of their contributions to addressing the issues associated with these territories, as well as by converging the interests of all involved parties, minimizing potential conflicts.

The interviews conducted with key-actors also suggest that the contributions resulting through public participation processes, particularly through the POC, do not have great expression in the final design and implementation of these programmes. Similar to the results obtained by the research projects mentioned above, the interviews confirmed a very small public participation in this type of processes, which was already denoted as a weak point in relation to national public policies. As the literature points out, decisions continue to be made based on a top-down planning model (Schmidt, Gomes, et al., 2013).

Carmo (2017) reinforces the idea that for an action to be successful, in coastal zones planning and land management, it must be well understood and accepted by all stakeholders and their local communities. The involvement of all parties in coastal planning and management is thus understood as crucial for a sustainable coastal development (Veloso-Gomes et al., 2004). This is clearly not yet the case in Portugal.

In the former POOCs, public hearings were carried out just before the approval of the Plan. The people who had interest in a specific coastal area included in the Plan were heard only when the programme was almost finished. At this stage, there was no possibility of going back on structural decisions. This was clear in the various public discussion sessions, and a finger pointing at this type of participation model.

According to some of the key-actors interviewed, conflicts could be avoided if public participation is ensured from the very beginning of planning processes. A common voice states that it is better to work with people than against them, and that people feel heard and more valued when they are included in the process. This is also a conflict that should be settled right from the beginning, since the decisions and the structuring lines of the new POC will have to be incorporated in the PDM, and therefore, it is up to the municipalities to promote hearings and public participation.

In spite of the above, it is necessary to consider two important aspects. Firstly, that there is no capacity to identify all the actors and stakeholders nor to do a detailed discussion at the local level, given the extent of the territories. Secondly, public participation is characterized by the absence of participation and participants.

There are some justifications for the reduced number of participations in public participation processes. One of the justifications is how information about participation processes reaches stakeholders. Nowadays, participation is made via an Internet portal, the “Participa”, where people can submit their participation. Somehow, this information does not seem to reach most of interested parties. Nevertheless, this new method is favoured by decision makers because it avoids conflicts that used to happen in the past. Disagreements between stakeholders and decision makers occur at public hearings and in some situations lead to threats and possible physical confrontations. This new method put an end to these types of situations but at the same time increased the distance between the people involved.

Another justification for low or no participation falls on the main components associated with the methodologies applied, which are very technical and scientific, and therefore only someone who has deep knowledge can engage and contribute.

The modest participation recorded is very much associated with the problems of each individual, with their individual concerns and problems, and few or nothing reflect the problems of a community as a whole. Coastal communities express no will to leave or retreat, complaint about Government decisions and demand coastal defences. There is a lack of knowledge where no one is prepared for what the future may be. It also does not help that the media, except when there are catastrophes, do not discuss this issue. The common perception of people living in coastal areas is still that the Government has the duty and will be able to provide protection to everyone through the construction and maintenance of coastal defences.

According to the key-actors, one of the main reasons for people to participate is to contest a Safeguard Line that falls into their property and consequently will impact any changes that may or may not occur in that area. In other words, people do not contest why the line falls on their property, people just do not want the consequences of such decision in their properties. Such consequences are linked to building interdictions.

In conclusion, in the opinion of the key-actors interviewed, given the soundness of the methodologies used, the contributions of stakeholders could hardly result in the modification of a decision previously made.

### IV.6.2. STAKEHOLDER INVOLVEMENT IN SOUTH AFRICA

Every management decision has to be subject to consultation. In the case of Coastal Management Lines (CML), section 53 of the ICM Act says that stakeholders must be consulted. However, similarly to the Portuguese case study, in the view of interviewed key-actors, there is a great concern because the vast majority of stakeholders are poorly informed. Only a minority of people are knowledgeable of the coastal issues. Moreover, there is also a huge indifference identified by the key-actors. People are asked to participate but do not attend the meetings, or attend in very reduced numbers. There are few situations where participation has been successful.

Key-actors foresee that such situations may be a problem because there is new legislation, which stakeholders are not sufficiently familiar with, and it may be quite restrictive. There is a certain concern because later stakeholders will argue that there was no information about the decisions that were made, even though there was advertisements and a period for consultation.

The interviewees gave some examples that illustrate such concerns. In Durban, despite large advertisement and a period for consultation of one month, there was not a single answer. In the Eden area, stakeholders have proved dissatisfied with the amplitude of the hazard line fearing that it might affect the price of properties, and there is nothing preventing stakeholders to contest a decision in the courts if they feel they are being disadvantaged. However, the court will not rule on the extension of the CML but on whether the process set in the Act was followed correctly, if the methodology was solid, if there was consultation, if the inputs and comments were considered. It does not matter whether the comments were relevant or not, the process must be transparent.

Despite all the above concerns, key-actors attribute a very important role to stakeholders. Section 53 of the ICM Act is all about stakeholder involvement. Any decision needs to involve all parties, coastal communities in particular, because these are the ones affected. Some interviewees referred to the engagement with the public to be neglected, mostly from the National and Provincial levels of government, and less at the Municipal level. This situation has been changing but it is still considered one of the most challenging parts in the entire CML implementation process, if not the most challenging.

Therefore, when asked about the role of stakeholders in relation to CML, some refer that the politically correct answer would be that these lines should be drawn with the consultation of all coastal communities and stakeholders. The reality is that this is quite impossible. There are so many different views, agendas and positions that it overcomplicates the process to the point that it is practically impossible to ensure participation of all stakeholders. Even though full participation is academically, politically and socially the most correct, the really has been proving it differently.

Key-actors suggested explanations to this situation. Most people in South Africa, particularly poorer communities, when asked what they want in their coastline, will say “development”. For them, the line could be drawn right at the water’s edge. In their perception, wealthy coastal areas are developed coastal areas, which is why restrictions to development or prohibition are not socially well accepted, despite the risks involved. This is why key-actors foresee the need for proper CML methodology to enable people to understand coastal risk, understand the various pressures and have an objective way of trying to come up with something that works from a society point of view, an economic point of view, and an ecologic point of view.

In the Western Cape Province, the City of Cape Town has been working closely with their communities, which are very contrasting communities, in part because of the history of Apartheid. Therefore, there are very wealthy suburbs, the desirable suburbs located in the Atlantic seaboard, such as Camps Bay, Clifton and Hout Bay, generally inhabited by white people and properties valued at hundreds of millions of Rand right at the water’s edge. Then, there are the suburbs of False Bay coastline, generally inhabited by black and coloured communities, which are setback from the coastline in smaller properties. Key-actors refer to these contrasts as frightening.

Drawing a CML with the best of the intentions to protect people and goods, to preserve a natural environment, to maintain a public space is not always well understood by those disadvantaged communities which in the past had limited use of coastal areas. They argue that part of the South African population was allowed to occupy the coastal strip in the past, and today those coastal communities are wealthy. One cannot ignore the history, and it has to be part of the coastal management process. In this sense stigma is still present, and coastal managers are dealing with risk prevention at the same time as trying not to limit development or to exacerbate inequalities.

### IV.7. IMPLEMENTATION CHALLENGES

### IV.7.1. IMPLEMENTATION CHALLENGES IN PORTUGAL

The work that has being developed by academics is terms of identification of coastal risk areas is considered essential and has been critical to decision-making by policy makers. Despite, it is still considered a big challenge in terms of implementation due to the restrictions inherent to coastal risk areas.

In Portugal, Safeguard Lines implementation has a few major issues that are worth mention. One of the issues is related to the over trust of coastal communities on coastal defences. It is hard for people to accept that for a single area the POC predicts the need for both, building or reinforcing coastal defences and implementing Safeguard Lines. In people's understanding, if there are or will be coastal defences, then there is no risk and, therefore, no need for these lines to be adopted and the restrictions associated with it. As mentioned above, coastal defences do not guarantee total protection and, in some cases, they fail. Therefore, these measures are planning tools that aim to protect people and property at present time and creating conditions for preventing more people from being exposed to risk in the future.

However, the application of interdiction regimes is not so linear. In practice, the implementation of Safeguard Lines will prohibit or restrict new constructions. It should be noted, however, that in cases where property owners already have permits, these new measures do not apply. These measures would fully apply if the owners were compensated, but the Government does not have enough funds to meet all these needs. Not even to supply the current needs for construction and maintenance of coastal defences. There is a need for prioritization. Thus, the implementation of these measures in the framework of the POC emphasizes the need to put an end to this false sense of security, since coastal defences alone are not a solution, and to draw attention to risks exposure and highlighting that this should not increase in the future.

Another argument used by property owners in urban areas is the exact same argument used by urban planners, i.e. the need to consolidate the urban fabric. Before, the used arguments in urban planning referred to the inevitability of not to increase the urban perimeter and therefore one would have to consolidate the urban fabric instead.

Today this is one of the most used arguments by coastal property owners that, for several reasons, want to build in coastal areas at risk. In this sense, coastal managers have to deal with these different types of situations: property owners that have already built; and those who still want to build, having or not permits to do so. To add to this, coastal managers know that coastal issues associated with erosion and overtopping will worsen, and therefore, these problems must be somehow halted. Situations that in the near future may require relocation measures need, as of today, the implementation of a set of measures linked to urban planning that strongly restrict new construction in those areas. Such measures may include land swap and equalization mechanisms, which have already been implemented in other urban contexts.

