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Irrigation Canal System Automation to Reduce Groundwater Extraction and Energy Consumption

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Over the semi-arid region of Iran due to the inadequate, unreliable and inequitable surface water and poor operational performances of the current irrigation systems, there is an increasing dependence on groundwater resources. For instance, in the state of Qazvin, which is located in central part of Iran, the "scheme irrigation efficiency"(subdividing in "conveyance efficiency" and "field application efficiency") has decreased about 1% from 1900 to 2016. Accordingly, the efficiency has declined from 48% in 1990 to 30% in 2016. In such a conditions, farmers have to extract more groundwater as a supplementary source alongside surface water resources to meet the crop's needs. However, pumping groundwater has been led to adverse impacts on the aquifer (e.g., lower water table), environmental consequences (e.g., co2 emissions due to diesel or electro engines).
The objective of this study is to examine the efficiency of the irrigation system by upgrading water distribution and delivery systems within the central irrigation canals. Also, we investigate reduction in groundwater pumping and consequently on energy consumption due to a potentially better-managed irrigation system. To achieve these goals, a model with the decentralized control system, employing Proportional-Integral (PI) configuration, is designed, calibrated and used. The decentralized configuration is chosen based on execution, operation and maintenance considerations (e.g., operator's knowledge and skills) and the social conditions of the region. Most often this is not only a matter of costly implementation of the centralized automation systems but also because of the frequent damage and robbery of the on-site control equipment. Therefore, we need to consider social states of the region of the interest.
Performance of the designed automated control system is compared to the current operating of the system under the regular and severe water shortages scenarios. The results reveal that operational performance improvements were achieved by using the automated decentralized control system. The spatial distribution of the adequacy indicator alongside the main canal is determined, to demonstrate consequences of enhancing the surface water distribution systems on the aquifer's water extraction. The results for the scenario without water shortages shows that the automatic system improves the adequacy index up to 13%, resulting 26.3% groundwater withdrawal reduction over the study region. This amount of reduction in the groundwater extraction leads to 22.7% energy saving due to shutting off pumping of the currently deep and semi-deep tube-wells. Also, the results of the operational scenario under water scarcity, show an improvement of the adequacy index on order of 70%. Accordingly, the reduction in pumping groundwater from the aquifer and energy consumption for the proposed automation method is 28.3% and 21.3%, respectively. The proposed framework of this study can be used for the assessment of the impacts of irrigation network operation on aquifers restoration and energy consumptions.