

FUTUROS DA ÁGUA
RESILIÊNCIA,
GOVERNAÇÃO
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Abordagem multiescalar baseada em dados de satélite para a análise de tendências da linha de costa em Portugal Continental

Satellite-driven multi-scale approach for shoreline trend analysis in Mainland Portugal

Andreia Alves da Silva

Luís Pedro Almeida

António H.F. Klein

Resumo

Portugal continental possui cerca de 415 km de costa baixa-arenosa, dos quais 45% apresentam tendência de erosão. Com o objetivo de quantificar as tendências de variação da linha de costa portuguesa, foi usada a ferramenta CASSIE (Coastal Analyst System from Space Imagery Engine) e imagens Sentinel-2 (2015-2023) para gerar as linhas de costa, que foram analisadas em três escalas administrativas: nacional, regional e municipal. Os resultados indicam que 41% dos setores são estáveis, 31% em acreção, 19% em erosão e 9% em erosão crítica. O município de Ovar é o que apresenta a maior taxa média de erosão (-2,6 m/ano), abrangendo algumas das praias que apresentam os índices mais críticos de erosão costeira.

Palavras-chave: Linha de Costa, Monitorização Costeira, Erosão Costeira.

Andreia Alves da Silva

Luís Pedro Almeida

CoLAB +ATLANTIC, IPL-ESTM, Peniche, Portugal

António H.F. Klein

Coordenadoria Especial de Oceanografia, Universidade Federal de Santa Catarina, Florianópolis, Brazil

[0000-0002-2767-6671](https://orcid.org/0000-0002-2767-6671)

[0000-0001-7805-9086](https://orcid.org/0000-0001-7805-9086)

[0000-0002-2565-8891](https://orcid.org/0000-0002-2565-8891)



Abstract

Mainland Portugal has approximately 415 km of low-lying sandy coastline, 45% of which show an erosion trend. In order to quantify the shoreline trends, the CASSIE (Coastal Analyst System from Space Imagery Engine) tool and Sentinel-2 images (2015-2023) were used to generate the shoreline position, which were analyzed at three administrative scales: national, regional, and municipal. Results indicate that 41% of sectors are stable, 31% accreting, 19% eroding, and 9% critically eroding. Ovar municipality shows the highest average erosion rate (-2.6 m/yr), encompassing some of the beaches experiencing the most critical coastal erosion rates.

Keywords: Shoreline Position, Coastal Monitoring, Coastal Erosion.

Introduction

Portugal is a coastal country with a mainland territory composed of ~415 km of low-lying sandy coastlines. According to the Portuguese Environmental Agency, 45% of these low-lying areas registered a long-term erosion trend (Agência Portuguesa do Ambiente, 2024). These regression rates can be attributed to various factors, such as changes in sediment transportation, as result of an hhard engineering of coastal structures, and the construction of river dams during the 1950's. Identifying and mapping coastline variations is not only crucial for an effective coastal management, but to also pinpointing erosion hotspots along the sandy coasts.

Remote sensing tools such as CASSIE (Coastal Analyst System from Space Imagery Engine), represent a promising solution to address this challenge. This open-source free web-tool utilizes co-registered historical satellite imagery to automatically extract the waterline and perform several statistical analysis (Almeida et al., 2021).

In this work, CASSIE web tool was implemented to quantify the trends of the shoreline position of mainland Portugal beaches. With this information, it was possible to identify the coastal sectors that experienced erosion, stability, or accretion, and conduct a multi-scale approach that includes three different administrative levels: i) National; ii) Regional, and iii) Municipal.

Methodology

CASSIE web tool was applied to generate the statistics for mainland Portugal. The purpose was to analyse the short-term evolution of the coastline, therefore, the satellite mission used was Sentinel-2 (from 2015 to 2023). The shoreline used to generate the transects was defined based on the waterline. The transects were generated, with a spacing of 100 m, transversal to the waterline. The administrative chart of Portugal was also used and

intersected with the transects, to provide a multi-scale approach.

A post-processing was later applied to delete the non-high tide data, and to reduce the possibility of errors related to a terrace. The linear regression rate (LRR) was accessed for all the sandy points.

Results

The results shown in Figure 1, reveal that 41% of the analysed transects show shoreline stability ($LRR > -0.5$ & < 0.5 m/yr), 31% show accretion, 19% are experiencing erosion, and 9% critical erosion ($LRR < -2$ m/yr). The thresholds were adapted from Luijendijk et al., (2018).

