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Transboundary Diagnostic Analysis of the Eastern Kalahari-Karoo Transboundary Basin Aquifer system (EKK-TBA)

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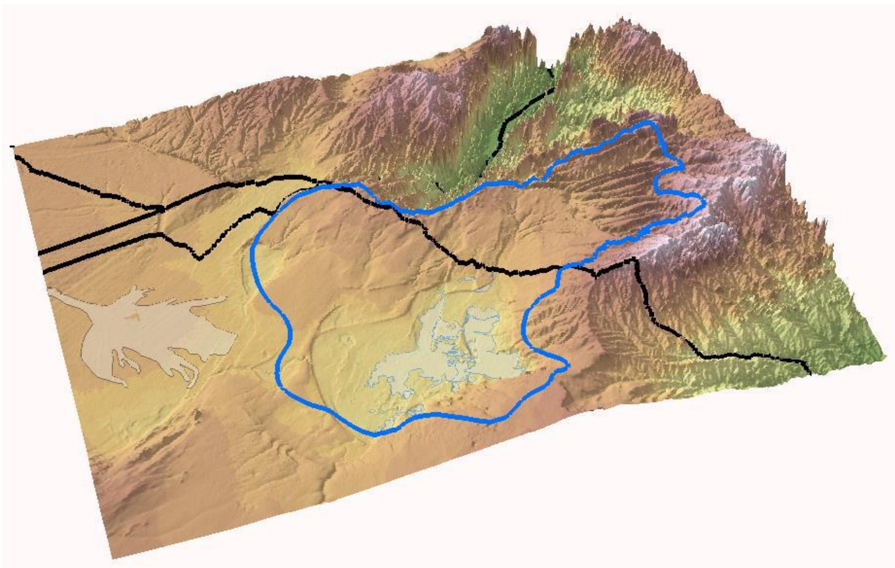

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Transboundary Diagnostic Analysis of the Eastern Kalahari-Karoo Transboundary Basin Aquifer system (EKK-TBA)

Authors

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Abstract

A Transboundary Diagnostic Analysis (TDA) of the Eastern Kalahari_Karoo Transboundary Basin Aquifer system (EKK-TBA) was conducted presenting a comprehensive understanding of the state of surface water and groundwater resources, their uses, spatial and temporal variability, interactions, and impacts as well as human benefits derived from ecosystem services and existing infrastructure. The EKK-TBA is shared between Botswana and Zimbabwe. Water-related issues of the Basin are identified and lay the foundation for a basin-wide Strategic Action Plan (SAP).

The EKK-TBA is unique in that it straddles two river basins: Okavango and Zambezi, and covers an area of 127 000 km^2 (65% in Botswana and 35% in Zimbabwe). The topography is generally flat, (880 – 1400 m amsl) and the climate is semi-arid. Surface water drainage is mainly through ephemeral rivers towards the Makgadikgadi Pans in the southern part of the Basin and through the Gwayi River system in the northeast towards the Zambezi River. The 2020 Basin human population is estimated at 595 000 (16% in Botswana and 84% in Zimbabwe) and the Basin's economy is mostly driven by diamond mining, ecotourism and agriculture (livestock and cropping).

Groundwater forms the main source of potable water supply within the Basin for both humans and animals. Shallow aquifers are constituted by the Kalahari Group deposits whereas the main aquifers are the deep Ntane/Forest Sandstone and the Mea Arkose Sandstone. Wellfields have been developed along the southern and south-eastern fringes of the Basin where the sandstone aquifers outcrop and are recharged from rainfall (direct and indirect).

Key issues emanating from the TDA included:

- Water insecurity due to increasing water demand against the backdrop of limited groundwater resources
- Data scarcity (central and northern EKK-TBA) and inaccessibility and poor quality of data
- Deforestation and poor agricultural practices resulting in land degradation
- Lack of adequate resources to carry out effective and efficient groundwater management including monitoring of water resources
- Lack of transboundary groundwater management

Keywords: Eastern Kalahari-Karoo Transboundary Basin Aquifer, Transboundary Diagnostic Analysis, Botswana and Zimbabwe, Okavango and Zambezi River Basins, Key Issues

Introduction

Most of the population in Southern Africa relies on groundwater for basic needs, and many aquifers from which groundwater is abstracted constitute transboundary aquifers. A growing body of work has identified and delineated more than 30 transboundary aquifers in the Southern African Development Community (SADC), Figure 1, and many more in Africa as a whole (Altchenko and Villholth, 2013). Joint management of these aquifers can foster progress towards the region's socio-economic development goals including enhancing water security and agricultural production and strengthening of resilience to climate variability and change. However, despite the seemingly prolific activity in transboundary water cooperation and River Basin Organisation development in Africa in general and SADC in particular, actual cooperation on the ground on SADC's shared aquifers is currently low (Lautze and Giordano, 2005; Saruchera and Lautze, 2016).

This paper presents a Transboundary Diagnostic Analysis (TDA) of the Eastern Kalahari-Karoo Transboundary Basin Aquifer (EKK-TBA) system, which is a multi-layered aquifer system and is shared between Botswana and Zimbabwe and constitutes the study area (Figure 1).

The TDA is a technical assessment, through which water-related issues of thematic areas (demography and socio-economy, surface water and groundwater, land use and land cover, environment and water governance) of a basin are identified and discussed. The TDA provides the technical justification for the development of a Strategic Action Plan (SAP) of the EKK-TBA to address the issues (SADC-GMI, 2020a). As groundwater is the main source of water in the Basin, a hydrogeological study of the Basin (SADC-GMI, 2020b) was simultaneously undertaken to better inform the TDA.

The TDA is part of a larger facilitative process that involves stakeholder engagement and consultation from the initial TDA steps through to the subsequent development of alternative solutions during the formulation of the SAP. The TDA can be seen as a process that can help create confidence among the stakeholders concerned as they are engaged and involved at every step of the process.

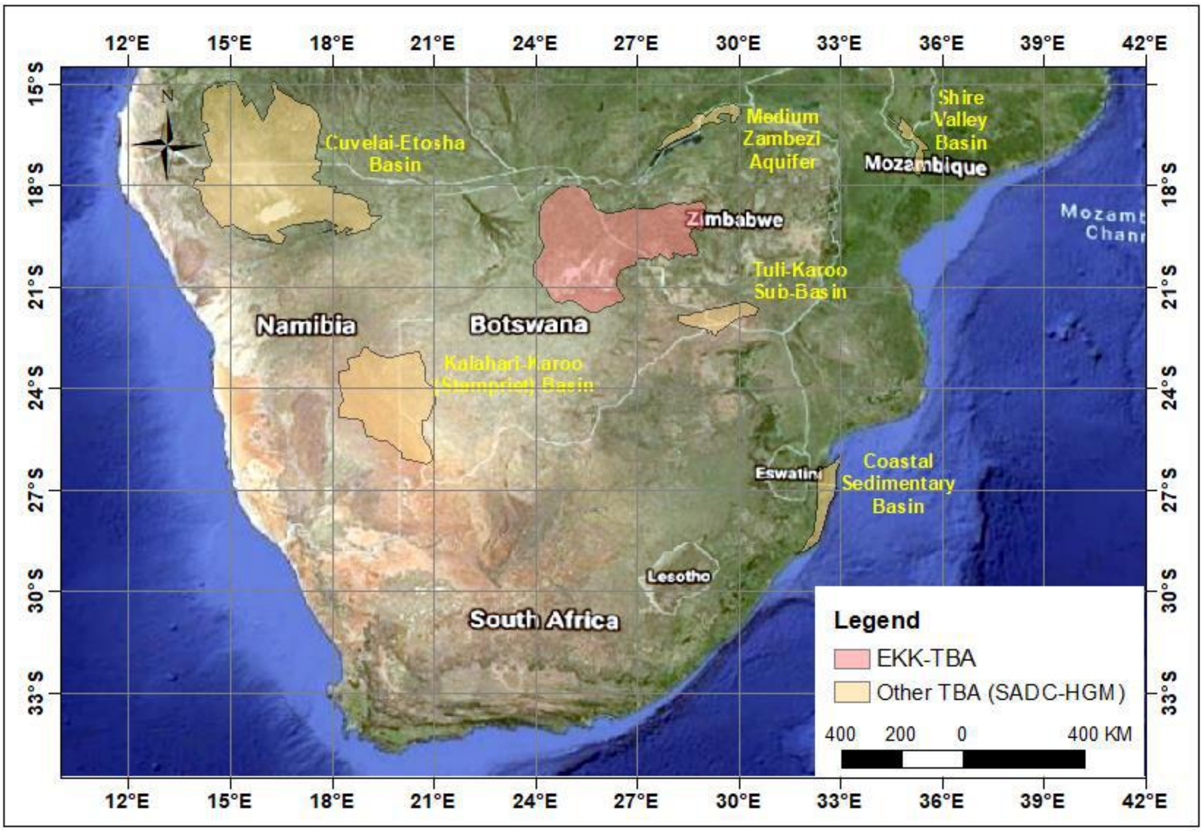

Figure 1: TBAs in Southern Africa

Source: modified after SADC-HGM (2010); SADC-GMI (2020b)

Methodology

Thematic data and information was derived from peer reviewed publications, technical reports and consultant's knowledge of the study area. Additional data and information was acquired through the SADC-GMI focal points within the two countries. Field visits could not be made and neither could some of the data be collected due to the constraints imposed by the Covid-19 pandemic. Hence, multi-stakeholder virtual workshops were conducted for their input, discussion and validation of findings during the TDA development process.

