Integrated impact modelling of climate change and adaptation policies on land use and water resources in Austria

M. SCHÖNHART¹, M. ZESSNER², A.P. BLASCHKE³, J. PARAJKA³, G. HEPP², B. STRENN², H. TRAUTVETTER², E. SCHMID¹

¹Institute for Sustainable Economic Development, University of Natural Resources and Life Sciences Vienna
²Institute for Water Quality, Resources and Waste Management, Vienna University of Technology
³Institute of Hydraulic Engineering and Water Resources Management, Vienna University of Technology

MACSUR Conference, 22-24 May, Berlin
Research questions

• How do climate and socio-economic changes affect Austrian land use, nutrient emissions as well as the low flow and quality of water bodies?
• Which agricultural adaptation measures can cost-effectively counteract adverse impacts?
• What are effective policies to manage water quality under climate change?
Integrated modelling framework
Zessner et al., 2017, Sci Tot Envi 579, 1137-1151
## Climate and policy scenarios

### Reference scenario
- **Reference**
  - Observed land use based on current market situation and policies; serves calibration purposes

### Policy scenarios
- **BAU**
  - Current and foreseeable policy changes and autonomous adaptation on climate scen. Similar

<table>
<thead>
<tr>
<th>Climate change scenarios (2040)</th>
<th>Reference scenario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Similar (precipitation)</td>
<td></td>
</tr>
<tr>
<td>Temperature: +1.5 °C</td>
<td></td>
</tr>
<tr>
<td>Precipitation: observed</td>
<td></td>
</tr>
<tr>
<td>Dry (low precipitation)</td>
<td></td>
</tr>
<tr>
<td>Temperature: +1.5 °C</td>
<td></td>
</tr>
<tr>
<td>Precipitation: decline</td>
<td></td>
</tr>
<tr>
<td>Wet (high precipitation)</td>
<td></td>
</tr>
<tr>
<td>Temperature: +1.5 °C</td>
<td></td>
</tr>
<tr>
<td>Precipitation: increase</td>
<td></td>
</tr>
</tbody>
</table>

- **IMPact wet/dry**
  - Same as BAU

- **WAtter Protection I**
  - Water protection policies to improve compliance to the WFD

- **WAtter Protection II**
  - Water protection policies to further improve compliance to the WFD
### Water protection policies

<table>
<thead>
<tr>
<th>Policy</th>
<th>BAU</th>
<th>IMP</th>
<th>WAP_I</th>
<th>WAP_II</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Market regulation and direct payments</strong> (CAP 1. pillar)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production quotas (e.g. dairy quota)</td>
<td></td>
<td></td>
<td>Not available</td>
<td></td>
</tr>
<tr>
<td>Coupled direct payments</td>
<td></td>
<td></td>
<td>Not available</td>
<td></td>
</tr>
<tr>
<td>Single farm payment</td>
<td></td>
<td></td>
<td>Regional premiums</td>
<td></td>
</tr>
</tbody>
</table>
| Cross compliance: e.g. Nitrate directive\(^1\)  
N.... Nitrogen at field level (ha) | Max. 100kg N/application  
Max. N according to Annex 3  
Max. 170kg N with organic fertilizers | Max. 80kg N\(^2\)  
Like BAU  
Max. 150kg N  
No maize, soy, sugar beets, potatoes, and pumpkin on areas > 8% slope close to surface waters\(^3\) | Max. 80kg N\(^3\)  
Like BAU  
Max. 150kg N  
No maize, soybean, sugar beets, potatoes, and pumpkin on areas > 8% slope close to surface waters\(^4\) | |
| Greening | Maintenance of permanent grassland  
5% ecological focus areas  
Crop rotation restrictions | like BAU  
5% set aside  
Like BAU + max. 50% maize | Like BAU  
Like WAP_I  
Like BAU + max. 33% maize | |
| **Rural development** (CAP 2. pillar) | | | | |
| Less favoured area payments | Available | | | Like BAU |
| **Agri-environmental program (ÖPUL)** | Premium levels and standards according to ÖPUL, for the following measures:  
Environmentally sound and biodiversity-promoting management  
Limitation of yield-increasing inputs  
Greening of arable land – intermediate crops  
Greening of arable land – “Evergreen” system  
Direct seeding and seeding on mulch  
Preventative surface water protection on arable land  
Management of arable areas particularly threatened by leaching  
Organic farming | Like BAU, additionally (regional):  
+25% premiums\(^5\) for greening of arable land, direct and mulch seeding, preventative surface water protection, limitation of yield-increasing inputs, and organic farming | Like BAU, additionally (national):  
+25% premiums\(^6\) for greening of arable land, direct and mulch seeding, preventative surface water protection, limitation of yield-increasing inputs, and organic farming | |
| **Waste water treatment** | Total phosphorus < 1 mg/l  
N removal > 70% (current standards) | Total phosphorus < 0,5mg/l\(^7\)  
N removal > 85%\(^8\) | Total phosphorus < 0,5mg/l\(^9\)  
N removal > 85%\(^10\) | |
Seasonal differences in runoff from TUWmodel

