



Impact of climate change on bioclimatic zoning of chestnut trees in Portugal

CL3.2.5 - Impact of climate change on agriculture

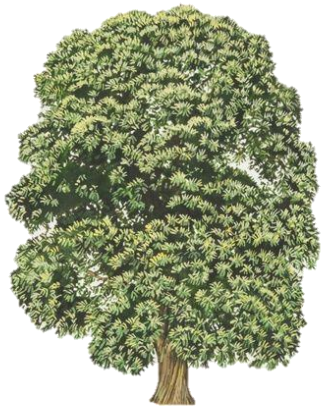
Freitas, Teresa R., Santos, João. A., Silva, Ana P. and Fraga, Hélder



Vienna - Austria, 26th May of 2022

1 Study description

Species



Chestnut tree
(*Castanea sativa*)

Area



Mainland Portugal

Climate Variables/Datasets

Climatic variables:

- Degrees days : 1900 to 2400 °D
- Annual mean temperature: 8 to 15 °C
- Summer days with maximum temperature below 32°C
- Annual accumulated precipitation: 600 to 1600 mm
- Chestnut suitability Index

Datasets:

- IBERIA01 (1985-2005)
- MPI-M-MPI-ESM-LR
- IPSL-IPSL-CM5A-MR
- ICHEC-EC-EARTH
- CNRM-CERFACS-CNRM-CM5

RCP: RCP 4.5 and RCP 8.5

Period: 2021-2040; 2041-2060; 2061-2080.

Objective: Bioclimatic zoning of chestnut in Portugal

2 Chestnut tree evolution on Portugal

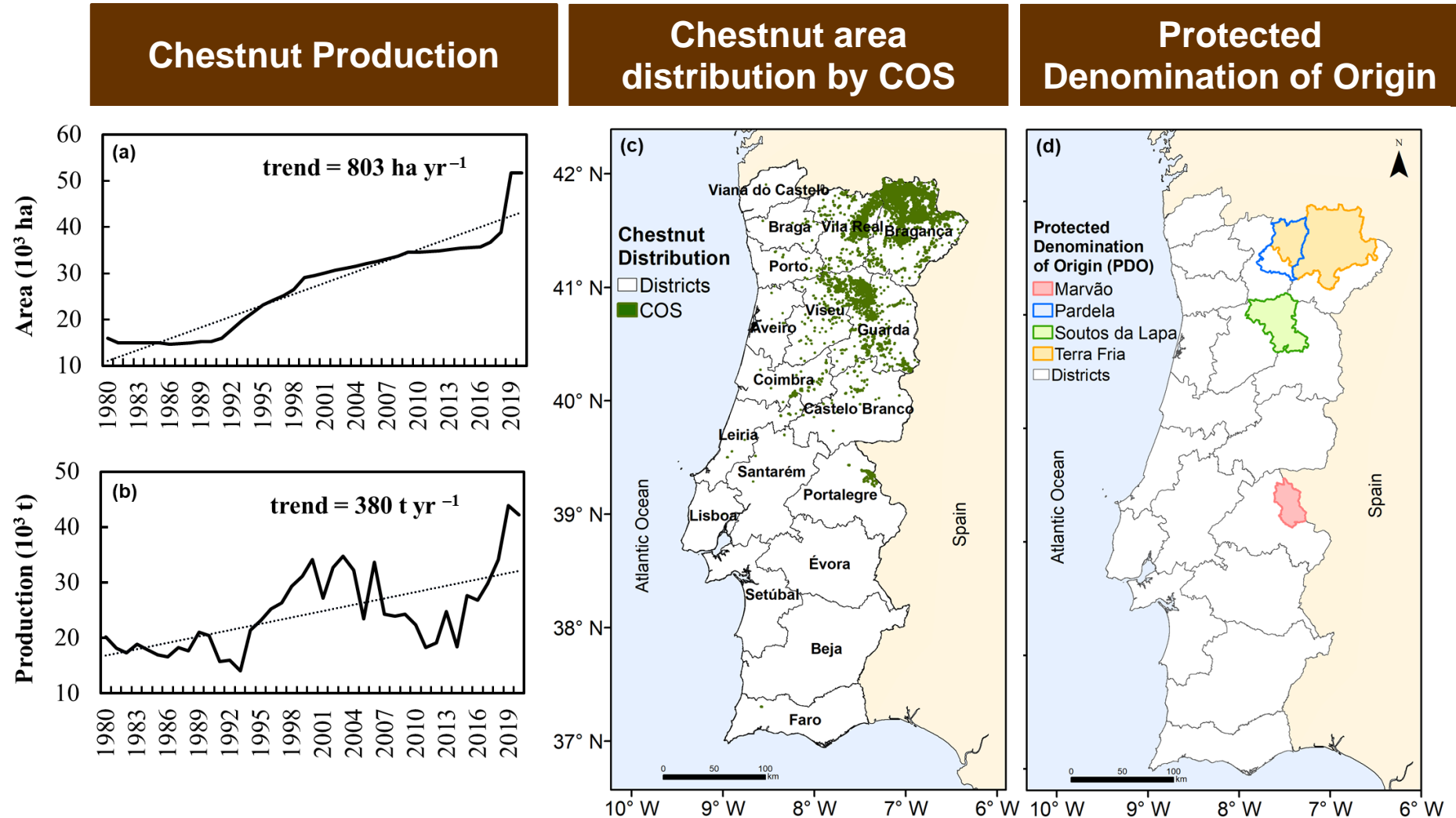


Figure 1. Chestnut (a) land cover area (hectares) and (b) yield (t) in Portugal, between 1980 and 2020. The linear regression trends are also shown, along with the corresponding trend value (c) chestnut distribution areas in mainland Portugal; (d) location of the chestnut Protected Denomination of Origin (PDO) regions.

