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

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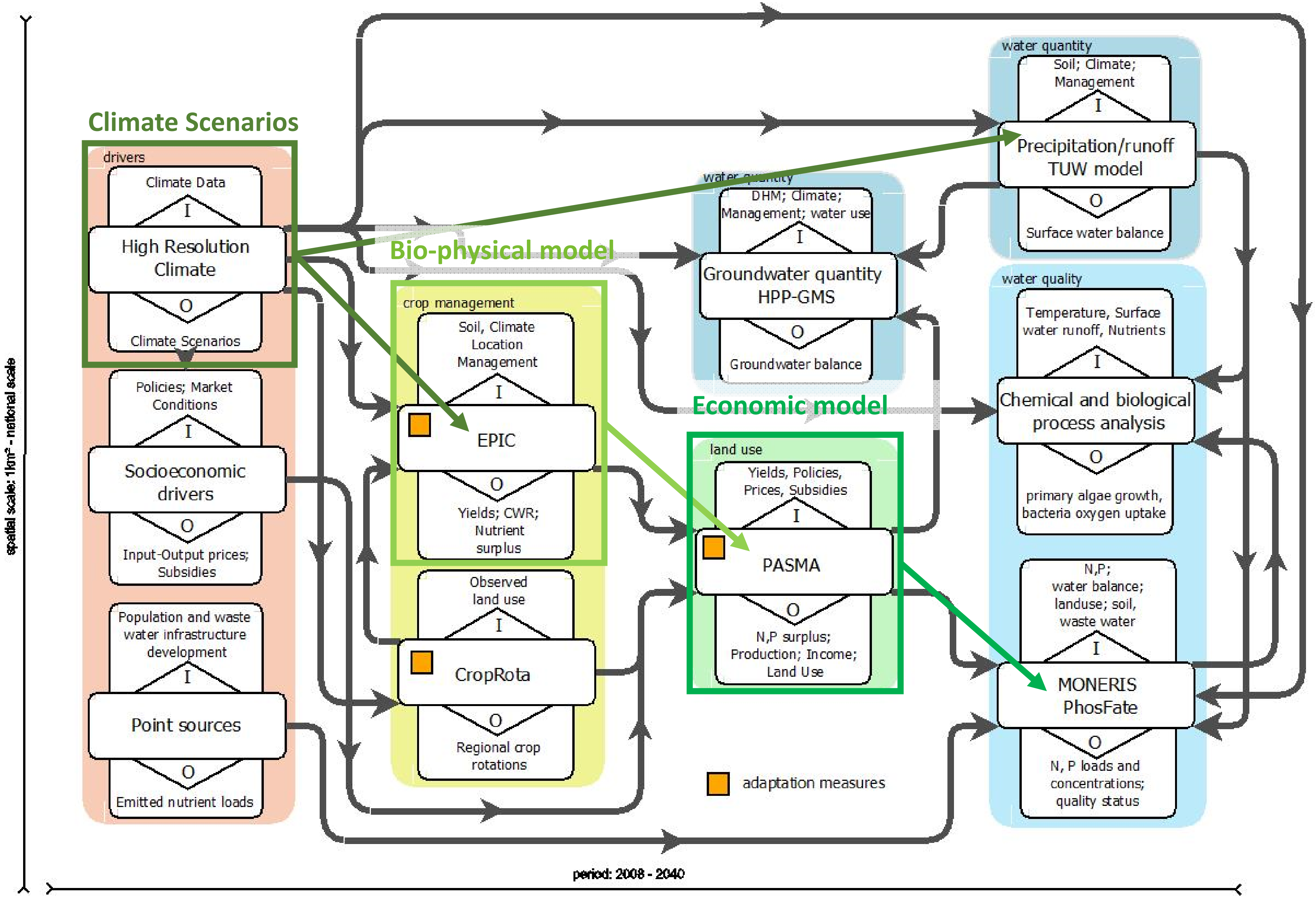
Research questions

- 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

Climate change scenarios (2040)

Similar (precipitation)	Dry (low precipitation)	Wet (high precipitation)
Temperature: +1.5 C° Precipitation: observed	Temperature: +1.5 C° Precipitation: decline	Temperature: +1.5 C° Precipitation: increase

