IWMI
International Water Management Institute

Project Brief
Transboundary Water Management in Southern Africa

A first step toward integrated management: Transboundary Diagnostic Analysis of the shared **Tuli Karoo System, Limpopo River Basin**

The Tuli Karoo Aquifer Area — as well as the broader surface water system that encompasses the aquifer — is shared among Botswana, South Africa and Zimbabwe, and forms part of the Limpopo River Basin. There has been very little investigation into the Tuli Karoo aquifer or the associated surface waters, and no report to date has engaged the three countries to acquire and integrate data to provide an in-depth examination of the aquifer area and associated river system. To fill this gap and lay a basis for improved management, a Transboundary Diagnostic Analysis (TDA) of the Tuli Karoo System was undertaken (IWMI 2019). Data were compiled and synthesized according to relevant themes, including water resources and uses, the environment, socioeconomics and institutions. Ultimately, information collected as part of the TDA was synthesized to reveal a set of critical issues related to achieving water security, with specific attention to the opportunities that can be harnessed and challenges that can be addressed through conjunctive approaches.

Confluence of two ephemeral rivers, the Limpopo and Shashe, appearing as large sand rivers for the better part of the year (photograph taken from South Africa) (*photo*: Resego Mokomela, IWMI).

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Key messages

- **Conducting a TDA is an extensive consultative effort.** In the Tuli Karoo System, this was an important first step toward strengthening cooperation among the three countries (Botswana, South Africa and Zimbabwe) on this shared aquifer system.
- **Shared groundwater-surface water systems within and beyond Africa are gaining importance.** The TDA of the Tuli Karoo System – as part of broader cooperation on the shared system – adds to the growing body of knowledge on strengthening conjunctive water management in transboundary contexts.
- **Several key issues emerged from the TDA of the Tuli Karoo System:** (i) the need for joint monitoring to better understand water resource dynamics, both groundwater and surface water; (ii) there is potential for irrigation expansion, alongside the improvement of irrigation efficiency in the shared system; (iii) the impacts of climate change on water availability are apparent and need to be adequately addressed with solutions that build resilience through improved water and food security.

Population and climate

Population distribution in the Tuli Karoo System. More than 1.8 million people currently live in the Tuli Karoo System (Figure 1), and more than 120,000 people in the Tuli Karoo Aquifer Area (Figure 2). Close to half of the population in the aquifer area falls within Zimbabwe. Despite possessing the smallest population and land area relative to the total aquifer area, the South African portions of the Tuli Karoo System are growing the fastest.