3 Chestnut tree characterization by climate conditions

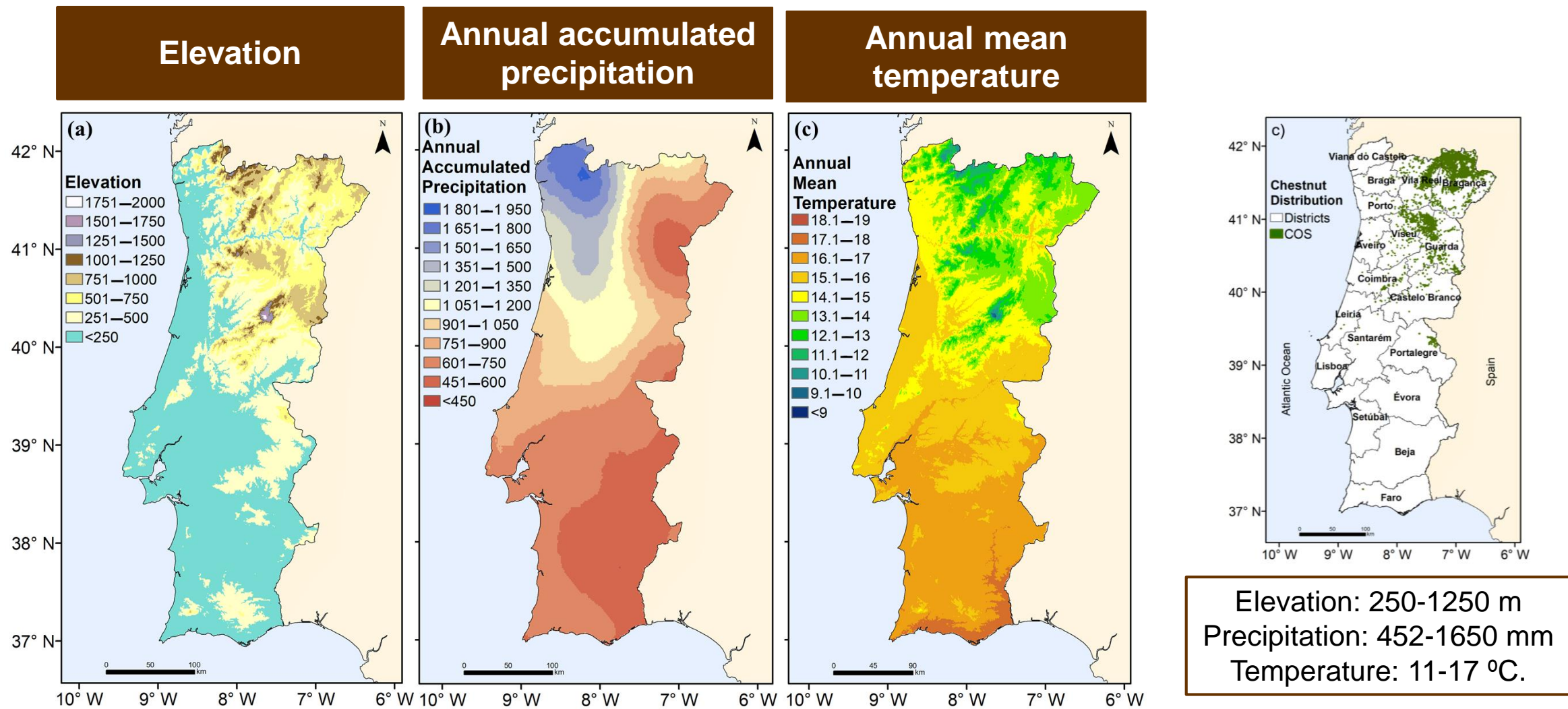


Figure 2. Mainland Portugal characterization of (a) elevation; (b) annual accumulated precipitation; (c) annual mean temperature.