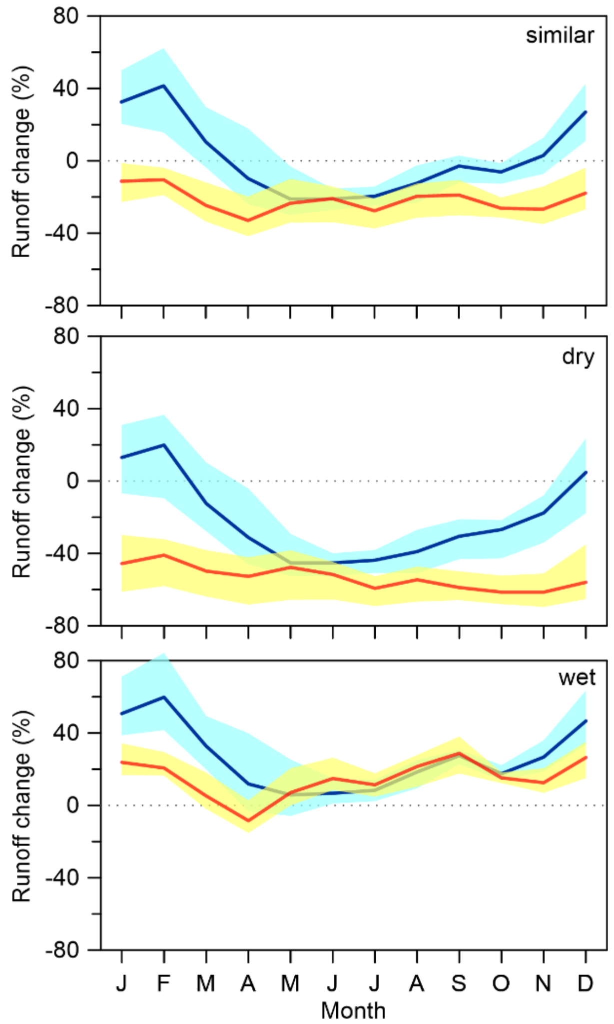
Policy scenarios

BAU	IMPact wet/dry	WAter Protection I	WAter Protection II
Current and foreseeable policy changes and autonomous adaptation on climate scen. Similar	Same as BAU	Water protection policies to improve compliance to the WFD	Water protection policies to further improve compliance to the WFD

Water protection policies

	Policy	BAU	IMP	WAP_I	WAP_II
Market regulation and direct payments (CAP 1. pillar)	Production quotas (e.g. dairy quota)	Not available			
	Coupled direct payments	Not available			
	Single farm payment	Regional premiums			
	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[3,5]	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[4,5]
	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	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[3] 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[4] 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[3] N removal > 85%[3]	Total phosphorus < 0,5mg/l[4] N removal > 85%[4]

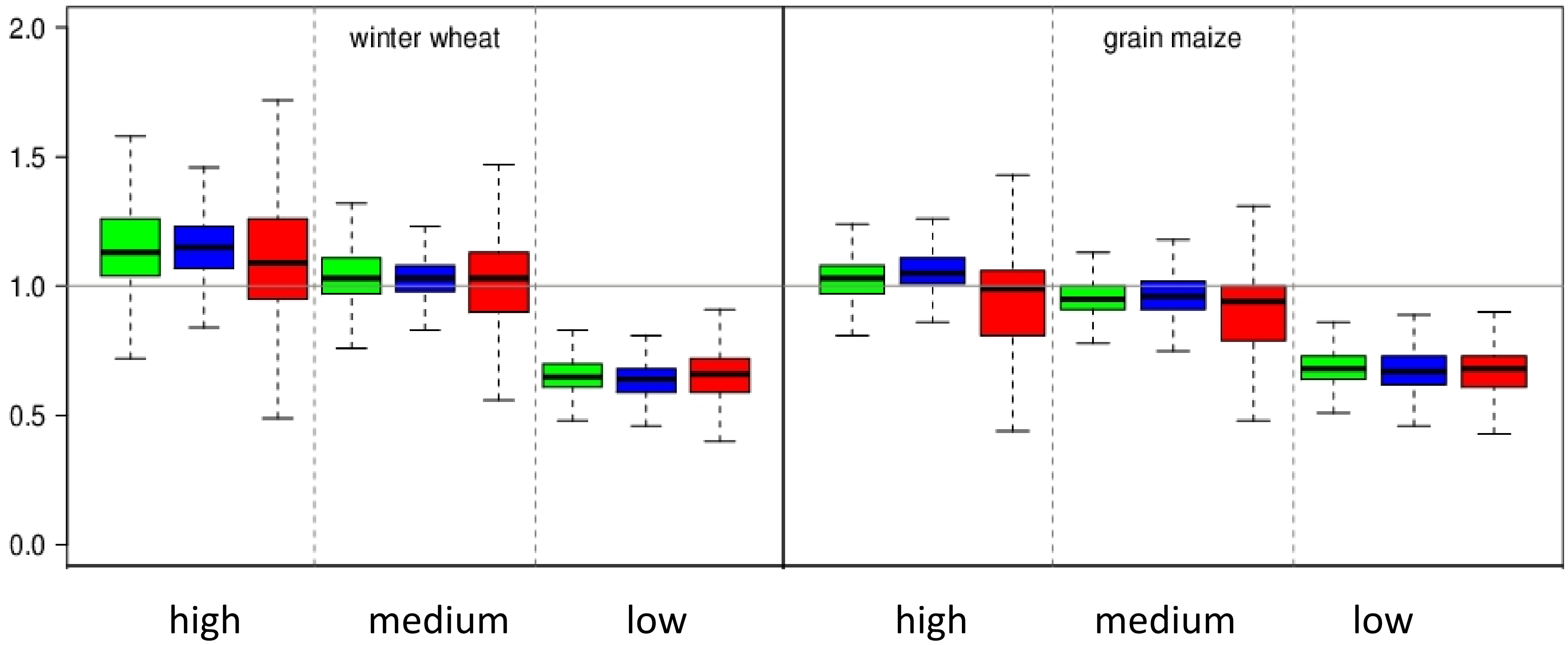
Seasonal differences in runoff from TUWmodel



