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Simulation–optimization modeling for sustainable conjunctive water management in irrigated agriculture: WEAP-MODFLOW application in the Miyandoab plain, Urmia basin, Iran

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In this study, we present a simulation-optimization model for sustainable conjunctive water management in the Miyandoab plain, northwest of Iran. The Miyandoab plain is a strategic irrigated area in the Urmia basin confronted by several complex water problems. A recent drought has led to reductions in environmental flows to Lake Urmia, which is located downstream of the irrigated plain, leading to continued shrinking of the lake. These environmental demands are in direct competition with water demands for irrigated agriculture, which requires a sufficient supply of surface water (SW) and groundwater (GW). Droughts lead to reductions in SW supply, increases in GW pumping, and subsequent decreasing GW levels and increasing crop water stress. Most inhabitants of this region rely on agriculture for their living. Therefore, strategies for solving the water problems in this region should not lead to a reduction in farmer income. To this end, a spatially distributed simulation-optimization model was developed to investigate potential strategies for reducing drought impacts on farmer's profits while satisfying environmental flow requirements. These strategies include conjunctive management of SW and GW resources, and engineered improvements such as changes in cropping patterns. The simulation model is based on a dynamic coupling of WEAP and MODFLOW to account for storage and flow through a surface water reservoir, an alluvial aquifer, irrigated root-zones, and routing through rivers and canals. For the optimization, two opposing objectives are maximized, i.e. the extent to which environmental flow requirements are met and agricultural profit subject to groundwater level constraints. A Multi-Objective Particle Swarm Optimization (MOPSO) algorithm and the PARETO optimality method were used to solve the resulting optimization problem.