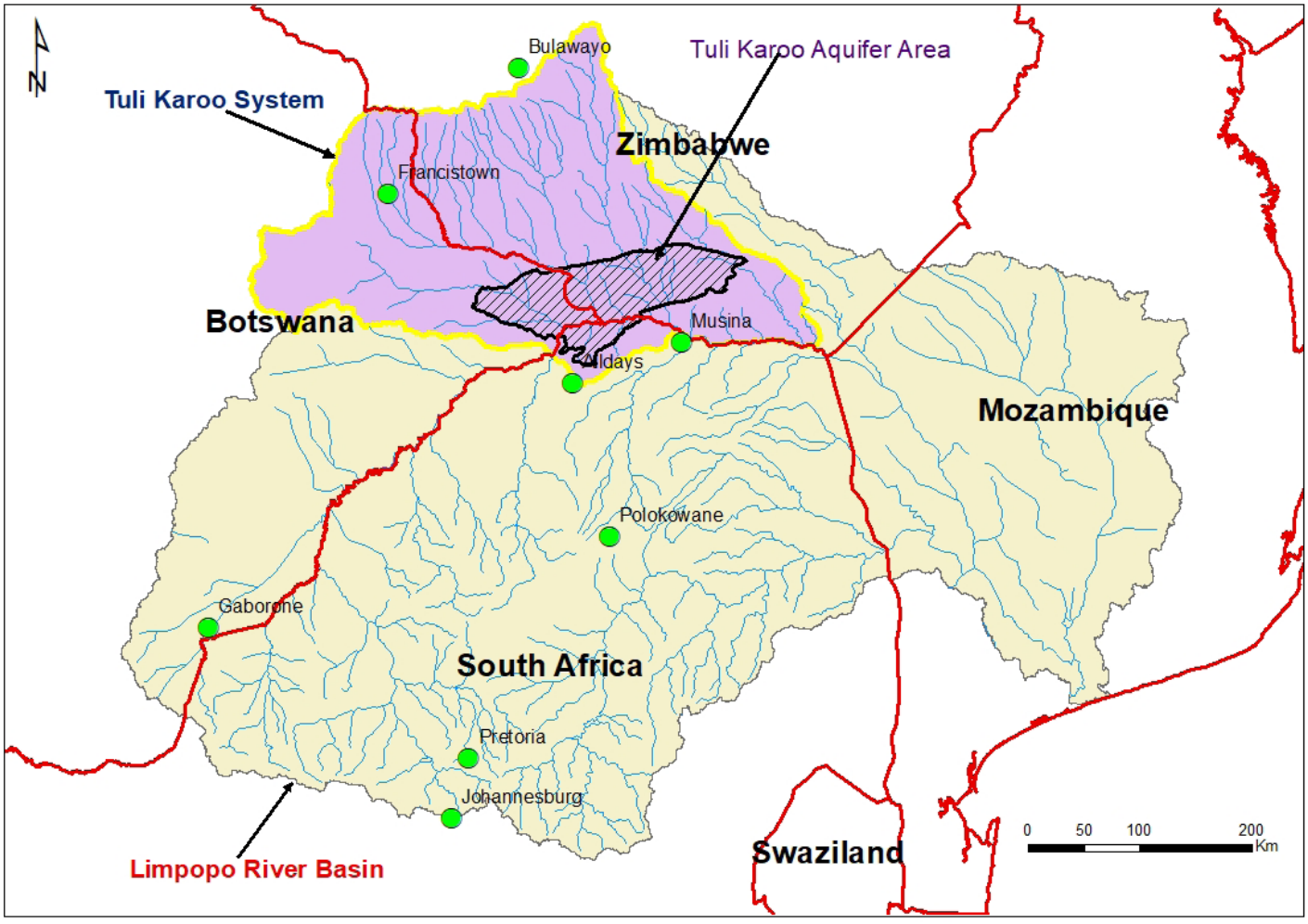

Figure 1. Map of the Tuli Karoo System in the larger Limpopo River Basin.

Source: IWMI 2019.