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.

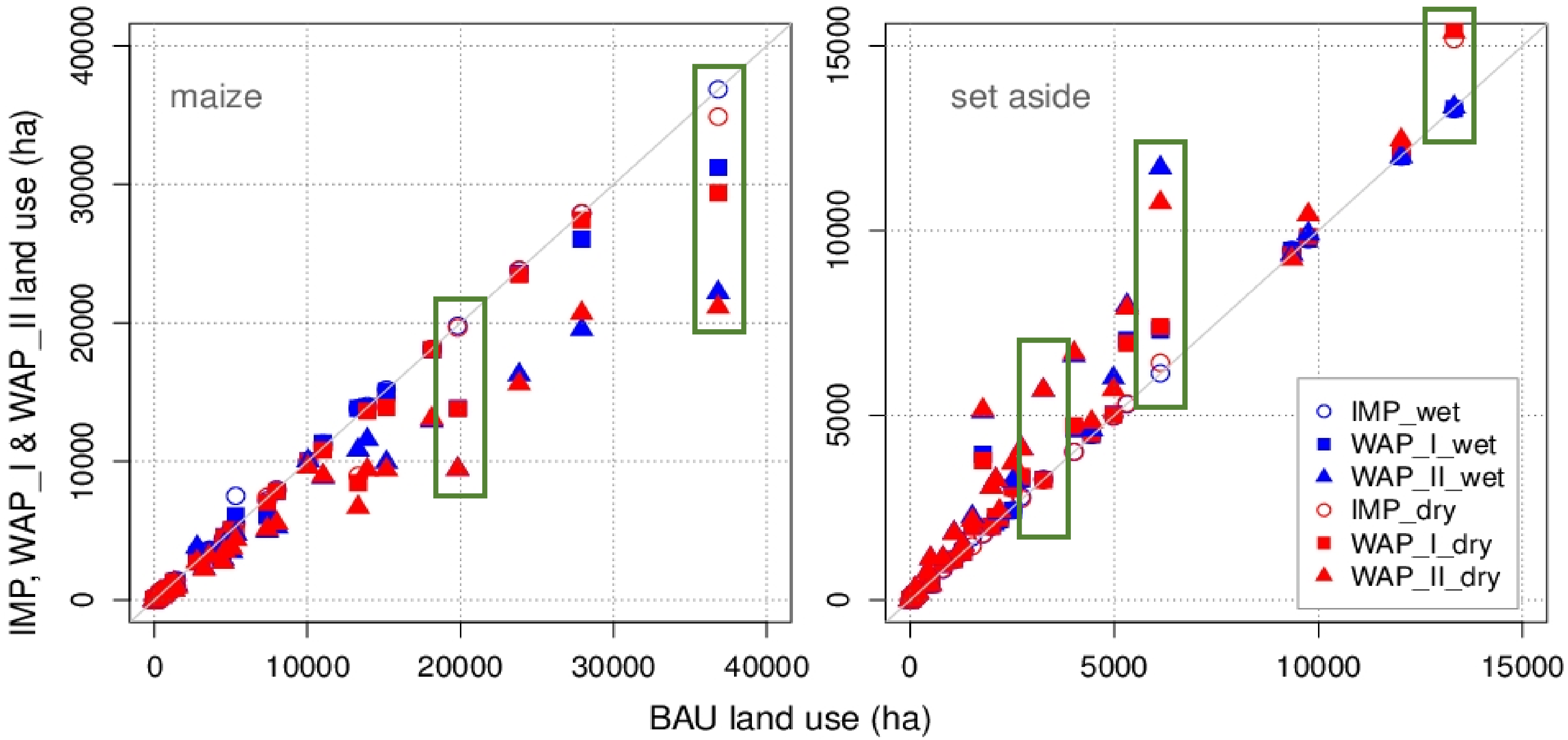
Examples for relative yield changes from EPIC



