IECAG 2025 Conference

How Climate Change Could Affect Drought Risk in Portugal's Traditional and Super-Intensive Olive Orchards

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Introduction

- Portugal is one of the top 10 olive producers in the world;
- Low and intermediate olive orchard (OR) densities are found in northern Portugal, even intensive and super-intensive are found in southern regions;
- Droughts are driven by recurrent and persistent precipitation deficits;
- The increase frequency and intensity of drought can cause physiological and biological effects in plants.

Objective

Assess future drought and aridity conditions and the impacts on ORs located in the PDOs.

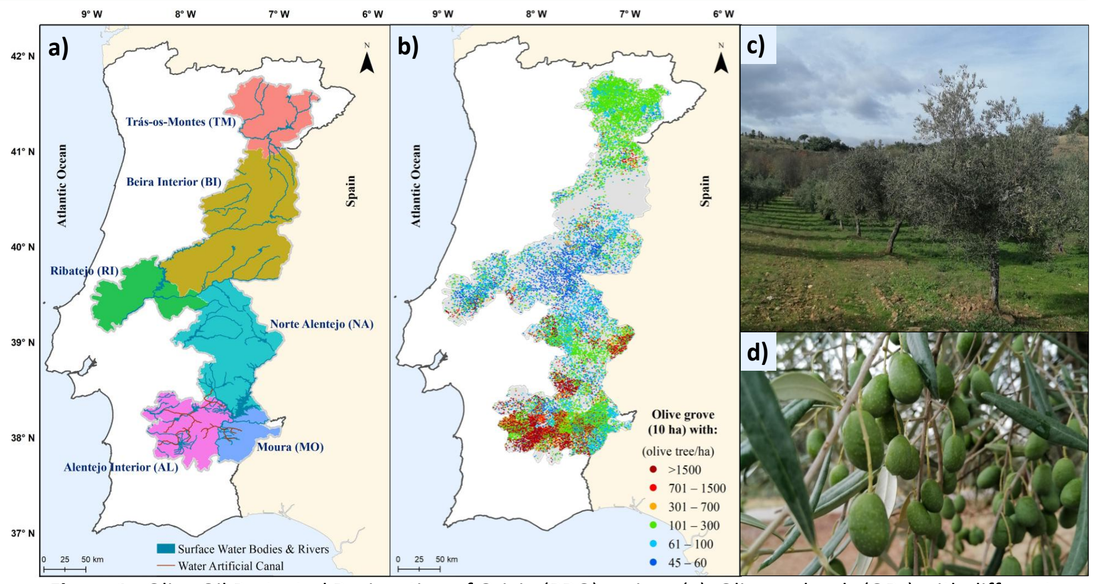


Figure 1 - Olive Oil Protected Designation of Origin (PDO) regions (a), Olive orchards (ORs) with different densities in Olive Oil PDOs (b), olive orchards (c) and olive fruit (d) (photos taken by Ana Gonçalves).

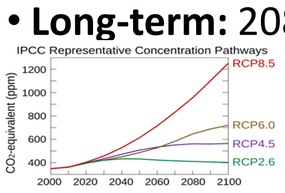
Material and Methods

1 Database selections

BIOCLIMATE_1km_CMIP5

(Climatic dataset, 1 km × 1 km)

- **Historical period:** 1981–2000
- **Medium-term:** 2041–2060
- **Long-term:** 2081–2100



- **RCP scenarios:** RCP4.5 e RCP8.5

Figure 2 – Representative Concentration Pathway (RCP).

INFOSOLO

(Soil dataset)

2 Bioclimatic Indicators

Climate data

- **AIA** (Aridity Index, annual mean)
- **AIW** (Aridity Index in Winter)
- **AIS** (Aridity Index in Summer)
- **DD** (Dry Days)
- **MIDS** (Mean Intensity of Dry Spells)
- **MLDS** (Mean Length of Dry Spells)

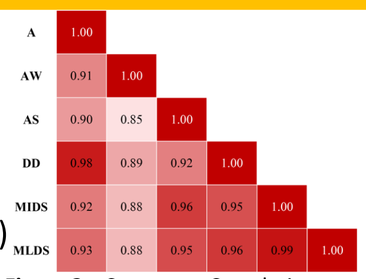


Figure 3 – Spearman Correlation between drought and aridity indices.

