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Hydroeconomic Analysis for Climate Adaptation Guidance under Future Climate Water Stress

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Climate water stress internationally challenges the goal of achieving food, energy, and water security. This challenge is elevated by population and income growth and by considerable uncertainty about future water supplies. Increased climate water stress levels reduce water supplies in many river basins and intensify competition for water among sectors and over time periods. Organized information is needed to guide river basin managers and stakeholders who must plan for a changing climate through innovative water allocation policies, trade-off analysis, vulnerability assessment, capacity adaptation, and infrastructure planning. Several hydroeconomic models have been developed and applied assessing water use in different sectors, counties, cultures, and time periods. However, none to date has presented an optimization framework by which historical water use and economic benefit patterns can be replicated while showing measures to adapt to future climate water stresses to inform the design of policies not yet implemented. This paper's unique contribution is to address this gap by designing and presenting results of a hydroeconomic model for which optimized base conditions match observed data water use and economic welfare for several urban and agricultural uses at several locations in a large European river basin for which water use supports a population of more than 3.2 million. We develop a state-of-the arts empirical dynamic hydroeconomic optimization model that integrates hydrology, economics, climate stress, and institutional water sharing measures. The model is used to discover land and water use patterns that optimize sustained farm and city income under various levels of climate-water stress. Findings using innovative model calibration methods allow for the discovery of efficient water allocation plans as well as providing insight into marginal behavioral responses to climate water stress and water policies. Results show that a water trading policy for handling climate water stress provides more economically efficient water use patterns, reallocating water from lower valued uses to higher valued uses such as urban water. The Ebro River Basin in Spain is used as an example to investigate water use adaptation patterns under various levels of climate water stress. That basin's issues and challenges light a path to relevance for other river basins internationally.