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

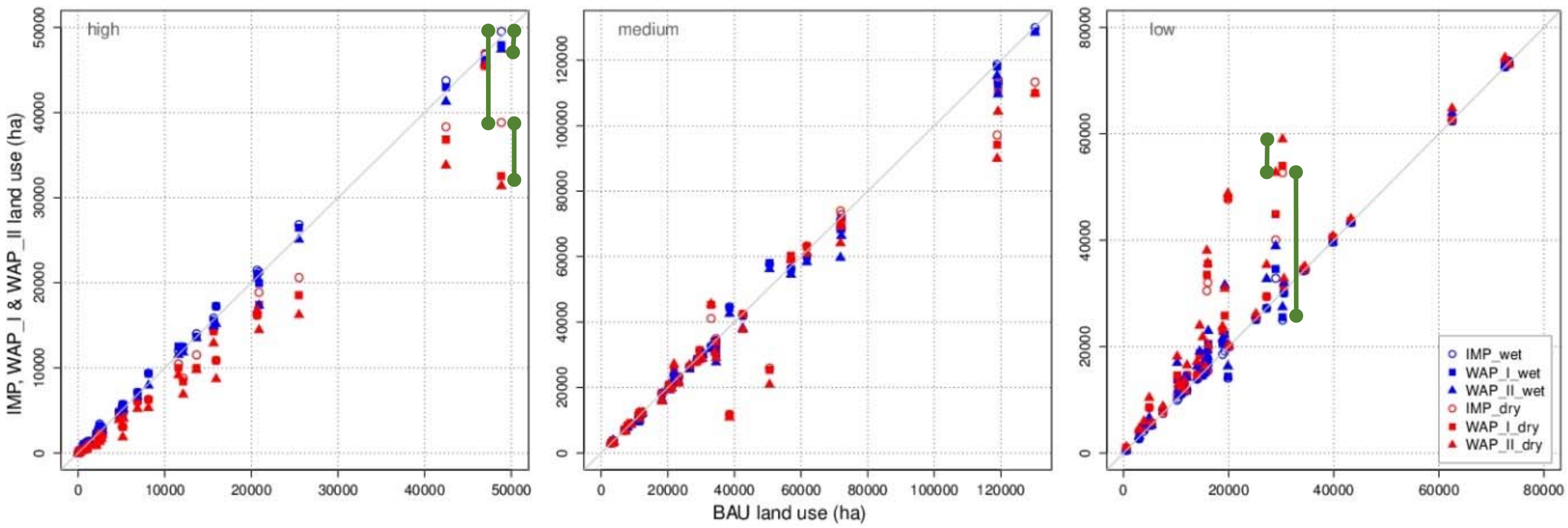
climate scenarios similar (green), wet (blue) and dry (red).