The multidisciplinary character of the TDA and the complexity of transboundary issues necessitated the involvement of a wide range of stakeholders from the public and private sector and civil society in Botswana and Zimbabwe. As the new EKK-TBA partly overlaps two river basins, the Okavango River Basin and the Zambezi River Basin, the River Basin Organisations OKACOM and ZAMCOM were also a major constituency of consultation during the TDA.

Borehole data and related information for the Basin within the area bounded by longitudes 22 and 30 degrees East and latitudes 16 and 22 degrees South was obtained from Botswana, Namibia, Zambia and Zimbabwe in electronic format from the SADC-GMI Groundwater

Information Portal (GIP). Quality control filtered out correct data for use in re-delineating the EKK-TBA boundary (SADC-HGM, 2010).

Key messages were formulated based on the analysis of the thematic areas and provided the foundation for the compilation of key issues related to the Basin and the key issues fed into the EKK-TBA Strategic Action Planning process.

System boundary of the EKK-TBA

The boundary of the EKK-TBA as presented in the SADC-GIP, shown in Figure 2 (red line), was defined during the SADC-Hydrogeological Mapping Project (SADC-HGM, 2010), and was mainly based on the topography and surface water drainage.

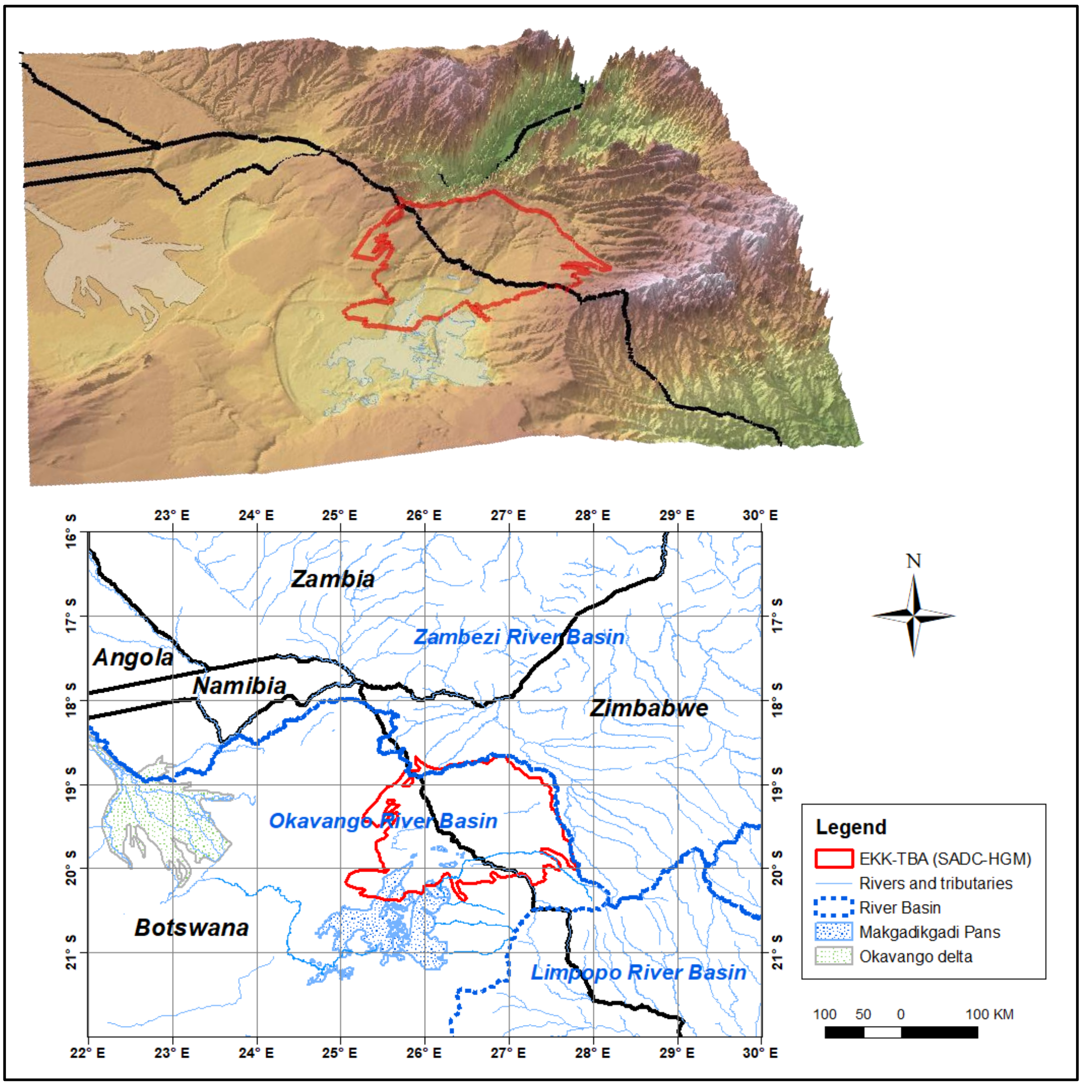

Figure 2: Topography (DEM) and surface water drainage of the EKK-TBA and surrounding

Source: modified after SADC-GMI (2020a)

The EKK-TBA is ~34 000 km^2 and falls within the Okavango River Basin. The eastern boundary of the EKK-TBA coincides with the surface water divide between the Okavango and Zambezi

River Basins. To the southwest of the EKK-TBA, the surface water drainage towards the Makgadikgadi Pans is truncated, and suggests a larger area for the EKK-TBA.

The EKK-TBA covers the NE Kalahari-Karoo Basin in Botswana and the Mid-Zambezi Basin in Zimbabwe and comprises Kalahari Group deposits overlying lithostratigraphic units of the Karoo Supergroup (Basalt and Upper and Lower Karoo sediments) which is underlain by Basement Complex, Figure 3. The Kalahari Group deposits form the shallow unconfined to semi-confined aquifer and the Ntane/Forest Sandstone of the Upper Karoo Group and the Mea Arkose Sandstone of the Lower Karoo Group in Botswana, or the Wankie Sandstone in Zimbabwe, form the deeper (confined) aquifers (SADC-GMI, 2020a and b).

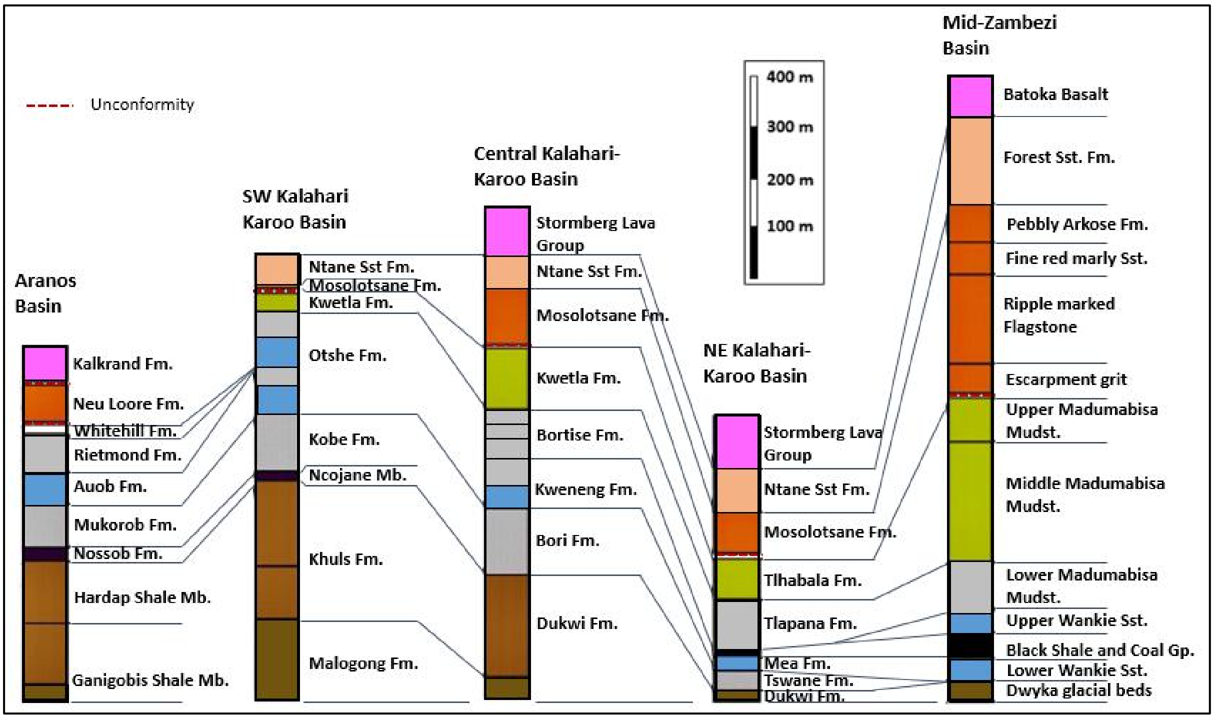

Figure 3: Correlation of Karoo Supergroup lithostratigraphic units

Source: modified after Catuneanu et al. (2005)

The lithostratigraphic units of the Karoo Supergroup are well correlated between the Aranos Basin stretching from north-western South Africa into south-eastern Namibia, the main Kalahari-Karoo Basin (NE, Central and SW) in Botswana and the Mid-Zambezi Basin in Zimbabwe (Catuneanu et al., 2005). Figure 4 shows the EKK-TBA boundary overlain on the Kalahari-Karoo Basin (Haddon, 2005). From the map, it can be seen that the sedimentary rocks and the Basalt from the Karoo Supergroup extend well beyond the area demarcated by the SADC-HGM (2010) and also suggest a larger size of the EKK-TBA.