To add to the above, another issue that coastal managers and decision makers have to deal with is the manifested unawareness of coastal communities, of stakeholders, about coastal issues. Most people think one has the ability to stop erosion and stabilize the coastline, as if it was possible to control nature. Moreover, this is something that needs to be demystified, by educating people, by transmitting knowledge since early stages, starting in schools with the youngest and organizing training sessions, talk with teachers, with users, with fishermen, with residents, with associations, etc. There is an emergent need to disclose, to explain why these measures are useful, by giving good examples, by mention where there were no application and what the losses and the damages were. Also, explain that there are uncertainties inherent in these planning models and that existing knowledge is not perfect. Thus, lack of knowledge is possibly the main obstacle to the acceptance of measures such as Safeguard Lines.

In rural areas, there are no complications inherent to the implementation of Safeguard Lines. Law does not allow construction in these areas already. Therefore, the implementation of these measures in this typology of coastal areas is not critical. In fact, outside urban areas, regardless of the existence of Safeguard Lines, it is considered that the coastal zone functions as a buffer zone of decompression with high coastal values, i.e. beaches, dunes, cliffs, and other important natural systems. Coastal management should thus continuously guarantee that these areas are progressively less occupied in order to have this added-value of non-degradation of coastal systems, and less exposed.

Thus, and to safeguard these natural coastal systems, some areas are classified as *non aedificandi* areas, regardless of the existence of Safeguard Lines.

Nowadays, from a legal point of view, the emergence of a new urban area along the coast is quite improbable, and the reasons are varied. Previously, there were already planning instruments that imposed serious limitations to construction in coastal zones such as the existing PROT[15] and REN. More recently, the Safeguard Lines within the POC have reinforced this premise. Today there are more tools available and more information, than in the first generation of POOCs. Therefore, the ability to monitor through existing spatial information such as aerial photographs, satellite imagery and increasingly the capture of images by drones (UAV) reduces the likelihood of new illegal construction along the coast.

The inclusion of Safeguard Lines in the Municipal Master Plans (PDM) is mandatory, when the POC legally overlaps with the administrative area covered by the PDM. In this sense, municipalities enter the process of coastal management as secondary actors, not because they are less important, but because they are the receivers of a set of measure and restrictions on land use imposed by the POC, through the Safeguard Lines established by the Central Government (through APA). Local Governments will have to transpose these restrictive measures to the PDM.

This transposition of safeguard Lines regimes to the municipal land management instruments and specifically to the PDM requires the identification of the norms of the territorial plans that are incompatible with the rules in force. Incompatibility can arise, for example, when for a same given area, the POC enforces a norm regarding forbidden actions, thus prohibiting any type of construction, and, at the same time, the PDM foresaw or allows construction. Once the incompatibility is identified in the Resolution of the Council of Ministers, a maximum period of 60 days is given for the PDM to adapt to the new provisions. If after 60 days, the Municipality has not yet implemented corrective and adaptive changes, incompatible norms in the PDM are suspended. Other punitive measures include the suspension of access to European Community funds.

[15] Regional Spatial Plans (*Planos Regionais de Ordenamento do Território – PROT*)

In practice, for the approval of Safeguard Lines what really matters is the transposition of a regime associated with a Safeguard Line. In this respect, there are two distinct situations that have already been addressed and which need to be recovered. One is related to the areas that were already built, the urban areas, and the other one refers to areas outside the urban perimeters.

According to the experience of the key-actors, there have been no problems in the implementation, management or even concertation under the POC protection regimes of the Safeguard Lines outside urban perimeters. Inside urban perimeters, there are two situations. In urban perimeters where Risk Lines have already been implemented in the past, there is already a management experience. Then, with the new POC, there are now other urban areas that before had no Risk Lines and are now incorporated in the new Safeguard Lines regimes.

In spite of urban areas and the new framework brought by the new POC, key-actors distinguish two opposite situations according to their experiences. Firstly, there are municipalities where the acceptation by the competent authorities was commendable, showing enthusiasm and constructivism in the incorporation of the new Safeguard Lines. This is usually the attitude manifested by smaller municipalities. These are the municipalities that achieve greater proximity to their citizens, where urban development is moderate, mainly in the coastal strip. Its stakeholders look at this guidance as an opportunity to value natural resources and sustainably develop.

The second situation concerns municipalities that see changes brought by the new POC as another burden, another factor hindering the development of the municipality. This last situation is more recurrent than the first, and is closely associated with the fact that a good part of their revenue comes from urbanism. Furthermore, key-actors foresee that these may be the areas that will experience greater difficulties in the transition to new regimes, which may cause conflicting situations between the Central Government and Local Authorities and between all the other involved parties.

The figure IV.7.1.37 illustrates some of the restrictions introduced by Safeguard Lines through the new POC and that have been largely debated by interviewed key-actors. In the Coastal Zone Spatial Programme, Ovar – Marinha Grande, the most restrictive regimes were applied in both Safeguard Lines in sandy and cliff in coastal urban areas. Meaning that new buildings and building extensions are not allowed in the delimited areas, except in those cases where there are pre-existing and legally consolidated rights (CEDRU & Universidade de Aveiro, 2015, pp. 46–53).

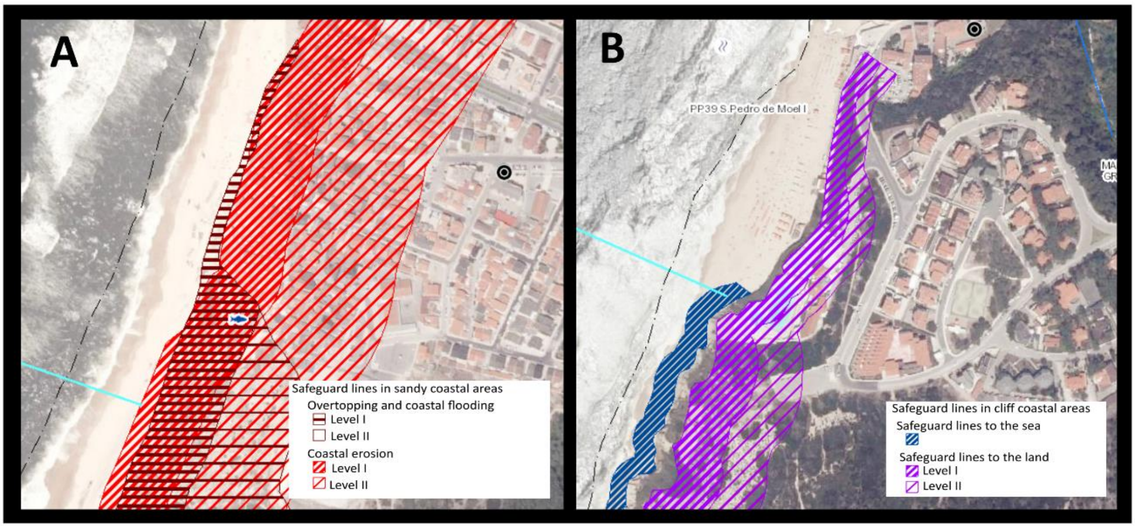


Figure IV.7.1.37. Examples of the application of Safeguard Lines in POC Ovar – Marinha Grande. Most restrictive regimes applied. Source: Retrieved from Web Viewer SNIAmb[16] as part of the content of the POC.

### IV.7.2. IMPLEMENTATION CHALLENGES IN SOUTH AFRICA

One of the biggest challenges relies on the methodologies used, and some key-actors have been struggling with this for about 10 years. They argue that the country should agree on what methodology and assumptions to use. Whether it is the latest IPCC scenarios, for 1 in 10 years, 1 in 25 years, or 1 in 50 years, the Brunn Rule or others. A single methodology based on the same assumptions allows for comparing different areas, different regions. The argument is simple: if the City of Cape Town uses their studies to determine, for example, sea level rise, and in Durban their assumptions are different, one cannot compare results. It may seem that one region is highly vulnerable compared to the other, when the only reason is the use of different methodologies and

[16] WebGIS https://sniamb.apambiente.pt/

assumptions. In turn, this is the result of having different teams of consultants using different techniques to draw the management lines.

In this sense, some key-actors mentioned the hypothesis of a single methodology to be done at National Government level, so Provinces and Municipalities would take responsibility for the implementation of the CML. In their opinion, this could work slightly easier, because other major challenges are insufficient information and human capital. Some provinces have been much slower to develop their lines, and a line is only as good as the data and the information that informs it.

In spite of the above mentioned, key-actors recognize that the complexity in the implementation of CML goes further beyond a uniform methodology. An example was given of a Province that appointed consultants to develop a method to determine a Coastal Setback Line. No faults were given to the methodology, it was theoretically sound. Everything was considered: storm surge modelling; coastal erosion; sea level rise; coastal dynamics; and so forth. However, this in itself was a problem. It was completely theoretical and it did not work because there were no economic and social issues considered. It did not consider the practicalities and the implications it would have on property values. It seemed perfect but it failed. The human dimension must be considered otherwise it is bound to fail. In short, the absence of a single methodology is associated with a lack of leadership. In the view of key-actors, both are crucial for the implementation of CML.

In this sense, there are major concerns with CML in urban environments. Historically people made mistakes and now there is a need to prioritise intervention, to protect. It is private property that has raised more concern in the view of key-actors. If a line passes through a private property, the person will want to know why, they will argue it will devalue their property, and that person will not be able to sell it. Furthermore, CML raise the issue that by drawing a risk line through a property it might affect the insurance premium of the property. The insurance industry is identifying different legislation and how it may affect them. There are financial implications, whether it is private individual property or services. If the premium raises to a certain extent, then the owner or a business will certainly be penalized. There are social and economic impacts that may have been unforeseen and whose circumstances may have far reaching implications. These are the kind of arguments that decision makers have been dealing with. People along the coast have paid more for their premiums than somebody two rows of houses back. Suddenly CML are drawn and property owners understand them as a problem. In the view of interviewed key-actors, built-up environments require another type of approach to address the realities of property rights and land ownership.