Crop choices from climate change and policies



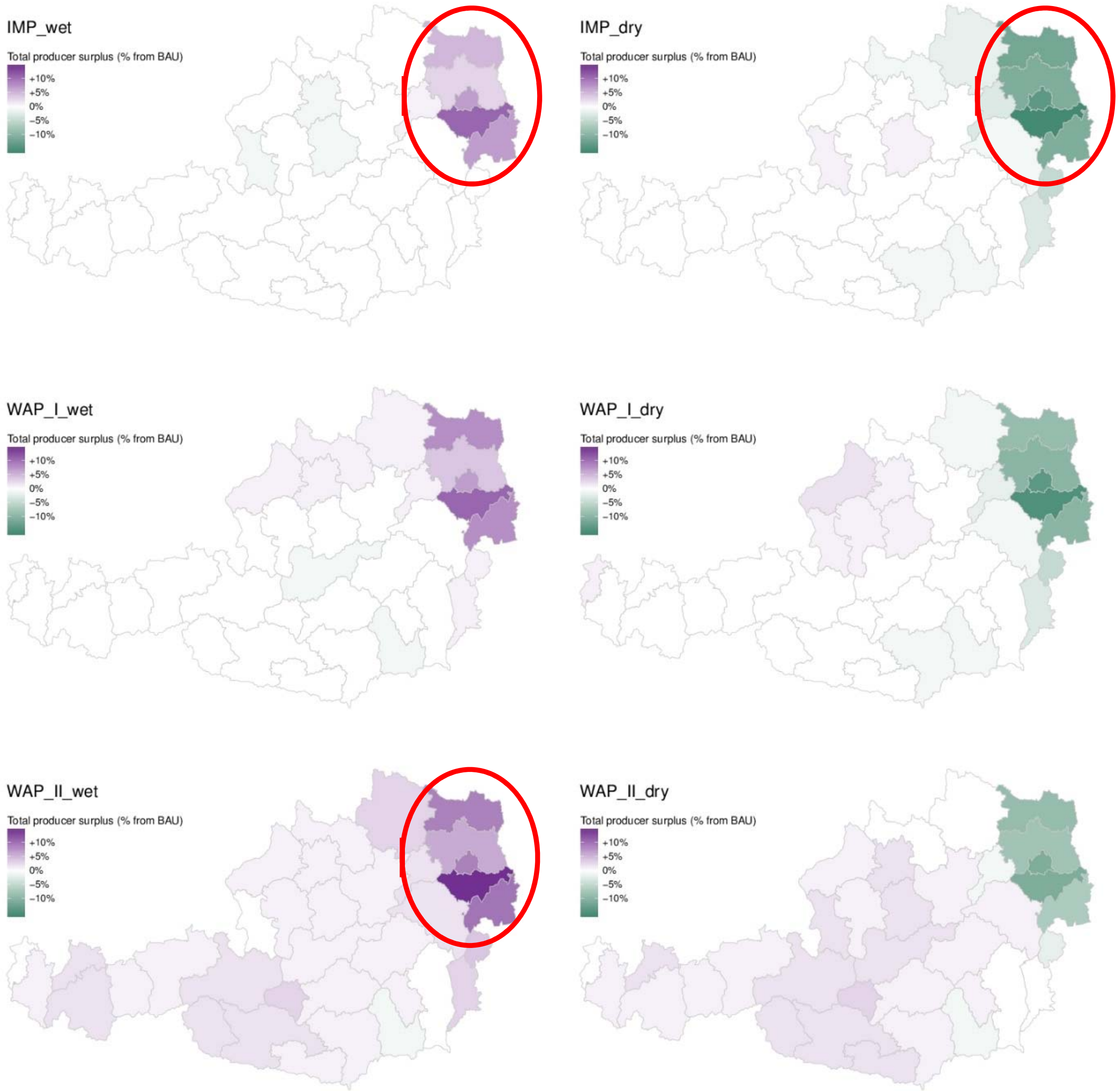
Comparison of maize and set aside area with the BAU scenario for two climate and three policy scenarios for 35 Austrian NUTS-3 regions

