Research Terms of Reference

Groundwater and Use Assessment
AFG2602
Afghanistan

20 August 2026
V3

AGORA Localised Response Inclusive Recovery Effective Stabilisation

1 Executive Summary

Country of intervention	Afghanistan					
Type of Emergency	□	Natural hazard	□	Conflict	x	Other: Agricultural livelihoods
Type of Crisis	□	Sudden onset	□	Slow onset	x	Protracted
Mandating Body/ Agency	Norwegian Ministry of Foreign Affairs (NMOFA)					
IMPACT Project Code	02BAS					
Overall Research Timeframe (from research design to final outputs / M&E)	01/07/2026 to 31/12/2026					
Research Timeframe Add planned deadlines (for first cycle if more than 1)	1. Pilot/ training: 17/09/2026		6. Outputs sent for validation: 19/11/2026			
	2. Start collect data: 22/09/2026		7. Outputs shared with partner: 03/12/2026			
	3. Data collected: 22/10/2026					
	4. Data analysed: 28/10/2026					
	5. Data sent for validation: 29/10/2026					
Number of assessments	X	Single assessment (one cycle)				
	□	Multi assessment (more than one cycle)				
Humanitarian milestones Specify **what** will the assessment inform and **when** e.g. The shelter cluster will use this data to draft its Revised Flash Appeal;	**Milestone**		**Deadline (can be tentative)**			
	□	Donor plan/strategy				
	□	Inter-cluster plan/strategy				
	x	Cluster plan/strategy (WASH Cluster)	30/12/2026			
	x	NGO platform plan/strategy (Acted, UNICEF)	30/12/2026			
	□	Other (Specify):				
	Audience type		**Dissemination**			

Audience Type & Dissemination Specify **who** will the assessment inform and **how** you will disseminate to inform the audience	□ Strategic X Programmatic X Operational		□ General Product Mailing (e.g. mail to NGO consortium; HCT participants; Donors) X Cluster Mailing (WASH) and presentation of findings at next cluster meeting □ Presentation of findings (e.g. at HCT meeting; Cluster meeting) □ Website Dissemination (Relief Web & REACH Resource Centre) x Bilateral dissemination (Acted, UNICEF, and WVI)	
Stakeholder mapping *Has a detailed stakeholder mapping been conducted during research design to identify all actors that could **contribute** to and/or **benefit from** the research?*	x	Yes	□	No
General Objective	To understand groundwater availability, access, use, quality, reported reliability, and governance for programmatic decision-making across Faryab, Samangan, Jawzjan and Balkh provinces.			
Specific Objective(s)	**Component 1: GIS/RS analysis** 1) To identify and map areas with relatively low groundwater recharge favourability across Faryab, Samangan, Jawzjan, and Balkh provinces using GIS and remote sensing analysis, in order to support the identification and prioritization of areas facing potential groundwater-related constraints. **Component 2: Province-wide KIIs** 2) To document settlement-level water access, water use patterns, irrigation water demand, common water-extraction infrastructure, reported water-related challenges, water management arrangements, and priority actions for improving water availability and access across sampled rural settlements within target provinces. **Component 3: Household survey** 3) To assess household water-use practices, access to water for domestic and irrigation purposes, perceived reliability and affordability of water sources, seasonal variations in water availability, and household coping strategies across selected most ground-water depended districts in the target provinces. **Component 4: Well assessment** 4) To characterize the physical condition, functionality, and water quality of selected groundwater sources across different recharge-favourability zones through well inspections, groundwater-level measurements, field-based water-quality testing, and targeted laboratory analysis.			

	5) To examine short-term pumping-related water-level variation, drawdown and well performance and functionality through one full daytime monitoring exercise at a subset of the physically assessed wells. 6) To provide field-based evidence for comparison with GIS/remote sensing-derived recharge-favourability patterns.
Research Questions	**Component 1: GIS/RS analysis** 1) Which areas exhibit relatively favourable and unfavourable environmental conditions for groundwater recharge? 2) How do recharge-favourability patterns spatially overlap with areas of intensive irrigation demand? **Component 2: Province-wide KIIs** *3)* What are the principal water sources used for domestic and agriculture purposes across sampled settlements? 4) What types of water-extraction infrastructure are most commonly used, and how are they operated and maintained? 5) What are the main challenges affecting water access, water availability, and irrigation water supply in sampled settlements? 6) What seasonal and longer-term changes in water availability and demand have been reported by community informants? 7) How are water resources managed at settlement level, and what arrangements exist for water allocation, and maintenance? 8) What actions and measures are perceived as priorities for improving water availability, access, and reliability? **Component 3: Household survey** 9) What water sources do households use for domestic and agriculture purposes? 10) How accessible, reliable, and affordable are household water sources? 11) What coping strategies do households employ during periods of water shortage or reduced water availability? 12) What changes in water availability, source reliability, and perceived water quality have households observed over the past five years? **Component 4: Well assessment** 13) What well types, construction characteristics, pumping systems, and usage patterns are observed among sampled groundwater sources? 14) What groundwater-level, physical-condition, and functionality characteristics are observed across sampled wells? 15) What water-quality characteristics are observed through field-based testing and laboratory analysis, and how do these vary by well type and location? 16) How do observed well characteristics and water-quality conditions vary across different groundwater recharge-favourability zones and well types? 17) How do groundwater levels change before, during, and after one full daytime pumping cycle? 18) What is the maximum observed drawdown, and how quickly does the groundwater level recover after pumping stops?

	19) How do pumping conditions, nearby pumping, and well characteristics influence short-term well performance?					
Geographic Coverage	4 targeted provinces: Balkh, Jawzjan, Samangan, and Faryab in northwest Afghanistan. GIS/secondary review and KII screening cover all districts in those provinces. Detailed household and physical well assessment will cover 15 districts.					
Secondary data sources	See table *2: Secondary Data source*					
Population(s) Select all that apply	□	IDPs in camp		□	IDPs in informal sites	
	X	IDPs in host communities		□	IDPs [Other, Specify]	
	□	Refugees in camp		□	Refugees in informal sites	
	□	Refugees in host communities		□	Refugees [Other, Specify]	
	X	Host communities		X	Households and communities using groundwater or other sources for domestic, and irrigation needs	
Stratification Select type(s) and enter number of strata	X	Geographical #: 4 provinces Population size per strata is known? x Yes □ No	□	Group #: _ _ _ Population size per strata is known? □ Yes □ No	□	[Other Specify] #: _ _ Population size per strata is known? □ Yes □ No
Data collection tool(s)	x	Structured (Quantitative)			Semi-structured (Qualitative)	
	Sampling method			**Data collection method**		
Structured data collection tool (s) # 1 Province-wide groundwater screening	x Purposive			x Key informant interview (Target #): 2,521 KIIs in total across approximately 2,521 settlements. 1KII with a knowledgeable informant per settlement		
Structured data collection tool (s) # 2 Household survey	X Probability / stratified cluster sampling			**X** Household level interview (Target #): Target approximately 5,090 HHIs across 15 districts		
Target level of precision if probability sampling	95% level of confidence			6+/- % margin of error		
Structured data collection tool (s) # 3 Physical well and water-quality assessment	**X** Purposive stratified well selection			**X** Structured physical well assessment: Target approximately 400 wells, with **X** Integrated field physical-water-quality screening: Target approximately 400 tests **X** Laboratory water-quality analysis: Target, up to 45 groundwater samples **X** Full daytime monitoring exercise on physically assessed wells: Target, up to 45 exercises 3 per district.		
	Gender			Age		

Disaggregation by gender and age Are you planning to conduct sex/age disaggregated analysis?	x	Yes		□	Yes	
	□	No		x	No	
Data management platform(s)	X	IMPACT		□	UNHCR	
	□	[Other, Specify]				
Expected output type(s)	x	Situation overview #: 1	□	Report #:	X	Profile #: 1 compendium containing 15 district profiles
	X	Presentation (Preliminary findings) #: 1		Presentation (Final) #: 1	□	Factsheet #: _ _
	□	Interactive dashboard #:_	□	Webmap #: _ _	X	Map #: 2, Groundwater surface-condition recharge-potential favourability map and groundwater-level map covering measured wells in the 15 districts
Access	X	(available on REACH resource center and other humanitarian platforms)				
	□	Restricted (bilateral dissemination only upon agreed dissemination list, no publication on REACH or other platforms)				
Visibility Specify which **logos** should be on outputs	AGORA					
	Donor: Norwegian Ministry of Foreign Affairs					
	AGORA					
	Partners: N/A					

2 Rationale

2.1 Background

A large majority of Afghanistan's population depends on agriculture as a key income source. While the exact proportion for whom this holds true is hard to determine in rural areas of the Northern Region (Balkh, Faryab, Jawzjan, Samangan), it is likely to align with, if not exceed, 80%, a figure commonly cited at the national level. Groundwater is increasingly used for irrigation and drinking, particularly where surface-water supplies are limited or subject to seasonal restrictions.