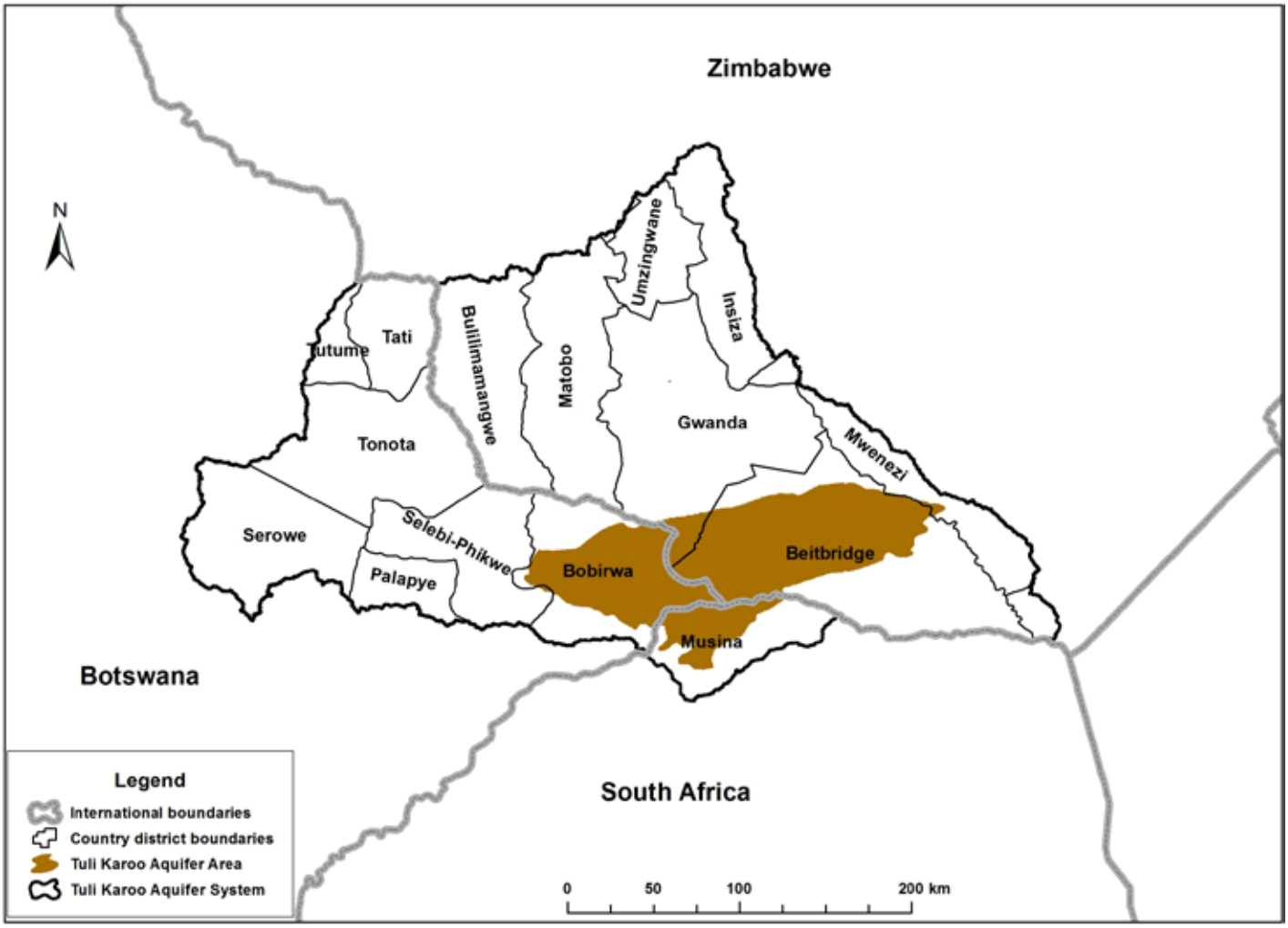

Figure 2. Map of Tuli Karoo Aquifer Area (shaded) and broader Tuli Karoo System showing subnational administrative boundaries.

Source: IWMI 2019.

Largely rural population is dependent on pit latrines for sanitation. On the Zimbabwe portion, 88% of the population lives in rural areas (ZimStat 2012), while the rural-urban split is almost 50-50 in Botswana. In South Africa, urban areas represent just 0.08% of total land use in the local municipality (MLM 2018). In the Botswana portion, an estimated 75% of the households use pit latrines as sanitation facilities, including both ventilated improved pit latrines and ordinary pit latrines (Statistics Botswana 2018). In Zimbabwe, more than 80% of the population in Beitbridge district are reported to have no access or unsafe access to types of sanitation facilities (RWIMS 2019).

Mining and agriculture are the main local economic activities in the Tuli Karoo System. The Tuli Karoo System contains coal deposits, lending itself favorably to coal mining, with future exploration plans envisaged (MoMMD 2019). Commercial irrigated farming is common in the Botswana and South African portions of the aquifer. The mostly rural population of the Tuli Karoo System is poor and depends on smallholder crop production – both rain-fed and irrigated – as well as livestock farming, especially in the Botswana and Zimbabwe portions of the system (Masundire et al. 2016; EMA 2019). Biodiversity is nonetheless rich, evidenced by the presence of game reserves and conservation activities. Therefore, tourism is an important sector.

Floods and droughts are worsening. High inter-annual rainfall variability in the Tuli Karoo System has resulted in a notable rate of droughts and floods in recent decades. The Tuli Karoo System is warming—likely associated with climate change. Results of rainfall analyses were less conclusive; nonetheless, mean temperatures showed a significant change, and two of ten rainfall stations analyzed revealed significant declines in volumes. Conditions of rising temperatures and variable rainfall patterns present additional stress on the already arid context of the Tuli Karoo System.

Smallholder plot in Beitbridge district, Zimbabwe (*photo:* F. Simba).

Groundwater and surface water

Transboundary impacts on groundwater. While knowledge on the direction of groundwater flow in the Tuli Karoo aquifer is limited, it appears to flow toward the southeast portion of the aquifer in South Africa and Zimbabwe—which renders these two countries somewhat vulnerable to changes in upstream portions of the aquifer in Botswana and partly in Zimbabwe. Data from Botswana indicate declining water levels presumably due to increased water abstraction in the aquifer area; limited data on water levels in the South African portion of the aquifer, however, showed no such trend. It could be that the current intensity of groundwater use, low transmissivities and consequent low borehole yields of the Karoo rocks across Botswana, South Africa and Zimbabwe mediate the transboundary impacts of groundwater abstraction. It could also be that investigation based on a deeper dataset produces a more realistic situation. Whatever the case, there is a need to closely monitor the area so that potential impacts are well managed.

Weak groundwater monitoring compromises full understanding of the aquifer. There are four priority areas of focus to better understand the aquifer. First, groundwater levels, especially in Zimbabwe, should be monitored. Second, stable isotope investigations can be undertaken to establish sources and interactions of groundwater across the three countries. Third, aquifer response during periods of high rainfall can be investigated to understand how these rainfall events contribute to local or regional groundwater recharge. Fourth, with the increase in the frequency of high rainfall events, understanding their relationship to groundwater levels will be key to enabling effective management.

