Impacts of climate change on water availability in Alentejo (Portugal)

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Mediterranean water resources (already vulnerable at present) - high potential to be affected by climate change

- Decreases in runoff and streamflow
- Increases in evapotranspiration and CO² atmospheric concentrations
- Shifts in crop growth cycles
- Changes in land-cover / land-use

What are the impacts of climate change in Alentejo

- Water availability (quality/quantity)
- Reservoirs response
- Irrigation water requirements
- Reservoir phosphorus inflows

Development and implementation of adaptation strategies to future climate
The Monte Novo and Vigia catchment (814.7km²) is a multipurpose reservoir system used for water supply (district of Évora) and irrigation. Drains into the Alqueva reservoir (largest artificial lake in the Iberian Peninsula - 4150hm³)

Rainfed crops - 44% (oats 60%; winter pasture 40%)

Agroforestry - 30% (evergreen oaks interspersed with winter cereals or pasture) - “montado”

Broad-leaved forest - 13% (cork oak)

Permanent crops - 7% (olive groves, vineyards)

Irrigated crops - 4% (corn, sunflower, olive groves, vineyards)

The area is under dry Mediterranean climate (less 500mm/yr)
**Methodology**

**SWAT** Soil & Water Assessment Tool (SWAT2012)

1973 – 2012

(daily meteorological data from 3 measuring stations)

4 years warm up

manual calibration

Sufi2

Climate change scenarios

climate models (euro cordex) projections

RCA4 RCP 4.5

RACMO22E RCP 8.5 “worst” scenario

2010-2040 10 years warm up

2030-2070 10 years warm up

2060-2100 10 years warm up

Compare with each climate model control period (1971-2000)
RCP 4.5 and RCP 8.5 ("worst" scenario) projections

- 330 ppm CO₂ (SWAT default)
- 503 ppm CO₂
- 490 ppm CO₂
- 850 ppm CO₂
- 597 ppm CO₂
- 999 ppm CO₂
- 1197 ppm CO₂ (SWAT model conflict)

**Periods:**
- 2010-2040: 10 years warm up
- 2030-2070: 10 years warm up
- 2060-2100: 10 years warm up

**Calibration period:**
- 1973-2012
Monte Novo reservoir inflow (Jan 1994 to Dec 2005)

<table>
<thead>
<tr>
<th>NSE</th>
<th>bR²</th>
<th>Pbias</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.89</td>
<td>0.89</td>
<td>7.94</td>
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</table>

Very good performance rating (Moriasi et al. 2007)

Vigia reservoir inflow (Oct 1994 to Dec 2005)

<table>
<thead>
<tr>
<th>NSE</th>
<th>bR²</th>
<th>Pbias</th>
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<tbody>
<tr>
<td>0.83</td>
<td>0.84</td>
<td>6.21</td>
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Very good performance rating (Moriasi et al. 2007)
**Monte Novo reservoir volume (Jan 1990 to Dec 2012)**

<table>
<thead>
<tr>
<th>NSE</th>
<th>bR²</th>
<th>Pbias</th>
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<tbody>
<tr>
<td>0.51</td>
<td>0.52</td>
<td>3.31</td>
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Satisfactory performance rating (Moriasi et al. 2007)

- SWAT limits a “realistic” simulation of inter-annual variations - reservoir water consumption depends on irrigation requirements and storage volume.
- Monthly “average input” constrains the simulation of drought situations/water conservation measures/changes to irrigated area or crops.

**Vigia reservoir volume (Jan 1990 to Dec 2012)**

<table>
<thead>
<tr>
<th>NSE</th>
<th>bR²</th>
<th>Pbias</th>
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<tbody>
<tr>
<td>0.72</td>
<td>0.74</td>
<td>8.37</td>
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</table>

Good performance rating (Moriasi et al. 2007)
Monte Novo reservoir phosphorus (Jan 1995 to Dec 2005)

<table>
<thead>
<tr>
<th>NSE</th>
<th>bR²</th>
<th>Pbias</th>
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<tbody>
<tr>
<td>0.33</td>
<td>0.33</td>
<td>9.11</td>
</tr>
</tbody>
</table>

Satisfactory performance rating
(Moriasi et al. 2007)

- Phosphorus data is given by one daily record per month (records are not continuous)
- Phosphorus high peaks linked with low reservoir water volume

Vigia reservoir phosphorus (Jan 1995 to Dec 2005)

<table>
<thead>
<tr>
<th>NSE</th>
<th>bR²</th>
<th>Pbias</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.15</td>
<td>0.49</td>
<td>1.74</td>
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</tbody>
</table>

Satisfactory performance rating
(Moriasi et al. 2007)
LAI (leaf area index) average for all crops

- Gradual anticipation of the start of vegetation development in spring and lower vegetation cover in summer and autumn
- Higher frequency of water stress conditions, due to the higher climatic aridity (i.e. a combination of lower rainfall and higher potential evapotranspiration)
LAI (leaf area index)

Vine

- Earlier begging of growing season (up to 2 month) due to a favorable winter - warmer but still humid

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**RACMO 8.5**

- Yellow line: RACMO control
- Green line: RCA control
- Blue line: 2010-2040
- Light blue line: 2030-2070
- Blue line: 2060-2100

**RCA 8.5**

- Yellow line: RACMO control
- Green line: RCA control
- Blue line: 2010-2040
- Light blue line: 2030-2070
- Blue line: 2060-2100
Irrigation water requirements (mm/year)

- Moderate increase of water requirements (in line with the decrease in annual rainfall, coupled with an increase in temperature and potential evapotranspiration)

Annual crops (sunflower and corn) are less sensitive to climate changes due to seasonal changes, namely a decrease in autumn rainfall
Monte Novo reservoir phosphorus (kg/month)

- Increase in phosphate exports from agricultural fields, due to rainfall and runoff in the wet season, with higher impacts on soil losses.

- Changes to phosphate transport until the reservoirs, which closely follow the inflow variation trends.

Vigia reservoir phosphorus (kg/month)

- The Monto Novo reservoir vulnerable - watershed has a larger occupation of intensive croplands (annual cultures), with a consequential higher use of fertilizers and soil mobilization.
adaptation strategies

- Water exploitation index (WEI)
  \[ \text{WEI} = \frac{\text{Water use (urban + irrigation)}}{\text{water available}} \]
  (based on irrigation requirements and inflows to each reservoir)

- Monte Novo reservoir will continue to be, in moderate water stress

- Vigia reservoir will continue to be in severe water stress.

- Moderate increase of the irrigated area (from 3.9% up to 7.1% - 2041)
• Low capacity to support climate change adaptation measures involving an increase in irrigated area

• Water efficiency measures, both for irrigated systems and for crop selection, could limit foreseen water stress conditions

• Climate change adaptation measures might already lead to short-term improvements in water resources

• Changes in the management operations – anticipating planting operation 1 or 2 months

• Adaptation strategies to future climate change:
  • increase of the irrigated area (from 3.9 % up to 7.1% - 2041) – unsuitable system response due severe to water stress
  • changes on crops – plants with lower water dependency
  • more efficient irrigation systems for olive groves and vineyards
Thank you

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