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Optimal water resources allocation modelling in the Lowveld of Zimbabwe

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The aim of this research is to develop an operating policy model for a multi-reservoir system that can be used to optimally allocate water to the sugar cane estates in the Lowveld of Zimbabwe. Specific objectives are to assess the spatial and temporal variability of rainfall and reservoir inflows in the catchment; to calibrate and validate the water allocation model (WEAP) for the catchment; and develop a model which optimizes operation policy of multiple reservoirs and productive water use in the catchment. The Mann Kendall Trend and Wilcoxon Signed-Rank tests were used to test the trend and variability of historic monthly rainfall and inflows of the catchment respectively. The WEAP water allocation model was set up to evaluate the allocation system of the catchment for 2016. Stochastic Dynamic Programming using LINGO was used for optimisation of the multi-reservoirs releases. Different scenarios were developed to assess the allocation in the catchment for different time steps and the scenarios run in WEAP. The Mann Kendall Trend test showed that there was generally a significant seasonal trend in the series of the rainfall and inflows at 0.05 significance level. The Wilcoxon Signed-Rank Test showed a significant change (negative ranks>positive ranks) in the inflows and rainfall over the years (1901-2014) at α=0.05. The WEAP model showed significant deficits in irrigation water allocation for the catchment of average 40% in the reference scenario.The optimal steady state policies for the different reservoirs was obtained to be a suitable approach for solving complex multi- reservoir management problems within the catchment. The optimal steady state policy computed the end of state storage that needs to be maintained given the initial storage and inflow at any period. The resulting inflow, storage and release tables are efficient and illustrative tools to guide the decision makers in the release of water without emptying the reservoirs but at the same time maximising the system annual performance (optimal crop yield).

Key Words: Optimisation, Water allocation, Multi-reservoirs, Stochastic Dynamic Programming