



**PEACE, PROSPERITY AND
REGIONAL INTEGRATION**

HORN OF AFRICA - GROUNDWATER FOR RESILIENCE PROJECT (P174867)

Terms of Reference For

**International Consultant to support the Joint Regional Study on Appraisal of Climate
Risks on Groundwater Resources in the Horn of Africa**

15th August, 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 and management, 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 the Joint Regional Study is fully aligned with and contributing to Sub-Component 2.2. that supports activities promoting trans-boundary dialogue and collaboration on groundwater among IGAD Member State’s (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 surface groundwater units of the region, and fluctuations therein resulting from climate variability.

Joint Regional 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 Focal Groups or other national experts and will be supported by a National Consultant to be hired by the IGAD Groundwater for Resilience Project. 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

The proposed Standards Methodology for the Assessment of Potential Groundwater Recharge in the Horn of Africa will be executed collaboratively by dedicated national consultants for each of the three countries (Ethiopia, Kenya, and Somalia), with the invaluable support of an international consultant. This comprehensive study will encompass all three nations and is designed to adhere to a meticulously crafted series of well-defined following steps to ensure the attainment of accurate and reliable results.

Step 1: National Data Collection and Hydrogeological Unit Classification The first step involves Guidance and support to the development of a joint approach. Using a shared methodology, the study will delineate hydrogeological units that benefit from seasonal groundwater recharge in each country. Additionally, a well-studied pilot aquifer with sufficient historical groundwater data will be carefully selected to serve as a reliable benchmark for validating recharge estimates.

Step 2: Compilation of Groundwater Recharge Data to create a regional knowledge base, similar to the successful approach in the SADC region, the study will compile comprehensive national data on groundwater recharge. This knowledge base will include expertise and experiences from the Horn of Africa, evaluating different methods and approaches used for recharge assessment. It will also assess the advantages, challenges, applicable scales, and reliability of these methods.

Step 3: Determining Rainfall-Recharge Relationships In this step, the study will identify specific rainfall-recharge relationships for lithology classes in the Horn of Africa, leveraging shared knowledge and expertise. The assessment will not only consider lithology and climatological data but also account for other key surface parameters, such as slope, soils, soil moisture, vegetation, and land-use, which influence recharge. Remote sensing data products will be utilized to support the national data compilation and evaluation.

Step 4: Elaborate Joint Protocol for Recharge Calculation The study will actively contribute to the development of a joint protocol for calculating recharge in hydrogeological/lithological units. This protocol will involve the integration of satellite-based rainfall data and other relevant datasets, utilizing Horn of Africa-specific rainfall-recharge relationships to calculate annual recharge volumes for different lithological units.

Step 5: Guidance and Supporting National Pilot Aquifer Assessment and Protocol Validation The study will provide support for the assessment of recharge in pilot aquifers, which involves comparing annual recharge estimates with ground data-based assessments for as many years as possible. Adjustments to the methodology will be made if necessary to ensure accurate results.

Step 6: Guidance and Support in the Preparation of National Recharge Map Using the validated protocol, the study will assess annual recharge for all surface aquifers of the three member states, ultimately contributing to the preparation of a Regional annual recharge map.

The National Focal Group will play a vital role in supporting both the national and international consultants throughout the entire project. They will actively participate in national and aquifer level consultations, provide expert inputs at various stages, and contribute to the finalization of the country deliverables. Their expertise and contributions will ensure the successful execution of the Assessment of Potential Groundwater Recharge for the Horn of Africa.

Expected Outputs from the Joint Regional Study

The Joint Regional Study is expected to produce significant deliverables tailored to each country's specific needs in Ethiopia, Kenya, and Somalia. These deliverables include:

- A Joint Methodology for the Classification of Surface Groundwater Units, facilitating a standardized approach to delineate and classify hydrogeological units benefiting from seasonal groundwater recharge.
- A Joint Methodology for Evaluation and Compilation of Recharge Values from National Studies and Data, enabling the evaluation and compilation of existing national groundwater recharge data and studies.
- Reference Rainfall-Recharge Relationships for Different Surface Groundwater Units in each country, considering local lithology and other surface parameters.
- Unified Approach for Groundwater Recharge Calculation of Surface Groundwater Units will outline the steps to calculate annual groundwater recharge volumes using standardized methods.

- Furthermore, the Joint Regional Study will lead to the development of a Regional Annual Groundwater Recharge Map, providing a comprehensive display of the annual groundwater recharge distribution across the three countries.
- Lastly, the study will include capacity-building efforts to Train Hydrogeologists of Ethiopia, Kenya, and Somalia on the Joint Methodology for Assessment of Potential Groundwater Recharge, empowering them with valuable knowledge and skills in groundwater recharge assessment.

Duration of the Task

The entire assignment is expected to last for a maximum of 100 days, spread over a period of one year. Payment will be made based on the completion of tasks and deliverables as specified above.

Main tasks of this assignment providing technical guidance to every step of the JRS and scientific support to I-GWC and national teams.

Inputs for this assignment will involve remote back-stopping from home-base, physical missions to the three Member States and I-GWC during Joint Regional Study and participation in regional workshops.

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 from the start of contract)
2. National and reference data sets on rainfall / recharge relationships (4 Months from the start of contract)

3. Rainfall / recharge relationships for different lithological units in the HoA (6 Months from the start of contract)
4. Joint regional methodology for recharge calculation (8 Months from the start of contract)
5. Validated joint regional methodology for recharge calculation (10 Months from the start of contract)
6. a Joint/regional recharge Map for the three member states (12 Months from the start of contract)

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

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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>

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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.

Berghuijs, W. R., Luijendijk, E., Moeck, C., van der Velde, Y., & Allen, S. T. (2022). Global recharge data set indicates strengthened groundwater connection to surface fluxes. *Geophysical Research Letters*, 49, e2022GL099010. <https://doi.org/10.1029/2022GL099010>

Appendix

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	<p>Compile available reference data on groundwater recharge</p>	<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

Activity	Step	Month:	1	2	3	4	5	6	7	8	9	10	11	12
1	Elaborate joint approach for classification of groundwater units		WS1											
	Delineate groundwater units													
	Identify pilot aquifer													
2	Elaborate joint approach for evaluation of recharge data		WS1											
	Compile national reference data on groundwater recharge & rainfall													
	Compile global reference data on groundwater recharge & rainfall													
3	Determine rainfall-recharge relationships for HoA groundwater units							WS2						
4	Elaborate methodology to calculate recharge for groundwater units							WS2						
5	Validate methodology on pilot aquifers													
6	Apply recharge equation to other groundwater units													WS3
7	Final Report Joint Regional Study													