4 Results

IBERIA01 1989-2005

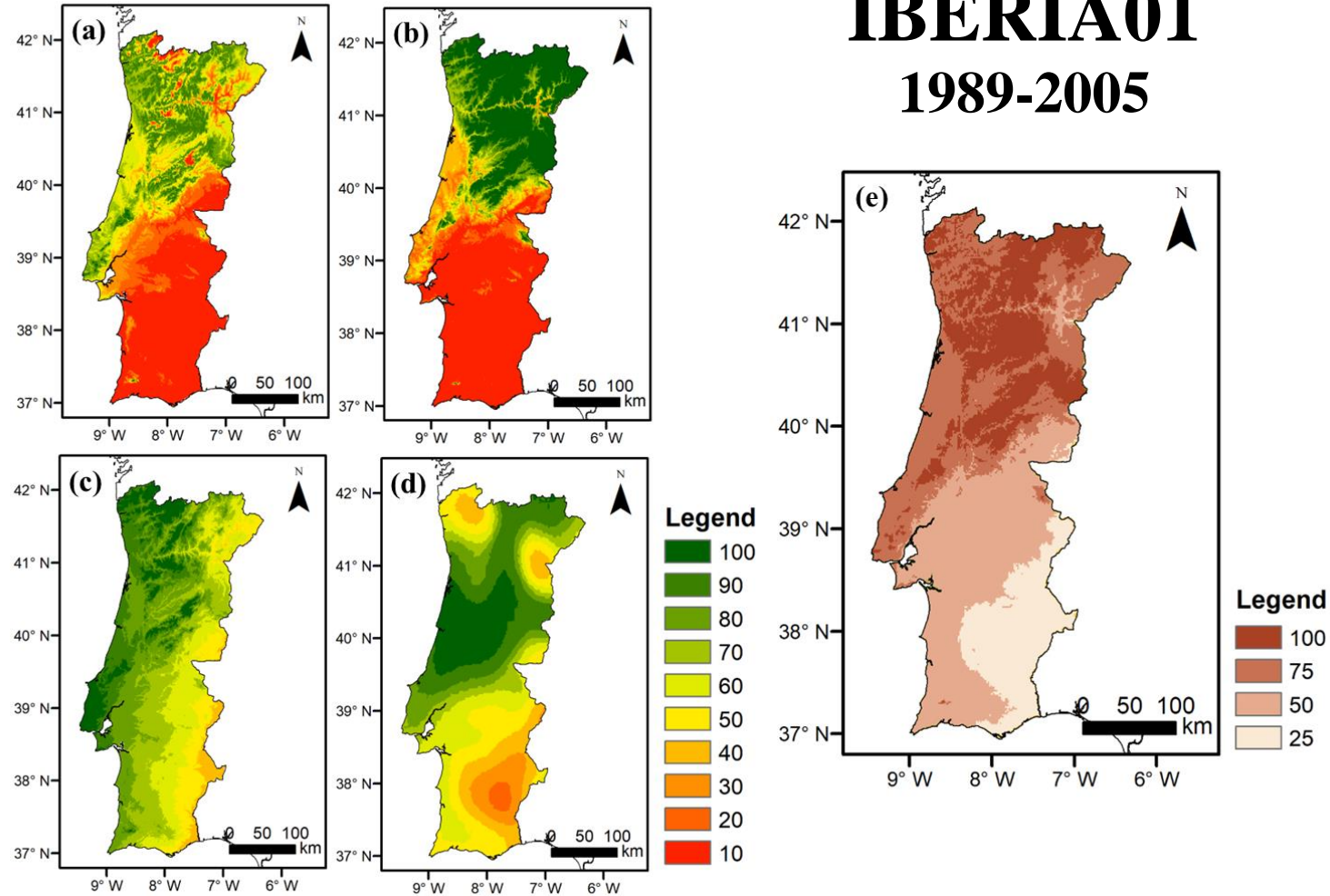


Figure 3. Mean percentage of occurrence of (a) growing degrees days between 1900–2400 °C, (b) annual mean temperature between 8–15 °C, (c) summer days with maximum temperature below 32 °C, (d) annual accumulated precipitation between 600–1600 mm and (e) chestnut suitability index, for the baseline (IBERIA01; 1989–2005) period.