Afghanistan experienced several consecutive years of drought between 2021 and 2025, likely reducing groundwater recharge. Remote-sensing data also indicates a declining trend in terrestrial water storage, including in the Northern River Basin. Despite these pressures, the current status, availability, use, and sustainability of groundwater resources in the Northern Region remain poorly documented.

Groundwater use is also largely unmanaged at community level. While traditional systems such as *mirabs* and *chakbashis* regulate surface water, similar mechanisms for groundwater extraction are limited. The absence of systematic monitoring and effective regulation of borehole drilling and extraction raises concerns about over-extraction and long-term water security. Findings from a 2025 HH survey on irrigation water management point to the scale of borehole uptake, at least at

a local level, with 100% of respondents reporting boreholes as their main irrigation water source in one of the five assessed locations.

Groundwater quality is another concern, particularly in lowland areas where salinity and other dissolved minerals may affect soil productivity and agricultural yields. This risk is particularly relevant in the lowland and piedmont (bottom of the mountain) areas of the Northern Region, where naturally occurring deposits contribute to brackish groundwater in some aquifer systems.

To address these evidence gaps and support evidence-based decision-making by WASH actors, the assessment aims to improve understanding of groundwater availability, use, quality, access, and governance. The assessment will provide evidence to inform more sustainable groundwater management and support the design of WASH, irrigation, drought-response, and natural-resource programming across the four provinces of the Northwest Region.

2.2 Intended impact

The assessment is expected to improve evidence-based management and sustainable use of groundwater resources in Afghanistan's Northwestern Region by generating a baseline on groundwater availability, quality, use, and governance. Its findings will support humanitarian and development actors, local communities, and relevant authorities to better identify groundwater depletion and quality risks, inform drought and water-resource programming, strengthen community-level groundwater management, and guide more sustainable investment in water and irrigation infrastructure.

The planned activities will strengthen operational evidence on groundwater reliance, household water access, reported reliability, water-quality concerns and conditions observed at selected wells. The assessment is intended to improve geographic prioritization and programme design for Acted, UNICEF, WASH cluster, agriculture and livelihoods actors, relevant authorities and United Nations (UN) agencies. Findings will help identify groundwater-dependent communities, reported reliability concerns, locations requiring technical follow-up, and priorities for programme adaptation.

3 Methodology

3.1 Methodology overview

The assessment will use a quantitative, multi-component design comprising four components implemented largely in parallel as follows.

- First, standalone remote-sensing and GIS analysis will map relative surface-condition recharge favorability across Balkh, Jawzjan, Faryab and Samangan.
- Second, a standalone structured KII screening will collect indicative settlement-level information on water sources, groundwater use, irrigation water demand, water-extraction infrastructure, reported functionality and reliability, water-quality concerns, access and management arrangements through one knowledgeable informant per sample settlement.
- Third, a district-representative household survey will assess household water-source use, access, reliability, affordability, seasonal availability and coping strategies for domestic and irrigation needs across 15 selected districts.
- Fourth, a purposive technical assessment will examine the physical condition, functionality, groundwater levels and physicochemical water quality of selected wells in the same districts through well inspections, field screening, targeted laboratory testing and a structured full-day time monitoring of physically assessed wells. Targeted laboratory testing and daytime groundwater-level monitoring will be conducted at eligible subsets of the physically assessed wells. The full daytime monitoring exercise is a sub-activity of Component 4, not a fifth assessment

component. The physical well assessment remains the parent record, and every monitoring record should be linked through the same unique well ID.

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Table 1: Methods summary

Component	Research Question (RQ)	Data collection method
Remote-sensing and GIS analysis	RQ1. Which areas exhibit relatively favourable and unfavourable environmental conditions for groundwater recharge? RQ2. How do recharge-favourability patterns spatially overlap with areas of intensive irrigation demand?	Remote sensing and GIS-based multi-criteria analysis using secondary spatial data
Settlement KII screening	RQ3. What are the principal water sources used for domestic and agriculture purposes across sampled settlements? (probably here we can keep both domestic and agriculture, but the rest focus more on agriculture) RQ4. What types of water-extraction infrastructure are most commonly used, and how are they operated and maintained? RQ5. What are the main challenges affecting water access, water availability, and irrigation water supply in sampled settlements? RQ6. What seasonal and longer-term changes in water availability and demand have been reported by community informants? RQ7. How are water resources managed at settlement level, and what arrangements exist for water allocation, maintenance, and conflict resolution? RQ8. What actions and measures are perceived as priorities for improving water availability, access, and reliability?	One structured KII per sampled settlement
Household survey	RQ9. What water sources do households use for domestic and agriculture purposes? RQ10. How accessible, reliable, and affordable are household water sources? RQ11. What coping strategies do households employ during periods of water shortage or reduced water availability? RQ12. What changes in water availability, source reliability, and perceived water quality have households observed over the past five years?	Household interviews, representative at district level
well assessment	RQ13. What well types, construction characteristics, pumping systems, and usage patterns are observed among sampled groundwater sources?	Purposive well inspection, groundwater-level

	RQ14. What groundwater-level, physical-condition, and functionality characteristics are observed across sampled wells? RQ15. What water-quality characteristics are observed through field-based testing and laboratory analysis, and how do these vary by well type and location? RQ16. How do groundwater levels change before, during, and after one full daytime pumping cycle? RQ17. What is the maximum observed drawdown, and how quickly does the groundwater level recover after pumping stops? RQ18. How do pumping conditions, nearby pumping, and well characteristics influence short-term well performance? RQ19. How do observed well characteristics and water-quality conditions vary across different groundwater recharge-favourability zones and well types?	measurement, field physicochemical screening and targeted laboratory analysis

Findings from household surveys, settlement-level KIIs and well assessments will be triangulated to examine how reported household water access and reliability relate to observed groundwater-source characteristics, water quality, and community-level groundwater conditions.

3.2 Population of interest

The populations and units of interest differ by assessment component. For the province-wide KII screening, the population of interest comprises sampled settlements and eligible adult informants with direct and recent knowledge of groundwater sources, use, reliability or management in their settlement. For the household survey, the population of interest comprises all resident households that rely on groundwater sources for domestic and irrigation needs in the 15 targeted districts. For the technical component, the unit of interest comprises accessible boreholes and hand-dug wells in the same 15 districts that meet the defined consent, safety and measurement-feasibility requirements.

3.3 Secondary data review

In general, there is very little recent literature on groundwater in Afghanistan, especially for areas outside the Kabul basin. The study on Helmand is an illustrative and engaging read on risks in Southern Afghanistan, including a short section on solar borewells, much of which is probably relevant for the Northwest as well. Secondary data will inform context, spatial modelling, district prioritization, sampling frames, questionnaire development and triangulation.

Table 2. Secondary sources table

Secondary Source	Purpose of Source
ALOS PALSAR DEM; CHIRPS; USGS geology/lithology; Sentinel-2; and river data	ALOS PALSAR DEM; CHIRPS; USGS geology/lithology; Sentinel-2; and river data
WASH Cluster and partner water-point/borehole data	Known groundwater infrastructure, functionality, quality and screening-frame validation.
MSNA district data	District-level domestic groundwater reliance and water-access context.
Kakar, N., S. Metzger, T. Schöne, et al. (2025). *Interferometric Radar Satellite and In-Situ Well Time-*	Contextual information on groundwater extraction in urban and rural Afghanistan.