Fertilization choices from climate change and policies

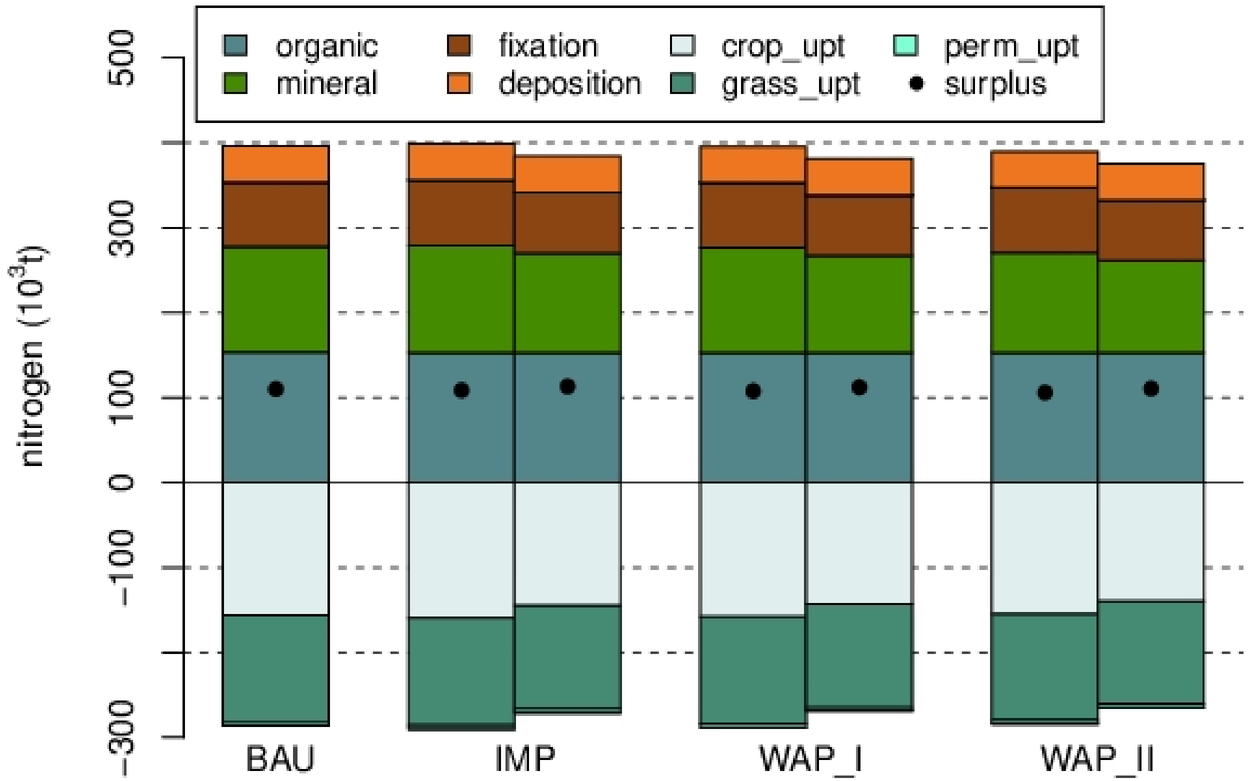


Comparison of three intensity levels in two climate and three policy scenarios with the BAU scenario for 35 Austrian NUTS-3 regions

Change in agricultural producer surplus at NUTS-3 level from PASMA[grid]



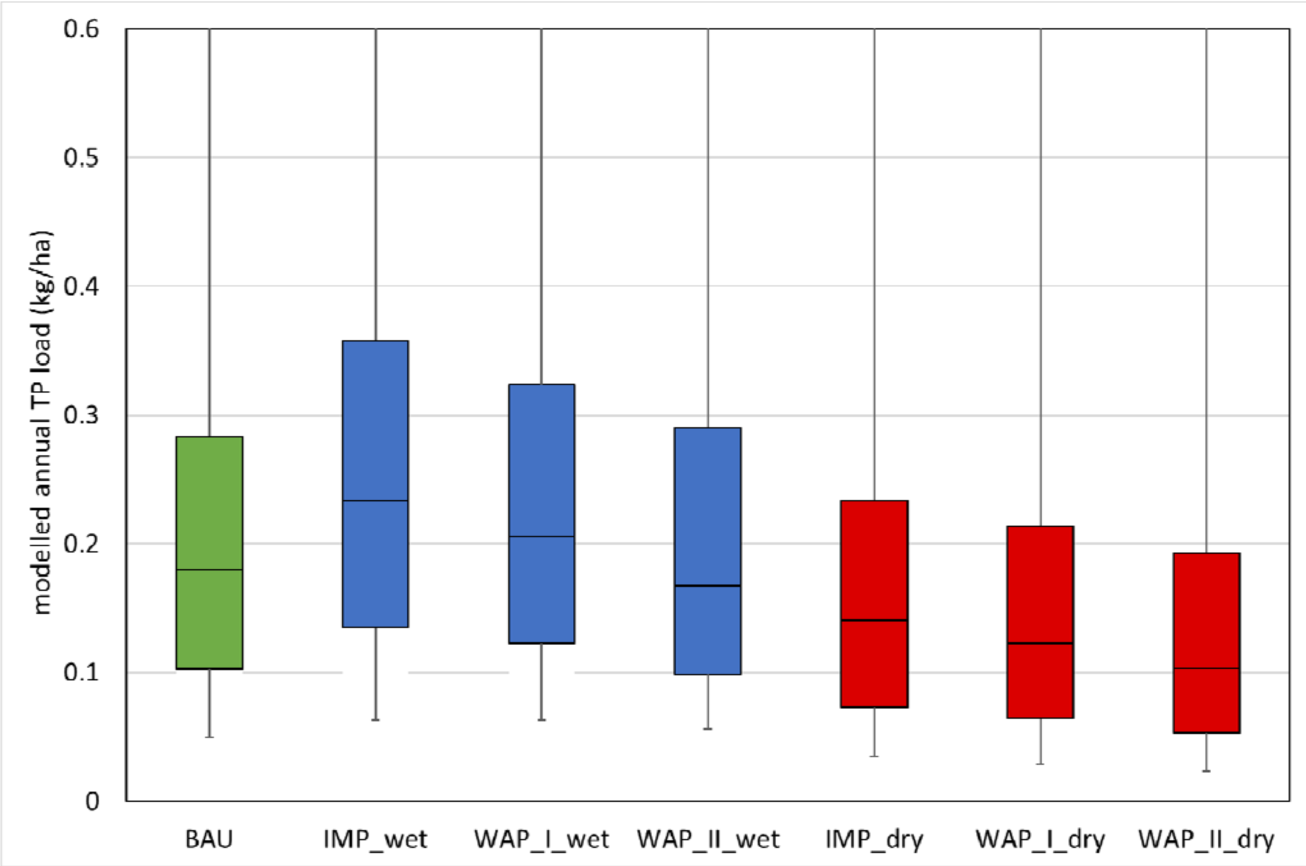
Impacts on the nitrogen cycle at national scale



