



PEACE, PROSPERITY AND
REGIONAL INTEGRATION

HORN OF AFRICA - GROUNDWATER FOR RESILIENCE PROJECT (P174867)

Terms of Reference

For International Consultant for the

Joint Regional Study on

**Appraisal of Climate Risks on Groundwater Resources
in the Horn of Africa**

March 26th, 2023

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Project Background

The Horn of Africa Groundwater for Resilience (HoA GW4R) Program aims to increase sustainable access and management of groundwater (GW) in the Horn of Africa as a key contribution to strengthen the climate resilience of targeted communities, using the Multiphase Programmatic Approach (MPA). Three countries, the Federal Democratic Republic of Ethiopia, the Republic of Kenya, and the Federal Republic of Somalia, as well as the Intergovernmental Authority on Development (IGAD), are included in the Horn of Africa – Groundwater for Resilience (HoA GW4R) Project (P174867), constituting phase I of this Regional Program. The Program has one overarching development objective and a common structure for the connected projects. The Project Development Objective (PDO) is to increase the sustainable access and management of groundwater in the Horn of Africa's borderlands.

Under the HoA GW4R Project, IGAD is in charge of the implementation of the IGAD regional project that aims to address gaps in information about regional groundwater resources and in the capacity to manage them as well as promote regional collaboration and harmonization in groundwater policies and guidelines. The project that started in August 2022 is implemented by IGAD's Water Unit (I-WU) and has a duration of 6 years. It's structured around the three following components:

Component 1. Strengthening Regional Capacity & Information for Sustainable Groundwater Management

Component 2. Promoting Regional Integration and Collaboration

Component 3. Regional Program Coordination, Monitoring & Evaluation

Acknowledging that the region's knowledge and capacity gaps are significant, and that addressing them requires a prolonged collective effort, the Project supports the establishment of the IGAD-Platform for Groundwater Collaboration (I-PGWC) that provides a long-term framework for MSs to collectively identify short-, medium- and long-term priority actions for groundwater knowledge generation, information sharing, capacity building and harmonization.

The proposed joint regional study (JRS) is part of Sub-Component 1.3 of the Project (Building a Regional Information Base) and aims to contribute to the building of a core regional knowledge base, indispensable for the sustainable development and management of the region's groundwater resources. At the same time is the Joint Regional Study fully aligned with and contributing to Sub-Component 2.2. that supports activities promoting trans-boundary dialogue and collaboration on groundwater among IGAD MSs.

Objective of the Joint Regional Study

The main objective of the JRS is to develop a joint methodology to map annual groundwater recharge volumes, suitable for the hydrogeological and climatic conditions in the Horn of Africa and building on the experience and aligned with data availability in MSs. Given the limited availability of historical groundwater data, indispensable for a reliable assessment of recharge processes and dynamics, the methodology to be developed aims at maximizing the use of remotely sensed data sets. The joint methodology will be validated in pilot aquifers in each participating MS and, if successful, can be converted into a monitoring tool to assess annual recharge volumes received by the shallow groundwater units of the region, and fluctuations therein resulting from climate variability.

Study Approach

The study will be conjunctively implemented by teams in the participating Member States Ethiopia, Kenya and Somalia, and the IGAD-Groundwater Center (I-GWC), with support from 1 international and 3 national consultants, under the guidance of and coordination of IGAD-Water Unit(I-WU).

Member States (MS) 's teams will be composed of professionals from the National Groundwater Centers (NGWCs), National Focus Groups or other national experts and will be supported by a National Consultant to be hired by the Project of each country. IGAD-GWC will technically coordinate the study, supported by an International Consultant to be hired by the IGAD Project. I-WU will be in charge of the study coordination, management of contracts and organization of regional workshops included in the scope of work.

Based on the current status of knowledge in the participating MSs the proposed methodology includes the following steps:

- Classify groundwater units;
- Compile available reference data on groundwater recharge;
- Determine rainfall - recharge relationships for different lithology or surface classes;
- Elaborate methodology to calculate recharge for groundwater units;
- Validate methodology through the assessment of recharge for pilot aquifers;
- Apply recharge assessment methodology to all groundwater units of the participating MSs.