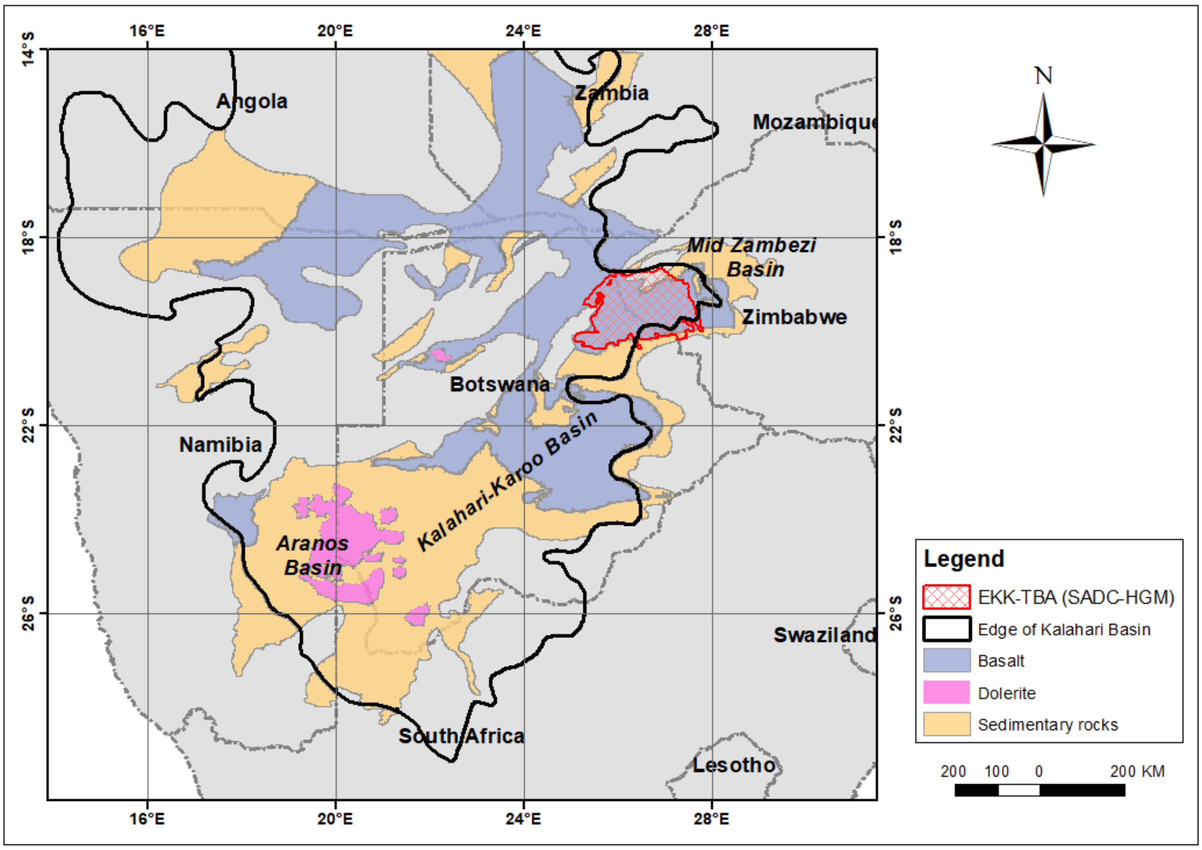

Figure 4: EKK-TBA as part of the Kalahari-Karoo Basin

Source: modified after Haddon (2005) and SADC-HGM (2010)

Regional piezometry and deduced groundwater flow directions, mainly of the Kalahari Group aquifer, based on the SADC-HGM database (2010), confirm the above postulated larger size for the EKK-TBA. A provisional boundary was drawn based on the groundwater divide to the north, east and south of the original boundary (Figure 5). The western boundary is based on converging/parallel groundwater flow directions. Further refinement of the provisional EKK-TBA boundary was carried out after considering the surficial geology (excluding the outcropping basement rocks to the south and south-east), Figure 6. The size of the new EKK-TBA is ~127,000 km^2 and is more than triple the original size, with 65% of the area in Botswana and 35% in Zimbabwe.

This new EKK-TBA boundary overlaps part of the Okavango and Zambezi River Basins and now also includes major wellfields in Botswana (Orapa, Letlhakane, Dukwi, Chidumela and Maitengwe) and Zimbabwe (Nyamandlovu and Epping Forest) as well as the Makgadikgadi Pans which are the surface water and groundwater discharge zone. The upper course of the Gwayi River system (Khami and Umguza Rivers) in the Gwayi Catchment forms part of the EKK-TBA even though the Gwayi River ultimately drains into the Zambezi River.

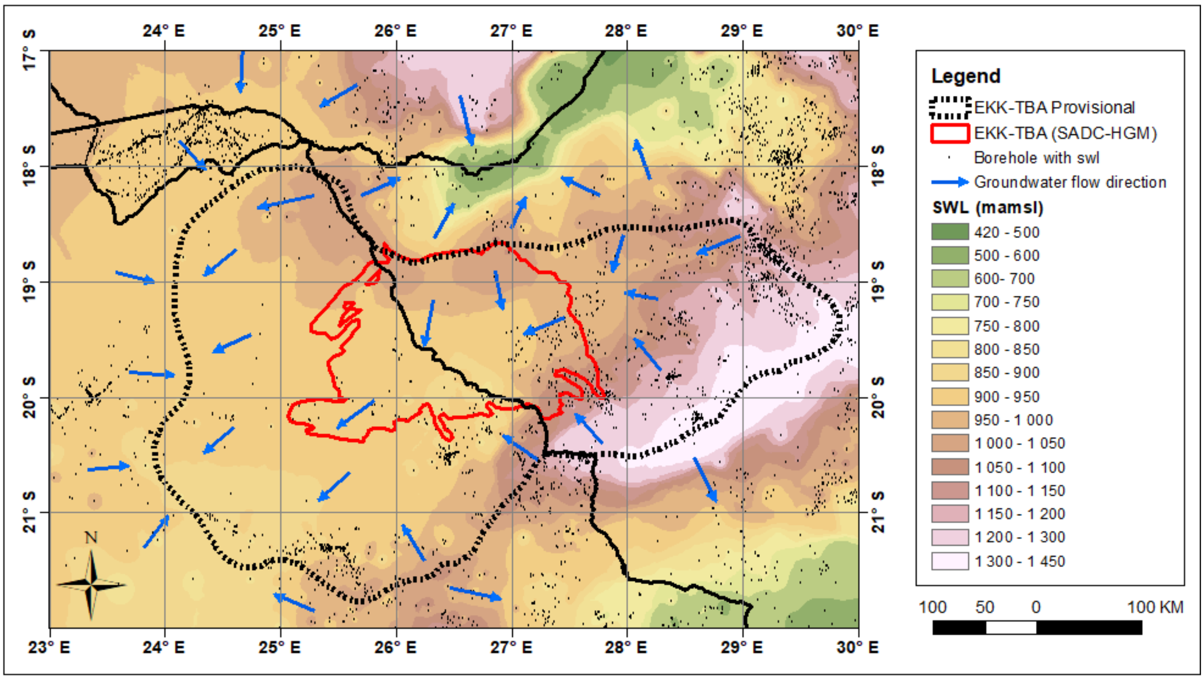

Figure 5: Provisional EKK-TBA boundary based on groundwater flow pattern
Source: modified after SADC-GMI (2020a)