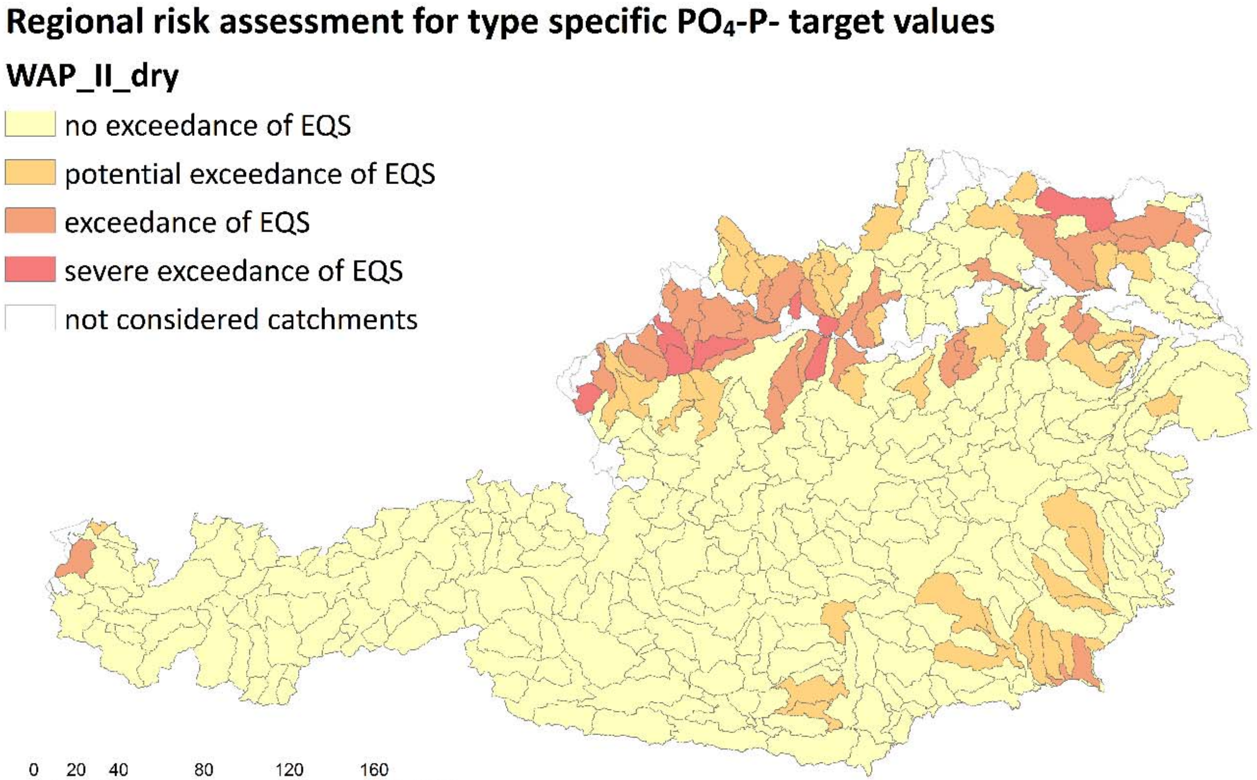
wet (left column) and *dry* (right column)

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.