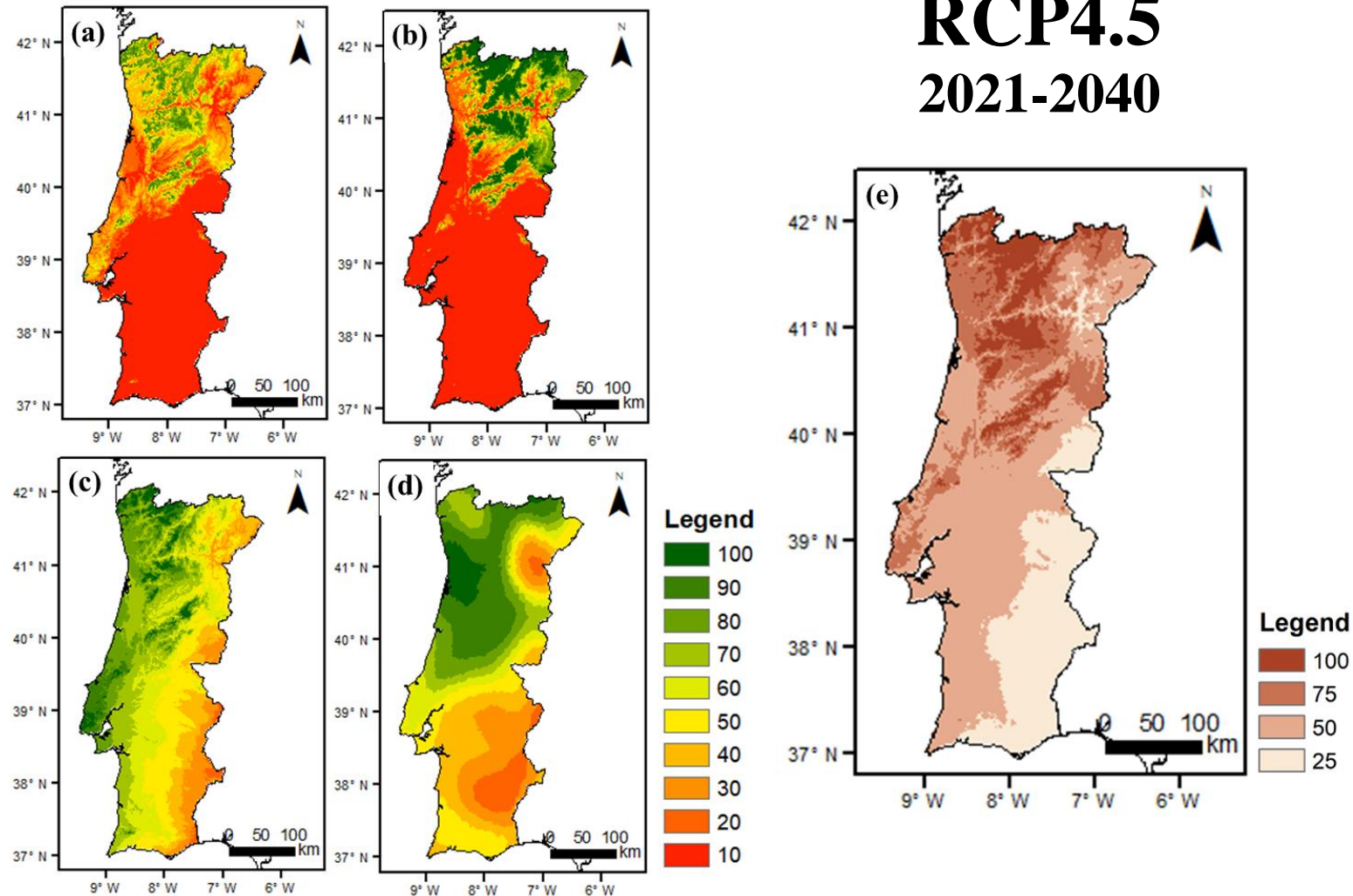


Figure 4. Mean percentage of occurrence of (a) growing degrees days between 1900–2400 °C, (b) annual mean temperature between 8–15 °C, (c) summer days with maximum temperature below 32 °C, (d) annual accumulated precipitation between 600–1600 mm and (e; j) chestnut suitability index, for 2021–2040, four GCM-RCM experiment, under RCP4.5.