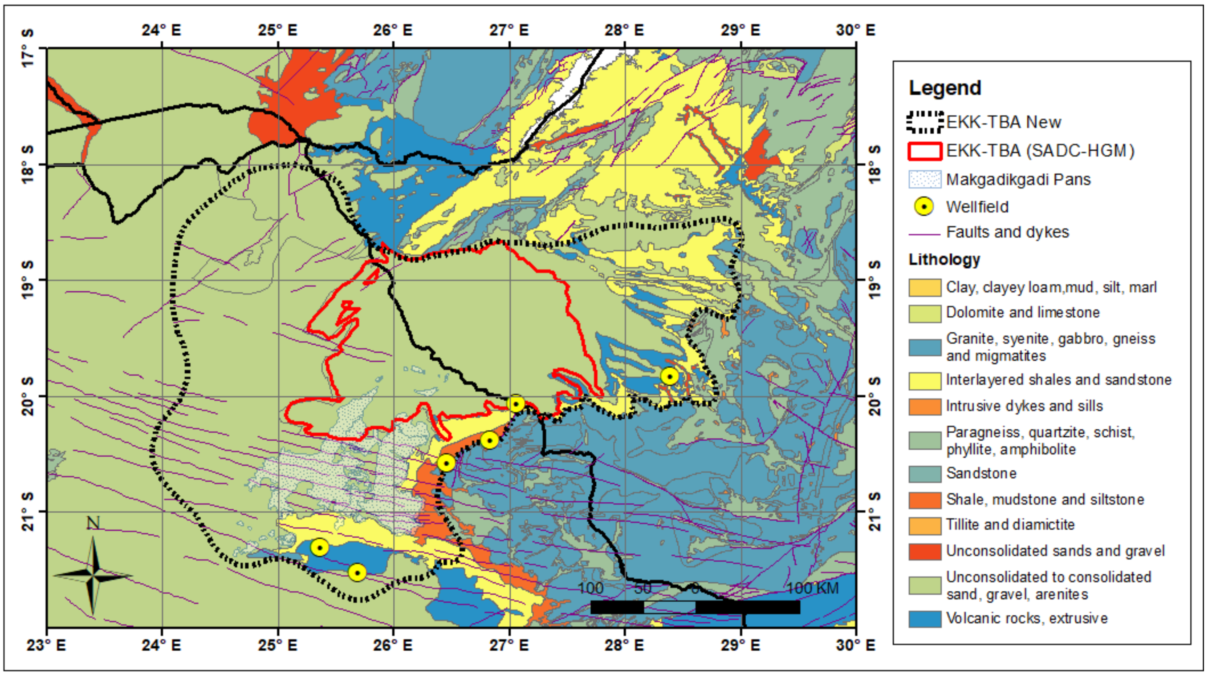

Figure 6: New EKK-TBA boundary excluding basement rocks
Source: modified after SADC-GMI (2020a)

Results and discussion

Transboundary diagnostic analyses were conducted of the thematic areas of demographics and socio-economics, climate, surface water, groundwater, land use and land cover and groundwater governance and key messages for each area were formulated, from which key issues were derived.

Demographics and socio-economics

Figure 7 shows the location of Bulawayo City, towns, villages and Rural District Councils within and just outside the new EKK-TBA.

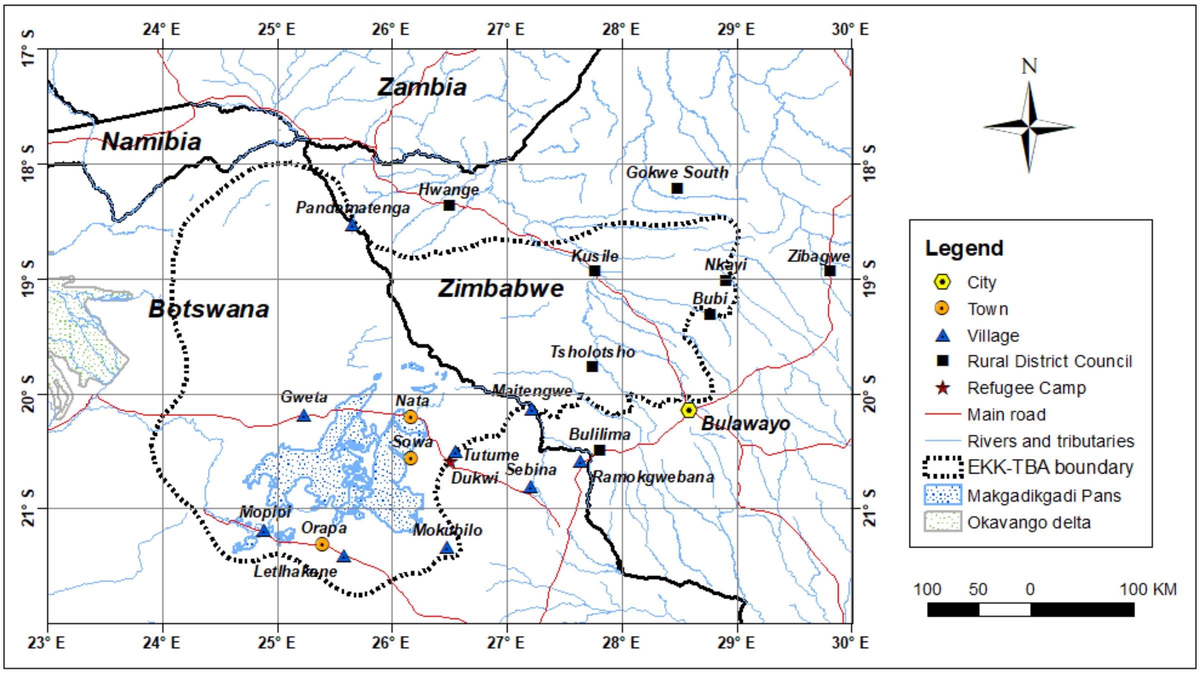

Figure 7: Location of Bulawayo City, towns, villages and Rural District Councils
Source: SADC-GMI (2020a)

The current (2020) EKK-TBA population is estimated at 595 278 (Botswana: 16% and Zimbabwe: 84%) based on projected national population growth rates since the 2011 and 2012 censuses for Botswana and Zimbabwe respectively (United Nations – World Population Prospects (www.macrotrends.net/countries/BWA/botswana/population-growth-rate; Zimbabwe). The EKK-TBA population is projected to almost double by 2050. Literacy of the population of the EKK-TBA was found to be relatively high, at 90%.

Mining (diamonds), tourism (National Parks: Makgadikgadi Pans and Hwange National Park and game reserves), and commercial and subsistence farming are the key socio-economic activities in the Basin. Unemployment is in excess of 25% and regarding water and sanitation, access to piped water in the Botswana part of the EKK-TBA is more than 90% whereas in the Zimbabwean side of the EKK-TBA, it is less than 30%. Open defecation is a major issue on the Zimbabwean side of the EKK-TBA.

Life expectancy at birth is only a few years more for the Botswana part of the EKK-TBA (62.6 and 64.6 years for males and females respectively) than for the Zimbabwean part of the EKK-TBA (59.5 and 62.6 for males and females respectively). Mortality rates for under 5 year olds per 1 000 live births in 2019 for Botswana was 42/1 000 and for Zimbabwe 55/1 000 (https://data.worldbank.org/indicator/SH.DYN.MORT?locations=BW or ZW).

Key messages:

- The projected doubling of the EKK-TBA population by 2050 will exert additional pressure on the natural resources, such as water and land
- The actual Basin population and its distribution has not been quantified and this needs to be determined in order to evaluate the risks and opportunities that arise from the available natural resources
- High open defecation, particularly in Zimbabwe poses a serious risk of water borne diseases and needs to be addressed
- High infant mortality rates for the under 5 year olds also need to be addressed

Climate

Data from five climate stations covering the study area were available for analysis (4 from Botswana and 1 from Zimbabwe). In addition, data from the Climate Research Unit (CRU) Version 4.04 dataset (http://www.cru.uea.ac.uk/data; Harris et al., 2020) were used to complement the limited data available. The climate dataset used are precipitation (rainfall), and minimum and maximum temperatures. Data from Zimbabwe could not be accessed from the responsible institution. Virtual climate stations were assumed at the centre of each grid as shown in Figure 8, and in total, seventy nine virtual stations were established in such a way that they covered the whole EKK-TBA and the surrounding area. This was done in order to determine spatial climate trends over the EKK-TBA. While the CRU data starts from 1901, the data period selected for the EKK-TBA was 1970-2019, which represents a period where historical climatic observations are available in the two countries.

