Analyzing competing land use policy objectives under climate change – a regional case study from Austria

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In the semi-arid Seewinkel region in Austria, competing demands exist for land and water such as from agriculture, nature protection, tourism and settlements. In addition, water quality problems are prevalent due to nitrate leaching in groundwater in the region. Climate change likely will amplify existing resource demands and environmental impacts, imposing considerable challenges for adapting and regulating agriculture in the Seewinkel. Hence, compromises between competing policy objectives are needed.

The aim of this presentation is to assess efficient land and water management strategies considering several economic and agro-ecological policy objectives in the Seewinkel region in context of climate scenarios. A multi-objective optimization experiment was performed with an integrated modelling framework to compute agro-economic-ecological Pareto frontiers. The frontiers combine levels of (i) net benefits from agricultural production, (ii) groundwater extraction for agricultural irrigation, (iii) nitrate leaching from agricultural production, and (iv) topsoil organic carbon stocks. 30 stochastic realizations of three climate scenarios are considered for a future period of 31 years: WET, SIMILAR and DRY, which mainly differ regarding annual precipitation volumes.

Model results show that a 1% (20%) reduction of agricultural net benefits can lower groundwater extraction by 11-83% (61-100%) and nitrate leaching by 18-19% (49-53%) as well as increase topsoil organic carbon sequestration by 1% (5%) depending on the climate scenario. However, substantial changes in land use and management would be required. For instance, less groundwater extraction by 11-83% requires a 6-21% reduction of irrigated cropland, a 21-33% reduction of highly fertilized cropland, a 10-24% increase of grassland, and a 23-52% increase of abandoned land depending on the climate scenario. Less nitrate leaching by 18-19% (or higher topsoil organic carbon stocks by 1%) require that highly fertilized cropland decreases by 9-13% (4-7%), abandoned land increases by 5-9% (19-49%) and grassland either declines by 3% (14%) or increases by up to 5% (32%) depending on the climate scenario. In general, the share of grassland increases in the wetter climate scenario.

Overall, the analysis reveals that especially groundwater extraction and nitrate leaching can be reduced substantially for fairly small reduction in agricultural net benefits in all climate scenarios. 50% of maximum modelled improvements of agro-ecological objectives can be already achieved at 1-15% reductions of agricultural net benefit depending on climate scenarios. Thus, respective land use policies would allow considerable improvements of the agro-ecological performance at
relatively low costs. However, improving the agro-ecological performance beyond a particular level can quickly lead to high reductions of agricultural net benefits, as depicted by the non-linear form of the Pareto frontiers. This is mainly related to large declines of cropland and increases in grassland or abandoned land. Furthermore, the results indicate that water management policies are less costly than climate change mitigation policies, at least in the Seewinkel region.