Terms of Reference (ToRs)

CONSULTANCY SERVICES FOR DEVELOPMENT OF A NUMERICAL GROUNDWATER MODEL FOR THE EASTERN KALAHARI-KAROO TRANSBOUNDARY BASIN AQUIFER SYSTEM (EKK-TBA)

1. Background

After successful completion of the Sustainable Groundwater Management in SADC Member States Phase 1 project, the SADC-GMI is now implementing phase 2 of the same project, under the strategic guidance of the SADC Secretariat. The 4-year phase 2 project is financed by the Multi Donor Trust Fund Cooperation in International Waters in Africa (CIWA), through the World Bank, and comprises of the following key components:

Component 1: Capacity building for sustainable groundwater management
Component 2: Knowledge development, dissemination, and advocacy
Component 3: Building resilient livelihoods, and inclusive groundwater management

Component 2 of phase 2 project foresees the support to Member States in conducting groundwater studies, preparing monitoring plans, and compiling groundwater data to produce groundwater assessments. The development of a Groundwater Model for the Eastern Kalahari Karoo Transboundary Aquifer (EKK-TBA) was foreseen under sub-component 2.1.3 as a follow-up activity to the development of a Transboundary Diagnostic Analysis (TDA) conducted in 2020 within the context of the SADC-GMI, “Water Resources Management Research in the Eastern Kalahari Karoo Basin Transboundary Aquifer (EKK-TBA)” project, to identify water related issues and problems of the Basin and prioritize the problems and the implementation of projects. The TDA formed the basis for developing a Strategic Action Plan (SAP), which was done with the engagement and involvement of stakeholders, to address the water related issues and problems.

The EKK-TBA extends from eastern Botswana into western Zimbabwe, is mainly located between latitudes 17° S and 22° S and longitudes 23° E and 29° E and covers approximately 127 000 km2, of which 65% is in Botswana and 35% is in Zimbabwe. The EKK-TBA system straddles two river basins: the Okavango and the Zambezi. Figure 1 and Figure 2 show the location of the EKK-TBA within southern Africa and within Botswana and Zimbabwe respectively. The climate of the Basin is semi-arid with rainfall occurring between October and April. Groundwater constitutes the main source of water in the Basin. The 2020 population of the EKK-TBA was estimated at 595 278.