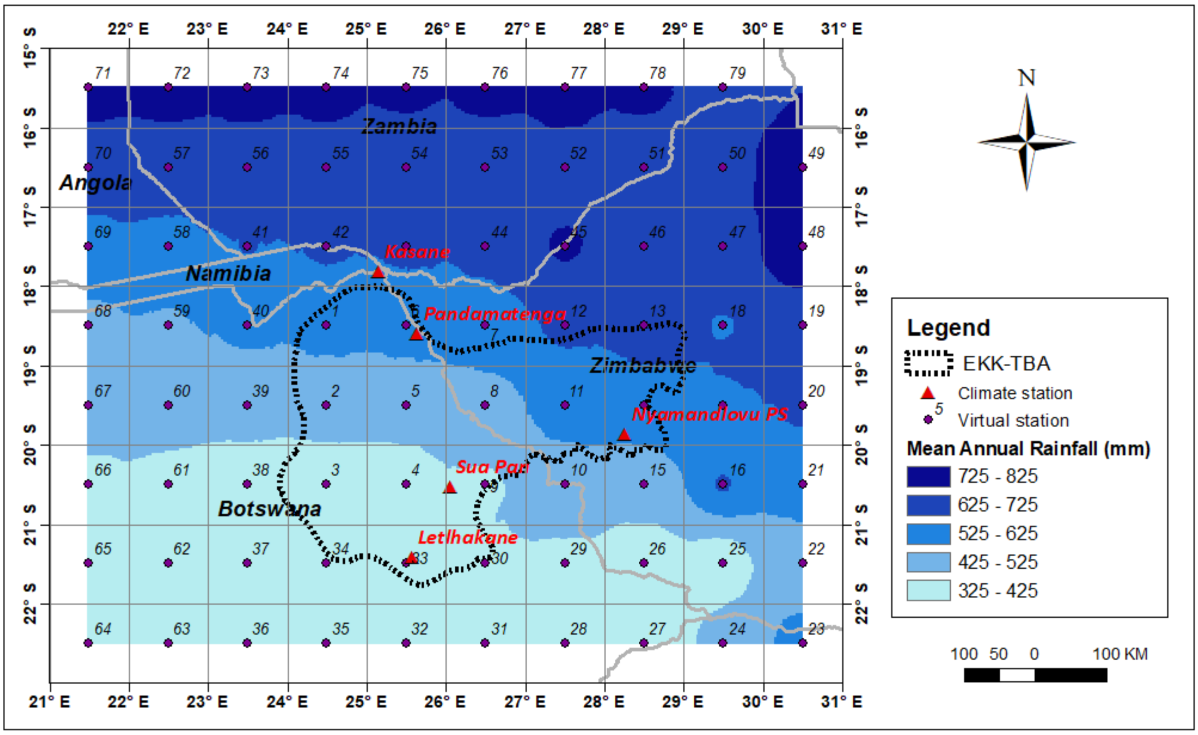

Figure 8: Mean annual rainfall from virtual stations

Source: modified after SADC-GMI (2020a)

The EKK-TBA mainly lies in a semi-arid region with average annual rainfall ranging from 325mm/yr in the southwest to 625 mm in the north and north-eastern parts of the Basin. Mean monthly minimum and maximum temperatures range from 13 to 15 °C and 27 to 30 °C respectively from the eastern to the western parts of the EKK-TBA. There was good correlation between CRU data and observed data from the five climatic stations (SADC-GMI, 2020a). For annual rainfall, no statistically significant trend was found but for mean monthly minimum and maximum temperatures, an increasing trend was observed and this is consistent with studies conducted in Botswana (Byakatonda et al., 2018) and Zimbabwe (Mazvimavi, 2010), and would negatively impact water resources availability.

Key Messages:

- Access to climate data is a challenge particularly from the Zimbabwean side of the EKK-TBA
- There is high interannual rainfall variability in the EKK-TBA and temperatures were found to increase in the course of time
- Climate variability and change negatively impacts water resources and there is a need to establish resilient and adaptation strategies to mitigate the negative impact

Surface water

The EKK-TBA covers part of the Okavango and Zambezi River Basins and is neighbouring the Limpopo River Basin on the south-eastern side (Figure 9). The EKK-TBA is linked to the Okavango River system on the west by the Boteti River which drains into the Makgadikgadi Pans. Note, the Boteti River only flowed in 2010 after some 20 years of no flow.

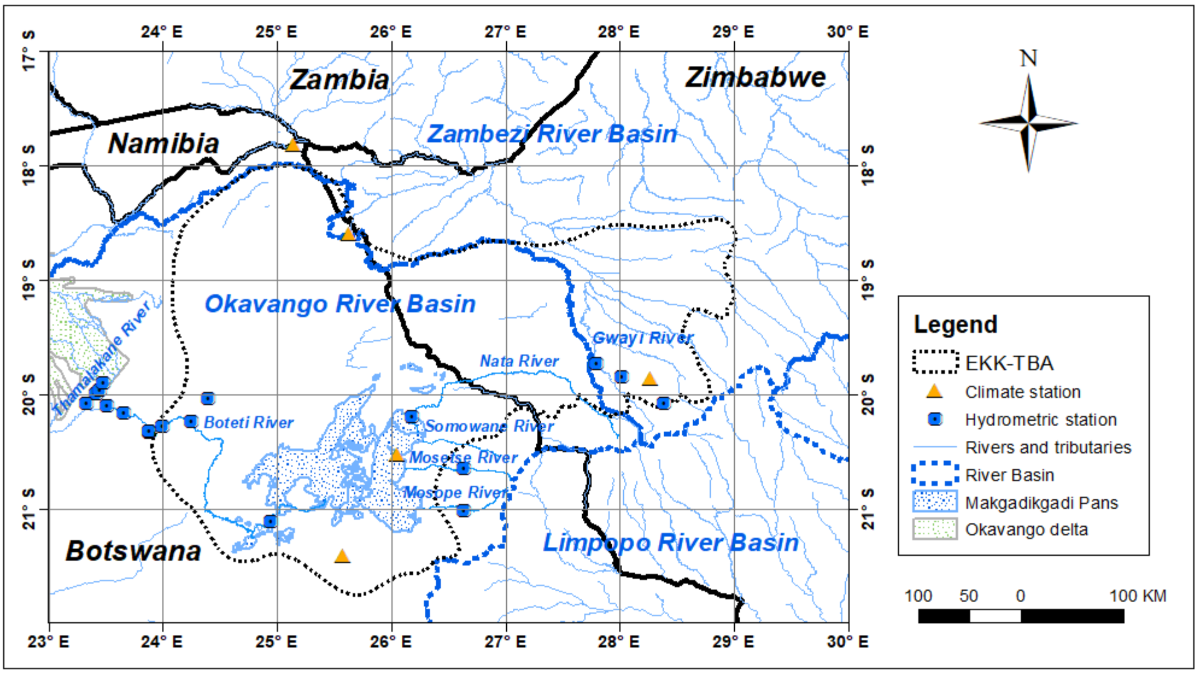

Figure 9: Surface water drainage and climate and hydrometric stations in the EKK-TBA
Source: SADC-GMI (2020a and b)

Similarly, on the eastern side, the Nata River, which originates from Zimbabwe, flows into the Makgadikgadi Pans. The Gwayi River in Zimbabwe, in the eastern part of the EKK-TBA, with the Khami and Umguza Rivers as tributaries in its upper reaches, flows north-west towards the Zambezi River. Except for the Gwayi River System with annual runoff generally less than 10 mm/yr, all other rivers in the Basin are ephemeral. Overall, surface water resources in the Basin are limited. Despite the ephemeral nature of the rivers, baseflow indices (BFIs) were determined for the Boteti River (BFI=29.9) and Gwayi River (BFI=11.3) (SADC-GMI, 2020a and b). Baseflow, however does not occur for long after the rainfall events. Data quality, gaps and accessibility is a major challenge.

Key messages:

- The EKK-TBA falls within two river basins: the Okavango River Basin and the Zambezi River Basin
- Data quality in terms of its, inter alia, accuracy, gaps and accessibility, is a major issue that needs addressing
- Surface water availability is limited and constraints conjunctive water use

Groundwater

EKK-TBA data and information provided by both countries on the geology and hydrogeology is sparse, and is mostly limited to the wellfields and surroundings on the southern and south-eastern fringes of the Basin. Most data and information was not collected during groundwater development phase (geophysical investigations, borehole construction and pumping tests) which presents data gaps. Some of the data had quality issues and the databases are not harmonised. Accessibility of the data was a major challenge, particularly on the Zimbabwean side of the EKK-TBA. There is also inadequate to no data on abstractions, groundwater levels and groundwater quality at the Basin scale. The approach adopted was to upscale local information to a Basin level after verifying findings with peer reviewed publications, technical reports and published geological and hydrogeological maps.

Geology

A simplified geological cross section running from SW to NE and cutting through the central portion of the EKK-TBA from Botswana to Zimbabwe (Figure 10), showing the Kalahari Group deposits and Karoo Supergroup sediments, depicts a general horst and graben morpho-tectonic style, the horsts corresponding to uplifted basement complexes - highlands and the grabens to Karoo sedimentary depressions, **Error! Reference source not found.**. Dominantly SW-NE trending normal faults, and less dominant NW-SE faults have resulted in block faulting and compartmentalisation of the formations, especially on the Botswana side of the EKK-TBA, which has had an effect on the groundwater dynamics and the groundwater quality. Note that the Kalahari Group deposits constitute the upper unconfined to semi-confined aquifer and the Ntane/Forest Sandstone and the Mea Arkose Sandstone (the latter formation is part of the Lower Karoo Mudstone) constitute the deeper confined aquifers.