Scope of Work

Standards Methodology to be used by the international consultant for Assessment of Potential Groundwater Recharge for the Horn of Africa. Proposed steps includes:

1. Classification of hydrogeological units in each MS: delineate, following a shared methodology, the surface geological/lithological units that benefit from seasonal groundwater recharge and select a well-studied pilot aquifer with sufficient historical groundwater data to reliably assess recharge for validation purposes. **Back-stopping support to I-GWC, Guidance and support to the development of a joint approach**
2. Compile national data on groundwater recharge: constitute a regional knowledge base of groundwater recharge estimates, similar to what has been done in the SADC region (Yu and Beekman, 2019). The knowledge base will compile expertise and experiences from the HoA in recharge evaluation, evaluate the methods and approaches used and assess advantages and challenges, applicable scales and reliability. **Support development joint approach and compilation of global reference data, Guidance and support to evaluation of methods and recharge assessments from national studies**
3. Determine rainfall-recharge relationships valid for lithology classes in the HoA: use shared knowledge to identify specific rainfall-recharge relationships for the HoA. Be-sides lithology and climatological data, the assessment will also consider other key surface parameters that influence recharge and can be mapped from remote sensing data products, like slope, soils, soil moisture, vegetation, land-use, ... **Guidance and support to national recharge correlation assessment and analysis**
4. Elaborate joint protocol to calculate recharge for hydrogeological / lithological units: use satellite-based rainfall and other data sets in combination with HoA specific rain-fall-recharge

relationships to calculate annual recharge volumes for lithological units. **Guidance and support to development of joint methodology**

5. Validate protocol through the assessment of recharge for pilot aquifers: compare for as many years as possible annual recharge estimates with recharge assessments based on ground data and adjust methodology where necessary. **Guidance and support to pilot aquifer assessments**

6. Apply validated protocol to assess annual recharge to all surface aquifers of the MSs. **Guidance in development of national recharge map**

The detailed scope of work of the JRS, for each of the 6 study steps is elaborated in table 1 below. The table also details tasks and responsibilities for each of the study partners: I-WU, I-GWC, the 3 study teams in the participating Member States, the international consultant and the 3 national consultants.

Expected outputs from the joint regional study

The Joint Regional Study is expected to result in the development of the following deliverables:

- Joint methodology for classification of surface groundwater units.
- Joint methodology for evaluation and compilation of recharge values.
- Reference rainfall - recharge relationships for different surface groundwater units in the HoA.
- Joint protocol for groundwater recharge calculation.
- Regional annual groundwater recharge map for 3 MSs.

Duration

The duration of the entire assignment will not exceed 100 days, distributed over the course of one year. Payment will be disbursed upon the successful completion of tasks and deliverables outlined above.

The main responsibilities for this assignment include providing technical guidance and expertise at every stage of the Joint Regional Study (JRS) and offering scientific support to both the IGAD Groundwater Center (I-GWC) and the network of the National Groundwater Centers.

Inputs for this assignment will involve remote back-stopping from the home-base, as well as physical missions to the three Member States and the I-GWC, along with active participation in regional workshops.

The anticipated level of effort for this assignment is 100 days in total.

Minimum qualifications and experience

The expert should meet the following academic qualifications and experience as a minimum:

- a) Master's degree or higher in hydro-geology, groundwater management, water management with special focus on groundwater resources or any other closely related field;
- b) Minimum **10 years** of demonstrable experience in the technical area of Groundwater management, international waters or related fields;
- c) Previous proven experience in carrying out shared aquifer diagnostic/ assessments on at

least **three** assignments;

- d) Proven experience in groundwater recharge assessment and evaluation
- e) Proven experience in GIS and remote sensing applications for groundwater
- f) Strong writing and communication skills;
- g) Fluency in English is required

Deliverables and timelines

1. Map of main hydrogeological units in MS (2 Months)
2. National and reference data sets on rainfall / recharge relationships (4 Months)
3. Rainfall / recharge relationships for different lithological units in the HoA (6 Months)
4. Joint regional methodology for recharge calculation (8 Months)
5. Validated joint regional methodology for recharge calculation (10 Months)
6. Joint recharge map for 3 MSs (12 Months)

Reporting

The expert will report to the IGAD Water Unit Program Coordinator. The expert will also work closely with the IGAD member states' representatives and stakeholders during the JRS.

