Climate-instigated disparities in supply and demand constituents of agricultural reservoirs for paddy-growing regions

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Abstract

Agricultural reservoirs are critical water resources structures to ensure continuous water supplies for rice cultivation in Korea. Climate change has increased the risk of reservoir failure by exacerbating discrepancies in upstream runoff generation, downstream irrigation water demands, and evaporation losses. In this study, the variations in water balance components of 400 major reservoirs during 1973 - 2017 were examined to identify the reservoirs with reliable storage capacities and resilience. A conceptual lumped hydrological model was used to transform the incident rainfall into the inflows entering the reservoirs and the paddy water balance model was used to estimate the irrigation water demand. Historical climate data analysis showed a sharp warming gradient during the last 45 years that was particularly evident in the central and southern regions of the country, which were also the main agricultural areas with high reservoir density. We noted a country-wide progressive increase in average annual cumulative rainfall, but the forcing mechanism of the rainfall increment and its spatial-temporal trends were not fully understood. Climate warming resulted in a significant increase in irrigation water demand, while heavy rains increased runoff generation in the reservoir watersheds. Most reservoirs had reliable storage capacities to meet the demands of a 10-year return frequency drought but the resilience of reservoirs gradually declined over time. This suggests that the recovery time of reservoirs from the failure state had increased which also signifies that the duration of the dry season has been prolonged while the wet season has become shorter and/or more intense. The watershed-irrigated area ratio ($W\text{-}I_{ratio}$) was critical and the results showed that a slight disruption in reservoir water balance under the influence of future climate change would seriously compromise the performance of reservoirs with $W\text{-}I_{ratio} < 5$.

Keywords : reservoir water balance, climate change, reliable storage capacity, resilience

Acknowledgment

This work is supported by the National Research Foundation (NRF) of Korea grant No. 2020R1A2C1013947, funded by the Korean Government.

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