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Building Drought Resilience: Earth Observation for Groundwater Management in Botswana

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Botswana is one of the world's most drought-prone countries, with multiple, multi-year droughts recorded since the 1950s. Drought frequency in Botswana has increased progressively passing from a single drought during the 80s to recording six droughts from 2006 to 2016. The country faces critical challenges in ensuring a sustainable water supply for its growing population and its agricultural, mining and industrial sectors. Groundwater is the lifeline of Botswana, accounting for approximately 80% of the country's total water supply, with this percentage increasing in Western Botswana and rural areas, where most villages and the mining industry are entirely dependent on groundwater. This reliance is undermined by recurring droughts, low and unreliable rainfall, the overexploitation of groundwater resources, and the limited operational hydrological data monitoring network in recent years.

A collaboration between GMV and the World Bank, through the European Space Agency (ESA) Global Development Assistance (GDA) thematic area of Water Resources, is implementing Earth Observation-based services for groundwater quantification, monitoring, and resilient groundwater resources management in Botswana. Firstly, an initial groundwater recharge assessment was conducted by calculating the potential groundwater recharge at national scale for the 2003-2023 period. More specifically, the soil moisture balance was calculated using CHIRPS (precipitation) and MODIS (potential evapotranspiration) as inputs at daily resolution. The results show low annual potential recharge values, with a clear aridity gradient from southwest to northeast and a strong seasonality where most of recharge occurs between December and February.

Secondly, the Global Land Data Assimilation System (GLDAS) datasets (NASA) have been used to evaluate the groundwater availability and storage variations across Botswana through the study period. GLDAS is a modelling system which combines satellite and field station measurements to generate uniform land surface models (LSMs) outputs. The resulting groundwater storage variations display similar gradients and seasonal patterns than those observed with the potential groundwater recharge as well as large interannual variability. These data are then used to identify hotspots of ongoing significant groundwater through trend extractions and the calculation of the GRACE groundwater drought index (GGDI) among other indicators. Results from this study will be

used to communicate groundwater and drought conditions with relevant local stakeholders. Thus, these findings support the development of comprehensive groundwater and water security strategies in Botswana. Further work will be undertaken to contrast these results with catchment-scale groundwater recharge estimations and investigating the correlation between groundwater resources with other elements of the water cycle (e.g., rainfall, runoff) as well as large-scale circulation patterns. This work also evidences the way that bringing in earth observation products and land assimilation systems supports the design of resilient policies in countries with data scarcity and challenging climatic conditions.