Scientific References

John H. Kim, Robert B. Jackson (2012), A Global Analysis of Groundwater Recharge for Vegetation, Climate, and Soils, *Vadose Zone Journal*, Vol.11-1. <https://doi.org/10.2136/vzj2011.0021RA>.

Kotchoni, V., et al. (2019). Relationships between rainfall and groundwater recharge in seasonally humid Benin: a comparative analysis of long-term hydrographs in sedimentary and crystalline aquifers. *Hydrogeology Journal* 27:447–457. <https://doi.org/10.1007/s10040-018-1806-2>

Xu, Y., Beekman, H.E. (2019) Review: Groundwater recharge estimation in arid and semi-arid southern Africa. *Hydrogeology Journal* 27, 929–943. <https://doi.org/10.1007/s10040-018-1898-8>

Alan M MacDonald et al 2021, Mapping groundwater recharge in Africa from ground observations and implications for water security, *Environ. Res. Lett.* Vol.16-3.

1 Appendix

2 Table 1 Detailed scope of work and task distribution among study partners

	Step	Tasks	Tasks IGAD	Task MS	Task Consultants	Expected outcomes
1	Classify groundwater units	<ul style="list-style-type: none"> • Agree on joint approach to classify surface groundwater units • Delineate main surface groundwater units in country • Identify pilot aquifer based on available historical data 	<ul style="list-style-type: none"> • Coordination of study and contracts • organization of WS1 (I-WU) • Guide process for joint approach in GW units' classification • Technical coordination of study (I-GWC) 	<ul style="list-style-type: none"> • Appoint project team (NGWC, NFG, universities, ...) • Compile national maps & data on groundwater units • Delineate GW units • Identify pilot aquifer 	<ul style="list-style-type: none"> • Back-stopping support to I-GWC • Guidance and support to the development of a joint approach (IC) • Support in national data collection and compilation (NC) 	<ul style="list-style-type: none"> • Joint approach to delineate surface groundwater units (WS1) • Map of surface groundwater units in MSs (based on lithology, geology, morphology, soil, vegetation, ...)
2	Compile available reference data on groundwater recharge	<ul style="list-style-type: none"> • Agree on joint approach to evaluate & compile recharge data • Compile and complement national data on methods and estimates of groundwater recharge from existing studies and reports • Compile long-term annual rainfall data for compiled recharge sites/regions • Compile rainfall-recharge data and correlations from other regions (Xu and Beekman, MacDonald, ...) 	<ul style="list-style-type: none"> • Technical coordination of study and support to NGWC's • Compilation of reference data and methods from rainfall-recharge assessments from other regions (I-GWC) 	<ul style="list-style-type: none"> • Compile national studies and reports with recharge estimates and relevant reference information (methods used, reference period, representative area, ...) • Compile representative P / PET data series for identified recharge studies (NGWC) 	<ul style="list-style-type: none"> • Back-stopping support to I-GWC • Support development joint approach and compilation of global reference data (IC) • Guidance and support to evaluation of methods and recharge assessments from national studies (IC) • Support in compilation of national recharge case studies (NC) 	<ul style="list-style-type: none"> • Joint approach to evaluate & compile groundwater recharge data (WS1) • National and regional reference data sets on rainfall - recharge relationships

