National Roadmap for Adaptation XXI

Portuguese Territorial Climate Change Assessment for the XXI Century





The future of the Portuguese coastal areas under climate change

Iceland

Liechtenstein

Norway grants

REPÚBLICA PORTUGUESA

MBIENTE E ENERGIA



© Agência Portuguesa do Ambiente

Coastal vulnerability projections

The Portuguese coastal areas are projected to become extensively vulnerable to the impacts of climate change, arising from sea level rise and its combination with tides, storm surges and waves. Vulnerable ocean-facing coastlines are expected to ascend to **41.7** km² (2070 under RCP4.5), **49.7** km² (2070 under RCP8.5), **54.7** km² (2100 under RCP4.5) and **55.9** km² (2100 under RCP8.5). These areas, related to episodically flooded territory under extreme coastal events, amount to **3.09**, **3.68**, **4.05** and **4.14** times the Portuguese coastal area lost between 1958 and 2021 (13.5 km²). Considering the impact on inland waters (estuaries and coastal lagoons), an additional vulnerable area between **514** km² (2070 under RCP4.5) and **548** km² (2100 under RCP8.5) must be considered. For all Portuguese coastlines, future projections reveal up to **604** km² of vulnerable area by 2100, under the RCP8.5 scenario.

The benefits of adaptation

The increase in human pressure along the Portuguese coastlines calls for effective coastal management, sustainable development, adaptation, and impact mitigation strategies, strategically defined to withstand changes until 2100 and beyond.



Severe Impacts of Inaction

Global warming is driving sea level rise, but also changes in ocean waves and storm surges. Their combination is projected to result in more frequent coastal flooding in the future. If no action is taken, physical and socioeconomic impacts will be severe.

Significant benefits of adaptation

Adaptation measures could help avoiding up to 14200 million € of the economic costs in a no-action scenario.



© AZUL

RNA2100

The RNA2100 project the aims to support public policy exercises of adaptation to climate change, at different levels of territorial intervention in Portugal. RNA2100's main aims include the characterization of climate change physical and socioeconomic impacts on the Portuguese most vulnerable domains, the assessment of financial costs and needs, and the implementation of a National Spatial Planning Policy Programme.

Further information is available at https://rna2100.apambiente.pt/

National Roadmap for Adaptation XXI

Portuguese Territorial Climate Change Assessment for the XXI Century





Artificial beach nourishment

Since 1950, a total of **46.5 million cubic meters** of sediments has been deposited along Portuguese beaches and shoreface, an investment totalizing more than **200 million euros**.

Although projections indicate a slight reduction of the erosive trends towards the end of the 21st century, more than **1200 million euros** are required to maintain the current degree of protection commitment – by 2100 under the RCP4.5 scenario.

Accommodation against coastal hazards

The required heights for the coastal protection structures to withstand the future projected extreme coastal events (considering the possibility of severer events) are set at **8.23 m** (Norte), **7.06 m** (Centro), **8.40 m** (AML), **8.09 m** (Alentejo) and **7.77 m** (Algarve), for ocean-facing coastlines, and at **3.45 m** (Norte), **3.29 m** (Centro), **3.11 m** (AML), **3.05 m** (Alentejo) and **2.99 m** (Algarve) for inland waters – by 2100 under the RCP4.5 scenario.

Portuguese Adaptation Pathways

Norte

Moderate to high vulnerability (related to flooding at least once every 25 and 4 years), is projected as soon as by the mid-21st century, along **8.0– 10.3** km² of ocean-facing and **12.7–14.3** km² of inland waters' coastlines. Inaction costs top at 985 million € by 2100 under RCP4.5, from over 6200 vulnerable residents and 2300 buildings.

Proposed adaptation measures include artificial beach nourishment at least until the beginning of the 2040s, demolition of exposed illegal or nonessential structures, accommodation of adherent structures (seawalls, breakwaters) and finally, planned relocation of the most exposed urban segments (progressively after 2050).





Centro

Highly vulnerable areas are projected as soon as by the mid-21st century, along **16.3–20.3** km^2 of ocean-facing and **59.0–64.7** km^2 of inland waters' coastlines. Inaction costs exceed 2000 million \in by 2100 under RCP4.5, from over 12000 vulnerable residents and 6100 buildings.