To add to the aforementioned, insurance companies are aware of these issues, of the problems posed by coastal hazards and about what these lines represent. Therefore, they have done their own analysis, separate to the Government and were not sharing their results. In the view of key-actors there is some uncertainty related to the consequences of the dissemination of this information.

Because of the above mentioned, in urban environments, relocations are not well accepted as a management option. Property owners want more and more effective coastal defences, just like in Portugal. Then, there are inequality issues, already mentioned, that, in the view of key-actors, needs to be carefully managed. There are communities marginalised in the past, people who used to benefit and live of the coast and that have been displaced. The big challenge now is to remediate, to correct the injustices of the past. Presently, there are several coastal developed areas inhabited by minority groups that literally built up until the High Water Mark, as well as vast coastal areas undeveloped seen as an opportunity for development, for equality.

In environments that are more natural, implementation of CML may not face great challenges. Key-actors gave an example based on the Western Cape Province. There are large Nature Reserves along the Western Cape Province coast and because of it is relatively easy to draw the line, there is no development. Moreover, the environmental authorities see that line as straightening their ability to manage the environmental assets. Then it gets extra protection in terms of the legislation for Nature Reserves. By adding the CML, it makes it even less likely that there will be development in these specific areas in any form. Therefore, it is easier in these environments, where there are no arguments, no complaints.

There was large consensus on CML presenting a great opportunity as a coastal management tool for the sections of coastline that have not been developed. It is easier to engage with landowners that have not invested in infrastructures yet. In these cases, there is more room to negotiate where the infrastructure will be constructed considering a long-term risk impact perspective.

Despite this, relocations have been suggested in the more rural areas. According to the key-actors, the City of Cape Town has been trying this approach. In rural properties such as farms, permits may allow for one or two buildings. What is been recommended is to rezone or build out of the high-risk areas, which allows property owners to keep their existing rights, but not be given additional rights.

Concerning to the incorporation of CML into Municipal Master Plans, it is the Provinces responsibility to implement it, and after being approved by the MEC, these must be included in the Municipal Planning Schemes. These will then inform the level of risk each property may be facing. For key-actors, this is seen as a good source of information when one wants to buy a property, thus avoiding fraudulence.

One of the issues that has recently being generating some concern is that the ICM Act refers to Coastal Planning Schemes and Coastal Zoning Schemes. To add to that, there are other legislation, the Spatial Planning and Land Use Management Act (SPLUMA), that also has a focus on the issue of planning and zoning schemes. One of the questions recently raised is that one may now end up in a situation where there are two parallel processes governing planning, and that would include coastal planning.

Another issue is that National Government must pay attention to whether the management line, once developed, can be used to inform a planning process that is part of a different piece of legislation, because that is something municipalities in any case are in fact doing. Key informants argue that one does not want to end up with further misunderstanding with the municipal planners that are currently undertaking planning in terms of the SPLUMA and now have to incorporate the requirements of the ICM Act. In this sense, municipalities are required to find the best situation in terms of how to incorporate risk and planning for the coastal zone into the Spatial Development Frameworks which municipalities, in any case, are also legally required to be developing. It is crucial to avoid misunderstanding between involved parties because legislation is very easy to be developed but its implications are not always foreseen.

## IV.8. POLICY RISK ALTERNATIVES

### IV.8.1. POLICY RISK ALTERNATIVES TO THE USE OF SAFEGUARD LINES

Interviewed key-actors could not, at the time of interviews, suggest any alternatives to any type of Setback Line other than the existing ones. For Central Government interviewees, the Safeguard Lines are the correct path to follow. Academics look at these Safeguard Lines as a great tool for Coastal Management, although not essential. In their perspective, one can make fair and correct decisions, and adopt preventive measures in terms of coastal management even without Safeguard Lines.

### IV.8.2. POLICY RISK ALTERNATIVES TO THE USE OF COASTAL MANAGEMENT LINES

In the view of key-actors, Coastal Management Lines are probably the most important tool to assess coastal risks. Nevertheless, some barriers have been identified and doubts were raised as to its application in urban areas. In this sense, some interviewees mentioned the need to find an alternative that can respond to this issue.

In more undeveloped coastal areas, CML becomes a critical tool in avoiding creating the same risk repeatedly. It allows a more risk-averse approach going forward. There are huge concerns related to climate change scenarios. If those predictions are confirmed, coastal managers will deal with increased problems in very narrow spaces along urban environments.

**Summary of the chapter**

In both the case study countries, fixed setback lines were applied in coastal management instruments. However, like in other countries where the same type of measures were applied (see chapter II), these proved ineffective in halting or preventing new edification in coastal areas, particularly, those considered at risk as verified in chapter III.

Changes introduced by the new territorial management instruments, particularly those referring to coastal zones, brought a new sense of governance, more permissive to introduce sustainable measures to coastal management and, supported by new types of information, more accurate data and methods, incorporating climate change concerns. Despite the aim and scope of both the Safeguard and the Coastal Management Lines, widely divergent opinions were identified. Despite the meaning that these lines represent in coastal management, some key-actors argue that these should be reviewed within shorter periods of time, while others in longer time periods.

Key-actors in both the case studies approached the issue of institutional and stakeholders' involvement due to their relevance. In the past, the large number of actors with decision-making power over coastal zones has been widely criticized. Today, there is great concern, expressed in both case studies, regarding the capacity of institutions to respond to coastal management needs imposed by emergent directives and transposed into the new management instruments, particularly with regards to changes introduced by measures aimed at combating the fragilities imposed by past planning mistakes and actual climate change threats.

This is in itself a constraint. Institutions responsible for carrying out this type of specific tasks are not equally capacitated with technical and human resources, using consulting partnerships with institutions, sometimes, associated with the proximity of the intervention area. Because of these different partnerships, different methodologies are used to measure the same type of problem in different areas of intervention, which in itself may present a challenge to the implementation.

The major challenge, in the case of South Africa lies in the communication between institutions and stakeholder groups, which has largely contributed to delaying the approval of CML, particularly in urban areas. In Portugal, although participatory processes were not, generally, equally effective, the approval of the programmes and their respective Safeguard Lines did not raise major problems.

# CHAPTER V. GEOGRAPHIC INFORMATION SYSTEMS AND REMOTE SENSING TECHNOLOGIES IN COASTAL BOUNDARY DEMARCATION LINES

## Aim and scope

In this chapter, the technical aspects related to the use of Geographic Information (Systems) and with Remote Sensing are analysed, corresponding to the last group of questions in the semi-structured interview. In this regard, the chapter answers to objective number three in the introductory chapter by undertaking a critical assessment of practices, techniques and methods in the use of GIS/GIT (and RS) to render coastal boundary demarcation lines in coastal management.

In the semi-structured interviews, the last group of questions is composed by five questions, being two of the questions merged into one, and the chapter structured according to this restructuring.

The first point developed in the chapter concerns to public authorities' capacity level regarding coastal boundary lines delineation and implementation, which in the Portuguese case study, is National Government responsibility and in South Africa assumes a Provincial Government responsibility.

The relevance and role of GIS are assessed in the second point of the chapter. These topics assume considerable importance once both, as seen in Chapter IV, impact with the role of civil society and stakeholders in implementation and therefore, are one of the implementation challenges, particularly felt in South Africa, together with the third topic regarding data quality and availability, and how these issues are overcome.

The last topic of the chapter approaches alternative spatial representations for the use of Safeguard Lines in Portugal and Coastal Management Lines in South Africa, where major concerns are linked to urban environments.

Next, in the discussion chapter, both the issues presented in the Chapter IV and in this Chapter are largely debated.

## V.1. PUBLIC AUTHORITIES CAPACITY LEVEL

### V.1.1. THE PORTUGUESE AUTHORITIES CAPACITY LEVEL

In Portugal, as stated in the previous sections, the implementation of the Safeguard Lines within the POC is the responsibility of the APA. Under this premise, responses vary according to the key-actors in question. Central Government key-actors know their value and they have no doubts that they are able to such task. They developed the methodologies and sketched the Safeguard Lines.

Despite of the above mentioned the academics and consultants groups have more to add to this view. The APA is the institution in charge for the POC and therefore, for the Safeguard Lines implementation. However, this responsibility is then delegated to other entities whose responsibility is the elaboration of the Programmes. In this sense, APA has the power to elaborate both the POC and the Safeguard Lines but do not have the means. According to this group of interviewees, the APA has experts, they are well aware and extremely well qualified, but are manifestly insufficient to address the problem. Even with a scarce number of technicians, the APA follows the whole process. They have been doing systematic verifications covering the entire national coast and articulating with other entities such as the Civil Protection and other municipal bodies.

In short, they would be able but would not comply with the actual needs in terms of agenda. Key-actors would like to see more people working in these issues not only directly in APA but also in the most direct related bodies, such as the ARH and Commission for Regional Coordination and Development (*Comissão de Coordenação e Desenvolvimento Regional – CCDR*). This recognition of scarcity is not only at the level of human resources, but also financial and logistic resources. APA is well aware of these setbacks and they recognize that, in the past, there were more human and technical resources. This disinvestment in the Public Administration led to outsourcing, which has advantages but also constraints.

The fact that the Programmes are done by external technical teams, ends up creating some conflicting situations in terms of expected results. Despite of the external consultants in charge of the Programme, they must respond to the methodologies and scientific knowledge previously established by the competent authority. Thus, divergences result from the different academic backgrounds of the various entities and individuals involved in the process and from the different understandings that each has with what is intended with something as inclusive as the POC and the meaning that the Safeguard Lines have as a territorial management instrument. Even in subjects such as this, which seem to lead to direct answers, once more the issues associated with the more Social and more Natural Sciences have come to light and once again there has been a clear need for both to converge for this single purpose.