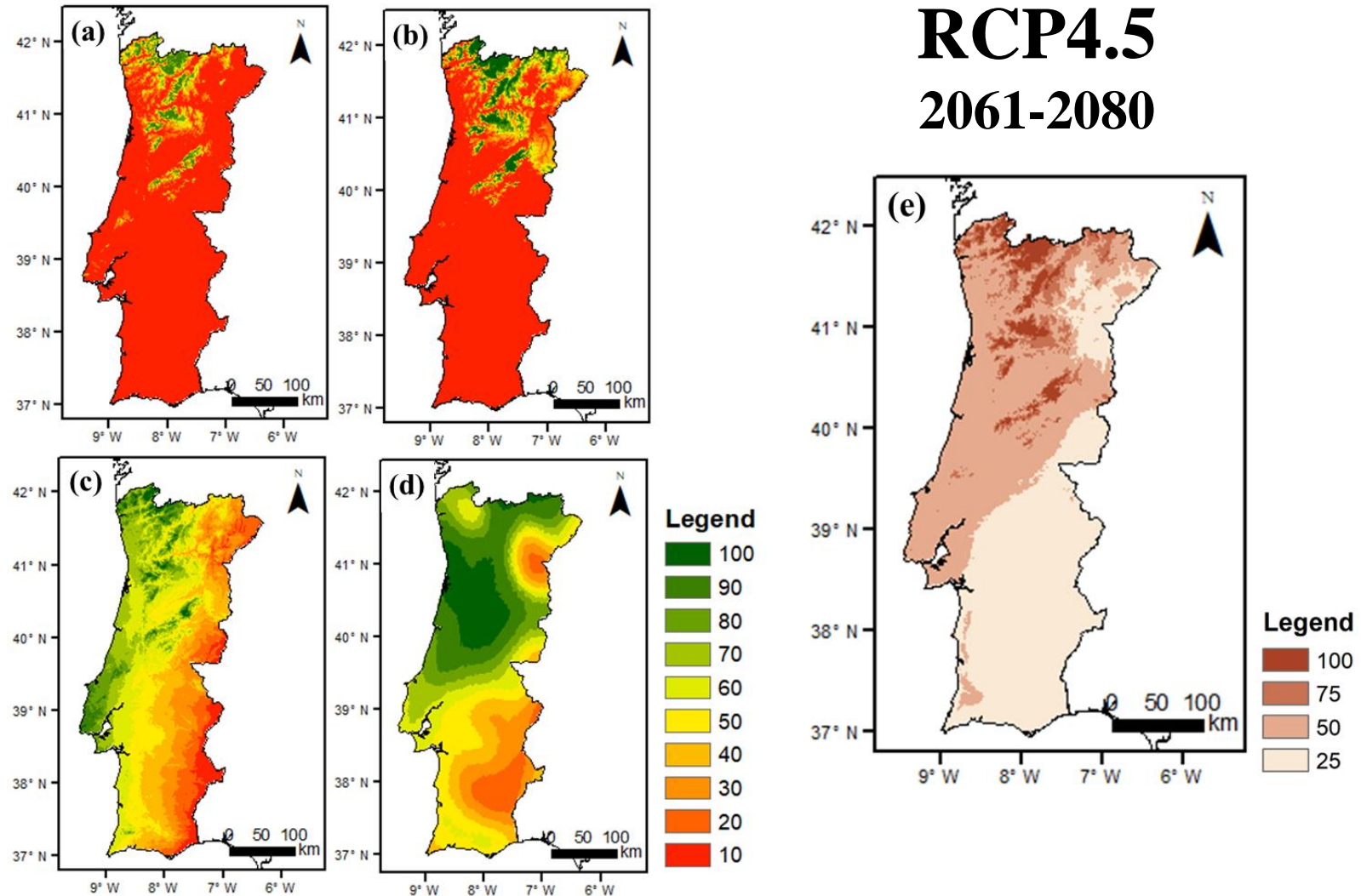


Figure 6. Mean percentage of occurrence of (a) growing degrees days between 1900–2400 °C, (b) annual mean temperature between 8–15 °C, (c) summer days with maximum temperature below 32 °C, (d) annual accumulated precipitation between 600–1600 mm and (e) chestnut suitability index, for 2061–2080, four GCM-RCM experiments, under RCP4.5.