Series Reveal Groundwater Extraction Rate Changes in Urban and Rural Afghanistan. Water Resources Research, 61(3). https://doi.org/10.1029/2023WR036626	
Mansfield, David. *Digging an Ever-Deeper Hole: The Response to Climate Change in the Helmand River Basin.*	Impacts of climate change, drought, and increasing water demand on water resources in the Helmand Basin.
WASH Cluster. *Groundwater Levels & Water Points Coverage.* Google Drive	Analysis of groundwater availability, water access, and potential areas of groundwater stress in Afghanistan.
UNICEF-commissioned Groundwater Literature Review.	Provides knowledge on Afghanistan's groundwater resources, hydrogeology, monitoring, and evidence gaps
Ahmad, I., I. Ul Haq, M. Ahmad, et al. (2025). *Groundwater Estimation and Determination of Its Probable Recharge Source in the Lower Swat District, Khyber Pakhtunkhwa, Pakistan, Using Analytical Data and Multiple Machine Learning Models.* https://doi.org/10.3389/fenvs.2025.1598307	Provides contextual information on groundwater assessment, particularly in data-constrained settings.
Hamidov, A., K. Daedlow, H. Webber, et al. (2022). *Operationalizing Water-Energy-Food Nexus Research for Sustainable Development in Social-Ecological Systems: An Interdisciplinary Learning Case in Central Asia.* https://doi.org/10.5751/ES-12891-270112	Conceptual framework for understanding groundwater pressures.
Kashani, A., & H. R. Safavi (2025). *Assessing Groundwater Drought in Iran Using GRACE Data and Machine Learning.* https://doi.org/10.1038/s41598-025-99342-9	Applies GRACE satellite data and machine learning to assess groundwater drought in Iran
Liu, Y., P. Wang, H. Ruan, et al. (2020). *Sustainable Use of Groundwater Resources in the Transboundary Aquifers of the Five Central Asian Countries: Challenges and Perspectives.* https://doi.org/10.3390/w12082101	Regional context for Afghanistan's shared water systems and groundwater governance.
Khaneiki, M. L., & A. S. Al-Ghafri (2023). *Water Cooperation and Ideology in Local Communities.* https://doi.org/10.58981/bluepapers.2023.1.14	Community-level groundwater governance and collective management of water resources.
Nixon, R., Z. Ma, B. Khan, et al. (2022). *Social Influence Shapes Adaptive Water Governance: Empirical Evidence from Northwestern Pakistan.* https://doi.org/10.5751/ES-13546-270337	Understanding community-level decision-making and adaptation related to groundwater management.
Tufail, M., M. J. Nasir, A. Rahman, et al. (2025). *A Geospatial Assessment of the Resilience of Municipal Water Supply to Flooding in Nowshera District, Pakistan.* https://doi.org/10.1016/j.hydres.2024.09.009	Focused on flooding, its GIS-based methodology assessed water infrastructure and groundwater-related risks.
Yasin, H. Q., J. Breadsell, & M. N. Tahir (2021). *Climate-Water Governance: A Systematic Analysis of the Water Sector Resilience and Adaptation to Combat Climate Change in Pakistan.* https://doi.org/10.2166/wp.2020.113	Systematic analysis of water governance, climate resilience, and adaptation.
Brandenburg, J. P. (2020). *Geologic Frameworks for Groundwater Flow Models.* The Groundwater Project. https://doi.org/10.21083/978-1-7770541-9-9	Accessible introduction to geological frameworks for groundwater-flow modelling.
van der Gun, J. (2023). *Large Aquifer Systems around the World.* The Groundwater Project. https://doi.org/10.21083/978-1-77470-020-4	Provides an overview of large aquifer systems worldwide, their characteristics, and their importance.
Singha, K., T. Johnson, F. Day-Lewis, & L. Slater (2023). *Electrical Imaging for Hydrogeology.* The Groundwater Project. https://doi.org/10.21083/978-1-77470-011-2	Introduces electrical imaging and geophysical techniques for hydrogeological investigations.

Winston, R. B. (2023). *Getting Started with MODFLOW.* The Groundwater Project. https://doi.org/10.21083/978-1-77470-030-3	Practical introduction to MODFLOW groundwater-flow modelling.
Guug, S. S., S. Abdul-Ganiyu, & R. A. Kasei (2020). *Application of SWAT Hydrological Model for Assessing Water Availability at the Sherigu Catchment of Ghana and Southern Burkina Faso.* https://doi.org/10.1016/j.hydres.2020.10.002	How hydrological modelling can support water-resource assessments in data-constrained environments.
Iqbal, K. M. J., M. I. Khan, A. Mikhaylov, et al. (2023). *Modeling Principles, Criteria and Indicators to Assess Water Sector Governance for Climate Compatibility and Sustainability.* https://doi.org/10.3389/fenvs.2023.989930	Potential framework for evaluating governance dimensions of sustainable groundwater management.
Labbe, J., H. Celle, J.-L. Devidal, J. Albaric, & G. Mailhot (2023). *Combined Impacts of Climate Change and Water Withdrawals on the Water Balance at the Watershed Scale.* https://doi.org/10.3390/su15043275	Highlights the need to consider both climatic pressures and human withdrawals when assessing groundwater sustainability.
Lian, J., Y. Li, Y. Li, et al. (2022). *Effect of Center-Pivot Irrigation Intensity on Groundwater Level Dynamics in the Agro-Pastoral Ecotone of Northern China.* https://doi.org/10.3389/fenvs.2022.892577	Provides relevant evidence on how agricultural water demand can contribute to groundwater depletion, particularly in dryland and agro-pastoral contexts.
MacDonald, A. M., H. C. Bonsor, B. É. Ó. Dochartaigh, & R. G. Taylor (2012). *Quantitative Maps of Groundwater Resources in Africa.* https://doi.org/10.1088/1748-9326/7/2/024009	Demonstrates approaches for groundwater-resource mapping where detailed monitoring data are limited, used as a context.
Mahakur, V., V. K. Mahakur, S. Samantaray, & D. K. Ghose (2025). *Prediction of Runoff at Ungauged Areas Employing Interpolation Techniques and Deep Learning Algorithm.* https://doi.org/10.1016/j.hydres.2024.12.001	Provide contextual information on surface water, the approach offers methodological lessons for Afghanistan's data-scarce hydrological environment.
Mas-Pla, J., A. Menció, & A. Marsiñach (2013). *Basement Groundwater as a Complementary Resource for Overexploited Stream-Connected Alluvial Aquifers.* https://doi.org/10.1007/s11269-012-0186-y	Highlights the importance of understanding connections between different groundwater systems when assessing water availability and sustainability.
Mekonnen, Y. G., T. Alamirew, A. D. Chukalla, et al. (2025). *Remote Sensing in Hydrology: A Systematic Review of Its Applications in the Upper Blue Nile Basin, Ethiopia.* https://doi.org/10.1016/j.hydres.2024.09.002	Provides useful methodological guidance for using satellite data in areas with limited ground-based observations.
Morrisett, C. N., R. W. Van Kirk, L. O. Bernier, et al. (2023). *The Irrigation Efficiency Trap: Rational Farm-Scale Decisions Can Lead to Poor Hydrologic Outcomes at the Basin Scale.* https://doi.org/10.3389/fenvs.2023.1188139	Assessing irrigation efficiency interventions and groundwater sustainability.
Pirasteh, S., A. Samad, R. Ahmad, et al. (2025). *Geospatial and AHP Based Identification of Potential Zones for Groundwater Recharge in Haridwar District of India.* https://doi.org/10.3389/fenvs.2025.1421918	Potentially transferable methodology for mapping recharge areas in Afghanistan.
Pointet, T. (2022). *The United Nations World Water Development Report 2022 on Groundwater, a Synthesis.* https://doi.org/10.1080/27678490.2022.2090867	Groundwater's importance, increasing pressures, governance challenges, and the need for improved monitoring and sustainable management.
Senthilkumar, M., D. Gnanasundar, B. Mohapatra, et al. (2020). *Earthquake Prediction from High Frequency Groundwater Level Data: A Case Study from Gujarat, India.* https://doi.org/10.1016/j.hydres.2020.10.004	The study highlights the potential benefits of continuous groundwater monitoring systems.
Van Loon, A. F., A. Matanó, S. Tirivarombo, et al. (2025). *Towards More Connection in Drought and Flood*	The study highlights the importance of coordinated and integrated water-resource management for addressing interconnected climate-related risks.

Management in the Transboundary Limpopo Basin. https://doi.org/10.4102/jamba.v17i1.1798	
Vicente-Serrano, S. M., M. Peña-Gallardo, J. Hannaford, et al. (2019). *Climate, Irrigation, and Land Cover Change Explain Streamflow Trends in Countries Bordering the Northeast Atlantic.* https://doi.org/10.1029/2019GL084084	Importance of distinguishing between climatic and human drivers when assessing changes in water availability.
Wilcox, B. P., S. Basant, H. Olariu, & P. A. M. Leite (2022). *Ecohydrological Connectivity: A Unifying Framework for Understanding How Woody Plant Encroachment Alters the Water Cycle in Drylands.* https://doi.org/10.3389/fenvs.2022.934535	Understanding how land degradation and vegetation changes may affect hydrological processes and groundwater recharge in arid and semi-arid environments.

