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Spatial analysis of private tanker water markets in Jordan: Using a hydroeconomic multi-agent model to simulate non-observed water transfers

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The country of Jordan is characterized by severe water scarcity and deficient public water supply networks. To address these issues, Jordan's water sector authorities have adopted a water rationing scheme implemented by interrupting piped water supply for several days per week. As in many arid countries around the world, this has led to the emergence of private markets of small-scale providers, delivering water via tanker trucks. On the one hand, these markets play a crucial role in meeting residential and commercial water demands by balancing the shortcomings of the public supply system. On the other hand, providers partially rely on illegal abstractions from rural ground and surface water sources, thereby circumventing regulatory efforts to conserve these resources.

Private tanker water markets, therefore, provide a substantial contribution to consumer welfare while jeopardizing freshwater resource sustainability. Thus, a better understanding of these markets is of great importance for the formulation of policy interventions pursuing freshwater sustainability in a socially acceptable manner. Direct assessments of the size of these markets or their responses to policy interventions are, however, impeded by their partially illegal nature and the resulting lack of available information.

To overcome this data collection challenge, we use a hydroeconomic multi-agent model developed in the Jordan Water Project to indirectly simulate country-wide tanker water market activities on the basis of demand and supply estimates. The demand for tanker water is conceptualized as a residual demand, remaining after a water user has depleted all available cheap and qualitatively reliable piped water. It is derived from residential and commercial demand functions on the basis of survey data. Tanker water supply is determined by farm simulation models calculating the groundwater pumping cost and the agricultural opportunity cost of tanker water. Finally, a spatial market algorithm matches rural supplies with users' demands across the 89 subdistricts of Jordan. This algorithm is parameterized with survey data we collected on tanker operators' transport costs and profit expectations.

The model is successfully validated with available data on tanker truck registrations and tanker water prices. Model results reveal the spatial distribution of the private tanker markets' freshwater extractions, sales quantities, and economic impacts on different water user groups across all of Jordan. The results confirm the quantitative importance of these markets for consumer welfare. A dynamic coupling of farm agents with a country-wide groundwater model allows us to capture feedbacks between tanker water markets and groundwater levels. This enables us to assess policy impacts over time. Model analyses show that policies aiming to mitigate the negative sustainability impacts of private tanker water markets need to simultaneously address the shortcomings of the piped water supply system in order to avoid undue burdens on water users.