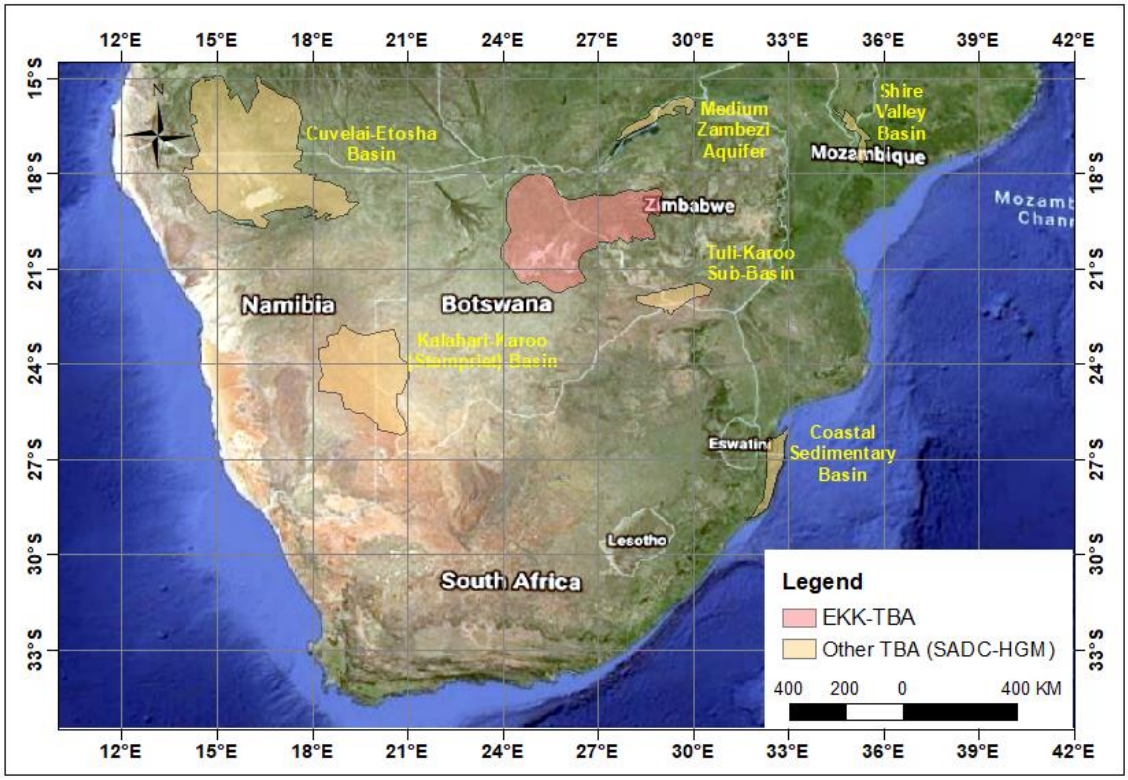

Figure 0: Location of the EKK-TBA in southern Africa
Source: SADC-HGM (2010); SADC-GMI (2020c)

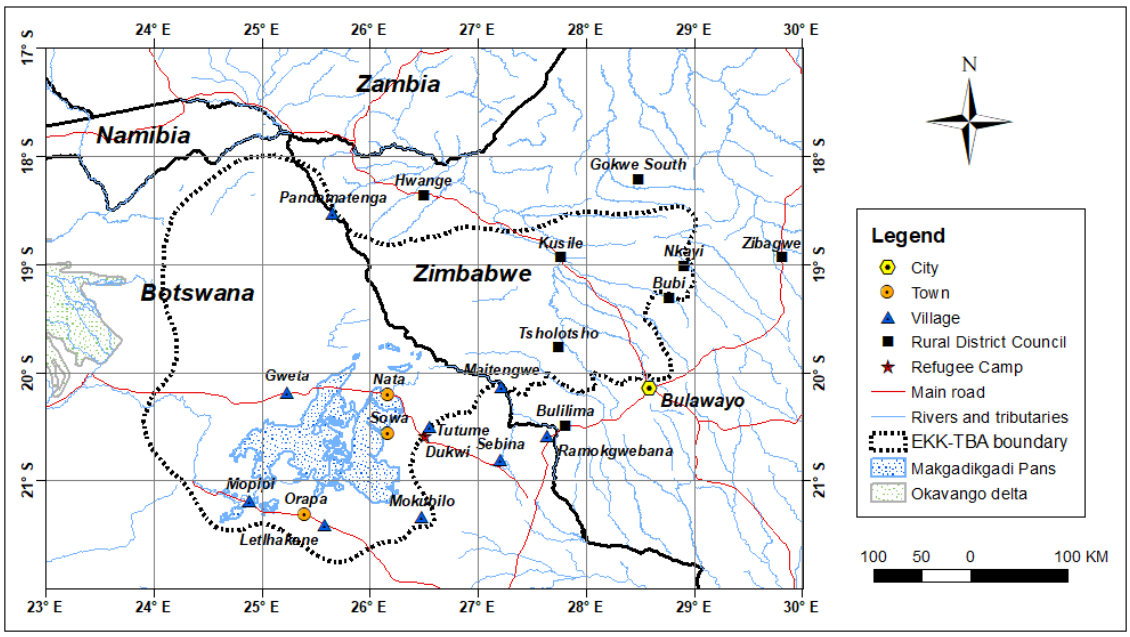

Figure 12: Location of the EKK-TBA within Botswana and Zimbabwe
Source: SADC-GMI (2020a)

A hydrogeological assessment of the aquifer system, based on a review and analysis of publications and technical reports (mostly within the public domain), provided a conceptual understanding of the Basin in terms of groundwater flow, recharge, hydrochemistry and groundwater abstractions. The first strategic objective of the SAP calls for increased knowledge and understanding of the transboundary aquifer for water and safety planning through catchment management. It is foreseen that the water availability situation within the Basin will worsen as a result of a growing population (projected to double by 2050 and this comes with increased demand for food, translating to increased irrigation, consequently imposing a higher demand for groundwater resources whose amount and availability will be impacted by climate variability and change.

To manage the groundwater resources in the Basin sustainably in light of the above, the impact of abstractions including climate variability and change need to be quantified.

These ToRs are for the construction of a regional Integrated Hydrogeology Model (IHM) to quantify and evaluate groundwater dynamics in the Basin building upon the 2020 hydrogeological assessment and conceptual model of the EKK-TBA completed by the SADC-GMI.

2. Assignment Objectives

The main objective of the assignment is to construct a steady-state groundwater model of the EKK-TBA to enable the quantification of groundwater in the Basin. The objective of the model is to;

- provide first estimates of sustainable abstractions (e.g., setting a limit to abstraction) which are important in joint sustainable groundwater management.
- contribute towards enhancing water security in the Basin.

Ancillary objectives are to.