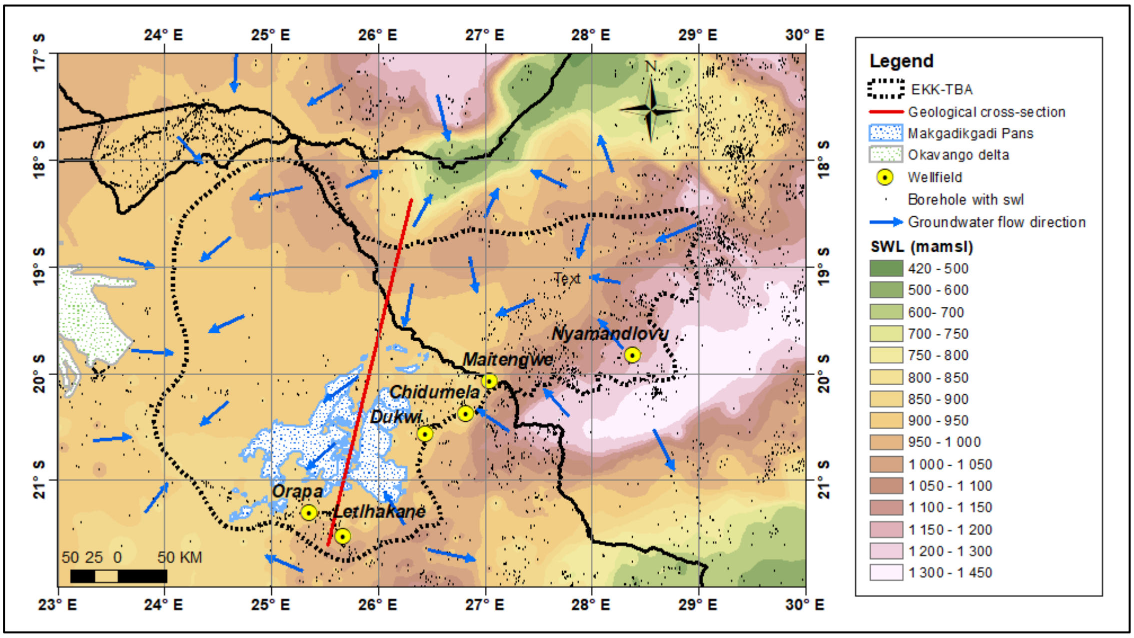

Figure 10: Regional piezometry, groundwater flow and location of geological cross-section

Source: modified after SADC-GMI (2020a and b)

Groundwater flow

The regional piezometry of mostly the Kalahari Group aquifer, Figure 10, shows that groundwater flows from Zimbabwe towards the Makgadikgadi Pans in Botswana. The general groundwater flow direction from Zimbabwe to Botswana is confirmed by a recent study by WWF (2019) of the Kalahari Group deposits within the Hwange National Park. The inferred groundwater flow direction in the southern and south-eastern parts of the EKK-TBA is supported by the general groundwater flow direction of the individual wellfields if the effects of localised wellfield drawdowns due to high abstraction rates are ignored.

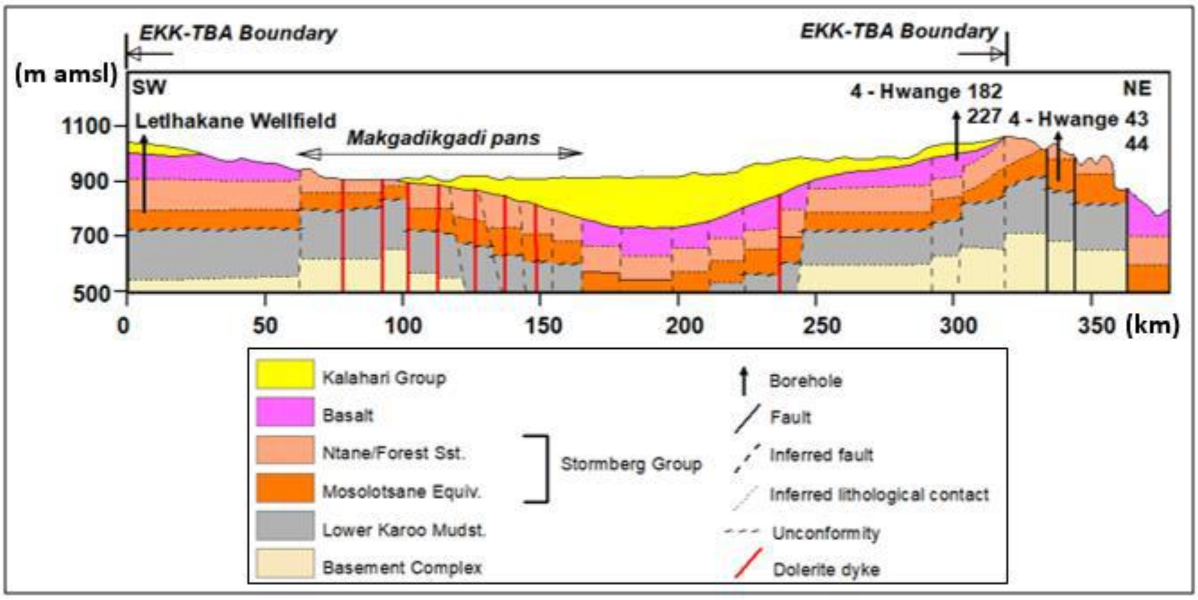

Figure 11: SW-NE geological cross-section through the EKK-TBA

Source: SADC-GMI (2020b)

Groundwater in the Kalahari Group aquifer along the western boundary is ultimately towards the Makgadikgadi Pans. Although information on deeper aquifers in the western part of the EKK-TBA is lacking, it cannot be ruled out that inflow of groundwater from deeper aquifers from the west and south-west into the EKK-TBA takes place and flows towards the Makgadikgadi Pans (Lekula et al., 2018; WCS, 2020; SADC-GMI, 2020a and b).

Groundwater recharge

Recharge studies within the EKK-TBA have been confined to the wellfields and the recharge rates varied from 2-37 mm/yr in the Botswana wellfields and 2-62 mm/yr in the Nyamandlovu Wellfield in Zimbabwe. The lower values are indicative of diffuse recharge rates whereas the higher values are due to preferential recharge along river systems, faults and fractures. The average annual groundwater recharge in the EKK-TBA is generally less than 3% of the average annual rainfall and is similar to what can be found in other semi-arid regions (Beekman et al., 1996; Xu and Beekman, 2019).

Groundwater chemistry

Basin-wide data on groundwater quality is very scanty and available data is mainly from the EKK-TBA wellfields. The groundwater quality in the EKK-TBA Botswana wellfields ranges from potable to saline. It is generally 'fresh' in the recharge zones and deteriorates in quality with increasing depth and movement away from the recharge zone (DWA, 2002; Kefentse, 2004; Geoflux, 2005; Legadiko, 2015), e.g. groundwater salinity increases within a short distance in the direction of groundwater flow and is typified by the Maitengwe area in which groundwater salinizes from SE to NW away from the recharge area, Figure 12.

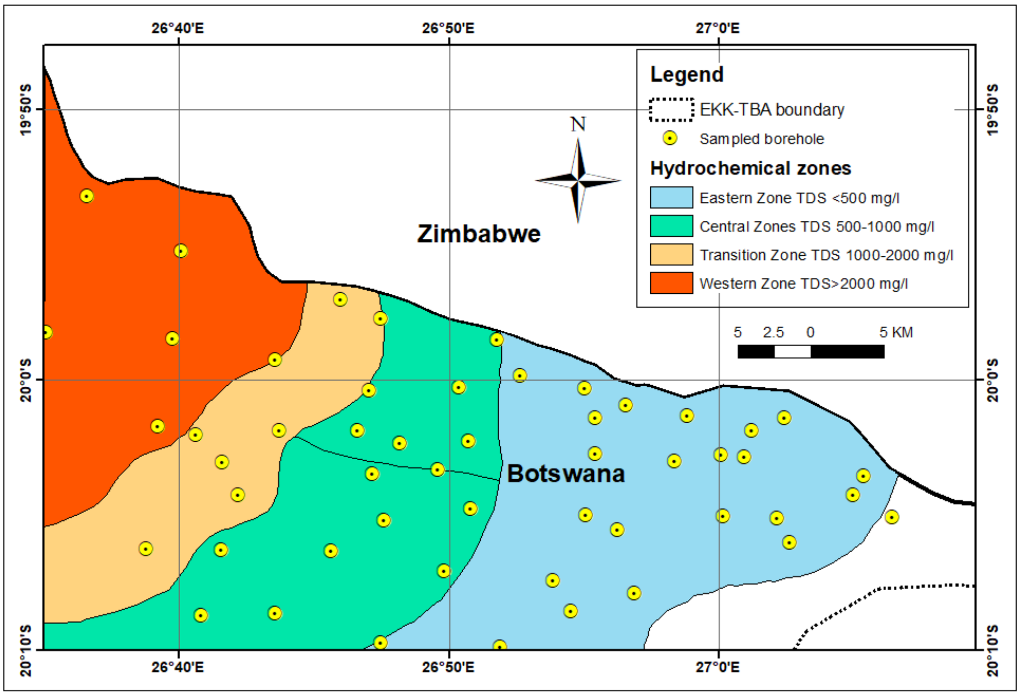

Figure 12: Upper Ntane Sandstone hydrochemical zones in the Maitengwe area
Source: modified after DWA (2002)

High nitrate values have been recorded in some of the Water Utilities Corporation owned and managed wellfields and are attributed to leaching of the nitrate from pans and cattle posts along fracture and/or fault zones, mostly during seasons of high rainfall (Kefentse, 2004). High nitrate levels within the diamond wellfields of up to 600 mg/l are partly ascribed to nitrate based explosives used in the blasting operations (Debswana, 2015).