### V.1.2. THE SOUTH AFRICAN AUTHORITIES CAPACITY LEVEL

In general, the competent authorities do not have the human resources to answer to required needs by the process of delineating and implementing the CML. Thus, it is a growing practice to hire consultants. In this sense, some interesting facts related to the engineering sector were mentioned by key-actors. Thirty years ago, 70% of Civil Engineers were employed in the Government sector. Now only 30% are employed in Government sector, the private sector has now 70%, and therefore Government is outsourcing that work. The loss of staff with the necessary skills and knowledge appears to be a common problem in many countries (House of Representatives, 2009, p. 258).

Although this competence is attributed to the Provinces, and in the protected areas to the Central Government (ICM Act No. 24 of 2008), few municipalities have been developing CML (Colenbrander & Sowman, 2015). Smaller municipalities are the least empowered and the ones that resort to outsourcing. In the view of key-actors, relying on consulting may have some limitations. It is good to have the skills in the house, whether it is National, Provincial or Municipal levels.

At the Municipal level, only the bigger municipalities and metropolitan municipalities such as the City of Cape Town and Durban have the capacity and the skills. However, beyond large that capacity does not exist at the Municipal level because it is a very specialized field. Smaller municipalities might have a single planner that knows how to work with GIS. This shortage of human resources and of know-how was one of the limitations pointed out to Local Government. In Australia, Local Government level is reported to have a relevant role in coastal zone management, however there has been a loss of staff retention capacity, which may affect decision making (House of Representatives, 2009, p. 258). Key-actors also refer to the already mentioned, existing mistrust in Local Government, recognizing that in the past illegalities has been allowed and for which the current legislative framework will have to somehow solve. In the view of key-actors, this is why the Provinces need to take that responsibility.

Key-actors appoint competencies to half of the coastal Provinces. In their view, only the Western Cape and KwaZulu-Natal have the capacity at the moment. Northern Cape and Eastern Cape do not have that capacity themselves now, and so they are reliant on consultancy. This diversity of teams and knowledge has been pointed out as a problem, since it tends to generate different outcomes, resulting from these factors. Nevertheless, Provinces are starting to talk to one another and so those divergences may be reduced.

A concern also mentioned by the interviewees is related to the inclusion capacity of CML by municipalities. There must be an understanding between the Provinces and their Municipalities so that they can integrate these lines into their Municipal Zoning Schemes enabling the public in determining the position of CML relative to existing cadastral boundaries. In this sense, there is a growing need to capacitate municipalities, particularly the smaller municipalities and in the rural areas. Thus, the National Government has been mentioned to make already an investment in the past to capacitate Local Government from a GIS perspective.

## V.2. GEOGRAPHIC INFORMATION SYSTEMS AND TECHNOLOGIES (GIS/GIT) RELEVANCE AND ROLE

### V.2.1. THE GIT/GIS RELEVANCE FOR THE PORTUGUESE KEY-ACTORS

All interviewees stated the relevance of GIS for coastal management. Answers vary between: absolutely fundamental; fundamental; or crucial. If key-actors would have to rate, from zero to 100, it would be 100. In their views, without GIS Safeguard Lines delineation and implementation would not be possible.

### V.2.2. THE GIT/GIS ROLE FOR THE PORTUGUESE KEY-ACTORS

In the 1990s GIS was still little used. There was still a lot of cartography on paper. In the first generation, POOC processes were also more time consuming and, as known, there is always more associated error when making cartography by hand than in GIS, and despite, the possibilities of crossing Geographic Information are exponentially higher in GIS. This existing situation proved to be favourable to economic interests that ended up overlapping in the past, giving rise to illegalities, to situations in which one should never have issued permits. In this regard, what Municipalities point to be justifications, key-actors refer to as excuses used by themselves. Amongst them, not having the appropriate cartography, the right cartography format at the time, that it was not digital cartography, were all mentioned. Since GIS was not properly developed, these types of situations have multiplied.

In this regard, key-actors are consensual. Today it would not be possible to develop this type of work without the use of GIS. Today, there are still great uncertainties associated with coastal phenomena, which does not evolve linearly in time or space, and thus the need to make use of more rigorous information systems, capable of working with larger volumes of data is increasing. There is a need for a system to enforce rules with fairness and ensure homogenous coverage throughout the territory. Otherwise, rules would be established for some and not for the whole.

GIS today has the ability to aggregate different types of information and give it a meaning. In addition, to update and modify maintaining the accuracy that otherwise would be unreachable. In this sense, the concept of georeferencing is absolutely vital, to this subject and in everything that has spatial representation. In practical terms, today, in terms of GIS there is a strip along the coast with all this information with the scale appropriate to this issue. A work with this extension that is only possible in the framework of GIS. Moreover, this is a type of information that is necessary, a system that allows rigour and solidity to apply a set of restrictions that are socially, politically and economically extremely impactful and therefore a system that is indeed unquestionable. Eventually, even an information system that feeds a communication strategy and that makes it more noticeable to all citizens concerning what is happening on the ground.

ESRI ArcGIS[17] was the only mentioned software used in the drawing and implementation of the Safeguard Lines, being its potential greatly enhanced by the interviewed key-actors. Furthermore, the Digital Shoreline Analysis System (DSAS) was equally highlighted by being an excellent tool to compute coastline changes over time, easing the task of predicting future scenarios.

### V.2.3. THE GIT/GIS RELEVANCE FOR THE SOUTH AFRICAN KEY-ACTORS

Interviewees have recognized the relevance of GIS and classified it as important to critical in the development of CML. Nevertheless, there were a couple of references to keep in mind. One must not focus exclusively on the use of GIS to assess risk modelling. There are socioeconomic aspects that have to be considered in the process of defining the CML. Furthermore, one must not forget that GIS is only as good as the data that is feeding that system.

### V.2.4. THE GIT/GIS ROLE FOR THE SOUTH AFRICAN KEY-ACTORS

All spheres of Government have been involved in developing tools to assist coastal management. The national level has developed the National Oceans and Coastal

[17] Available at: https://www.esri.com/

Information Management System (OCIMS)[18] which allows users to access coastal and oceans data, decision support tools, and other relevant information.

At the Municipal level, GIS are critical. Municipalities have been storing their spatial information in GIS, sharing that information through users and departments so everyone can access, use and modify that data. Furthermore, few Municipalities and Provinces have made coastal information available in Web Portals and Web GIS for public information and consultation. That is the case of KwaZulu-Natal Province, which developed the CoastKZN[19] and where, amongst other aspects, provides scientific information, coastal and estuarine data, and a platform to assist decision-making associated with coastal issues.

In this sense, there is a strong conviction that GIS must be used as a technical tool to represent a number of informants, when drafting a CML. The setback, in the past and still present to some extent, is that GIS is used to assess coastal risk exclusively, and that approach has been proven manifestly insufficient. It should incorporate a range of other informants, a range of other information on top of risk. It is a powerful tool and it would certainly bring more benefits to the development of CML if those shifts would be incorporated. Some interviewees are of the view that it may be one of the reasons why the progress with implementation have been behind expected.

[18] Available at: https://ocims-dev.dhcp.meraka.csir.co.za/

[19] Available at: http://www.coastkzn.co.za/

### V.3. DATA QUALITY AND AVAILABILITY

#### V.3.1. DATA QUALITY AND AVAILABILITY IN PORTUGAL

This issue related to Geographic Information received much attention from key-actors. Currently, all the conditions have been created for Safeguard Lines to be ensured in the second generation of POC, following a methodology, generally, uniform. If the positive aspects were, in general, exalted, some needs were also highlighted. Of these, some were generally addressed, such as Geographic Information being spread across various organizations with distinct methodological criteria. Regarding this issue, Marinho et al. (2019) suggests a single data infrastructure, an online platform, to aggregate all relevant data and make it available. Therefore, the England's Channel Coastal Observatory[20], an online platform for coastal management, was given as good example. Taking into consideration the standardization of technical concepts and methodologies for cartographic representation of information, National Government had already assumed it as essential issue by publishing a "Methodological guide for producing hazardous municipal cartography and for creating municipal-based Geographic Information Systems (GIS)" (*Guia metodológico para a produção de cartografia municipal de risco e para a criação de Sistemas de Informação Geográfica (SIG) de base municipal*). It aimed at the production of municipal risk-based mapping, including coastal issues, recognizing that risk goes beyond administrative boundaries (Julião et al., 2009), and that risk assessments are essential to support coastal decision making.

Other constraints referred to more specific territories i.e. low-lying coastal areas, cliff, and submerged areas. Thus, it is perceived that there are still some limitations regarding the availability of Geographic Information in low-lying coastal areas. This information is still very diffuse and fragmented and therefore has different methodologies. In cliff coastal areas there are still some locations where information is non-existent. In these situations, broader and more preventive criteria are adopted to overcome this absence. Then, one of the great constraints pointed to coastal

[20] Channel Coastal Observatory Website available at: https://www.channelcoast.org/

management is the absence of knowledge about flooded areas. Portugal has been focused mainly on the monitoring of coastal visible areas, but that is not enough. There is a growing need to monitor bathymetry to better understand the behaviour of these very specific areas and what types of impacts they may cause in emerging areas.

Another issue raised by the interviewees refers to the quality of data and for which some notes, that have some implications in the territory, have been made.