Component 1: Remote-sensing and GIS Analysis

A GIS-based multi-criteria analysis will be used to develop a relative surface-condition groundwater recharge-favorability index across Balkh, Jawzjan, Faryab and Samangan, using available secondary data on lithology, rainfall, slope, proximity to rivers, dry-season vegetation persistence, proximity to snow-covered areas, and elevation. Standardized layers will be weighted and combined to classify the study area into five relative surface-condition groundwater recharge-favorability classes: very high, high, moderate, low and very low.

The index does not measure actual groundwater recharge. Actual recharge is a temporally and spatially variable downward water flux reaching the saturated zone and would require hydrogeological observations, water-balance analysis, monitoring or other dedicated methods beyond the scope of this activity. The index will therefore be used only as a comparative spatial screening product.

3.4 Primary Data Collection

The groundwater assessment will use a structured, quantitative, multi-component primary data-collection approach combining **Key Informant Interviews (KIIs) and Household Interviews (HHIs)**, supported by **physical well assessments and water-quality testing**. Data will be collected using structured digital tools programmed on the Kobo Collect platform. General enumerators will conduct the KIIs and HHIs, while trained technical teams/enumerators will undertake well measurements, field water-quality testing, and laboratory sample collection.

3.5 Component 2: Province-wide KII Groundwater Screening

Approximately 2,521 structured Key Informant Interviews will be conducted across around 2,521 sampled rural settlements in Balkh, Jawzjan, Faryab and Samangan provinces (total of 53 districts). The KII will serve as a settlement-level screening exercise and will collect indicative information on domestic and agricultural water sources, irrigation water demand, approximate well numbers and types, water-extraction and pumping infrastructure, well functionality and seasonality, reported water-related challenges, reported changes over approximately five years, perceived water-quality concerns, ownership, operation, maintenance, access and water-management arrangements.

The total KII target of approximately 2,521 interviews will be allocated across the target districts using a coverage plan informed by the number of rural settlements in each district and the district-level accessibility classification. Districts assessed as fully/partially accessible for the planned data-collection period are included (42 fully accessible districts and 12 partially accessible districts, based on the accessibility list), while districts assessed as inaccessible will be excluded and documented. The number of KIIs assigned to each included district will be determined primarily by the district's

number of rural settlements, subject to the overall sample target. Within each included district, settlements will be randomly selected using R script. The selection process will also seek adequate geographic dispersion across the eligible settlement frame and avoid unnecessary concentration of selected settlements in a limited part of the district. The final district coverage, district-level allocations and random settlement-selection table will be documented before fieldwork.

One knowledgeable informant from the following key people will be interviewed separately in each settlement:

Priority	Informant profile	Preferred respondents
1	Community/governance	Community elder, shura/CDC representative, water committee member
2	Groundwater/agriculture user	Irrigation-well owner, farmer, pump operator
3	Technical/service	Well driller, pump technician, caretaker, WASH technician

Potential key informants will be identified through community representatives, field-team networks and local referral.

The KII component will provide indicative findings for sampled settlements. Reported well numbers will not constitute a complete inventory, and reported changes or quality concerns will not be interpreted as physically measured conditions.

Groundwater Key Informant Interview Sampling

Basis: 1 key informant (KI) per settlement. Therefore, the number of settlements equals the number of KIs.

Province	District	# of KIIs/ District	Province	District	# of KIIs/ District
Balkh	Balkh	101	Faryab	Almar	51
Balkh	Chaharbolak	74	Faryab	Andkhoy	13
Balkh	Chahi	26	Faryab	Bandar	48
Balkh	Charkent	56	Faryab	Bilcheragh	41
Balkh	Chemtal	53	Faryab	Chehel Gazi	50
Balkh	Dawlat Abad	37	Faryab	Dawlat Abad	39
Balkh	Dehdadi	54	Faryab	Ferdows	32
Balkh	Kaldar	19	Faryab	Garziwan	36
Balkh	Kohi-e-Alborz	44	Faryab	Khaibar	40
Balkh	Kushenda	127	Faryab	Khan-e-Char Bagh	25
Balkh	Marmul	19	Faryab	Khawaja Musa	43
Balkh	Nahr-e-Shahi	45	Faryab	Khwaja Sabzposh	56
Balkh	Sholgarah	100	Faryab	Kohistan	35
Balkh	Shortepa	19	Faryab	Maimana	9
Balkh	Zari	130	Faryab	Pashtun Kot	127
Balkh Total		**904**	Faryab	Qaisar	128
Jawzjan	Aqcha	43	Faryab	Qaramqul	30
Jawzjan	Darz Ab	21	Faryab	Qurghan	44
Jawzjan	Fayzabad	27	Faryab	Shirin Tagab	47
Jawzjan	Kham Ab	6	**Faryab Total**		**894**
Jawzjan	Khanaqa	16	Samangan	Aybak	70
Jawzjan	Khwaja Dukoh	20	Samangan	Dara-e-Suf-e-Bala	50
Jawzjan	Mardyan	12	Samangan	Dara-e-Suf-e-Payin	77

Jawzjan	Mingajek	7	Samangan	Feroz Nakhchir	22
Jawzjan	Qarqen	8	Samangan	Hazrat-e-Sultan	61
Jawzjan	Qush Tepa	20	Samangan	Khulm	76
Jawzjan	Sheberghan	91	Samangan	Khuram Wa Sarbagh	55
Jawzjan Total		**271**	Samangan	Ruy-e-Duab	41
			Samangan Total		**452**
Grand Total	**2 521**				

Across the districts, the KII screening will contribute to a province-wide settlement groundwater database and identify locations that may require future assessment, programming or technical follow-up. The detailed sampling frame can be accessed here:

Component 3: Household Survey

Based on Acted's recommendation, the selected locations will be 15 districts across the four target provinces. Further this is determined before fieldwork based on MSNA-reported household reliance on groundwater as the main drinking-water source, accessibility and geographic balance across the four provinces (see Annex 2).

The HHI will use a two-stage stratified cluster sampling methodology based on the population size. REACH divided the total population per settlement by 7 (the average household size in Afghanistan) and then took a population sample of 95% Confidence level with a 6% Margin of Error for each district, and the buffer was set at 5%. Selected districts (total of 15) serving as explicit strata and selected settlements as primary sampling units (clusters). Households within selected settlements will then be randomly or systematically selected using a standardized and auditable field protocol.

The household survey will be designed to produce district-level representative findings at a 95% confidence level and 6% margin of error, approximately 5,090 **HHIs will be conducted across the 15 selected districts** (based the HQ sampling tool- Shiny app). The final sample size, cluster allocation and number of interviews per district will be confirmed through the final sampling design.

The survey will assess the water sources used by households for domestic purposes and, among relevant households, irrigation purposes. It will examine household water-source accessibility, reliability and affordability, including reported interruptions, seasonal shortages, access constraints and perceived water-quality concerns. The survey will also assess household coping strategies and livelihood adjustments during periods of insufficient water. In addition, it will document changes in household water access over approximately five years and, among knowledgeable users of a specific well, reported changes in well performance. The sample will include households relying on **groundwater (for domestic or irrigation use), mixed, and other water sources**.

Sampling strategy

The total population for each settlement is derived from the World Pop Database, and divided by 7 (the average household size in Afghanistan and the standard for the humanitarian community) to estimate the number of households at settlement level.

The household (HH) tool utilised a random **two-stage stratified cluster sampling** method using data from secondary sources. The strata are the **15 districts**, and the settlements as clusters. The two-stage stratified cluster sampling approach is as follows:

- The first stage uses the random stratified cluster sampling of settlements. A minimum of 6 households will be interviewed per settlement (cluster) to qualify for random selection based on the required number of interviews at the district (strata) level.

- The second stage entails the random sampling of households within each settlement that was selected in the first stage.

Once the sampling has been determined, in the field, to ensure randomisation of household selection, enumerators will be provided with the sample size in the settlement (PSU) they are visiting. They will then approach the centre of the village, pick a random direction (by dropping a pen and following the direction it points) and then walk in that direction to the edge of the village, counting the number of houses passed. The number of houses will then be divided by the number of interviews to be completed, with the enumerator approaching every n-number house for data collection. If the household identifies as one of the target respondent in the PSU, the interview will be completed, and the enumerator will carry on to the next n-number house. If the household is not one of the target population groups in the PSU, the enumerator will then return to the original location (village centre) and continue the randomisation process in a new direction determined by the drop of a pen. This will ensure that all households are randomly selected, to produce a representative household analysis for each of the 15 districts. Enumerators will carry a smartphone with the pre-installed Kobo tool, introduce themselves and the purpose of the data collection, and ensure informed consent as well as the majority of age of the respondent.