- identify data gaps and data needs and
- to capacitate technical staff from both riparian states in the modelling process and application of the model.

The model would also be essential in the designing and implementation of a basin-wide integrated monitoring network of water levels, abstractions, and water quality with the engagement and involvement of stakeholders from both public and private sector and civil society.

3. Young Professionals Capacity building

The Consultant is also expected to provide hands-on training to two Young Professionals nominated/seconded to the project by the Focal Persons of Botswana and Zimbabwe. The Young Professionals will be part of the project from inception to completion, with project specific assignments and deliverables agreed to by the consultant, Young Professionals, Focal Persons and the Client. The Young Professionals will be contracted to the SADC-GMI, with the Consultant responsible for their supervision.

4. Outline of Key Tasks to be Carried Out

The following key tasks will be undertaken by the service provider to achieve an understanding and quantification of groundwater processes including estimation of sustainable abstractions of the EKK-TBA system:

4.1 Task 1: Inception (10 Workdays)

- Planning of activities.
- Identification and selection of appropriate modelling and accessory software.
- Development of a ToR for Young Professionals
- On-boarding of the seconded Young Professionals
- Drafting Inception Report.

4.2 Task 2: Collation of data and information in time and space (15 Workdays)

- Groundwater level maps (local and regional) with flow direction
- Borehole abstraction rates
- Hydrochemical and isotope data of groundwater
- Groundwater recharge; delineate unconfined and confined parts of the aquifer system
- Aquifer characteristics such as storativity and transmissivity
- Discharge (streamflow) rates

4.3 Task 3: Construction of finite-difference groundwater model (35 Workdays)

- Delineate the model domain
- Conceptual numerical groundwater model
  - Determine the precise model boundary
  - Determine the hydrostratigraphic units to be modelled
  - Develop the 3D hydrostratigraphic model (surface elevation)
- Construct the numerical groundwater model
  - Develop the finite difference mesh including refinement around wellfields
  - Assign the model layer surfaces

- Assign the model boundaries (perimeter boundaries and surface water features)
- Assign groundwater recharge
- Develop the hydraulic conductivity data for the model layers and assign to the model layers
- Prepare pumping borehole data and assign to the model
- Testing the model and making sure that the model runs properly

4.4 Task 4: Calibration of model – Steady state (20 Workdays)

- Construct a groundwater level contour map representing a steady-state or quasi steady-state condition
- Prepare the steady-state water level target for steady-state model calibration
- Conduct a sensitivity analysis to gain insight into model behaviour
- Develop a calibration strategy including:
  - Calibration targets: water level and surface water baseflow data if there are any
  - List of adjusting parameters, and ranges
- Prepare the PEST (a model-independent parameter optimiser) data for steady-state model calibration
- Conduct the PEST run, review the results and re-run PEST iteratively until an acceptable match is achieved

4.5 Task 5: Scenario analysis (pumping) (20 Workdays)

- Stakeholder consultation for the design of model scenarios
- Design of model scenarios
- Prepare the scenario model
- Conduct the scenario model run
- Review and summarize simulation results

4.6 Activity 6: Groundwater model report and course notes (30 Workdays)

- Compile the groundwater model report
  - Conceptual groundwater model
  - Construction of the model
  - Calibration steady state
  - Simulation of pumping scenarios
- Course notes on the setting up and use of the groundwater model

4.7 Activity 7: Training and handover of the model to stakeholders (10 Workdays)

- Training of Botswana and Zimbabwe groundwater Government Institutions staff on the setting-up and use of the groundwater model
- PowerPoint presentation on the results
- Handover of the deliverables of the assignment

The total number of working days for the proposed project amounts to 140.

5. Schedule for Completion of Tasks

This is a once off assignment for which the successful service provider is expected to deploy a cumulative of up to 140 Workdays over a period of 27 weeks. The provisional commencement date for the assignment is 1st July 2022. The anticipated timing for accomplishment of the respective tasks is summarised in the table below:

Task	Delivery Deadline Date from Project Start
Inception	Week 2
Collation of data & info	Week 8
Construction of groundwater model	Week 10
Calibration of groundwater model	Week 14
Scenario analysis	Week 18
Groundwater model report & course notes	Week 24
Training and handover	Week 27

6. Data, Services and Facilities to be Provided by the Client

The anticipated work will mostly be conducted remotely without the necessity to travel. To facilitate the successful service provider to deliver on the assignment, the client will avail the following support and documentation:

a. Letters of support, where required, to enable the service provider to access different types of information and data from the project stakeholders and informants
b. Final Report - Hydrogeology of the Eastern Kalahari-Karoo Basin Transboundary Aquifer System (EKK-TBA) – SADC-GMI (2020)
c. Strategic Action Plan of the Eastern Kalahari-Karoo Basin Transboundary Aquifer (EKK-TBA) - SADC-GMI (2020)
d. Transboundary Diagnostic Analysis of the Eastern Kalahari-Karoo Basin Aquifer system - SADC-GMI (2020)