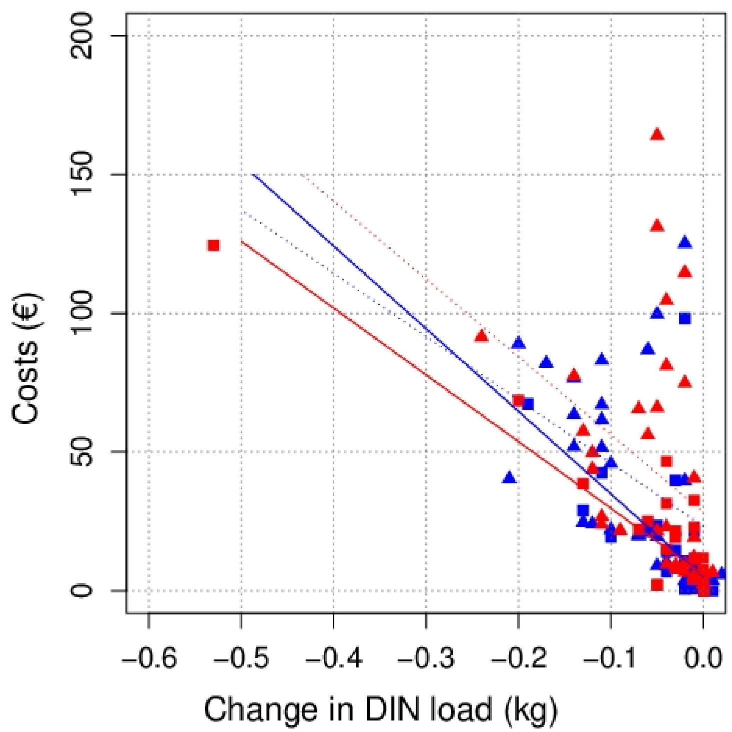
Modelled annual Total Phosphorus export loads per watershed

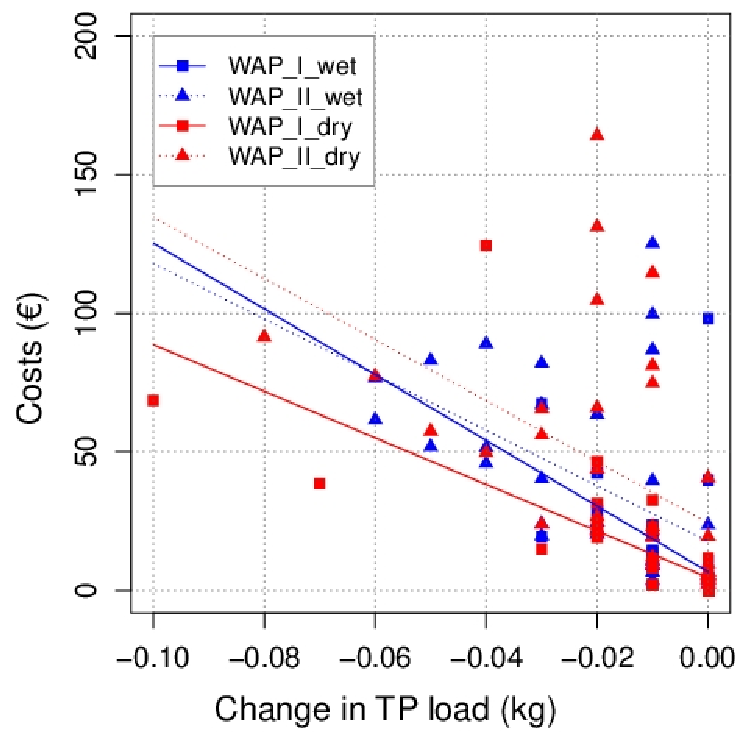


Regional risk assessment for EQS exceedance



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

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