Proposed adaptation measures focus on artificial beach nourishment to re-stock the most problematic areas, while accommodation of adherent structures (often present in the region) takes place. Planned relocation is considered a viable option after 2050 along the most exposed urban segments.

Lisbon Metropolitan Area

Lisbon Metropolitan Area (AML) reveals highly vulnerable areas essentially along the Tagus River estuary and the sandy coastlines of Caparica, within the next five decades. Vulnerable areas range from **3.0–3.4 km²** for ocean-facing coastlines, and **217.0–218.2 km²** for inland waters. Inaction costs may exceed 3800 million € by 2100 under RCP4.5, from over 18000 vulnerable residents and 4500 buildings.

Proposed adaptation measures focus on continuous artificial beach nourishment for urban and/or anthropized beaches, accommodation of seawalls and tidal dykes (from the 2040s onwards), demolition of illegal exposed infrastructure and finally, planned relocation of the most exposed urban segments (after 2070).



National Roadmap for Adaptation XXI

Portuguese Territorial Climate Change Assessment for the XXI Century

Planned relocation

The demolition of illegal or non-essential infrastructures is considered a priority throughout the Portuguese coastline. After 2050, progressive planned relocation becomes the most cost-effective measure in several densely urbanized coastal stretches of the Norte and Centro regions. For the AML and Algarve, relocation is suggested after 2070, whereas for Alentejo the most pressing period starts in 2100.

Adaptation pathways

Potential sequences of adaptation measures which can be progressively implemented, depending on future projected dynamics. Produced for each 2013 NUTSII region, pathways recognize the increased need for artificial beach nourishments in the Norte and Centro regions, prioritizing planned relocation actions as soon as by 2050.



Methodology

Contact information

Gil Lemos (grlemos@ciencias.ulisboa.pt) Carlos Antunes (cmantunes@ciencias.ulisboa.pt)

Projections of sea level rise, storm surges, tides, and ocean waves, under a moderate mitigation scenario (RCP4.5) and high emissions scenario (RCP8.5) were used to project extreme total water levels towards 2100, then used to compute the future Coastal Vulnerability Index (CVI) along the Portuguese coastlines (including inland waters). Total inaction costs were estimated as a function of the patrimonial value of vulnerable buildings and land, and adaptation costs were calculated based on the six most prevalent interventions at national scale (artificial beach nourishment, cliff stabilization, maintenance of groins, breakwaters, dykes and adherent structures, as well as their accommodation). Adaptation pathways were build based on the cost-benefit analysis between inaction and adaptation costs, for each of the five 2013 NUTSII Portuguese regions.

RNA2100 publications - https://rna2100.apambiente.pt/pagina/programa-ambiente-alteracoes-climaticas-e-economia-de-baixo-carbono



Alentejo

Portuguese Adaptation Pathways

Coastlines facing inland waters are projected to become more widely threatened, in comparison to the ocean-facing ones. While projections revealed **7.9–9.8** km² of vulnerable ocean-facing, **198.8–212.9** km² of vulnerable inland waters' coastlines are expected. Inaction costs top at over 230 million \in by 2100 under RCP4.5, considering over 800 vulnerable residents and 600 buildings.

Proposed adaptation contemplates only limited artificial beach nourishments, especially in relevant pocketed beaches south of Sines. Accommodation of preexisting infrastructures may be considered, especially in the Sado River estuary and Sines harbor. While planned

relocation of the few urbanized coastal stretches may be only be necessary after 2100, the demolition of illegal exposed infrastructures is advised within the next decades.

Algarve

Highly vulnerable areas are projected throughout most of the Algarve coastline, as soon as by the mid-21st century, totalizing **6.5–12.5** km² of ocean-facing and **36.2–40.8** km² of inland waters' coastal areas. Inaction costs are estimated at nearly 5000 million €, from over 15000 vulnerable residents and 6600 buildings.

Proposed adaptation measures include artificial beach nourishment at least until 2050, depending essentially on the beaches' relevance for tourism, demolition of illegal exposed infrastructures,

accommodation of adherent structures and finally, progressive relocation of the most vulnerable urbanized stretches (generally after 2070).