In addition, the possibility to access female household members will be informed by the accessibility list developed by REACH, which includes the mapping of female access to determine the most inclusive and safest option for reaching female respondents. For the targeted districts, interviews with female respondents will be carried out by female enumerators, following the approach outlined above.

In the targeted districts where the female respondents can not be accessed, female enumerators can conduct interviews remotely only (no in-person access). A male enumerator will visit the target settlement in-person seek consent to provide a phone to an adult, knowledgeable female household member to be interviewed by a female enumerator working from her home. Based on this approach, IMPACT will aim to interview a minimum of 20% female respondents, subject to access and informed consent.

Household survey sampling frame

Province	District	# surveys	# PSUs to assess	# Unique PSUs	Population	Cluster size set (planned)	Effective sample size	% buffer	Confidence level	Error margin
Samangan	Aybak	340	68	39	10507	5	274	0.05	0.95	0.06
Samangan	Feroz Nakhchir	320	64	27	2723	5	258	0.05	0.95	0.06
Balkh	Nahr-e-Shahi	345	69	32	30174	5	278	0.05	0.95	0.06
Balkh	Balkh	345	69	51	23887	5	278	0.05	0.95	0.06
Jawzjan	Sheberghan	345	69	51	17688	5	278	0.05	0.95	0.06
Jawzjan	Khwaja Dukoh	340	68	18	7304	5	274	0.05	0.95	0.06
Jawzjan	Khanaqa	330	66	19	4802	5	266	0.05	0.95	0.06
Jawzjan	Aqcha	340	68	35	8425	5	274	0.05	0.95	0.06
Faryab	Pashtun Kot	345	69	55	26455	5	278	0.05	0.95	0.06
Faryab	Khwaja Sabzposh	345	69	38	13854	5	278	0.05	0.95	0.06
Faryab	Almar	345	69	38	13816	5	278	0.05	0.95	0.06
Faryab	Qaisar	345	69	52	30961	5	278	0.05	0.95	0.06

Faryab	Qaramqul	335	67	32	6135	5	270	0.05	0.95	0.06
Faryab	Qurghan	335	67	40	7020	5	270	0.05	0.95	0.06
Faryab	Khan-e-Char Bagh	335	67	30	6978	5	270	0.05	0.95	0.06
Total		**5090**								

The household survey uses **cluster sampling across 15 district strata**, with sample sizes allocated according to the population of each district. The planned sample includes **80% interviews with men and 20% with women** to support the approved respondent distribution. The sample is designed for a **95% confidence level and a ±6 percentage-point margin of error** at the district level.

3.5 Integrated Physical Well and Water Quality Assessment

Approximately 26 functional or seasonally functional wells wither used for domestic purposes or Irrigation purposes or for both will be purposively selected per district, for a total target of approximately 400 wells across the 15 assessment districts (Detailed sampling frame can be found here. The same wells will undergo physical assessment, groundwater-level measurement and field physicochemical screening where technically feasible. Well selection will ensure variation in domestic/irrigation/mixed use, broad geographic distribution within each district, and borehole/hand-dug type. The sample will not be considered representative of all wells in a district.

Eligibility requirements:

- A fixed and clearly identifiable measuring point, and a safe measuring pathway with no unacceptable risk of trapping the electronic probe or approved manual line among pipes, electrical cables, ropes, joints, or pump components.
- Functionality- to be functional (because groundwater-level and water-quality measurements require an accessible water column)
- Owner or caretaker consent;
- Safe access;
- Borehole or hand-dug well;
- Irrigation, domestic or mixed use;
- Broad geographic distribution within each district

Note: the technical well assessment will be conducted in the same districts as the HHI.

Well assessment

Field physical parameter water quality testing

Field physicochemical screening will be integrated into the physical well-assessment form rather than implemented as a separate data-collection stream.

Portable groundwater level meter and portable multiparameter water quality meter will be used to measure pH, electrical conductivity (EC), total dissolved solids (TDS), temperature and preferably salinity, with automatic temperature compensation and calibration capability.

The field component will provide field physicochemical screening, principally for salinity and irrigation-related concerns. It will not establish microbiological safety, arsenic, nitrate, fluoride or complete drinking-water suitability. The report will not label assessed sources “safe” or “unsafe for drinking” on the basis of field-meter results alone.

The assessment will also record observed contamination and environmental risks near each well.

Equipment specification

Equipment	Minimum specification
Portable groundwater-level meter	At least 200 m cable; 1 cm graduation; audible buzzer and LED; stainless-steel/PVC probe; reel/winch; carrying case.
Portable multiparameter water-quality meter	pH, EC, TDS and temperature; preferably salinity; automatic temperature compensation; calibration function; rugged field design.

3.7 Targeted Laboratory Analysis

Up to 45 groundwater samples will be purposively selected from assessed wells. Geographic distribution across the 15 districts will be considered, but samples will primarily be selected according to field EC, TDS, salinity or pH results, reported crop or soil impacts, source use and contrasting well characteristics. The laboratory component is diagnostic and cannot estimate district-level prevalence of poor-quality groundwater.

Sample selection will consider:

- Elevated field EC, TDS or salinity;
- Unusual field pH;
- Reported crop or soil impacts;
- Reported domestic water-quality concerns;
- Intensive irrigation use;
- High-use domestic or mixed-use sources;
- Upstream vs downstream locations
- Contrasting well types and primary uses;
- Geographic distribution across the assessment districts;

Note: Potential external influences on water quality are already recorded in the integrated well-assessment checklist. Wells affected by visible surface-water entry, return flow, nearby potential pollution sources, or other conditions that could compromise the quality of the groundwater sample will not be recommended for laboratory testing. The reason for exclusion will be documented, and another eligible well without these influences will be considered.

The final parameter package will be agreed with the selected laboratory and technical reviewer (see Annex 3). For irrigation interpretation, the preferred core package is laboratory EC/TDS, pH, sodium, calcium, magnesium, chloride and bicarbonate/alkalinity, supporting calculation of Sodium Adsorption Ratio where feasible. Sulfate, nitrate and boron may be included subject to cost and laboratory capacity.

Daytime Well Monitoring

Wells for full daytime groundwater-level monitoring will be selected from the completed physical Well Assessment sample. Selection will be limited to technically eligible, functional wells that are actively used for irrigation or mixed purposes, operate during the daytime, have a safe and consistent groundwater-level measuring point, and have owner or operator permission. The eligible sample will be stratified by province, district, well characteristics, pumping conditions, and relevant groundwater context. Wells will then be selected transparently, with reserve wells identified for documented replacement where necessary.

Up to three technically eligible wells per district will be selected, for a maximum of 45 wells across the 15 districts. All monitored wells must first be included in the integrated physical well assessment and linked through the same well ID. Preferred wells will have access, secure owner permission, a recordable pumping schedule and relevance to district well/use variation. Reserve wells should be identified in each district, while completing the checklist for a well under the integrated physical well assessment.

Eligibility requirements: A monitored well must have:

- A completed physical well-assessment record and ID;
- Primary use is irrigation or mixed use, unless a domestic well is included for a defined comparison purpose.
- Confirmed owner or caretaker permission (ideally obtained one or two days in advance);
- A functional pump;
- A predictable or observable pumping schedule;
- Accessible.

Among eligible wells, the final selection may consider differences in primary use, well type, pumping intensity and operating context. A reserve well is a technically eligible alternative identified in advance in case the selected well becomes unavailable because of access constraints, withdrawal of consent, or schedule change. Each daytime monitoring well will receive one full daytime monitoring exercise.

Monitoring protocol: The technical team will aim to arrive before pumping begins and obtain duplicate pre-pumping readings. The initial condition will be classified as rested, pre-pumping but not fully rested, recovering or unknown. Measurements will then be recorded during pumping, immediately before and after pump stop and during early recovery, according to the actual pumping schedule.

The activity will describe within-day pumping-related drawdown and early recovery only. It will not estimate actual recharge, transmissivity, sustainable yield, seasonal variation or long-term groundwater decline. The detailed monitoring protocol is presented in Annex 4 of this document.