Groundwater quality is generally acceptable; hot spots are nonetheless a concern. Limited data suggest that groundwater quality in the Tuli Karoo Aquifer Area is generally good, and does not appear to pose major health risks to the human population. There is, nonetheless, a need for careful mapping and monitoring of potential hot spots to ensure risks to groundwater quality are mitigated. The aquifer area hosts several open-cast, underground mines and industrial sites, for example, which may be releasing radionuclides and radioactive material into the groundwater and this is not being monitored. There are currently no

aquifer-wide radionuclide or radioactivity monitoring programs. Therefore, their abundance is unknown.

Extensive development of surface water resources. Three catchments – Motloutse, Mzingwane and Shashe – contribute more than 90% of flow to the Tuli Karoo System. There has been considerable development on these catchments since 1990; more development is planned, putting further strain on available resources. While the increased water availability generated through water storage augmentation is positive, it appears that development was undertaken unilaterally. It may have been possible to achieve additional gains through greater collaboration among countries sharing the Tuli Karoo System (e.g., through the Limpopo Watercourse Commission).

Rivers in the Tuli Karoo System are key to sustaining groundwater levels. Based on a baseflow analysis, rivers of the Tuli Karoo System appear to contribute (or 'lose' water) to groundwater. Surface flows are, therefore, key to sustaining groundwater levels, and reductions in surface flows may have impacts on groundwater availability. Ultimately, there appear to be key changes in water storage and use in the Tuli Karoo System. A review of results based on current data suggests potential impacts, but a more comprehensive monitoring program would allow for far greater clarity. In particular, streamflow gauging stations near the outlets of tributaries such as Motloutse, Mzingwane and Shashe – downstream of water storage infrastructure – would constitute an important step forward.

Water and land use

Agriculture is a major land use. Although nearly 12% of the Tuli Karoo System is cultivated, less than 1% of the land area is irrigated. Given the necessity to increase food security and climate change resilience, there may be a need to expand irrigation in an efficient and sustainable way. Shrubland, grassland and pastureland that cover most of the Tuli Karoo System play a valuable role that should not be overlooked. The services derived from such land use help to attenuate surface flow and facilitate groundwater infiltration. Both of these processes add value.

Access to water and sanitation should be expanded. More than one-third of the population in the Tuli Karoo Aquifer Area lack access to safe drinking water supplies, and nearly half have no access to adequate sanitation facilities. The realities undermine efforts towards development, and pose health risks to the populations that should be avoided. Expansion of water supplies is, therefore, necessary for improved health. Similarly, improved access to safe sanitation practices could enhance the protection of groundwater from contamination.

Thune Dam, Botswana (*photo:* T. Dlamini).

There is potential for expanding shared wildlife protection areas for tourism. The concentration of wildlife conservation reserves in the Tuli Karoo Aquifer Area calls for consideration of transboundary integration, within feasible limits. Protection of conservation areas and limiting transboundary animal disease are essential for maximizing the benefit gained from a Transfrontier Conservation Area (TFCA), such as the potential achievements from the proposed Greater Mapungubwe TFCA. If carefully undertaken, benefits derived from a TFCA may exceed benefits derived from separate, neighboring conservation areas in each of the three countries.

Water abstraction in the Tuli Karoo Aquifer Area. More than 40% of water in the Tuli Karoo System is now stored behind a growing number of large dams. Most of this stored water is abstracted and utilized. Irrigation is the largest water user (> 80%) in the Tuli Karoo Aquifer Area (Figure 3), followed by mining (6.5 %), environmental flows (5.3%), water supply service including domestic use (2.5%), livestock (0.9%) and industry (0.3%). Irrigation schemes do not have sufficient water to meet their potential in any given season (FAO 2004).