One of those notes refers to Light Detection And Ranging (LiDAR) data, which has increasing importance in an increasing number of countries, namely being applied in coastal management due to its accuracy. Data quality of the first LiDAR survey for the national coastal zone has been recognised. However, some weaknesses were pointed out. One is that officially, it is a 2001 survey, but the aerial photographs that served as the basis for photogrammetric restitution date from 2000 to 2003. Thus, depending on the zones, there are temporal mismatches that result from different dates. Now, these questions are quite relevant given the importance of detail in these specific territories. In this sense, another identified problem refers to the coordinate system of origin, the Datum 73. In the view of key-actors, there has always been no acceptable solution in the transposition of the Datum 73 to the ETRS 89. There have always been gaps, which in these cases is critical. One may be considering movements or retreats in cliff areas where there has never been any change. The same holds for the low-lying coastal areas, in particular, changes in the coastline. The latest LiDAR survey covering the entire national territory dates back to 2011. In short, timescale and positional accuracy assume particular importance in issues associated with coastal zone management, namely the Safeguard Lines delimitation.

These accuracy and overlapping issues in Geographic Information are, in turn, associated with problems of the scale of information and with its uses. Currently, much of the cartography used is already produced in a GIS environment, for GIS, that is, it is Digital Cartography. However, there is still being in use a great volume of base cartography that does not have these specificities. Today, both in coastal management and in other areas of territorial management, much of the information used is Geographic Information that is digitized but that was not designed for this purpose, i.e. the Geological Map of Portugal (1:500 000), among other Geographic Information that still has an important role in these planning issues, and to which there are not yet an alternative.

The acquisition of up to date information stands out as one of the major issues inherent to the accuracy needs. In this sense, there are minimum requirements that, in the understanding of the key-actors, should be fulfilled to meet such needs and maintain high levels of cartographic standards. Thus, in their view, the minimum periodicity for aerial photography surveys should be annual.

This crucial requirement would eventually refer to the first question raised in this chapter, in particular to the constraints identified with the cut of human resources in the Public Administration. The lack of human resources limits the reaction time, monitoring and consequently the update of information in situations that may be relevant in terms of coastal management. Thus, key-actors consider that the creation of full-time local teams, with more expertise in these issues associated with different types of coastline and obviously able to work with either GIS and other acquisition methods on the ground such as GPS would be essential. This issue arose because one of the constraints that were largely mentioned is associated with the scarcity of human resources and bureaucracy. Currently, expert technicians working on these types of issues are spending a good part of their time with bureaucratic processes.

To all of these issues regarding the availability of existing, update and quality of data, another aspect is raised regarded as crucial to decision making, i.e., the uncertainties intrinsic to the studies of natural phenomena and also Climate Change. All these aspects combined have an impact on the choice of methodologies to identify and analyse a certain phenomenon in these contexts of uncertainty. Given this incapacity for scientific or technical argumentation, the option often ends, as has been seen previously, by falling on the implementation of a Safeguard Line that causes a greater impact, which is more conservative. This type of decision is not a deliberate decision. It breaks with the type of decisions made in the past, and with a previously existing occupation model, drawing attention to an emerging and existing risk situation. Then, as knowledge evolves, data are updated, scientific and technical knowledge evolve, the methodology is improved and consequently, more coherent decisions are made regarding coastal management. In this sense, future generations will find it easier to draw and implement Safeguard Lines closer to their needs.

### V.3.2. DATA QUALITY AND AVAILABILITY IN SOUTH AFRICA

The interviewees point out some inherent weaknesses in the availability of information. In their understanding, there is a responsibility that must be assumed by the Central Government, and that, in some way, already begins to be visible and widely discussed. In this sense, some reference information has been made available under the OCIMS project through the Web Portal. It is understood that responsible and sustainable use of Geographic Information acquired by National level must be made. It is also necessary to make a survey of the information type to be acquired attending to the needs of possible users in order to expedite the contracting of information, supplying each one needs.

In the view of some key-actors, this information should be shared not only by all levels of Government and by whoever needs it, including consultants. The rationale for these arguments is that access to the latest information favours decision-making, allowing for better recommendations and decisions. In this sense, more coherent management in terms of cost-effectiveness, while avoiding the promulgation of laws, directives, reports and other relevant documents that are based on less rigorous Geographic Information. Thus, they consider that essential information such as LiDAR data, due to its degree of accuracy, should be made available on an annual basis.

The eThekwini Metropolitan Municipality shares this view. The municipality is flying LiDAR every year. In one year, data is acquired for the coastal strip and the year after, for the inland municipal territory. Thus, the municipality can update this type of information every two years. Although this capacity is only within the reach of some municipalities, its value is largely recognized. The municipality recognizes the importance of this type of information for planning in coastal zones in the sense that it allows verifying the coastal topography with great accuracy. Nevertheless, it is also used in other fields of management, namely in identifying and informing new informal settlements, so services can be addressed, or any other kind of required measure. In forests, it is used to survey canopy or to identify other types of changes such as deforestation.

In this sense, the municipality presents itself quite versatile in the use of this type of Geographic Information, recognizing a vast set of advantages in the acquisition of LiDAR data. It recognizes, in fact, some valences that have not yet been acquired and would contribute to significantly improve the modelling of CML. LiDAR is multi-beam and is, therefore, able to penetrate water, consequently, survey bathymetry. However, due to the high price of this functionality has not yet been acquired despite being part of the plans, given recognized value.

Data quality has been pointed out as a key issue and can make a difference in the approval process of any kind of document, namely legislative. The same applies to the scientific validity and integrity of CML. As in the first point of this chapter, there are still some asymmetries, both in terms of Provinces and Municipalities regarding this issue.

Thus, LiDAR data turned out to be the type of data most referred, also regarding to quality of Geographic Information in the modelling process of CML. At the Province administrative level, this type of information assumes a character of extreme importance. These are tasked with outlining and implementing the CML. However, key-actors remember that best available science does not come cheap and South Africa have around 3 000 km of coastline. To add to that, by the time interviews were made, South Africa was going to process budgeting and cost-cutting measures that may influence decision-making.

Two Provinces were reported to be using LiDAR data, Western Cape and KwaZulu-Natal. Northern Cape and Eastern Cape do not have LiDAR data, even though both are already developing their CML.

In this sense, some of the interviewed key-actors raised the question to what extent their CML will be valid without the use of LiDAR data. Northern Cape used a very different approach to the issue of coastal risk. The Province has identified coastal risk through the visual observation process based on the changes in the High Water Mark, crossing the entire coastline in an exhaustive and long fieldwork. This led to another concern, the CML alignment between coastal Provinces. It is already complicated the alignment of CML between Provinces using the same type of information, elaborated by different people with different skills, knowledge, and backgrounds. The fact that a completely different methodology is applied further increases this challenge. Alignment between Provinces has been to some extent mentioned as a challenge that has to be addressed, and, once again, the National Government must assume it as its responsibility. In this regard, the National Guideline Towards the Establishment of Coastal Management Lines, already drafted by the National Department of Environmental Affairs, when interviews were being performed at the end of 2017, was raising already some expectations.

In addition to the above-mentioned concerns related to the specificities inherent to availability and quality with a type of information such as LiDAR, other limitations related to Geographic Information, in general, were approached. In essence, these refer to the level of knowledge in GIS acquired by the various users associated with the determination of CML, with information date stamp; and scale of Geographic Information.

In South Africa, a person assigned as its primary function to work with GIS must be registered with the South African Geomatics Council[21]. Then, there are different levels of registration, which actually allow one to undertake different tasks. The Land Surveyors, they register with the same Council as well. As a GIS practitioner, one cannot do a cadastral survey because there is what is referred to as job reservation. In other words, anybody can draw, in this case, the line, but it needs to be verified by a person that is legally capacitated to supervise that work.

The pertinence of this issue would be followed by two other concerns associated with it, stemming from the existing inequalities in terms of human resources, technical expertise, in the different spheres of government, as well as the spatial information each has available to rely on.

Thus, it is important that, for whatever data type to be used, it must be as up to date as possible. It would not be responsible, for example, that the current HWM would be drawn based on a decade-long imagery. In turn, here the issue of resolution of the

[21] Available at: https://sagc.org.za/

imagery is equally important, to which a method is associated and that must be kept constant. A GIS person who is not particularly trained in GIS may start drawing a line on one day, and obviously, that line is being drawn at a certain suitable scale. If the next day that person or another person in charge for that task, for any reason, zoom out and continues the line drawing, there will be differences, error that just had been added to the work. In terms of accuracy, this is a huge downfall, and there are still many people performing these tasks who are not aware of these particularities, who do not have the adequate proficiency level, who do not have the necessary sensitivity to perform this type of task. Kastrisios & Tsoulos (2016) adds other limitation to the aforementioned, which relates to the fact that in order to respond to the actual needs, more than one software or modules are necessary. Besides, the steps necessary to perform these tasks are not exactly straightforward and can be time-consuming. Therefore, agendas must be met.

By contrast, the City of Cape Town has Geographic Information, human resources and knowledge accumulated over several decades, which combined, allows the municipality to have a rigorous understanding of the coastal zone. This intersection of factors allows for easily fulfilling any need that has to be met in terms of data quality with validation done in the field. This is an added-value that, as previously mentioned, is still within the reach of a small number of entities directly linked to this type of problem. In this sense, Overberg has sometimes been referred to as an example that brought some lessons to bear in mind, and that could have had a far more favourable outcome.

## V.4. ALTERNATIVE SPATIAL REPRESENTATIONS

### V.4.1. ALTERNATIVE SPATIAL REPRESENTATIONS: THE PORTUGUESE VIEW

Key-actors are in general pleased with what has been achieved. What is currently implemented in Portugal is more than a Setback Line, it is a deeper concept, restriction and interdiction regimes were associated. Interviewees refer to this union as a good marriage. It is a spatial management tool at the National Government level. Therefore, it was designed to safeguard national values, and this is assumed through these lines.