Activity	Minimum protocol
Daytime baseline	Establish a fixed measuring point; record pump status, time since pumping, nearby pumping and a duplicate rested or pre-pumping level.
Daytime monitoring	Measure during initial pumping, mid-morning, midday and afternoon as relevant to the pumping schedule, then at pump stop, immediately post-pumping and during early recovery where safe and feasible.
Interpretation	Describe short-term variation, drawdown and early recovery; do not infer transmissivity, sustainable yield, annual seasonality or long-term decline.

Primary Data Collection Summary

The province-wide KII screening will be implemented as a standalone settlement-level activity. The household survey, physical well assessment, field physicochemical screening, laboratory analysis and daytime groundwater-level monitoring will be conducted in the same 15 selected districts and will provide complementary household-level and well-level evidence. Findings from these activities may be presented alongside one another where geographic coverage, indicators and reference periods are comparable. However, each dataset will retain its own unit of analysis, sampling approach and level of inference. Household survey findings will be representative at district level, while technical findings will apply only to the purposively assessed wells and tested samples.

The primary data-collection framework is summarized below:

Component	Activity	Coverage	Planned sample	Inference/use

Province wide KIIs	Province-wide KII screening	All 54 districts	Approximately 2,521 settlements; one KII per sampled settlement	Indicative settlement screening and within-district/province variation.
Household survey	Household Interviews	15 selected district strata	Approximately 5,090 HHIs; final number of clusters and households per cluster to be determined through the updated HQ Probability Sampling Tool	Target district-level 95/6
well assessment	Physical assessment and field physicochemical screening	Same 15 districts covered by the household survey	Approximately 26 wells per district, for approximately 400 wells and field screening tests	Purposive characterization of assessed wells including measured groundwater level, field physicochemical parameters and observed environmental risks.
	Targeted laboratory water-quality testing	Selected wells from the physical well-assessment sample across the 15 districts	Up to 45 groundwater samples	Targeted diagnostic evidence concerning selected chemical and irrigation-related water-quality parameters.
	Daytime groundwater-level monitoring	Technically eligible subset of physically assessed wells in the same 15 districts	Up to 45 wells, targeting up to three wells per district	One full daytime exercise per well to understand the well performance and functionality

3.6 Data Processing & Analysis

All data collected through KIIs, HHIs, physical well assessments, and water-quality testing will be reviewed and cleaned on a continuous basis in line with IMPACT Data Cleaning Minimum Standards. Data collected through Kobo will be uploaded daily and reviewed by the Assessment and Data teams. The data will be anonymised where required and checked for completeness, consistency, logical errors, outliers, duplicate records, and other quality issues. Monitoring data will be checked for complete stage records, chronological measurement times, consistent measuring point and units, pump-status consistency, nearby-pumping context, and documented reasons for any missing stage.

For KIIs and HHIs, quality checks will include interview duration, response consistency, skip patterns, outliers, missing data, and open-text responses. Data from physical well assessments will be checked for completeness and consistency across well characteristics, including well type, depth, functionality, water levels, pumping systems, and location. Water-quality data from field testing and laboratory analysis will be reviewed against standard recording formats and linked to the corresponding settlement and district. Sentinel-well monitoring data will be checked for temporal consistency and anomalous observations.

Data quality issues identified during daily checks will be communicated to field teams and supervisors for verification and correction where possible. Any changes or corrections will be documented through a cleaning log to maintain a clear audit trail. At the end of data collection, a final cleaning and standardisation process will be conducted, with the cleaned datasets and cleaning logs processed through reproducible R scripts where applicable.

A Data Analysis Plan (DAP) will guide the analysis of the KII, HHI, well, water-quality, and monitoring datasets. Quantitative data will be analysed in R, taking into account the sampling design, clustering, unequal selection probabilities, non-response, and weighting where applicable. KII data will primarily support province-wide groundwater screening, while HHI data will be used to assess household-level groundwater dependence, access, use, costs, and perceived changes. Physical and water-quality data will be analysed alongside survey findings to triangulate reported and measured conditions.

Key Informant Interviews analysis

Each KII will produce one settlement-level record. Analysis will describe the number and proportion of assessed settlements reporting different groundwater uses, source types, approximate infrastructure, reliability concerns, changes, water-quality concerns and governance arrangements. District and provincial summaries will refer only to assessed settlements and will not be interpreted as statistically representative.

Household survey analysis

The HHI dataset will be analysed using the final survey strata. District-level estimates will be accompanied by appropriate measures of uncertainty, and results will only be reported at disaggregation levels supported by adequate sample sizes. Results will be disaggregated by district, main water-source type, groundwater use, livelihood group, displacement status and respondent gender where sample sizes allow.

Physical well and field physicochemical analysis

Each integrated technical assessment will represent one purposively selected well. Analysis will describe assessed wells by:

- Well type and primary use;
- Ownership and service arrangements;
- Reported total depth;
- Operating and functionality status;
- Pump type, energy source and pumping intensity;
- Measured depth to groundwater and measurement condition;
- Field pH, electrical conductivity, total dissolved solids, temperature and salinity, where available;
- Observed wellhead and environmental risks;
- Reported seasonal reliability and five-year changes.

Measured groundwater levels will always be analysed with the recorded operating condition, including whether the well was rested, pumping, or recovering status.

Laboratory analysis

Laboratory results will be linked to the original physical well record through the unique well ID. Analysis will report the measured parameter values, analytical units, laboratory method where available, sampling conditions and relevant quality-control information. Results may be interpreted against appropriate irrigation or domestic-water guidelines according to the intended use of each assessed source.

Because laboratory samples are purposively selected, results will be treated as targeted diagnostic findings. They will not be aggregated into district-level prevalence estimates or used to classify an entire district's groundwater quality.

Daytime groundwater-level monitoring analysis

Every daytime water-level reading will be stored in long format and linked to the initial well-assessment record. Each observation will include the well ID, date, time, measurement stage, pump status, nearby pumping status, depth below the measuring point and calculated depth below ground.

For each monitored well, the analysis will derive, where data quality permits:

- Accepted pre-pumping baseline;
- Baseline condition and confidence;
- Deepest observed water level;
- Maximum observed drawdown from baseline;
- Observed pumping duration;
- Water level at pump stop;
- Final recorded recovery level;
- Recovery from the deepest observed level;
- Return towards the day's baseline;
- Pump-interruption and nearby-pumping flags;

Each monitored well will be presented as a within-day time series of groundwater depth against time, annotated with pumping status, interruptions and nearby pumping. Cross-well comparisons will remain descriptive and will account for differences in well type, pump characteristics, primary use, baseline status and observation duration.

Comparison across components

The KII, HHI and technical datasets will not be merged into a single statistical indicator. HHI and technical findings may be presented alongside one another because they cover the same selected districts, but their different units of analysis and inference will remain explicit.
Comparison across components will only be undertaken where indicators, geographic coverage and reference periods are sufficiently aligned. A household perception or settlement-level report will not be treated as validated by a technical observation unless both records refer to the same source and measure a comparable condition.

3.7 Limitations

- **Remote-sensing and GIS limitations:** The surface-condition recharge-favorability index is a relative screening model based on selected environmental and terrain indicators. It does not measure actual groundwater recharge or the downward flux of water into the saturated zone. It also does not delineate aquifers or groundwater-flow boundaries and cannot directly determine groundwater availability, storage, depth, yield, quality, sustainable abstraction or suitability for borehole drilling. Areas classified as highly favorable indicate that the selected surface and near-surface conditions are comparatively more supportive of potential infiltration under the model assumptions. They do not necessarily contain productive, shallow or good-quality groundwater..
- **KII and settlement-screening limitations:** The KII component is designed as an indicative settlement-level screening exercise. One knowledgeable informant will be interviewed in each sampled settlement, and the respondent may not have complete information on every groundwater source, user or management arrangement in the settlement. Reported well numbers will be approximate and will not constitute a verified well inventory. Reported changes in groundwater levels, well production, reliability and water quality will reflect the informant's knowledge and perceptions rather than measured historical trends. Reported explanations for changes will not establish causality. KII findings will apply to assessed settlements only. District- and province-level summaries may describe patterns among assessed settlements, but they will not be treated as statistically representative estimates for all settlements in those areas.

- **Well-measurement and monitoring limitations:** Groundwater levels and field physicochemical parameters will generally be measured once at the assessed wells, providing a snapshot of conditions at the time of assessment. Individual water-level measurements may be affected by recent or ongoing pumping, nearby abstraction, well construction and the timing of the visit. The full daytime monitoring exercise will capture short-term pumping-related drawdown and early recovery only. It will not provide evidence of monthly, seasonal or long-term groundwater trends.

