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Impacts of rainfall uncertainty on water resource planning models in the Upper Limpopo basin, Botswana

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Abstract In water resource planning in semi-arid Africa and comparable regions, uncertainty is high due to limitations in historic observations, uncertainty in hydrological models, uncertainty over future demands for water, and uncertain influences of future climate and hydrological change. The uncertainty in the future supply–demand balance should be considered in planning decisions, as it affects the risk associated with any planning option, and can help identify priorities for data collection. Focusing on rainfall and hydrological uncertainty, this paper outlines a framework of uncertainty analysis, which allows such consideration to be given. The framework consists of multi-site continuous time stochastic rainfall modelling to infill historic rainfall data. The stochastic infilling of rainfall data allows calibration of a hydrological model under input uncertainty. The rainfall model, together with the uncertain hydrological model, is then used to generate multiple realisations of reservoir inflow over a 100-year period. This framework is applied to the Upper Limpopo basin in Botswana, using 25 years of observed daily rainfall and flow data for model calibration. A generalised linear model was used for the rainfall and a semi-distributed version of the IHACRES model was used for the hydrology. A proposed 382×10^6 m^3 reservoir at the outlet of this catchment, which is part of Botswana's national water resource strategy, is re-evaluated in light of the extended inflow data and the estimated uncertainty. Results show that the uncertainty has a considerable effect on the reliability of the reservoir; for example, the proportion of time for which demand for water was not met ranged from 0 to 13% over the different flow realisations. The main assumptions made, to be addressed in our future research, are stationarity of climate and that all the hydrological uncertainty arises from the historic rainfall uncertainty due to missing data.

Key words IHACRES; rainfall–runoff; generalised linear models; semi-arid; Botswana; reservoir operation