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A Modelling Framework for Ground Water Sustainability in the Upper Orange Catchment of South Africa

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Abstract

The paper aims to model important parameters governing the sustainability of groundwater systems in C52 catchment of the Upper Orange River system of South Africa. The Upper Orange River is part of the broad Orange River System. Due to the adverse impact of climatic change and increased dependence on the groundwater systems in the catchment, there is a need for development of a framework for sustainable groundwater management by modelling hydrological and human induced factors affecting the sustainability of the groundwater system.

The conceptual framework was based on the physical processes governing hydrological cycles in relation to groundwater sustainability in the upper Orange catchment. Some of these processes are surface to groundwater interactions, land use to groundwater interactions and land use and climate interactions. These processes were grouped as factors and includes climatic, socio-economic and land use, aquifer sustainability, right and equity of resources.

The methodology involved a detailed understanding of the parameters and ranking of the physical processes affecting groundwater system of the upper orange river catchment such as the climatic factors (precipitation, evapotranspiration, sunshine, slope, topography, climatic zones), aquifer system (recharge, yields, storativity, aquifer types, lithology/rock types). Other important catchment factors and parameter rankings which are human induced are rights and equity (number of issued permits per year in the catchment, duration of the permits, number of boreholes in the sub-catchment, pump rate per year), socio-economic and land use (use per capita, population in the catchment, water uses and Tariffs).

The developed framework was proposed in a sustainability index. The sustainability indices were ranked based on a scoring system from the highest score of 100 which implies highly sustainable system to the lowest score of 19 which suggest the least sustainable. Rating of 1 was assigned to severe impact and rating of 5 was assigned to least impact on the groundwater sustainability status. The final groundwater sustainability index score of 19-35 means very low sustainability, 35-51 means low sustainability, 51-67 means moderate sustainability, 67-83 means high sustainability and 83-100 means very high sustainability.

The developed sustainability index will be applied to the 51 boreholes mapped in the C52 tertiary catchment of the Upper Orange River Catchment. The outcome will be in a sustainability map showing areas depicting the most to least sustainable aquifers in the catchment. The developed sustainability index and maps would be useful tools for future groundwater management.

Key words: Aquifer, groundwater sustainability, hydrology models, Orange River, Climate change.