- **Water-quality limitations:** Field measurements of pH, electrical conductivity, total dissolved solids, temperature and salinity, where available, will provide physicochemical screening rather than a comprehensive assessment of water quality. These parameters cannot establish microbiological safety or certify groundwater as safe for drinking. The limited number of purposively selected laboratory samples will provide targeted diagnostic evidence and will not support district-level estimates of the prevalence of water-quality problems.
- **Female respondent access:** Access to adult female household members may vary across districts. Before data collection, the REACH Regional Field Manager, in consultation with Acted security and field teams, will prepare an accessibility list identifying where in-person interviews with female respondents are feasible and where safe remote interviewing may be possible. REACH will aim for at least 20% female respondents across the HHIs, subject to access, privacy, informed consent and respondent safety. The achieved proportion and any resulting limitations will be reported transparently.

4 Key ethical considerations and related risks

The proposed research design meets / does not meet the following criteria:

The proposed research design…	*Yes/ No*	*Details if no (including mitigation)*
… Has been coordinated with relevant stakeholders to **avoid unnecessary duplication** of data collection efforts?	Yes	
… **Respects respondents, their rights and dignity** (*specifically by: seeking informed consent, designing length of survey/ discussion while being considerate of participants' time, ensuring accurate reporting of information provided*)?	Yes	
… Does not **expose data collectors to any risks as a direct result** of participation in data collection?	Yes	
… Does not **expose respondents / their communities to any risks as a direct result** of participation in data collection?	Yes	
… Does not involve **collecting information on specific topics which may be stressful and/ or re-traumatising** for research participants (both respondents and data collectors)?	Yes	
… Does not involve **data collection with minors** i.e. anyone less than 18 years old?	Yes	
… Does not involve **data collection with other vulnerable groups** e.g. persons with disabilities, victims/ survivors of protection incidents, etc.?	Yes	

… Follows IMPACT SOPs for management of **personally identifiable information**?	Yes	

5 Roles and responsibilities

Task Description	Responsible	Accountable	Consulted	Informed
Research design	*Researcher*	*Senior researcher*	*Associate Research Manager (ARM), GIS Manager*	*Country Coordinator*
Supervising data collection	Senior Field Officer	*Senior researcher*	ARM	CC
Data processing (checking, cleaning)	DBO	Researcher/ *Senior researcher*	ARM	CC
Data analysis	DBO	Data Specialist	Senior researcher	ARM
Output production	Researcher	Senior researcher	ARM	CC
Dissemination	Senior Researcher	Senior Researcher	ARM	CC
Monitoring & Evaluation	Associate Research Manager	CC	Impact Research Team	Acted PD Team
Lessons learned	Associate Research Manager	CC	Impact Research Team	Acted PD Team

Responsible: *the person(s) who executes the task*

Accountable: *the person who validates the completion of the task and is accountable of the final output or milestone*

Consulted: *the person(s) who must be consulted when the task is implemented*

Informed: *the person(s) who need to be informed when the task is completed*

6 Data Analysis Plan

Annexes can be accessed by the following links:

Annex1: Structured Key Informant Interview (KII) Tool

Annex 2: Structured Household Interview (HHI) Tool

Annex 3: Well Assessment Checklist

Annex 4: Full Day time Monitoring Exercise Tool

Annex 5: Samplings

7 Monitoring & Evaluation Plan

IMPACT Objective	External M&E Indicator	Internal M&E Indicator	Focal point	Tool	Will indicator be tracked?
Humanitarian stakeholders are accessing IMPACT products	Number of humanitarian organisations accessing IMPACT services/products Number of individuals accessing IMPACT services/products	**# of downloads of x product from Resource Center**	Country request to HQ	User_log	x Yes
		# of downloads of x product from Relief Web	Country request to HQ		□ Yes
		# of downloads of x product from Country level platforms	Country team		□ Yes
		# of page clicks on x product from REACH global newsletter	Country request to HQ		□ Yes
		# of page clicks on x product from country newsletter, sendingBlue, bit.ly	Country team		□ Yes
		# of visits to x webmap/x dashboard	Country request to HQ		□ Yes
IMPACT activities contribute to better program implementation and coordination of the humanitarian response	Number of humanitarian organisations utilizing IMPACT services/products	# references in HPC documents (HNO, SRP, Flash appeals, Cluster/sector strategies)	Country team	Reference_log	*[List here relevant HPC-documents to be monitored: E.g. Iraq HNO 2018, Iraq Flash Appeal Mosul, Shelter Cluster strategy]*
		# references in single agency documents			*[List here relevant agency-documents to be monitored: E.g. UNHCR Country Strategy, UNICEF WASH Response Strategy]*
Humanitarian stakeholders are using IMPACT products	Humanitarian actors use IMPACT evidence/products as a basis for decision making, aid planning and delivery	Perceived relevance of IMPACT country-programs	Country team	Usage_Feedback *and* Usage_Survey template	*[Outline here the usage survey to be implemented for this research cycle*
		Perceived usefulness and influence of IMPACT outputs			*E.g. Usage survey to be conducted in November 2017,*
		Recommendations to strengthen IMPACT programs			

	Number of humanitarian documents (HNO, HRP, cluster/agency strategic plans, etc.) directly informed by IMPACT products				*following the release of x outputs, targeting at least 10 partners*
		Perceived capacity of IMPACT staff Perceived quality of outputs/programs Recommendations to strengthen IMPACT programs			*E.g. Usage survey to be conducted at the end of the research cycle related to all outputs, targeting at least 20 partners]*
Humanitarian stakeholders are engaged in IMPACT programs throughout the research cycle	Number and/or percentage of humanitarian organizations directly contributing to IMPACT programs *(providing resources, participating to presentations, etc.)*	# of organisations providing resources (i.e.staff, vehicles, meeting space, budget, etc.) for activity implementation	Country team	Engagement _log	□ Yes
		# of organisations/clusters inputting in research design and joint analysis			□ Yes
		# of organisations/clusters attending briefings on findings;			□ Yes

Annex 1: Remote-Sensing and GIS Methodology

A GIS-based Multi-Criteria Analysis will be used to map relative groundwater recharge favorability across Faryab, Samangan, Jawzjan and Balkh provinces. The model will combine seven environmental factors: lithology, rainfall, slope, proximity to rivers, dry-season vegetation persistence, Hydrological Snow Connectivity, and elevation. The thematic layers will be standardized, weighted according to their expected contribution to groundwater recharge and combined through a Weighted Overlay Analysis. The resulting map will classify the study area into five relative recharge-potential classes: **very high, high, moderate, low and very low**.

Standardized to 10 m Standardized to 10 m Factor	Source/year	Original unit	Resolution	Reclassification rule	Weight (%)	Direction/rationale	Limitation
Lithology	USGS geological data	Geological classes	standardized to 10 m	Alluvium, gravel, conglomerate = C5, limestone-dolomite, sandstone-conglomerate, eolian sand = C4; sandstone-siltstone, loess = C3; clay-siltstone, mixed volcanic-sedimentary = C2; shale, igneous, ultramafic, salt marsh = C1	30	Permeable and porous formations receive higher scores because they generally favour infiltration and groundwater recharge.	Generalized lithological classes may not represent local fractures, weathering or variations in permeability.
Rainfall	CHIRPS: Historical baseline (1981–2020) and recent mean (2021–2025)	Rainfall anomaly (%)	Original: 0.05° (~5 km); standardized to 10 m for raster alignment	C1 = -37.47 to < -31.88 C2 = -31.88 to < -26.29 C3 = -26.29 to < -20.70 C4 = -20.70 to < -15.11 C5 = -15.11 to -9.52	20	The 2021–2025 rainfall percentage anomaly was calculated against the 1981–2020 CHIRPS historical baseline and reclassified into five equal-interval classes. Areas with stronger rainfall deficits received lower scores because reduced rainfall limits potential groundwater recharge. C1 represents the	Rainfall anomaly does not directly represent actual groundwater recharge and should be interpreted with other factors.