Soil data

- **RAW** (Readily available water in soil)

$$TAW = (\theta FC - \theta WP)\, Zr\, 1000 \rightarrow RAW = p \times TAW$$

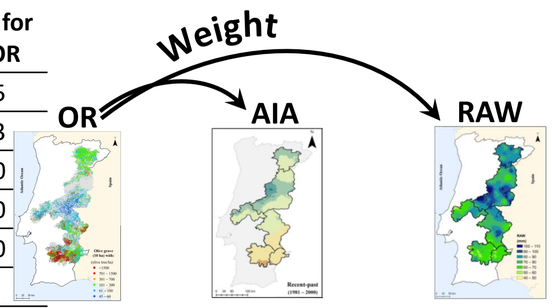
TAW (Total Available Water); **θFC** (soil water content at Field Capacity); **θWP** (soil water content at permanent Wilting Point); **Zr** (average root depth); **p** (soil water depletion fraction for no stress = 0.6)

3 Drough risk assessement index

Olive Drought and Aridity Risk (ODAR) index

This index allow to assess the future risks that each OR may be exposed to drought conditions, considering the relation between AIA and RAW.

Density	Weight for each OR
45–60	0.035
61–100	0.053
101–300	0.130
301–700	0.330
700–1500	0.730
> 1500	1



$$\text{Euclidian distance} = \sqrt{((AIA_{weighted2} - AIA_{weighted1})^2 + (RAW_{weighted2} - RAW_{weighted1})^2)}$$

Results

1 Bioclimatic Indicators

AIA

- **In RCP8.5 (2081–2100), southern Portugal will be more arid (0.69) than northern and central (0.60).**

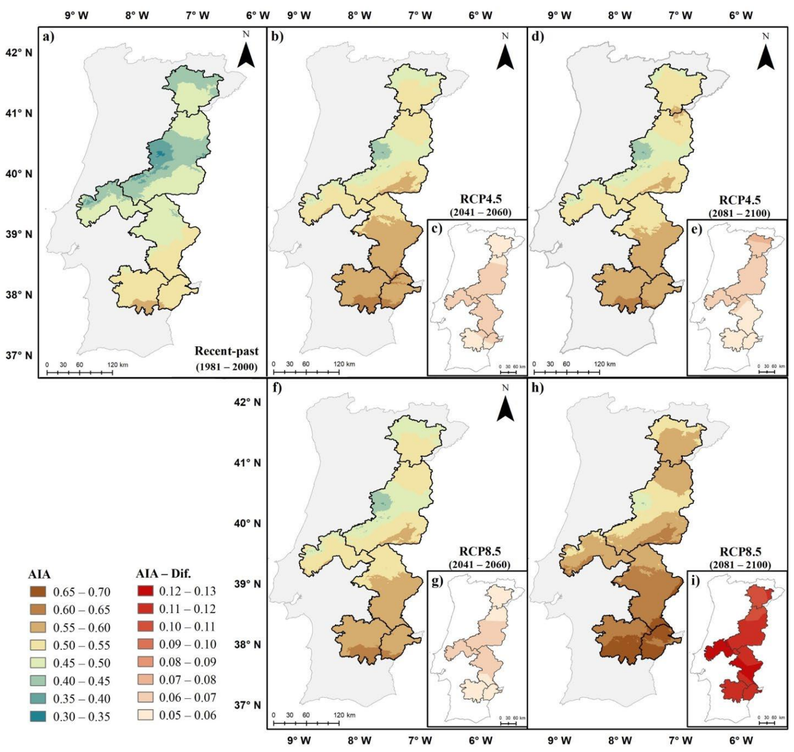


Figure 4 – Annual Mean Aridity (AIA) for (a) the historical period (1981–2000) and future scenarios: RCP4.5 for (b) 2041–2060, and (d) 2081–2100, and RCP8.5 for (f) 2041–2060, and (h) 2081–2100. Panels (c), (e), (g), and (i) show the respective differences between the future scenarios and the historical period.

RAW

- **ORs soil shows lower RAW in southern PDOs (< 60 mm) than in central and northern regions (> 90 mm).**

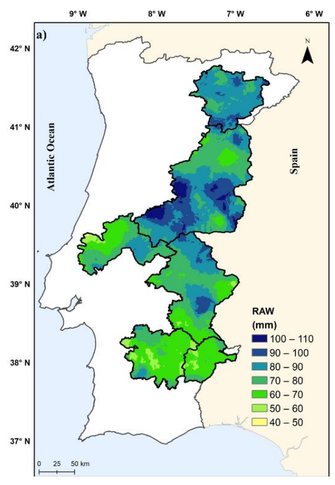


Figure 5 – a) Readily Available Water (RAW; mm) distribution in the study area.