Regardless of what has been achieved, there is always more that can be done. What currently exists in Portugal is nothing more than a line along the coastline, which is, in fact, a polygon, or more. What could possibly be done and this would be no more than another line, than a set of polygons, would be to map the risk, but not in qualitative terms: high; medium; or low, but in Euro or Dollar instead. The investment, the number of people at risk, cultural values, etc, should also be mapped. In the view of key-actors, further attention should be given to the magnitude of the costs of the affected areas.

### V.4.2. ALTERNATIVE SPATIAL REPRESENTATIONS: THE SOUTH AFRICAN VIEW

The majority of respondents that had a word on potential alternative spatial representations often mentioned "overlay" in some way. It is crucial that people can see the spatial representation and understand it, have no doubts by looking at it, whether it is through a Web GIS or another GIS tool. In this regard Lathrop et al., (2014) remind that although it does not have all the functionality of a Desktop GIS, Web GIS has the required functions to bridge the communication gap between decision makers and non-experts. For key-actors this is a concern that arises from the publication in the Government Gazette. Maps are often small in size and have not the adequate resolution instigating doubt to their viewers. Therefore, an overlay zone could avoid misguidance and is seen as a better approach. Maps must also include a set of coordinates, a table of coordinates to validate the accurate position and extension of the affected area, to eliminate any doubt that could possibly arise.

In addition to the above concerns with spatial representation, some concerns were raised that derive from the quality of fundamental Geographic Information and that is directly associated with the skills of the technicians in charge of these tasks. Thus, this idea of an overlay zone is once again referred to as an alternative capable of generating less bias if elaborated through Remote Sensing techniques instead of GIS. There are strong convictions that Very High Resolution (VHR) Raster Geographic Information will produce better results. Even working with LiDAR. Maintaining VHR reduces the error that otherwise would be added through the generalization of Geographic Information, such as lines, points or polygons, captured in 1:10 000 vector layer, resulting from the interpretation of someone more or less proficient. Furthermore, the Remote Sensing community often has GIS knowledge, which is not entirely true the other way around. This is a more disciplined and controlled environment because of its technical aspects. In this regard, literature refers to a joint approach, using both GIS and Remote Sensing techniques as being effective and cost-effective in monitoring coastal dynamics (Ahmed et al., 2018).

Another concern that was raised, relates to the GIS Software that this more or less skilled community is using. It is given more trust to ESRI ArcGIS Proprietary Software than any Open Source GIS Software. Convictions are that because one is actually paying someone to perform a task, in return one will have more reliable results and reliable algorithms behind each functionality. Regarding Open Source GIS Software algorithms, there is still some uncertainty as to its accuracy, which, in addition to the existing mistrust regarding the interpretation and elaboration of Geographic Information by more or less qualified GIS technicians, suggests that an overlay zone performed through Remote Sensing Map Algebra may be a very good alternative to the actual CML spatial representation. Furthermore, hydrodynamic modelling and GIS were highly debated by National Government level interviewees. This topic acquired particular relevance in the work of Seenath et al. (2016), concerning coastal flood vulnerability assessment, being both the hydrodynamic models and GIS bathtub based models assessed in order to understand their limitations. Although both have shown limitations, the latter may overestimate flood vulnerability.

Regardless of the above, the strongest conviction is that, apart from of the path to follow, one cannot rely exclusively on modelling. As long as the social component is ignored, as long as engaging with the public is ignored, CML will hardly work. Thus, it has being argued as relevant to enhance communication between science and society, improving decision-making in planning and management issues (Gourmelon et al., 2014). Despite, South Africa has a well-founded tradition of risk. The coastal engineering discipline is a very powerful discipline and the knowledge that comes from that is a powerful knowledge. As soon as Social and GIS are merged, the whole process will move forward.

**Summary of the chapter**

In Portugal, the APA, a National Government level body, is in charge for the implementation of Safeguard Lines within the Coastal Zone Spatial Programmes and according to interviewed key-actors they have the knowledge and have contributed to implementation methodologies, despite, due to the reduced number of human resources, the country relies on consulting. In South Africa, only half of the coastal Provinces have both the knowledge and the human resources, Western Cape and KwaZulu-Natal. As well as in Portugal, South Africa is dependent on consulting mostly from engineering.

In both case studies, GIS is described as fundamental. In Portugal, the fact that GIS was not much developed in the first generation of Coastal Zone Spatial Plans is used to illustrate nonconformities at the planning level. In this regard, South Africa has been providing Geographic Information on these matters in various Web Portals, at various levels of Government. In the view of key-actors, there is no other way of doing these types of tasks. Current needs can only be met using such tools, with this degree of accuracy.

Regarding the third topic, required Geographic Information is not available homogeneously throughout the countries. To add to that, some of the information is fragmented and conceived under different methodologies and scales. Furthermore, part of the information that is still being used is not up-to-date, does not have the appropriate scale, or was not designed for the purpose of digital cartography. Although there is a great concern to overcome these inconveniences, there is still great discomfort, in both countries, regarding the lack of knowledge and information concerning bathymetry, which should be met as soon as possible.

Given the strengths and constraints, both countries recognize that there is still room for changes. Portuguese key-actors suggested that these types of mapping should comprise the magnitude of costs. South Africa, in turn, revealed concerns in the form Geographic Information reaches stakeholders. In their view, Web GIS can reduce doubts in stakeholders' perceptions, and the inclusion of coordinates, eliminate misunderstandings. Furthermore, Remote Sensing may reduce human error in the information, but while using GIS, better rely on Proprietary Software.

## DISCUSSION

The premise initially presented in the introductory section, that similar consideration should be given to the use of mathematical modelling (linked to Natural Sciences) and to an active involvement of the stakeholders (linked to Social Sciences) is partially confirmed by results delivered in the last two chapters. Thus, there are a number of reasons that justify the achieved results.

In the past, the use of coastal adaptation measures, associated with the use of setback lines, focused almost exclusively on fixed methods, with much more countries using fixed methods than floating or mixed methods, as presented in Chapter II. In turn, due to high pressures and urban interests in coastal areas, fixed methods have shown limited capacity in responding and containing urban fabric expansion. In addition, there are often associated exception regimes, which eventually give room to new constructions. Moreover, coastal defences were highly associated with coastal development, with the need to secure coastal infrastructure, and thus giving a (false) sense of security to users in these areas, reinforcing exception regimes – a trend that was found in both case studies.

The delineation process of coastal zones and boundaries used to be performed, in the past, by cartographers on paper charts. Only later, with the introduction of Geographic Information Systems (GIS) in these processes, such work became substantially eased and tasks or problems that were before hardly managed, encountered a range of new possibilities (Calado & Gil, 2010; Kastrisios & Tsoulos, 2016). According to (Batty, 2010), today, all geographical issues are somehow interconnected to GIS, whether it is through software, the system or the science.

To add to the aforementioned, in Portugal, only few Coastal Zone Spatial Plans benefited from the implementation of Risk Lines in its early generation. At this time, these were not mandatory, and resulted from existing human capital, available Geographic Information and technical capacity of the teams responsible for implementing the plans. In South Africa, key-actors referred to the Potential Erosion Lines and Building Setback Lines, being Durban and Cape Town mentioned as the most capacitated Municipalities. Nevertheless, in both countries there was a need to make these measures more effective, to set back and to tell people that they were not safeguarded from risk associated to coastal exposure.

In this sense, the requirements in terms of technical expertise, regarding the rationale of measures aimed at safeguarding people and infrastructure, making use of Geographic Information Technologies was reduced. Therefore, expected and obtained inputs from stakeholders in participatory methods were, as needed, equally scarce.

In time, the development and growth of coastal urban population (chapter III), sea level rise and escalation in frequency and magnitude of extreme weather events (chapter I), in both countries urged for the implementation of more effective coastal adaptation measures, such as the Safeguard Lines in Portugal and Coastal Management Lines in South Africa. This urgency is particularly accurate along the most populated coastal regions due to increased vulnerability and subsequent risk.

South Africa saw their Integrated Coastal Management Act gazetted in February 11, 2009, which referred to Coastal Set-back Lines, a concept that would be later reviewed and designated as Coastal Management Lines (floated methods) in October 31, 2014, by enacting the Integrated Coastal Management Amendment Act. According to the ICM Act, every management decision must be subject to consultation. In Portugal, with the entry into force of the Decree-Law no.159/2012 of July 24, which regulates the development and implementation of Coastal Zone Spatial Programmes, the "*participation, empowering the active involvement of the public, institutions and local agents, through access to information and intervention in the procedures of elaboration, execution, evaluation and revision*" is reinforced. To add to that, Safeguard Lines (floated methods) are now included in these Programmes through the same Decree-Law.

These instruments reinforced the importance of public participation as one of the fundamental principles by making its implementation mandatory (the ICM Act through Section 53, in South Africa and the Decree-Law no.159/2012 through Article 5, in Portugal). Public participation regarding environmental issues gained greater recognition early on in the Rio Declaration on Environment and Development, at the United Nations Conference on Environment and Development, held in Rio de Janeiro from 3 to 14 June 1992 (UNCED, 1992). The Declaration identified as relevant and significant the role of stakeholders participation in addressing climate change problems and more specifically their involvement in the development of adequate responses and was published in the United Nations Framework Convention on Climate Change (1992) (Few et al., 2007).

In Portugal, climate policy has become more relevant since the publication of the National Strategy for Integrated Coastal Zone Management approved by the Council of Ministers Resolution (RCM no.82/2009, of September 8) and recently reinforced by the Strategic Framework for Climate Policy, and the National Strategy for Adaptation to Climate Change (RCM no.56/2015, of July 30). The integration of these policies into coastal management was bolstered by the emergence of new technologies and more and better quality of Geographic Information (chapter V) and the growing need to implement measures to adapt to coastal hazards, namely those resulting from climate change (Chapter IV).