						strongest deficit, while C5 represents the least deficit.
Slope	DEM from ALOS PALSAR High-Resolution RTC package, ASF Data Search	Degrees	output pixel spacing 12.5 m	0–5° = C5, 5–15° = C4, 15–30° = C3, 30–45° = C2, >45° = C1	15	Slope controls the movement and residence time of surface water. Gentle slopes allow water to remain longer and increase infiltration opportunities, whereas steep slopes accelerate runoff and reduce potential groundwater recharge.
River proximity	REACH data	Distance in Kilometers	Standardized to 10 m	0–2 km = C5; 2–5 km = C4; 5–15 km = C3; 15–30 km = C2; 30–50 km = C1	15	Areas closer to rivers may have greater recharge opportunity, particularly in permeable alluvial valleys
Dry-season NDVI	Sentinel-2 (2025)	NDVI/classes	10 m	Green vegetation = C5; non-green areas = C1	10	Dry-season NDVI was selected for July, August and September because vegetation persisting during these three dry months is more likely to reflect sustained moisture conditions, when rainfall is limited and reliance on groundwater is generally higher.
Elevation	ALOS PALSAR DEM	Meter	12.5 m	202–630 m =C5; 630–1290 m = C4; 1290–2060 m = C3; 2060–2,830 m = C2; 2,830–4,220 m = C1	5	Elevation was selected because it influences terrain position, recharge conditions, land accessibility and settlement distribution. Intermediate-elevation valleys

						and plains containing more settlements and usable land received higher scores, while high mountainous areas and very low, dry, sandy and sparsely inhabited plains received lower scores.	
Hydrological Snow Connectivity	MODIS (2000 – 2025)	Mean upstream snow persistence (%)	Original: 500 m; standardized to 10 m	0–4 = C1; 4–10 = C2; 10–17 = C3; 17–25 = C4; 25–41.6 = C5	5	Higher Mean Upstream Snow Persistence (MUSP) values received higher scores because they indicate greater snow persistence within the hydrologically connected upstream contributing area.	MUSP indicates potential upstream snow influence but does not directly measure actual snowmelt contribution to groundwater recharge.

Weighted Overlay Analysis: Each factor will be reclassified on the common five-class scale, where **C5 represents the most favourable conditions** and **C1 represents the least favourable conditions** for recharge under the model.
The groundwater recharge- favorability index will be calculated as:

- **Surface-Condition Groundwater Recharge-Favorability Index =** $\sum_{i=1}^{n}(ic \times iw)$
  w_i = Relative weight assigned to factor i;
- **c_i = Reclassified favorability score assigned to factor i;**
- **i = Individual factor included in the analysis; and**
- **n = Total number of factors included in the analysis.**

The final index will be grouped into very high, high, moderate, low and very low relative recharge- favorability classes. The index is dimensionless and comparative. It does not represent a recharge rate, recharge depth or recharge volume.

Note: The final GIS map and findings will be presented in a separate document and are not reproduced in this ToR.

Limitation: The terrain layers have 12.5 m output pixel spacing, while the reference processing grid is 10 m. This difference may introduce minor cell-alignment or interpolation effects during overlay. More importantly, the effective spatial detail of the final index is constrained by the coarser source datasets. The output should therefore be interpreted at broad spatial scales.

The GIS analysis will not attempt to delineate aquifers, hydrozones or groundwater-flow boundaries. The recharge- favorability map will be used only as a understanding the context and relative screening. It will not be interpreted as direct evidence of groundwater availability, depth, yield, quality, sustainable abstraction or suitability of a specific site for borehole drilling.

Annex 2: District Prioritisation and Accessiblity Table

Please click here

Annex 3: Laboratory Water Qulity Test Checklist

WATER QUALITY ANALYSIS CHECKLIST AND REPORT					
Well ID		**Sample ID**		**Source**	
Province / District		**Village / Site**		**Sampling date & time**	
Latitude / Longitude		**Sampled by**		**Lab / Analysis No.**	

1. PHYSICAL PARAMETERS									
No.	**Parameter**	**Symbol / form**	**Result**	**Unit**	**Priority**	**WHO ref.**	**ANSA ref.**	**Status**	**Comments / method**
1	Electrical Conductivity (EC)	EC		µS/cm	**Required**	≤1500	≤3000		
2	Total Dissolved Solids (TDS)	TDS		mg/L	**Required**	≤1000	≤2000		
3	Turbidity	-		NTU	**Required**	≤5	≤5		<1 NTU for effective chlorination
4	pH	pH		units	**Required**	6.5–8.0	6.5–8.5		
5	Temperature	T		°C	**Required**	-	-		
6	Salinity	-		%	Required				
7	Oxidation-Reduction Potential	ORP		mV	Optional	-	-		
2. CHEMICAL PARAMETERS									
No.	**Parameter**	**Symbol / form**	**Result**	**Unit**	**Priority**	**WHO ref.**	**ANSA ref.**	**Status**	**Comments / method**
2A. ALKALINITY AND ANIONS									
1	Chloride	Cl^-		mg/L	**Required**	≤250	≤250		Taste
2	Sulphate	SO_4^{2-}		mg/L	**Required**	≤250	≤250		Taste
3	Fluoride	F^-		mg/L	**Required**	≤1.5	≤1.5		
4	Nitrate	NO_3^-		mg/L	**Required**	≤50	≤50		
5	Nitrite	NO_2^-		mg/L	**Required**	0.2–3	≤3		Confirm applicable limit
6	Total Alkalinity	as $CaCO_3$		mg/L	**Risk-based**	-	-		
7	Boron	B		mg/L	**Risk-based**	≤2.4	≤2.4		
8	Alkalinity P	as $CaCO_3$		mg/L	Optional	-	-		
9	Alkalinity M	as $CaCO_3$		mg/L	Optional	-	-		
10	Bicarbonate	HCO_3^-		mg/L	Optional	-	-		
11	Carbonate	CO_3^{2-}		mg/L	Optional	-	-		
12	Hydroxide	OH^-		mg/L	Optional	-	-		
13	Sulphite	SO_3^{2-}		mg/L	Optional	-	-		
14	Sulphide	S^{2-}		mg/L	Optional	-	-		
15	Phosphate	PO_4^{3-}		mg/L	Optional	-	-		
16	Bromide	Br^-		mg/L	Optional	-	-		
2B. CATIONS, HARDNESS AND METALS									
1	Total Hardness	as $CaCO_3$		mg/L	**Required**	≤300	≤500		Taste / incrustation
2	Manganese	Mn^{2+}		mg/L	**Required**	≤0.4	-		Taste / staining
3	Total Iron	Fe^{2+}/Fe^{3+}		mg/L	**Required**	≤0.3	≤0.3		Taste / odour
4	Total Arsenic	As^{3+}/As^{5+}		mg/L	**Required**	≤0.01	≤0.05		
5	Sodium	Na^+		mg/L	**Risk-based**	≤200	≤200		
6	Chromium, dissolved	Cr^{6+}		mg/L	**Risk-based**	≤0.05	≤0.05		Industrial/geological risk
7	Ammonium	NH_4^+		mg/L	**Risk-based**	Verify	-		Odour / taste indicator
8	Copper, total	Cu		mg/L	**Risk-based**	≤2	≤2		

9	Calcium Hardness	as $CaCO_3$		mg/L	Optional	-	-		
10	Potassium	K^+		mg/L	Optional	-	≤10		
11	Calcium	Ca^{2+}		mg/L	Optional	-	-		
12	Magnesium	Mg^{2+}		mg/L	Optional	-	-		
13	Aluminium, total	Al		mg/L	Optional	-	≤0.2		
2C. OTHER CHEMICAL COMPONENTS									
1	Residual free Chlorine	Cl_2		mg/L	**Required**	0.2–0.5	0.2–0.5		Required where water is chlorinated
2	Hydrogen Sulphide	H_2S		mg/L	**Risk-based**	≤0.100	-		Test if a rotten-egg odour is reported
3	Silica	SiO_2		mg/L	Optional	-	-		
3. BIOLOGICAL PARAMETERS									
No.	**Parameter**	**Symbol / form**	**Result**	**Unit**	**Priority**	**WHO ref.**	**ANSA ref.**	**Status**	**Comments / method**
1	Total Coliforms	-		CFU/100 mL	**Required**	0	-		24 h at 37°C
2	Faecal Coliforms (E. coli)	E. coli		CFU/100 mL	**Required**	0	0		24 h at 44°C
3	H_2S determination	H_2S		Y/N	**Risk-based**	N	-		Rapid field screening
COMMENTS / RECOMMENDATIONS / CORRECTIVE ACTIONS									
Overall assessment				**Reviewed by**			**Approved by**		
Priority key: Required = routine core parameter; Risk-based = test where source, geology, land use or sanitary inspection indicates risk; Optional = detailed hydrochemical characterization.									