2 Interaction between AIA, RAW and OR densities

AIA and RAW according with OR

- **Southern ORs will be more exposed to water stress than the northern regions.**

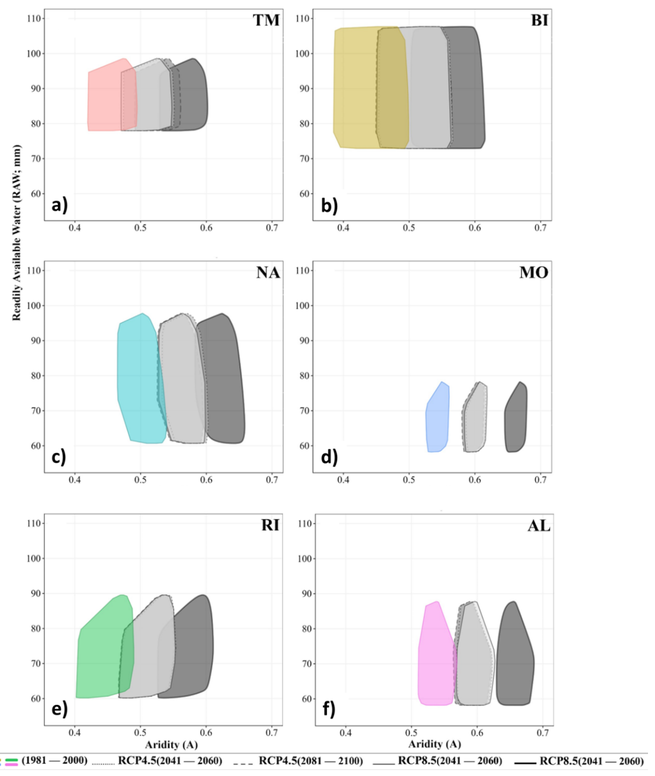


Figure 6 – OR distributions by olive oil PDO for AIA and RAW indices for the 1981–2000 and future scenarios: RCP4.5 for 2041–2060 and 2081–2100, and RCP8.5 for 2041–2060 and 2081–2100.

ODAR

- **In northern ORs, moderate to high risk will predominate. In the southern ORs the risk will be very high.**

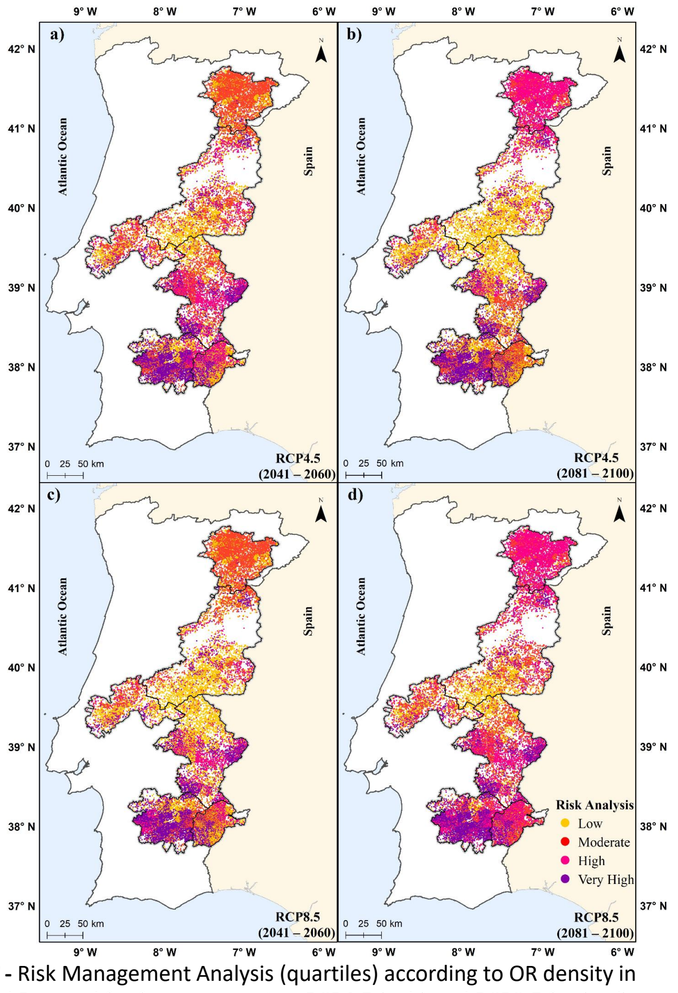


Figure 7 - Risk Management Analysis (quartiles) according to OR density in mainland Portugal for future scenarios: RCP4.5 (a, b) and RCP8.5 for (c, d).

Conclusão

- The risk increases with higher tree density since more intensive cultivation is associated with higher water use;
- In the south, the risk will be very high, which means that the olive tree growth, fruit development, and olive oil quality could be negatively affected;
- Implementation of tailored adaptation measures will be required to improve the climate resiliency of the sector.

This work is supported by National Funds by FCT – Portuguese Foundation for Science and Technology, under the projects UID/04033/2025: Centre for the Research and Technology of Agro-Environmental and Biological Sciences (https://doi.org/10.54499/UID/04033/2025) and LA/P/0126/2020 (https://doi.org/10.54499/LA/P/0126/2020).