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# System dynamics model to study the effect of different policies on Bahrain's hydrological processes

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**ABSTRACT**

System Dynamics (SD) modeling is a powerful tool for modeling complex interconnected and dynamic systems. It involves representing these systems with blocks and feedback loops defined mathematically. This kind of modeling can be very useful for decision-makers who want to understand the impact of different policies on a particular variable. SD modeling is aligned with the concepts of Integrated Water Resources Management and Water-Energy Nexus because it helps to account for the big picture. In this project, our goal is to conduct a holistic analysis of Bahrain's groundwater system. The effects of different policies in various relevant sectors, such as economic, environmental, and agricultural, among others, on the groundwater volume is studied. To do this, an SD model that represents the groundwater storage volume and its response to natural and artificial recharge, groundwater flow from the head aquifer in Saudi Arabia, abstractions for irrigation, agriculture, and domestic demands, and downstream outflow towards Qatar is developed. The SD model is validated with the help of a validated hydrological model and published information related to groundwater volume, recharge quantities, and abstraction rates, among others. The SD model is lumped for the study area (Bahrain) and ran the simulations for the period 2016–2070. The hydrological model is a semi-distributed model that calculates the water budget using a series of non-linear reservoirs for each catchment at every 30-minute time-step for the simulation period 2016–2021. The hydrological model is validated using regionalization techniques; hence, its results are considered the 'correct' values against which the SD model is validated. The initial results of the study show the effect of artificial recharge and abstractions for different water demands. These results are used as a starting point for the second stage of this work, which involves including socio-economic effects of groundwater abstraction, and implications on food security and energy generation.

*Keywords:* System dynamics modelling; Sustainable groundwater exploitation; Hydrological modelling; Interconnected systems

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