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Ensuring a Reliable Agricultural Water Distributions within Canal Automation under a Significant Inflow Fluctuations During the Water Shortages Periods

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Supply of food security with limited water resources in the agriculture sector, as a more significant consumer of water, is one of the sustainable development goals. The impacts of climate change are increasingly threatening the irrigation districts. Inflow fluctuations to irrigation districts located at the downstream parts of the rivers is a new phenomenon leading to the unreliable water supply for agricultural activities. The current study presents a practical solution to improve the operational condition of irrigation networks suffering from extreme inflow fluctuations without any constructional modifications to the main canal and off-take structures. This study was conducted on the mathematical model of the Roodasht North Branch (RNB) main irrigation canal located in the central part of Iran. Although the farmers within RNB district were prohibited from setting up the tube-wells, near to 2000 tube-wells, have been set up to extract underground water because of the unreliable operation of irrigation canal systems. To provide a reliable water distribution of the surface water resources, centralized model predictive control (MPC), a robust tool capable of dealing with several different optimization objectives, uncertainties, delays, and constraints, was designed and tested. The hydraulic simulation model of the canal was coupled with the designed MPC controller. The performance of the controllers was evaluated under the regular and severe inflow fluctuations scenarios. According to the obtained results, the controller, thanks to the prediction horizon, starts to store water before starting fluctuations for predictable fluctuations. The stored water efficiently used by the off-takes and the fluctuation consequences are successfully handled by the controller so that maximum water level error significantly decreases and the calculated performance indicators of MAE and IAE show approximately 26% and 14% improvement in comparison with the conventional canal operation. The adequacy performance indicator shows notable improvements, where the indicator has been improved by 15% at the upstream parts to 82% for the off-takes locating at the downstream parts of RNB main canal. Moreover, to demonstrate the importance of this achievements, the 82 percent improvement is translated to groundwater extraction. In this regard, the amount of groundwater extraction drops about 2.648 and 17.742 MCM/year respectively for semi-deep and deep tube-wells. In another word, with upgrading the operating systems in RNB irrigation district, near to 2000 numbers of tube-wells shut off. This study shows that application of automation is a promising way for upgrading the operational performance of the main irrigation canals suffering from inflow fluctuations creating by unsecured supplied water at the heat source.