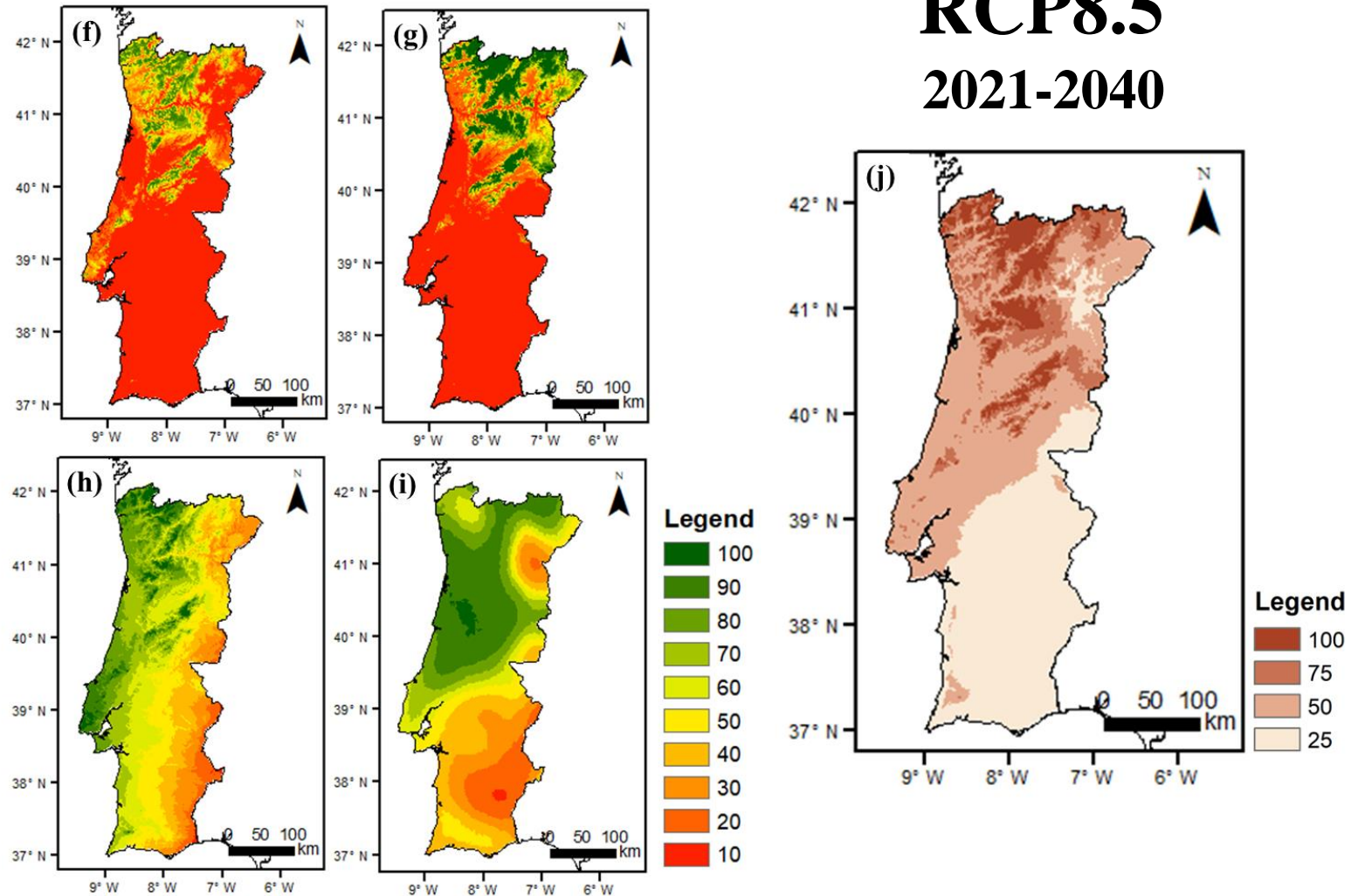


Figure 7. Mean percentage of occurrence of (f) growing degrees days between 1900–2400 °C, (g) annual mean temperature between 8–15 °C, (h) summer days with maximum temperature below 32 °C, (i) annual accumulated precipitation between 600–1600 mm and (j) chestnut suitability index, for 2021–2040, four GCM-RCM experiment, under RCP8.5.

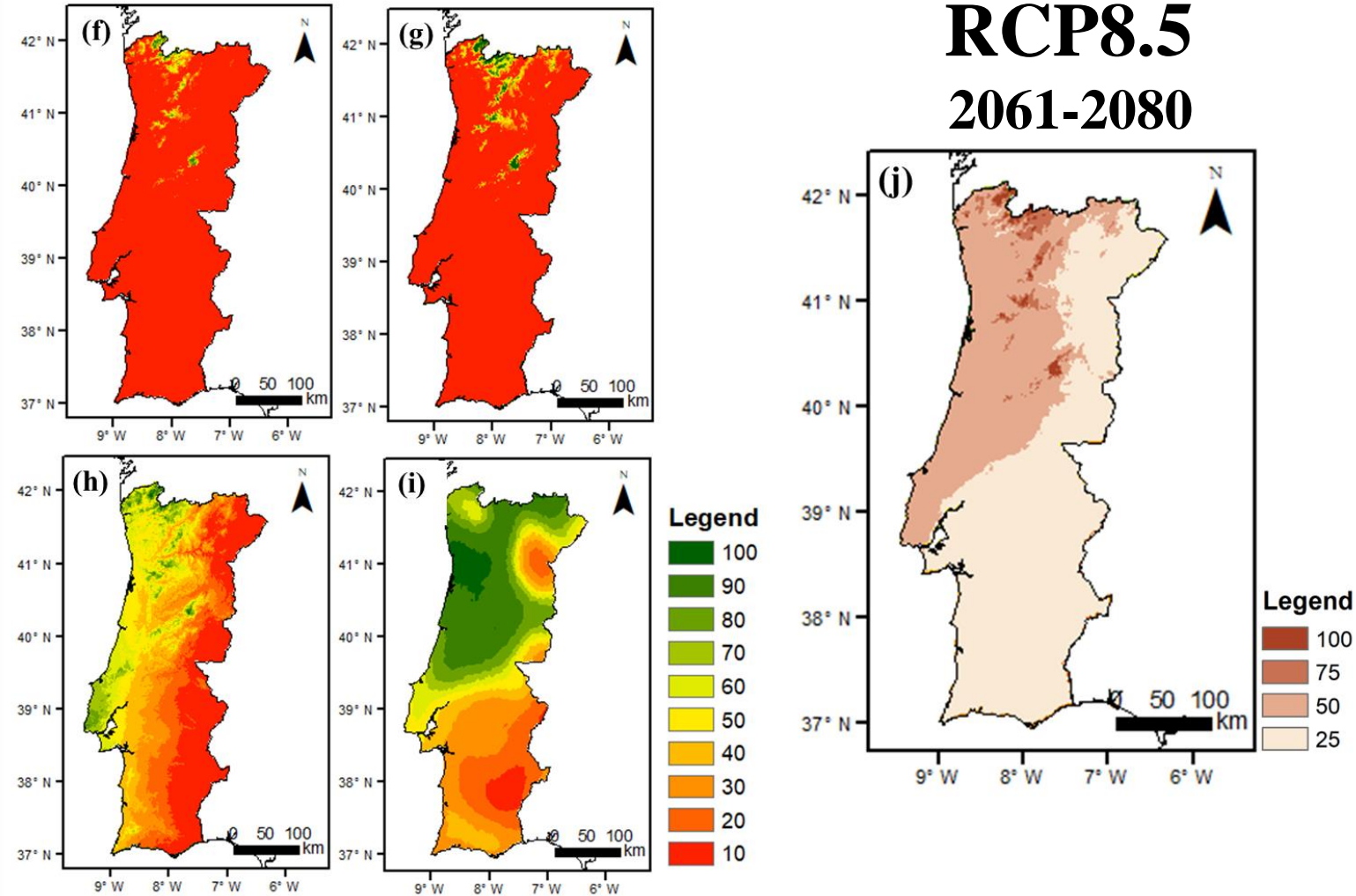


Figure 9. Mean percentage of occurrence of (f) growing degrees days between 1900–2400 °C, (g) annual mean temperature between 8–15 °C, (h) summer days with maximum temperature below 32 °C, (i) annual accumulated precipitation between 600–1600 mm and (j) chestnut suitability index, for 2061–2080, four GCM-RCM experiments, under RCP8.5.

