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Water Supply Performance Assessment of Gash Delta Spate Irrigation System, Sudan

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Abstract

Gash Delta Spate Irrigation System with total net command area of 100,000ha, located in Kassala State, eastern Sudan, was established in 1924 for poverty reduction through cultivation of cotton as cash crop and sorghum as main staple crop. Spate water from Gash River, with effective flood period of about 70 days, is diverted through seven intake structures and conveyed via main canals to the command area, which is subdivided in to six irrigation blocks. Under the original plan, land was cultivated every three years (3-year rotation), so that about 33,000ha of the 100,000ha is irrigated annually. Rehabilitation of the system, which restores the original capacity of the irrigation structures was made in 2003 accompanied by change from 3- to 2-year rotation (50,000ha irrigated annually). The annual target irrigated areas, of the 3- and 2-year rotation were decided on the basis of the average annual volume of the Gash River. However, the yearly variation of river flow should be also considered in the decision and many technical reports have stated that the above annual irrigation areas were not realistic. This study, therefore, deals with assessing the water supply performance of the 3- and 2-year rotation system using the Monte Carlo simulation by considering stochastic supply and deterministic demand for irrigation water. A total of 50 scenarios, five levels of river flow intake ratio (intake/total volume), five levels of irrigation efficiency and two rotation systems, were analyzed. After checking for serial independence, historical annual flow data of 107 years were fitted to Normal, Log-normal, Gamma, Log-Pearson Type III and Weibull distributions. Although the river flow data fit to all the distributions at 95% confidence interval of Chi-squared test, the Weibull distribution was the best on the basis of Akaike Information Criteria. For 5,000 Monte Carlo simulations, 100-year ensembles of random annual flows were generated by assuming the Weibull distribution and ignoring autocorrelation. These random annual flows are multiplied by the river flow intake ratio and irrigation efficiency of each scenario to generate irrigation water supply data series and then compared with the irrigation water demand of the respective scenario. The reliability, which measures how frequent the supply satisfies the demand and the vulnerability, which measures the magnitude of failure, were estimated for each scenario. The mean reliabilities of the 3- and 2-year rotation were 54% and 18% respectively for the average values of the river flow intake ratio and irrigation efficiency. For the same situation the mean vulnerabilities of the 3- and 2-year rotation were 31% and 38% respectively. Considering the river flow intake ratio and irrigation efficiency within their feasible ranges, the 3- and 2-year rotation have reliabilities in the range of 10-85% and 0-65% and vulnerabilities in the range of 22-41% and 30-47%, respectively, with the higher and lower values corresponding to the best and worst combinations of the supply and demand management. The obtained results showed that the developed methodology can provide scientific guidance for rehabilitation and operation plans of the irrigation system.

Keywords: Gash Delta, spate irrigation, reliability, vulnerability, Monte Carlo simulation