7. Deliverables

The following deliverables are expected by the stated deadlines against each task:

a. Inception Report – **2** weeks after project start
b. Digital Compendium of hydrogeological data – **8** weeks after project start
c. Numerical groundwater model of the EKK-TBA – **18**weeks after project start
d. Report on the design of the groundwater model including groundwater processes and sustainable abstractions of the EKK-TBA – **24** Weeks after project start
e. Training Report and Course notes on the EKK-TBA groundwater model – **27** weeks after project start

Each report is expected to detail the progress of the Young Professionals on the assignment. The SADC-GMI will pay the Young Professionals based on the report by the consultant.
Payments for services rendered will be negotiated to align with the successful submission and approval of the respective milestone deliverables listed under this section.

8. Consultant's Qualifications, Experience Requirements and Consultant's Team Composition with Estimate of Key Experts Input

This assignment is targeting a Consulting firm with at least five years' experience working on Transboundary Aquifers (TBA). Demonstrated experience of at least one project undertaking detailed work in a TBA context in the SADC region involving the development of Transboundary Diagnostic Analyses (TDA) and Joint Strategic Action Plans is mandatory. Specific knowledge in the requirements and processes for the construction and running of a steady-state groundwater model to enable the quantification of groundwater in a surface and groundwater system is essential.

For this assignment, the Consulting firm shall provide the following experts to execute the envisaged project tasks:

Key Expert 1: Principal Researcher - Team Leader (Estimated 25 Workdays)

At least a master's degree in Hydrogeology and 15 years' experience working in the groundwater field. At least 10 years should have been in the field of groundwater governance research and development. Demonstrated team leadership on at least 3 similar research projects, 1 of which should have been in the SADC region either at Member State or regional level. Proven proficiency with the conjunctive water resources management concept and engagement of multi-country transboundary water course stakeholder institutions and issues. The Team Leader should be fluent in English. Professional proficiency in the other SADC Languages (French and Portuguese) is an advantage.

Key Expert 2: Groundwater Modeller (Estimated 80 Workdays)

At least a master's degree in hydrogeology/geohydrology or related discipline and 15 years working experience in the groundwater modelling, 5 of which should have been in the SADC region. Demonstrated skills in construction and interpretation of groundwater models is essential. Ability to impart knowledge to peers is critical. Familiarity with a suite of modelling packages especially open-source packages and Integrated Hydrogeological Models (IHM) is required.

Key Expert 3: Hydrologist (Estimated 35 Workdays)

At least a bachelor's degree in an engineering discipline (Civil/Water) or similar and about 10 years' experience in the assessment of the hydrology of major rivers. Should have experience of at least two projects of a similar magnitude in Southern Africa. Experience within Malawi and Mozambique will be beneficial. Proven experience in data analysis and interpretation using computer software models is essential. Fluency in English is mandatory and working knowledge of French and Portuguese is an advantage.

Non-Key/Other Expert Staff

The Consultant shall select and hire other experts and support staff as required according to the deemed requirement to deliver the Services in accordance with the contract (e.g. Communications expert, Information Management System expert, Water quality experts, modellers, etc). CVs for such other experts should not be submitted in the Technical Proposal. Although the hiring of other expert staff will not be subject to the prior review of the Client, such staff shall otherwise meet the professional standards and possess adequate experience to conduct their work in a safe and professional manner.

NB:- *The Consultant shall include in their submission a refined proposal for the deployment of the key experts and any non-key experts deemed necessary to timely deliver the objectives of the assignment.*

9. Client Liaison, Assignment Management and Logistics

a. On a day-to-day basis, the consultant will liaise with the SADC-GMI through the Senior Groundwater Specialist.
b. If and where applicable, logistics pertaining to international air and road travel and cross-border travel are the responsibility of the consultant. However, if required, SADC-GMI can arrange necessary letters of support to facilitate the authorities issuing access to the Member States.
c. If required, the Consultants will meet the costs for lodging, car hire, visas and necessary cross border charges. These should therefore be included in the Consultant's technical and financial proposal.

Date for the submission of Expression of Interest

Interested and qualifying consulting firms are required to submit expression of interest Proposals to SADC-GMI on or before 10 June 2022 electronically to: procurement@sadc-gmi.org