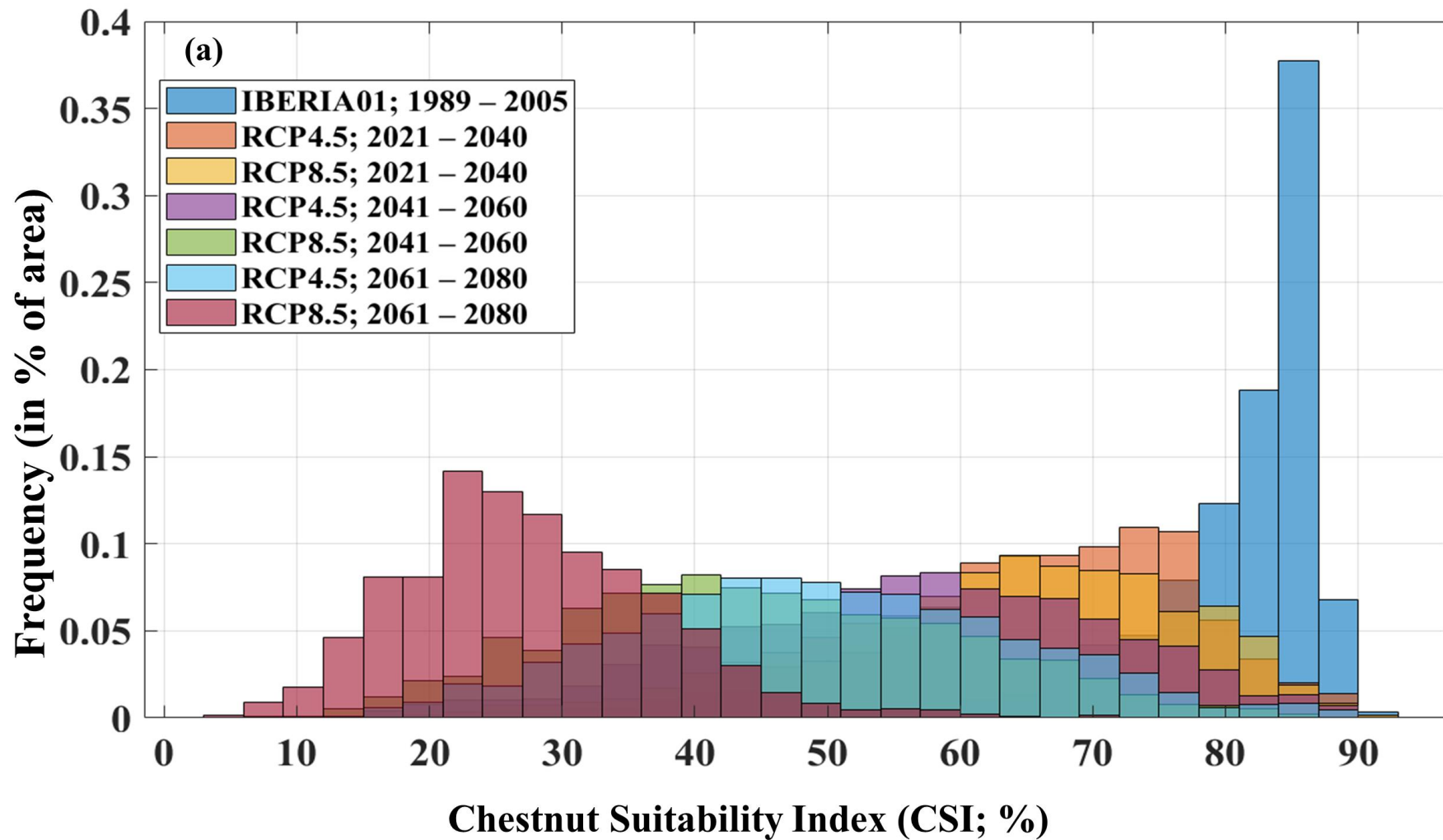


Figure 10. Relative distribution of chestnut areas (%) as a function of the CSI for (a) all periods (2021–2040; 2041–2060; 2061–2080) and the distribution for the baseline period (IBERIA01, 1989–2005).

5 Conclusion

- Climate change impacts on chestnut bioclimatic suitability may have socio-economic and ecological implications;
- This work intended to support chestnut tree sector with the implementation of adequate measures to warrant the sustainability of production and species adaptability.
- Partnerships with research units and agricultural associations are strongly encouraged to acquire more field data and outline strategies to cope with climate change and reduce its derived risks.