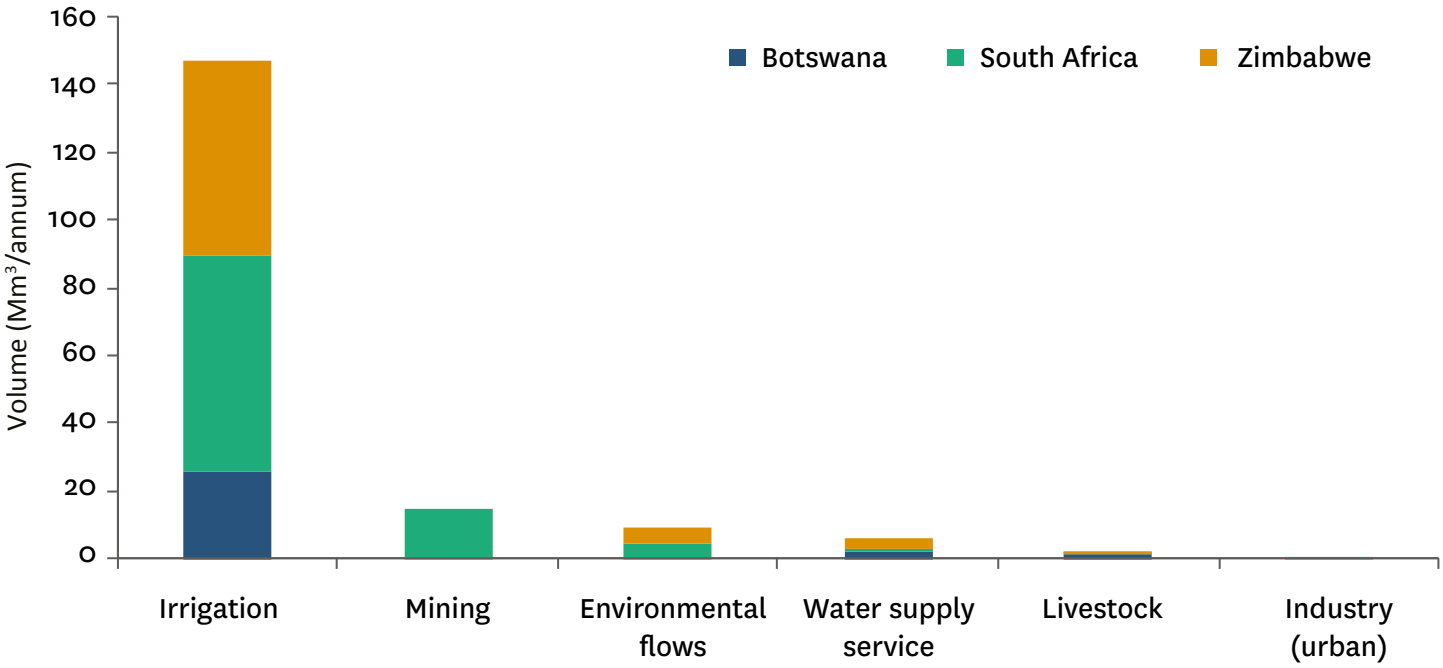

Figure 3. Summary of estimated water use in the Tuli Karoo Aquifer Area.

Note: Mm³ - Million cubic meters.

Irrigated smallholder plot in Bobonong, Botswana (*photo:* T. Dlamini).

Joint stakeholder workshop held in Francistown, Botswana - October 2019 (*photo:* T. Dlamini).

Conclusion

Knowledge gaps need to be filled through improved, joint monitoring efforts for better understanding the Tuli Karoo System. While the significant knowledge gaps on the Tuli Karoo System can be overwhelming, it is important to address approximately three areas: (i) understanding river flow and groundwater recharge through improved monitoring; (ii) determining surface water versus groundwater use; and (iii) understanding how surface water and groundwater interact. Increased monitoring may be able to address these gaps and provide a better picture of how the system functions.

Irrigation efficiency improvements should be explored. Irrigation is the largest user of water in the Tuli Karoo Aquifer Area and critical for food security. Water use relative to total renewable water resources is, nonetheless, quite high. There are, therefore, benefits to adopting more efficient irrigation technologies. Irrigation water-use efficiency can noticeably and substantially reduce irrigation water demand through the use of technologies such as Wetting Front Detectors (WFDs) and Chameleon sensors, which allow farmers to use less water and appropriately manage nutrients.

Suitable climate change resilience interventions should be identified, assessed and implemented. The risks of climate variability and change in the Tuli Karoo System are clear, and not unlike other regions in Africa. Interventions that strengthen climate change resilience and are suited to conditions in the Tuli Karoo System can help to protect communities from these climatic realities. It is critical to understand the suitability of current approaches such as subsurface dams and other forms of managed aquifer recharge, and to identify new approaches such as proactive alternation in the use of different water sources in a way that best ensures availability.

Source

This brief is largely adapted from the following source:

IWMI (International Water Management Institute). 2019. *Transboundary Diagnostic Analysis (baseline report) for the Tuli Karoo System*. Supported by the United States Agency for International Development (USAID). Pretoria, South Africa: International Water Management Institute (IWMI). Available at: http://conjunctivecooperation.iwmi.org/wp-content/uploads/sites/38/2020/01/TuliKarooTDA_2019.pdf

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Project

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