Groundwater availability

Groundwater availability in the EKK-TBA is determined by the nature of the aquifer, its location, groundwater development costs and water quality. The main source of groundwater comes from the Ntane Sandstone and Mea Arkose Sandstone Aquifers in Botswana and the Forest Sandstone Aquifer in Zimbabwe. The positioning of these sandstone aquifers within the Basin has a direct bearing on the aquifer yields. Yields are much higher at the peripheries of the Basin within the sandstone aquifers. Groundwater quality poses a great constraint on the groundwater availability since saline groundwater is predominant particularly on the Botswana side of the EKK-TBA. Unmanaged abstractions can result in the mobilisation of the saline groundwater, which will contaminate the potable groundwater, rendering it unusable and hence unavailable.

In the Botswana wellfields, borehole yields average 20 m^3/hr and in the Nyamandlovu Wellfield (Zimbabwe), yields range from 2-20 m^3/hr. Yields towards the central portions of the Basin are not known due to lack of data. Drilling deeper into the underlying sandstone aquifers (Ntane/Forest Sandstone, Mea/Wankie Sandstone) is expensive since the drilling has to go through unconsolidated Kalahari Group deposits and the indurated basalt and finally into the ‘collapsible’ sandstones, a process that calls for costly and specialised borehole drilling and development procedures since each lithological unit requires its own unique drilling approach, and this makes the groundwater inaccessible and unavailable. Salinity issues of the groundwater in the central parts would be another limiting factor.

Groundwater use

For Botswana as a whole, about 64% of the water use is from groundwater whereas for Zimbabwe, it is about 10% (SADC-GMI, 2020a). In both countries, agriculture is the sector consuming, percentagewise, most of the groundwater. For the EKK-TBA, groundwater is the main source of water. Groundwater use for the EKK-TBA was estimated for agriculture (crop water use); domestic water supply and (diamond) mining. Data and information of groundwater use mostly from the Kalahari Group aquifer, for the environment, ecosystems, game parks and reserves was lacking.

Sectoral groundwater use from the Ntane/Forest Sandstone and Mea Arkose Sandstone aquifers within the EKK-TBA, based on current abstractions from the wellfields, is estimated at 22% for the domestic sector, 15% for the agricultural sector and 63% for the industrial (mining) sector. Clearly, at 63%, the mining sector is by far the largest groundwater user in the EKK-TBA, Figure 13.

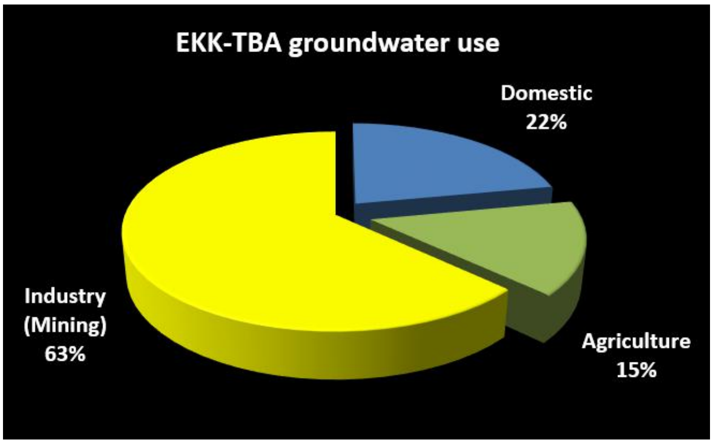

Figure 13: EKK-TBA sectoral groundwater use

Source: SADC-GMI (2020b)

The EKK-TBA wellfields provide the bulk of the groundwater but the potable groundwater resources are limited and mostly confined to the recharge areas. Increasing water demand resulting from population growth, expansion of agriculture and mining exert an increasing pressure on the groundwater resources. Upconing of saline water and declining water levels due to over-abstraction have already been observed (ref. decommissioning of Chidumela wellfield in 2008; Legadiko, 2015). Groundwater use in the mines is more responsive to the demand for water rather than the sustainability of supply and could result in overexploitation of the groundwater in an effort to satisfy the demand.

The absence of an EKK-TBA management institution results in the lack of a Basin-wide groundwater monitoring that would inform on available groundwater resources. Infrequent monitoring is conducted by various public institutions and private sector (mines) (within the two countries) which lack resources (human, material and financial) to fully execute their national mandates (public institutions).

Key messages:

- The vast majority of water use in the EKK-TBA is from groundwater
- Data and information:
    - Hydrogeological data and information is mostly confined to the wellfields on the fringe of the EKK-TBA
        - There is lack of comprehensive Basin-wide hydrogeological investigations
        - There is lack of hydrogeological data of the deeper aquifers in the western, central and northern parts of the EKK-TBA
        - Data on groundwater use for the environment, ecosystems, game parks and reserves is lacking
    - There is a lack of good quality hydrogeological databases. Standardisation of the data and information is also lacking, and this complicates harmonisation of the databases
        - The quality of hydrogeological data and information is generally poor and there is

    a lack of quality control
  - It is difficult to access data and information from the responsible institutions
- Groundwater overexploitation:
  - Water demand for all sectors (domestic, agriculture, industry including mining, and biodiversity) currently exceeds water availability which is compounded by an increasing population
  - A critical issue to consider is the potential upconing of saline groundwater and intrusion into shallower and lower salinity aquifers which would render the shallower aquifers unsuitable for domestic and agricultural purposes
  - Water supply for mining operations in Botswana is currently demand driven and this should be critically reviewed by the Water Apportionment Board in terms of setting timely, realistic and sustainable abstraction rates
  - Blending of (hyper) saline and fresh groundwater for mining and for other purposes may be an alternative to lessen the pressure on fresh groundwater resources
  - Over-exploitation of groundwater resources could potentially affect local farmers in both countries who also rely on the groundwater for agricultural activities and may result in conflict between them and the various groundwater users
- There is inadequate (integrated and automated) monitoring in both countries to allow for a thorough understanding of the groundwater dynamics and groundwater management in the EKK-TBA and where carried out, it is over too short time periods, infrequently, and mostly for very few parameters
- Groundwater management institutions:
  - Institutions in both countries lack adequate resources to carry out effective and efficient groundwater management including groundwater monitoring
  - There is also a critical need for the assessment and quantification of the sustainability of water resources, together with a sound understanding of current and future water use requirements for the various sectors (domestic, agriculture, industry including mining, and biodiversity). These would enable the development of a sustainable Basin level water allocation plan

Land use and land cover

The EKK-TBA is dominated by the presence of national parks, forest reserve areas and wildlife management areas (Figure 14). These areas are of significant international and national importance and also provide for local and associated socio-economic activities and however, have of late been affected by the Covid-19 pandemic.

Other land use activities in the EKK-TBA are mining (dominant in Botswana’s EKK-TBA), agriculture (including cropping, livestock and pastoralism) and human settlements. These can have a significant impact on the status of land and water resources (e.g. over-exploitation of (ground)water resources and pollution) in the EKK-TBA.

Increased land degradation in the North-Eastern District of Botswana, which partly covers the EKK-TBA, and in the Zimbabwean part of the EKK-TBA, is associated with poor land use practices deployed by communities, such as deforestation and overgrazing and would require strong political resolve and will (currently lacking) to be effectively addressed. Mining activities have the potential of polluting natural resources.