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Impact of climate change on bioclimatic zoning of chestnut trees in Portugal

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Chestnut tree cultivation is largely spread worldwide, with approximately 596 × 103 ha devoted to fruit production, raising global production to approximately 2.5 million t, with an upward trend of 56 × 103 t per year. In the European Union, Portugal is the largest chestnut producer (38,870 ha). In recent years, the country has shown an increasing trend of 723 ha per year, and the production was 35,830 t in 2019, but largely concentrated in the northeast. In the present study, bioclimatic indices are applied to analyse the spatial distribution of chestnut trees in mainland Portugal, namely degree days (suitability interval: 1900–2400°C), annual mean temperature (8–15°C), monthly mean maximum temperature <32°C, and annual precipitation (600–1600 mm). These indices are assessed for both historical (1989–2005, from (BERA01)) and future (from EURO-CORDEX) climates, within three sub-periods: 2021–2041, 2041–2060, and 2061–2080, and under two anthropogenic radiative forcing pathways (RCR4.5 and RCP4.5). For the historical period, in terms of degree days, the suitability for chestnut tree cultivation is, e.g., percentage of years fulfilling the predefined interval is 10% in southern Portugal, whereas much higher values are found at high elevations in the north (50–90%). For the annual mean temperature, most of northern Portugal shows almost 100% suitability. Concerning the maximum temperature, the suitability reduces from the west (100–90%) to the east (40%). Regarding the annual precipitation, the suitability is heterogeneous throughout the territory, with areas under 50%. A compound index is also defined, revealing suitability from 100 to 75% over northern Portugal, while central and southern Portugal show values in the approximate range of 25–50%. For future climates, a progressive and significant reduction in suitability was found, particularly for RCP4.5 and in the long-term period. Therefore, climatic changes embody an important threat to chestnut tree cultivation in Portugal, potentially affecting the plant physiology and phenology, ultimately leading to a reduction of the cultivation areas and yield. Adaptation strategies are critical to mitigate climate change detrimental impacts, it is indeed essential to implement measures that promote chestnut orchard's adaptive capacity, reducing vulnerability and risks of exposure to increasingly warm and dry climates, but also warranting the sustainability of the sector.

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Climate Change Projections for Bioclimatic Distribution of *Castanea sativa* in Portugal

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Abstract: The chestnut tree is an important forestry species worldwide, as well as a valuable food resource. Over recent years, Portugal has shown an increasing trend in chestnut tree area, as well as increases in production, leading to the socio-economic relevance of this agro-forestry species. In this study bioclimatic indices are applied to analyse the spatial distribution of chestnut tree in mainland Portugal, namely growing degree days (GDD: 1900–2400 °C), annual mean temperature (AMT: 8–15 °C), summer days with maximum temperature below 32 °C (SD32), and annual precipitation (PRE: 600–1600 mm). These indices are assessed for the baseline (BERA01: 1989–2005) and future climates (EURO-CORDEX: 2021–2041, 2041–2060, and 2061–2080) under two forcing pathways (RCR4.5 and RCP4.5), also taking into account the chestnut tree land cover. For the baseline, the GDD showed only 10% suitability for chestnut tree cultivation in southern Portugal, whereas much higher values are found in the north of the country and at higher altitudes (30–90%). For the AMT, higher elevation areas in northern Portugal show almost 100% suitability. Concerning SD32, the suitability reduces from the west (100–90%) to the east (40%). Regarding PRE, the suitability is heterogeneous throughout the territory, with areas under 50%. A new Chestnut Suitability Index (CSI) was then computed, which incorporates information from the four previous indices. The CSI reveals a suitability ranging from 100 to 75% in the north, while central and southern Portugal show values from 25 to 50%. For future climates, a progressive reduction in CSI was found, particularly for RCP4.5 and in the long-term period. Changes in bioclimatic conditions may restrict the 100% suitability to a narrow area in the north of the country. These reductions in chestnut bioclimatic suitability may have socio-economic and ecological implications for the management of the important agro-forestry species.

Keywords: chestnut; future climates; chestnut suitability index; precipitation; temperature

1. Introduction

Chestnut trees (*Castanea* spp., Fagaceae family) are important forestry species worldwide [1], as well as a valuable food resource, which has accompanied the evolution of the human population over the centuries. The *Castanea* Mill. genus is generally distributed throughout southern Europe, north-eastern America, northern Africa, and in certain parts of Asia, although there is a large variability in terms of species [2]. According to the Food and Agriculture Organization data [3] in 2020, the worldwide chestnut tree area was nearly 600 thousand ha, while chestnut production reached over 2 million t. This represents an increasing trend of nearly 80 thousand t/year. According to the latest available reports, Asia is the largest chestnut (*Castanea sativa* Siebold & Zucc.) and *Castanea mollissima*

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When a butterfly flutters its wings in
one part of the world, it can
eventually cause a hurricane in
another.

— *Edward Norton Lorenz* —