Can we Manage Groundwater? A statistical assessment of management plan effectiveness.
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Regulation of groundwater through the use of management plans is becoming increasingly prevalent as global groundwater levels decline. But seldom are plans systematically and quantitatively assessed for effectiveness. Instead, the state of an aquifer is commonly considered a proxy for plan effectiveness despite being a combination of many drivers,such as climate, extractions and management techniques, and not an indicator of the effectiveness of the plan. Groundwater management under uncertainty is challenging, often provisional and experimental, and for this research, was structured as a systems control problem. This enabled development of an assessment rubric to determine whether groundwater management plans have the required features that allow plan effectiveness to be quantitatively tested. Using systems control methods, seven components of a management plan representing the primary elements of a control loop were determined, then weighted and rated, allowing calculation of a numerical testability score. This enabled different plans to be rated and compared. Component importance varied, but, a measurable objective or acceptable impact, such as water level, was found to be necessary in order for plans to be testable. The rubric was applied to 15 Australian groundwater management plans and approximately 50% were found to be testable. Testability does not however, indicate plan effectiveness and testable plans do not necessarily achieve planned objectives. To numerically quantify the effectiveness of groundwater management, the impact of extraction restrictions was probabilistically assessed by simulating management of a highly connected, semi-confined, two dimensional groundwater system. Water managers were privy only to head levels in a varying number of grid cells assigned as monitoring wells, and used that limited information to infer aquifer properties and make allocation decisions at each time step. Extraction rates for each simulated management period were determined based upon observed heads from the previous management period and adjusted depending upon triggers outlined in the plan. The effectiveness of water restrictions as a management technique to maintain supply reliability under various decision making frequencies, aquifer response times and climate scenarios was explored.