three climate change scenarios similar, dry, wet compared to the past climate.

blue = water sheds with winter low flow regime
red = water sheds with summer low flow regime
line = median
shading = 25%- and 75%- percentile.
Examples for relative yield changes from EPIC

Modelled multi-year average at HRU level for three fertilization intensities. Reference is past climate with medium fertilization.

climate scenarios similar (green), wet (blue) and dry (red).
Crop choices from climate change and policies

Comparison of maize and set aside area with the BAU scenario for two climate and three policy scenarios for 35 Austrian NUTS-3 regions
Fertilization choices from climate change and policies

Comparison of three intensity levels in two climate and three policy scenarios with the BAU scenario for 35 Austrian NUTS-3 regions
Change in agricultural producer surplus at NUTS-3 level from PASMA[grid]
Impacts on the nitrogen cycle at national scale

Components of the agricultural N cycle are: organic and mineral fertilizer production, biological nitrogen fixation, atmospheric nitrogen deposition, nitrogen uptake by arable crops, permanent grasslands, and permanent crops.
Modelled annual Total Phosphorus export loads per watershed
Regional risk assessment for EQS exceedance

Regional risk assessment for type specific PO₄-P- target values

WAP_II_dry
- no exceedance of EQS
- potential exceedance of EQS
- exceedance of EQS
- severe exceedance of EQS
- not considered catchments
Cost-effectiveness of WAP policies to reduce DIN (dissolved inorganic nitrogen) and TP (total phosphorus) loads (prelim.)

Annual costs (€) for annual reductions compared to the respective IMP scenario at NUTS-3 level.

Note: Lines indicate linear trends of the respective scenario.
Discussion & conclusions

• Cost-effectiveness: challenge of multiple environmental effects
• Environmental effectiveness of selected measures rather low
• Results confirm other studies with heterogeneous impacts between regions
  • Target agri-environmental programs towards changing productivity
• Autonomous adaptation with declining fertilization intensity under DRY but increasing under WET
  • Adapt regulation of nutrient thresholds and fertilization schedules to maintain current levels of cost-effectiveness
• Mutual impacts of surpluses, emissions and dilution: important for national water quality but less so for total nutrient loads
• Policy objectives determine optimal policies: high cost-effectiveness for total nutrient loads may lead to local environmental deterioration
  • WAP I targeting effective for N loads -> WAP II more expensive per unit nutrient savings
Contact details: martin.schoenhart@boku.ac.at
BOKU University, Vienna

The presented results are derived from the “Aqua-Stress” Project “Water resources under climatic stress. An integrated assessment of impacts on water availability and water quality under changing climate and land use” (KR13AC6K11034). The project was funded within the 6th Austrian Climate Research Program by the Climate and Energy Fund.

The presentation has also been supported by the FACCE-JPI MACSUR project supported by BMLFUW