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	Step	Tasks	Tasks IGAD	Task MS	Task Consultants	Expected outcome
3	Determine rainfall - recharge relationships for different lithology or surface classes	<ul style="list-style-type: none"> • Identify empirical rainfall-recharge relationships for HoA • Compare with theoretical functions and reference data from other regions • Agree on most adequate rainfall-recharge relationships for different surface groundwater classes 	<ul style="list-style-type: none"> • Technical coordination of study and support to NGWC's 	<ul style="list-style-type: none"> • Analyze national data sets and compare to results from other MSs and regions 	<ul style="list-style-type: none"> • Back-stopping support to I-GWC • Guidance and support to national recharge correlation assessment and analysis (IC) • Support to national data compilation and evaluation (NC) 	<ul style="list-style-type: none"> • Rainfall - recharge relationships for different surface groundwater units in the HoA (WS2)
4	Elaborate concept methodology to calculate recharge for groundwater units	<ul style="list-style-type: none"> • Define data to be used, geographical units, data corrections and processing steps, time steps and reference periods, calculation method, ... 	<ul style="list-style-type: none"> • Coordination of study, contracts, organization of WS2 (I-WU) • Technical coordination of study and support to NGWC's • Prepare draft methodology for recharge assessment (I-GWC) 	<ul style="list-style-type: none"> • Contribution to development of joint regional methodology 	<ul style="list-style-type: none"> • Back-stopping support to I-GWC • Guidance and support to development of joint methodology (IC) 	<ul style="list-style-type: none"> • Concept joint methodology for groundwater recharge calculation (WS2)

	Step	Tasks	Tasks IGAD	Task MS	Task Consultants	Expected outcome
5	Validate methodology through the assessment of recharge for pilot aquifers	<ul style="list-style-type: none"> • Use methodology to assess recharge for pilot aquifer and compare to recharge estimates from water balance, chloride mass-balance, water level fluctuation, piezometric map, groundwater model or other method • Discuss and improve joint regional methodology based on pilot aquifer assessments 	<ul style="list-style-type: none"> • Technical coordination of study and support to NGWC's (I-GWC) 	<ul style="list-style-type: none"> • Apply protocol to pilot aquifer and compare to recharge estimates from ground data • Share and discuss results with other MSs • Validate joint regional methodology 	<ul style="list-style-type: none"> • Back-stopping support to I-GWC • Guidance and support to pilot aquifer assessments (IC) • Support to national pilot aquifer assessment 	<ul style="list-style-type: none"> • Validated joint methodology for recharge calculation
6	Apply recharge assessment methodology to all groundwater units of the participating MSs	<ul style="list-style-type: none"> • Prepare groundwater recharge map for 3 countries 	<ul style="list-style-type: none"> • Technical coordination of study and support to NGWC's (I-GWC) 	<ul style="list-style-type: none"> • Apply recharge assessment methodology to all groundwater units of the country 	<ul style="list-style-type: none"> • Back-stopping support to I-GWC • Guidance in development of national recharge map • Support in preparation of national recharge map 	<ul style="list-style-type: none"> • Regional annual groundwater recharge map for 3 MSs

Data needs for the joint regional study

The data needs for each of the study steps is summarized in Table 2 below.

Table 2 – Anticipated data needs for the JRS

	Step	Data needs
1	Classification of surface groundwater units	<ul style="list-style-type: none"> • GIS layers for each of the MSs (lithology, geology, hydrogeology, soils, DEM, vegetation, soil moisture, ...); • Piezometric records, water balances, recharge estimates, ... for selected pilot aquifers;
2	Compile available reference data on groundwater recharge	<ul style="list-style-type: none"> • Recharge estimates from previous reports and studies in MSs; • Relevant global reference information on rainfall-recharge research and evaluation methodologies (I-GWC); • Gridded rainfall and actual evapotranspiration data from remotely sensed platforms (I-GWC);
	Annual updates of recharge maps	<ul style="list-style-type: none"> • Update of gridded rainfall and actual evapotranspiration data from remotely sensed platforms (I-GWC);

Implementation Schedule

The proposed implementation schedule of the JRS is shown in Figure 1. Total duration of the study is expected to be 12 months.

Figure 1 – Implementation schedule of the Joint Regional Study