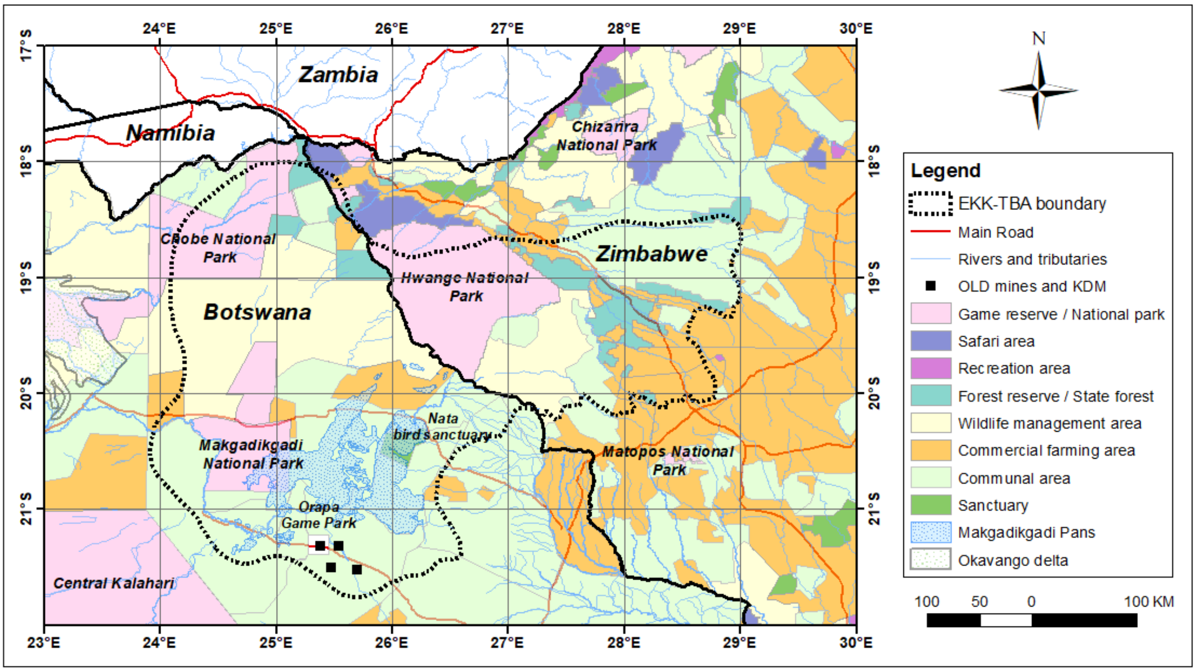

Figure 14: Land use in the EKK-TBA

Source: SADC-GMI (2020a)

Brazier (2015) in her report on climate change in Zimbabwe noted the following likely changes between 2050 and the end of the century:

- A modest decrease in total amount of rainfall
- Changes to the onset and end of the rainy season
- More frequent and longer mid-season dry periods
- Erratic rainfall distribution
- More droughts and floods that may recur in successive years
- Temperature increase of between 1°C and 3°C, which is greater than the global average

The abovementioned effects of climate change are also likely to apply to the EKK-TBA. The effects would lead to degradation of natural resources, especially soil, water, natural vegetation, crop, livestock and wildlife species. The future impacts of climate change in the EKK-TBA will exacerbate the harmful effects of poor land-use practices, notably deforestation and overgrazing.

Key messages:

- The EKK-TBA faces significant negative environmental threats from poor land use practices and climate variability and change

    - Deforestation and land degradation due to poor agricultural practices should be addressed by implementing climate smart agriculture (e.g. such as in Pandamatenga)
    - In the face of envisaged climate change impacts on the already vulnerable ecosystem, the protection of the EKK-TBA is paramount to ensure the preservation of the natural habitats and biodiversity in the Basin
- Owing to the large dependence on mining, Botswana's EKK-TBA faces risks of pollution of rivers, wetlands and in the longer-term, aquifers
- The range of biodiversity and ecosystems in the EKK-TBA, provides the basis for ecotourism as a major contributor to the economies of both countries. However, the travel ban due to the global Covid-19 pandemic has seen a significant impact on both countries' economies as revenues from international tourism has plummeted. The long-term impact on the countries' economies and the Basin's communities is yet to be quantified. Communities may be forced to look for alternative income generating activities that may negatively impact on land and water resources
- Political will and improved regulation will be needed to ensure the enforcement of government laws, policies, and regulatory instruments towards the necessary protection of this largely vulnerable semi-arid sandveld eco-system

Groundwater governance

The governance framework for groundwater management in the EKK-TBA was analyzed in the context of:

- Existence and comprehensiveness of bi- or multi-national level agreements/treaties, specific to the EKK-TBA and were found to be non-existent
- Existence and comprehensiveness of non EKK-TBA specific agreements/treaties, or other non-binding instruments, of relevance to the EKK-TBA

The comprehensiveness of the legal instruments was evaluated in terms of:

- Well drilling/abstraction/water utilisation
- Water pollution control
- Settlement of water disputes
- Institutional arrangements
- Other matters such as environmental protection and preservation, prevention of harmful effects, data exchange, prior notification of planned measures and emergency situations

These were established to be specific to the individual EKK-TBA riparian countries. Botswana is implementing water reforms which are not taking into account the TDA key issues.

Key messages:

- The EKK-TBA boundary straddles two shared watercourses: the Okavango – Cubango and the Zambezi, hence the boundary asymmetry adds additional complexity to the governance challenges

- There is need for a bilateral agreement or arrangements to manage the EKK-TBA. The SADC water institutional framework, Figure 15, does allow for the establishment of bi-lateral or multi-lateral water institutions to support specific purposes (SADC-GMI, 2019) and it provides an opportunity for an EKK-TBA specific policy addendum, memorandum of understanding or agreement around common purpose, e.g. groundwater management including groundwater monitoring, and data and information exchange in the form of a specific EKK-TBA groundwater management committee or unit
- The legislative frameworks in both countries do not address issues of transboundary aquifers and international obligations per se. However, the Zimbabwe legislation gives the Minister the function "to give effect to any international agreement, to which Zimbabwe is a party, on shared water course systems in a spirit of mutual co-operation"
- Water reforms in Botswana which are currently taking place need to take account of the key issues identified during the TDA

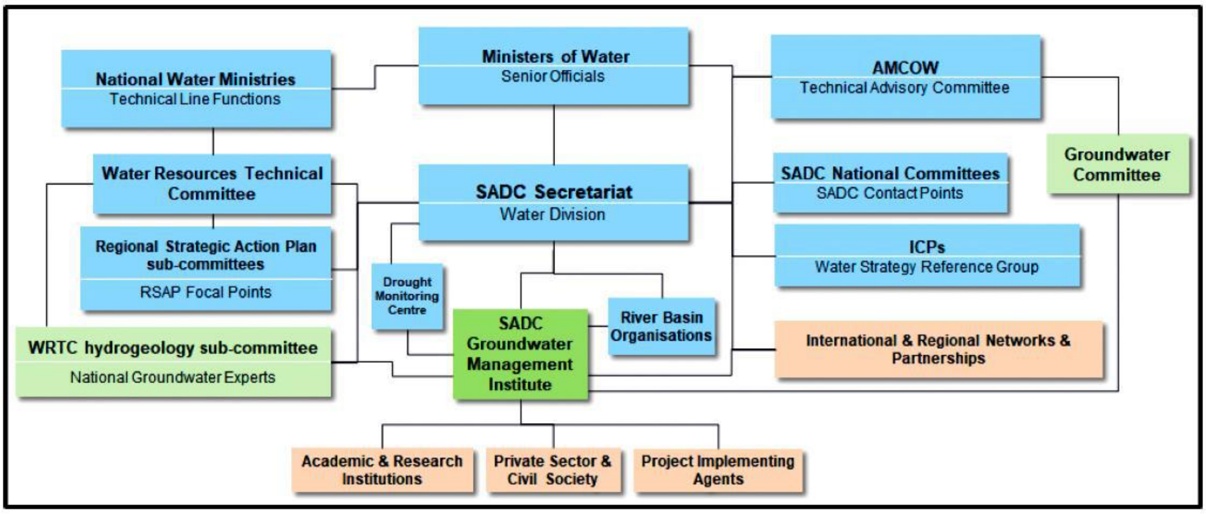

Figure 15: SADC water sector institutional framework

Note that the SADC Contact Points are known as National Focal Point Persons

Source: SADC-GMI (2019)

Conclusion

The following key issues emanated from the key messages of the various thematic areas and these provide the basis for a Strategic Action Planning process:

- Data and databases:
  - Data unavailability/scarcity and inaccessibility (especially from Zimbabwe) and poor quality (accuracy and gaps)
  - Lack of good quality hydro(geo)logical databases and limited standardisation of data and information
- Water insecurity:
  - Projected high interannual rainfall variability and increasing temperature

    - Upconing of saline groundwater and intrusion into shallower and lower salinity aquifers
    - Potential water related conflicts could ensue in the EKK-TBA: between the mining companies and local farmers on the Botswana side of the EKK-TBA and on the Zimbabwean side of the EKK-TBA in the Nyamandlovu area between local farmers and ZINWA (abstracting groundwater for the City of Bulawayo)
- Groundwater management:
    - Lack of adequate resources to carry out effective and efficient groundwater management (e.g. monitoring, uncontrolled drilling, etc.)
    - Groundwater over-exploitation: water demand for domestic water use currently exceeds supply; water supply in the mining sector is demand driven and negates sustainability of supply
    - Unregulated borehole drilling posing a risk to groundwater overexploitation and unwarranted competition of the groundwater resource
    - Inadequate use of innovative technologies: remote sensing has been proven to be an alternative tool that can be used in the timely determination of active crop areas and crop water requirements in the EKK-TBA and consequently, the amount of groundwater used
- Biodiversity: the EKK-TBA is endowed with a rich biodiversity which is critical to the countries' economies and the livelihoods of the basin communities and needs to be better protected
- Deforestation and poor agricultural practices are resulting in rapid land degradation
- The EKK-TBA boundary asymmetry adds additional complexity to the governance challenges (OKACOM and ZAMCOM)
- Lack of political will hampers enforcement of government laws, policies, and regulatory instruments
- The EKK-TBA population needs to be properly quantified in order to determine the risks and opportunities that arise from the available natural resources

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