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Sand river aquifers as a nature-based solution of water storage for food production: the example of the Shashane River in Southwest Zimbabwe

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Semi-arid regions are characterized by unpredictable intense but short rainfalls and long-lasting drought periods. Particularly in rural Sub-Saharan Africa, this water scarcity leads to marginalization and loss to socio-economic development induced by constant unreliable water supply. Given the limited amount of surface water, groundwater resources are often regarded as an alternative, but more difficult to assess and develop, particularly in hardrock aquifers that characterize much of the Sub-Saharan region. Thick sand beds of wide ephemeral rivers, formed as a consequence of pronounced dryland weathering and erosion, have been reported to present a possibly viable water source, but these so-called sand river aquifers have been poorly studied in terms of dynamics, recharge, evaporation and abstraction potential, as well as their role for groundwater dependent ecosystems such as riparian corridors. In the perspective of finding alternative water resources for rural communities to support current needs and future increased crop production, a portion of the Shashane River in the southern part of Zimbabwe is considered as a case study to characterize sand river aquifers for alternative water storage and analyze their potential in sustaining water supply and food production. Field assessment was coupled with modelling to achieve the objective of this research.

Soil gradation analysis in combination with in-situ slug tests and geophysical assessment were performed to determine the hydraulic properties that define the geometry, storage and flow capacity of the aquifer. Discharge records as well as groundwater level data were used to perform a dynamic analysis on the recharge frequency and the potential water losses from the system. The findings were used to build a 3D transient numerical groundwater model in order to understand the groundwater flow and the natural variation of the storage. In addition, the model was used to estimate the recharge of the system as well as to assess the impact of intensified abstraction scenarios on the storage, flow and evaporation losses from the aquifer.

The aquifer was found to have an available storage capacity of 0.35 Mm3 along the studied stretch of 5.6 km, naturally depleted by 50% due to evaporation when no abstractions occur. Less water is lost to evaporation when abstractions increase, and the system has the potential to fulfill a total demand of 800 m3/day without failure, which can irrigate a potential area of 3.5 ha per km. Despite the increased abstractions, fast and complete recharge in the following wet season is almost certainly ensured by infiltration from surface runoff, except for some extended dry years that occur once every 20 years. Increased recharge induced by abstractions leads to a reduction in runoff in the following year and thus may affect other users downstream, including dependent ecosystems, which requires further studies.