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Positive Multi-Attribute Utility Programming ensemble to assess modeling uncertainty in water rationing policies

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The compound effects of climate change and growing water demand, particularly from irrigation expansion, result in increasingly frequent and intense water shortages. The conventional response to this problem has focused on the development of water works to expand the supply base and thus meet increasing water needs. However, as the water crisis aggravates a growing number of basins worldwide are reaching a ‘maturity’ stage where the financial and environmental costs of deploying additional water works exceed the economic benefits of water uses in the margin. In this context, water authorities are increasingly constrained to change trajectory and adopt policies that adapt water withdrawals to the limited resources available.

This paper presents a multi-factor, non-linear Positive Multi-Attribute Utility Programming (PMAUP) to elicit the objective or utility function of representative agricultural water users. The calibrated PMAUP is then used to simulate agent’s responses to a set of water demand policies by means of maximizing the multi-attribute objective function within a domain. As opposed to conventional, single-attribute microeconomic models where profit is the single relevant attribute of the utility function, in our multi-attribute model the behavior of agricultural water users is driven by multiple (and often conflicting) attributes related to their socioeconomic, cultural and natural situation, including but not limited to profit. Our research uses three alternative calibration mechanisms for the PMAUP model to implement an uncertainty analysis on the impacts of three alternative water policies to reduce water use in the agricultural sector: caps, pricing, and buyback.

The methodology is illustrated with an application to the Douro River Basin in Spain, an otherwise water abundant basin increasingly exposed to drought events. Agriculture is the largest water user in the basin and represents 78% of annual withdrawals, while also concentrating the marginal (i.e. least valuable) uses of the resource. As a result, water conservation policies typically target this sector. Our methods and results can support the development of cost-effective water policies in a context of aggravating drought events while accounting for potential biases from calibration errors through an uncertainty analysis.