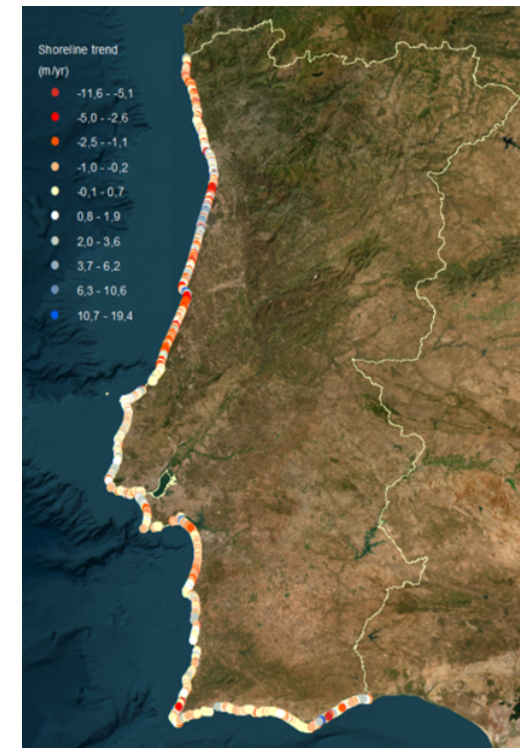


Figure 1. Shoreline trends for mainland Portugal (2015-2023).

Using a more detailed scale analysis, municipalities aligning with national trends and most affected by coastal erosion were identified, based on municipal averages of LRR. From all the analysed municipalities, Ovar is the one with the highest average erosion rate (-2.35 m/yr).

At the beach level, the highest mean erosion rates registered were: Praia das Furnas, Odemira (-8.4 m/yr), Praia de São Pedro de Maceda, Ovar (-6.1 m/yr), Praia das Dunas de Ovar, Ovar (-5.4 m/yr), Praia da Cova Gala (south), Figueira da Foz (-4.1 m/yr), Praia da Cova Gala (north), Figueira da Foz (-3.6 m/yr), Praia do Furadouro north, Ovar (-2.9 m/yr), Praia da Costa de Lavos, Figueira da Foz (-2.8 m/yr), Praia da Falca, Alcobaça (-2.7 m/yr), and Praia do Furadouro south, Ovar (-2.6 m/yr).

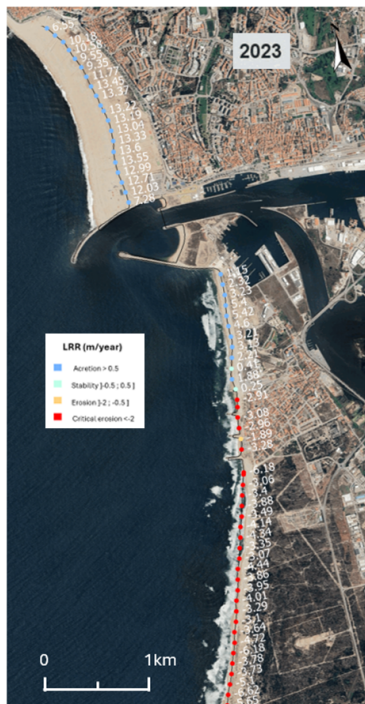


Figure 2. Shoreline trends for a sector of Figueira da Foz municipality.

Discussion

The comprehensive data approach reveals that the municipalities with the highest erosion rates may not necessarily correspond to those with the more beaches with critical erosion rates. One example is the Figueira da Foz Municipality, that has a mean LRR of 0.5 m/year and is classified as a stable, eventhought there are 3 beaches classified as “top beach erosion” located in this municipality. This is the result of the impact of the northern jetty extension of Figueira da Foz Port (in 2009). It generated accretion in the north beaches of the port and critical erosion in the south. The CASSIE results were able to detect these rates (Figure 2).

Conclusion

Analysing the results by municipality, we emphasize the importance of always considering the geomorphological context of the area, as the results may: 1) Experience critical rates in beaches strongly influenced by fluvial dynamics of sediment transport, as seen with Praia das Furnas, at the mouth of the Mira River; 2) Present stable municipalities with beaches undergoing critical erosion: the case of Figueira da Foz, where two beaches are experiencing critical erosion, which, in spite of significant areas of coastal erosion within the municipality, there are other sectors characterized by stability and accretion, resulting in a stable average rate of 0.5 m/year, underscoring the importance of examining with a more detailed scale of analysis; 3) Be similar to the existing knowledge for the municipality, such as with Ovar, which has the highest erosion rate (-2.6 m/year), encompassing some of the beaches experiencing the most critical coastal erosion rates.

The CASSIE tool can be applied globally, is freely accessible and serves as an essential tool for addressing coastal dynamics, playing an important role in coastal management. Additionally, it is worth noting that CASSIE's results are shown similar to those

from previous studies (Aleixo Pinto *et al.*, 2021). Nonetheless, its use should be complemented with the geomorphological settling of the area.

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