Nevertheless, some remaining constraints are worth mentioning. One is the institutional capacity to implement such measures in light of the changes introduced by the new coastal policies and directives. In Portugal, the central administration (through the *Agência Portuguesa do Ambiente* – APA) is responsible for the implementation of Safeguard Lines in Coastal Zone Spatial Programmes. In this regard, and according to the key-actors interviewed, APA has the knowledge and the people but they are manifestly insufficient to meet current needs. In South Africa, the Integrated Coastal Management Act attributes the responsibility of Coastal Management Lines implementation to the Provincial Level. The interviewed key-actors referred to the Western Cape and the KwaZulu-Natal provinces has the most capable of implementing such lines and the cities of Cape Town and Durban as having experience in these specific issues.

It thus can be said that the changes brought about by these new Territorial Management Instruments have not been accompanied by the need to strengthen knowledge and human resources in the institutions responsible for the implementation of these instruments. Consequently, and in the same way as in the past, the execution of these Programmes is carried out by teams of external consultants who thus put into practice the guidelines established by the Central Government (Portugal) and Provincial Government (South Africa).

Furthermore, other constraints identified in the past have not yet been overcome. In Portugal, coastal communities affected by coastal hazards and climatic changes, in general and according to literature, still have an insufficient level of knowledge that manifests itself in low numbers of participants in public participation processes and in low benefits for the decision-making process. At the same time, stakeholders perceive their contributions to be neglected, and therefore, in practice, the planning model retains its top-down character (Schmidt, Gomes, et al., 2013). Solutions to these constraints have been identified, such as the development of educational and citizenship programmes in order to bridge this gap (Craveiro, 2013b; Schmidt, Delicado, et al., 2013). Although, only a small number of people expressed to have already participated or acquired knowledge this way (Domingues et al., 2018). There is also a very entrenched culture of coastline protection, associated with a fear of decision-making, so contributions from stakeholders are usually vague, opting for "waiting and see", supported in reactive measures, ruling out any possibility of implementing measures adaptation (Few et al., 2007).

In South Africa, stakeholders' contributions have been equally scarce. According to the key-actors, the majority of stakeholders are poorly informed and indifferent to decision-making initiatives, even though these are largely advertised. In this regard, and in the view of key-actors, changes brought by the ICM Act attribute a major importance and weight to stakeholders' participation in decision-making. It is now considered crucial. Nevertheless, a couple of considerations must be mentioned. One is that CML should be drawn in consultation with all coastal communities and stakeholders. This has been referred to as the politically correct, from academic, political and social points of view. The other is that the former political regime created tremendous inequalities in terms of human occupation in coastal areas (Colenbrander et al., 2014). In this regard, a wealthy way of living associated to the coastline is now desired by every South African that as a wish for living nearby the coast and so, any restriction or prohibition to development associated to coastal hazards and climate change, are not socially well accepted, despite of the risks associated.

According to Gibbs (2016), there are a few reasons which can be particularly associated with the constraints in the implementation of such adaptation measures, highlighting a considerable array of studies, the sense of belonging from private owners of dwellings or properties. This sense of ownership is manifested into different aspects. It can be considered more social or emotional as it is related to the family or a sentimental connexion to the property or dwelling. This sense of belonging is also manifested having in consideration an economic perspective associated with the implications that the implementation of setback lines as an adaptation measure to sea level rise and related hazards might have on property or dwellings market values. Lastly, but not less important, is how climate change threats are perceived by private owners. Somehow, medium- to long-term hazard impacts are, tendentiously, not that well understood and consequently not well accepted. The immediate threats are now as relevant for private owners as adaptation measures are for coastal managers in the medium- to long-terms.

Regarding both the case studies, stakeholders are called upon to intervene in decision-making processes, which should happen since procedures of elaboration, execution, evaluation and revision are in place. Nevertheless, it is not what have been happening in practice and both countries have been dealing with this premise differently. When interviews occurred in South Africa, none of the CML had been approved as required by the ICM Act. Although municipalities have gone forward with drafting setback lines.

In the Overberg District Municipality, a private consulting team of coastal engineers, who established a period of six months for a formal public participation process in 2011, determined the setback lines. In the City of Cape Town, the municipality delineated setback lines. The process started in 2007 and with it continuous engagement with different groups of stakeholders through formal and informal meetings. The first was done through desktop analysis based on empirical modelling of biophysical processes and results were not validated due to time and budget constraints. The last considered biophysical processes but was more people centred. As a result, the first was highly contested due to not considering private sector socioeconomic factors, devalue of properties, and causing serious implications to the economy, while "*the shortness of the period of public engagement led to a negative and in some respects hostile response toward the process of defining the set-back*". In turn, the latter had the support of 97% of involved stakeholders and was formalised in 2012 (Colenbrander & Sowman, 2015).

In both the case studies key-actors referred as a common point the greater difficulty in applying these lines in urban environments by contrast with more natural environments. The rationale was that with no exposure of people and infrastructure, there is no risk, there is nothing to dispute, the process is considered to be simple, which is corroborated by Gibbs (2016).

Although it was not that straight forward in South Africa. It was considered that environmental pillars of governance would not reflect the needs of least favoured population groups in the Apartheid regime. In this regard socioeconomic and political issues were considered in the equation in order to find solutions in least developed coastal areas to promote equality and at the same time avoiding risk from coastal hazards (Colenbrander & Sowman, 2015). In this sense, the City of Cape Town seems to have open an exception in what was generally stated by interviewed key-actors, suggesting that the repercussions will be felt transversally across several coastal regions of the country, given the significant inequalities that resulted from the previous regime. Therefore, least developed coastal areas, may be subject development interventions of equal type.

In Portugal, at the time of the interviews, only one POC had been approved, the Ovar – Marinha Grande (RCM no.112/2017, of August 10). The Programme followed a similar approach to the Overberg District Municipality. It privileged a model based on technologies grounded in natural sciences. Stakeholders were consulted after advertisement for a period of 20 working days, between November 4, and December 1, 2015, in the fourth of five methodological phases. Given the robustness of the mathematical model, the considerations of stakeholders regarding Safeguard Lines were "*not considered*" by the team of experts (CEDRU & Universidade de Aveiro, n.d.).

The POC Alcobaça – Cabo Espichel was later approved in April 2019, through the Resolution of the Council of Ministers no.66/2019. The consultation period was similar to the previous POC, although slightly longer, during a period of 30 working days, between April and May 2017 (DRE, 2017). The POC Caminha – Espinho is waiting for approval and had a consultation period that lasted from November 5 until December

14, 2018. In both, stakeholders entered the process at an advanced stage of execution of the programme, just before completion, similar to the first POC mentioned above. In Alcobaça – Cabo Espichel stakeholders consultation took place in the third of four phases according to the chronogram (APA, n.d.-b), where in Caminha – Espinho, in the fifth of six phases (APA, n.d.-c).

In this regard, some considerations deserve to be highlighted. In both countries, relevance is given to the involvement of stakeholders in decision-making through participatory processes. Literature refers to six months of public participation as not being enough to engage with stakeholders in the case of the Overberg District Municipality, compared to the period of time in the City of Cape Town. This is due to changes occurring in terms of coastal management legislation (Colenbrander & Sowman, 2015).

In Portugal, changes in policy recognized existing weaknesses regarding the low participation of stakeholders in public participatory processes and reduced inclusion of their contributions. Despite of the ENNAC (2015) refer to the need to enhance stakeholders involvement, promote training and raising awareness as well as through other participatory mechanisms; stakeholders engagement to be considered a key component in coastal management and adaptation processes (Schmidt, Gomes, et al., 2013); the largely recognized imbalance between poor participative decision-making processes and excessive significance given to knowledge produced by natural sciences (Pires et al., 2012; Veloso-Gomes et al., 2004); of the principle of public participation being reinforced in Article 5 of Decree-Law no.159/2012 of July 24; and the Law on Public Policy Soil, Territorial Planning and Urbanism further reinforced the principle of participation in all components, namely drafting; implementation, evaluation and review of territorial programmes and plans (Law no. 31/2014 of May 30), there were not significant changes in terms weight and importance given to public participation in the new generation of POC.

With average schedules around 30 days for public participation, two of the three POCs previously mentioned are already approved. There were no challenges expressed relative to Safeguard Lines implementation, as the number of the participations registered, was low.

Furthermore, it was evident that in the Portuguese case study, the political old regime did not have the impact that the South African political old regime is having. Thus it is a fact that determination of any type of setback lines *"cannot be limited to any single discipline, but should rather be informed by various disciplines and knowledges across both the natural and the social sciences"* and therefore, "*one should abandon an exclusive focus on biophysical risk modelling and adopt a more holistic, integrated, and interdisciplinary approach that incorporates socioeconomic, cultural, political, and ecological consideration*" (Colenbrander & Sowman, 2015). In this sense, the methodology proposed by the City of Cape Town, far less conservative and more people centred favours its implementation. In contrast, the methodology first used in the Overberg District Municipally was highly contested. Nevertheless, Portugal, with a similar methodology, less time dedicated to public participation and far more restrictive Safeguard Line regimes was able to implement Safeguard Lines in considerably less time according to the entry into force of the new legislative framework.

Thus, as mentioned initially, the premise that coastal boundary demarcation lines must be based on two fundamental pillars, the GIT and the public participation turned out not to be seen as a whole. The answers given to the relevance of the GIT/GIS (chapter V sections V.2.1. and V.2.3.) would somehow predict this differentiation in how the subject is approached in both case studies. In the Portuguese case study the answers were straightforward, as in the case of South Africa, however, reservations were made, one of which refers to the data quality.

In this sense, Portugal recognizes the importance of homogenizing the coverage of Geographic Information from North to South. Yet, some limitations have been identified that are still awaiting resolution. On low-lying coastal areas is still diffuse and fragmented and consequently has different methodologies in its design. Key-actors also mentioned the non-existence of spatial information in some locations in cliff coastal areas. Key-actors attribute the responsibility of Geographic Information acquisition to Central Government, ensuring national coverage. In this regard, key-actors underlined the need for this information to be openly shared once the best and most up to date favours decision-making, allowing for better recommendations and decisions.

Further requirements were recognized to be a need in both countries. Key-actors acknowledge that better modelling would arise with the acquirement of accurate bathymetric data, which would consequently improve decision-making (Li et al., 2019). In South Africa this type of Geographic Information is recognized to be better acquired through LiDAR sensors due to the degree of precision. Furthermore, both countries are already using LiDAR data for terrestrial coastal areas.

Regarding accuracy, in Portugal, key-actors mentioned concerns related to the Datum used in the first LiDAR flight from 2001, and the second and the latest flight in 2011. The first flight uses Datum 73 while the second uses the Datum ETRS89. Thus, by recognizing the existence of overlying errors resulting from the transformation of coordinates from one Datum to another, given the detail of this type of information, one can suggest the occurrence of landslides, retreat or other types of movements in cliff coastal areas that in fact did not change in this period. The same is true for low-lying coastal areas. Regardless of the type of data being use, or purpose, key-actors extolled the need to validate the information through fieldwork and thus minimize possible errors that otherwise would not be possible to detect through work done by desktop analysis.

In South Africa the value of this type of information was largely recognized, and for key-actors, LiDAR data should be updated every year in order to better support changes occurring in such dynamic spaces. None of the countries is updating LiDAR data for coastal purposes with an annual basis. However, the eThekwini Metropolitan Municipality is updating LiDAR data for this purpose every two years.

Still in relation to this subject, in Portugal, being the most up to date LiDAR data from 2011, and considering that there are still POCs that are not yet or are already being prepared, or are still awaiting approval (see table IV.2.1.10 and figure IV.2.1.33), it is expected that this information may bring some additional error. Thus, it is possible that, as verified in the Safeguard Lines already implemented, a more conservative methodology is used and therefore, these may cause a greater impact from a social point of view. Again, it is not a deliberate decision but rather opposing to mistakes that have been made in the past regarding coastal management at the same time it draws attention to the current situation regarding coastal hazards and exposure in developed environments. In South Africa, data quality and availability, and scientific integrity and validity is a key issue regarding the approval process of CML.

In this regard, a caveat has to be made to the methodology that is being adopted in Portugal. A methodology described as solid, must consider in its development the most up to date Geographic Information, which is completely different from the best available information. Finally, as seen in the South African case, a methodology highly based on an extensive fieldwork component (Northern Cape) is equally penalizing as to a methodology that strongly emphasizes a Desktop analysis (Overberg District Municipality). Thus, and recognizing the agenda constraints often associated with these planning processes, it is understood that a balance between all components must be met.

## FINAL REMARKS

Coastal zones defined in literature as the interface between the land and the sea are highly dynamic territories, encompassing a great diversity of ecosystems namely, beaches, cliffs, coral reefs, deltas, dune systems, estuaries, mangroves, rocky shores, salt marshes, submerged vegetation and wetlands, and attracting wide-ranging uses and activities such as housing, industry, services, and tourism and leisure activities. Nevertheless, there is no agreement on spatial boundaries that define such areas, being this much dependent on individual views established mostly at National Government level. Definition of these areas is essential for planning interventions, which differ according to the type and scope of management instrument.

These attractive spaces are highly biodiverse and valued from a socioeconomic point of view, being more densely populated compared to other inland regions. Consequently, people and infrastructure here located are more vulnerable to coastal extreme weather events and sea level rise, exacerbated by the effects of climate change. The literature refers to sea level rise scenarios reaching up to two metres in 2100, which may exceed six metres by 2500. To add to it, extreme weather events are increasing in frequency, duration, and intensity. Scenarios on population also refer to global increase inhabitants of coastal zones, which is accurate for both case studies and where both natural and human pressures will see their impacts magnified.

Regarding constraints from exposure, decision-making processes have been historically characterized by reactive responses defined in the literature as the act of defending, being an immediate need of response to current and further threats in order to try to secure people and infrastructure from coastal hazards. Despite, natural and human pressures are raising the need to maintain and keep more coastal areas protected. At the same time, costs are increasing, hindering the task of protecting every stretch of the coast that may require intervention. In addition, there have been records where coastal defences have been manifestly insufficient to cope with the changes that have been driven by climate change.

Thus, more adaptive coastal management measures have been emerging in order to fill the gaps being left by reactive management initiatives. Adaptation measures seek for medium- to long-term solutions making precise interventions today. While coastal defences are more environmentally disrupting, the latter are described as socioeconomically disrupting, considering relocation of people and infrastructure and imposing rigorous restrictive regimes to further urban development in highly exposed coastal fringes to coastal hazards.

Regardless of any sort of constraints, Portugal and South Africa are shifting to more adaptive coastal strategies. Both countries have historically been expanding their artificial coastal areas along with an increase in population. Both kept that trend, continuing to increase population in coastal zones and scenarios foresee such tendency to continue in the next decades along with the expansion of artificial areas.

Both case studies have been using coastal hard and soft defences and enforcing adaptive measures such as fixed setback lines. Results have proven fixed setback lines not to be efficient in halting uncontrolled development in result of poor control mechanisms, fragmentation of competencies, and imposed restrictions often allowed for exceptions (which seemed to be the norm) prescribed in those territorial management instruments.

The end of the Twentieth century is guided by the introduction of individual adaptation measures related to setback lines, but only recently, floated setback lines acquire National scope with the emergence of new legislative instruments.

In Portugal, with the entry into force of the Decree-Law no.159/2012 of July 24, risk issues have become more relevant, and despite some doubts were raised regarding the mandatory implementation of Safeguard Lines, which in the view of few key-actors is unclear in the drafting of the legislative document, these floating setback lines are now being implemented nationally by every POC. South Africa have made Coastal Management Lines mandatory through the entry into force of the ICM Act in 2009.

Regarding the enforcement of floating setback lines, it was expected that, according to the literature review, issues associated with public participation would have acquired similar relevance in the methodologies used in both countries at the same time that mathematic modelling would level the relevance of the first, smoothing the significance attributed to natural and social sciences in decision-making processes.

International directives have been referring to the importance of public participation in decision-making processes as crucial, particularly those linked to climate change processes. Academia has largely recognized the advantages of public participation initiatives and national strategic frameworks and legislation have been including public participation in their recommendations, assuming that these should be part of the entire process.

Results for the Portuguese case study lead to conclude that in spite of the fact that international directives have been recognized and included in the national framework, there is still a considerable distance between theory and practice. Portugal is drawing their lines exclusively supported in mathematic modelling. Existent Geographic Information was acknowledged to be, sometimes, not the most appropriate or inexistent, which are offset by wider criteria. Public participation has registered no changes, in the sense it is still entering in the process at an advance stage of the programme. In this specific topic, contributions were not considered due to the methodology being described as scientifically solid. Nevertheless, inputs from stakeholders were considered in other subjects. In this regard, results suggest that in order for natural and social sciences to level their contributions, further modifications are still missing in the actual framework. Human resources are still in short number and do not match current needs, and both Government bodies and consultancy have constraints of agendas that have to be fulfilled. Consequently, the implementation of participative initiatives, as described in territorial management instruments, would require more time and increased costs in order to fulfil the requirements related to a broader participatory process.

In South Africa, as in Portugal, the lack of human resources is seen as a constraint, which ultimately ends up being reflected in the whole process. The results lead to conclude that because the implementation of the CML is a competence of the Province and because there was not a framework document for a unique methodology, it has further delayed the process. This constraint would be overcome with the publication of such document, led by National Government. In addition, similar to Portugal, South

Africa has identified constraints related to the availability and suitability of Geographic Information. However, results suggest that this may be overcome by the great significance given to public participation. The former regime largely favoured the use of the coast to a small part of the population, which is now associated with wealth generation. Thus, the fall of the authoritarian regime came to highlight a social problem for which the natural sciences alone cannot address. Therefore, a model that promotes greater equality can only be achieved through a more permissive approach, based on a governance model that actively seek to include citizens in the discussion of issues and in decision-making processes.

This is where up to date (and best available) Geographic Information gets interesting. It is methodological relevant to provide accurate information but not essential to delineate this type of setback lines. In this regard, academia, namely knowledge from the social sciences, proved to be closer to the decision-making processes in South Africa than in Portugal, although not for the best reasons.

Finally, and as results suggest, a framework that acts as a model, foreseen in the fourth bullet of the introductory chapter, is thus limited by the specificities of each territory. Portugal did not present major issues regarding the implementation of Safeguard Lines, unlike South Africa who presented various methodological constraints both in terms of the natural sciences but essentially at the level of the social sciences.

These results point to the need for further developments. The non-validation of the assumption that both “hard” (mathematical modelling) and “soft” (stakeholders’ involvement) components of the problem should have similar considerations clearly shows that the latter proves a greater challenge to the efficiency of future adaptation measures. In fact, setback lines alone do not prevent risk and potential loses, whether developed areas are included or not. As such, it should be imperative to understand exactly what institutions and the public has to gain (now and in the future) with processes of public participation. In this regard, it will be important to study the problems associated with decision-making and negotiation processes emerging from highly complex problems such as the ones studied here.

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