FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

MINISTRY OF WATER AND ENERGY

Terms of Reference

for

Consultancy Service for Integration of Groundwater Monitoring System with Existing Web-Based Information System

January 2024

Addis Ababa

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Acronyms and Abbreviations

API	–	Application Programming Interface
BDA	–	Basins Development Authority
CSA	–	Central Statistical Authority
CSS	–	Cascading Style Sheets
GSE	–	Geological Survey of Ethiopia
GSM	–	Global System for Mobile Communication
GW	–	Groundwater
HoA-GW4R	–	Horn of Africa Groundwater for Resilient
HTML	–	Hypertext Markup Language
IDE	–	Integrated Development Environments
ICT	–	Information and Communication Technology
IGAD	–	Intergovernmental Authority on Development
MoWE	–	Ministry of Water and Energy
PMCU	–	Project Management and Coordination Unit
ToR	–	Terms of Reference
UI	–	User Interface
UX	–	User Experience
UNICEF	–	United Nations Children's Fund
WPDx	–	Water Point Data Exchange

1. BACKGROUND

Groundwater resources are vital for drinking water supply, irrigation and the sustainability of rivers, lakes, and wetlands. However, increased demand, population growth and climate change are increasingly putting pressure on our groundwater resources. Lack of and inappropriate management has already led to contamination and overexploitation of aquifers in some areas and could result in additional water supply problems, land subsidence and deterioration of groundwater dependent ecosystems. Monitoring our groundwater resources is crucial for assessment, prediction and sound groundwater management. There is however, still a lack of groundwater information availability and resistance to share groundwater data. Lack of information, along with the transboundary nature of many of the aquifers, complicates sustainable water management at the national levels.

In 2021 and 2022, the Ministry of Water and Energy (MoWE) has carried out a hydrogeological mapping project in 53 woredas (BDA/ICB/GW01/2021). During this project a detailed assessment and review of the status and configuration of the existing Ethiopian national groundwater database system was carried out, and a web-based platform has been established taking lessons learnt from previous attempts into account. Data from publicly available sources (CSA, GSE, UNICEF, WPDx) have been migrated to the database. Although the database holds many data points already (about 50,000), a lot of data still need to be validated and entered, and the groundwater database is integrated with the national database.

Currently, the database can store information on wells, springs, well construction, well logs, geophysics (VES), pumping tests, water quality and time series on water quality, water level or discharge. The software may need to be upgraded to support the proposed monitoring hardware configuration, tailor made validation protocols or user interface improvements. Ministry of Water and Energy has expressed the need to have a telemetric groundwater monitoring network operational. Telemetric data loggers typically transmit the measurements over the GSM network to either the server of the supplier, or a dedicated internet address provided by the client. The current database system supports many different hardware suppliers and formats and can process data from any source (both supplier and client). Time series can be generated real-time.

In order to improve climate resilience in vulnerable areas, the Horn of Africa Groundwater for Resilience (HoA-GW4R) program seeks to expand sustainable groundwater access and management throughout the Horn of Africa. The program is an important endeavor that was started by Ethiopia, Kenya, and Somalia with funding assistance from the World Bank. With a budget of USD 210 million, the Ethiopia-HoA-GW4R project intends to administer the project, enhance groundwater database and information, and build groundwater infrastructure for inclusive communities. We are looking for potential consulting firms to help us implement some of the components of Component 2, which aims to strengthen groundwater database and

information by implementing the Enhancing Groundwater Monitoring System (Subcomponent 2.b.). These interventions include (i) developing tools that facilitate access to, monitoring of, and use of groundwater information, and (ii) combining, producing, and disseminating groundwater data and information.

With this foundation in place, the Ministry of Water and Energy has begun a subproject funded by the World Bank titled "Develop and Commission Groundwater Tools, Establish Groundwater Monitoring System and Integration with the Existing Web-Based Groundwater Database." In order to ensure the sustainable use and protection of groundwater for both the present and the future generations, this ToR has been produced to act as a guide for the successful execution of this effort. By offering dependable, long-term data sets, this program seeks to enhance knowledge and management of groundwater and facilitate the creation of integrated groundwater management plans at the national level.

The consulting service will entail creating easily navigable groundwater information access tools, creating a thorough program for monitoring groundwater, creating standard data collection protocols, setting up real-time data transmission mechanisms, creating a reliable data management system, and compiling current groundwater data from multiple sources. In-depth reports, bulletins, and publications that summarize groundwater data and offer insights into the state and trends of groundwater resources will also be prepared as part of this project. An existing web-based groundwater database can greatly enhance its data gathering, analysis, and visualization capabilities by developing and commissioning specialized groundwater monitoring system and mobile interface (application). These are essential instruments for many industries and sectors, including as home water supply, industrial, and agriculture.

2. OBJECTIVES

2.1. General Objectives

The general objective of the assignment is to establish a comprehensive and efficient system for monitoring and managing groundwater resources through integration of groundwater monitoring system with an existing web-based database to improve the sustainable management of groundwater resources of Ethiopia.

2.2. Specific Objectives

The specific objectives of the assignment are to:

- Enhance the existing web-based groundwater information and monitoring system by integrating the newly developed tools seamlessly.
- Design and implement a comprehensive groundwater monitoring plan that covers key aquifers and monitoring wells, ensuring standardized data collection and transmission to a centralized database.
- Develop technical specifications for the groundwater monitoring system and tools.

- Design and develop a user-friendly interface for data collection and analysis.
- Implement a comprehensive data validation and quality control mechanism.
- Establish protocols for data sharing and integration with the existing web-based groundwater database.
- Conduct training sessions and capacity-building programs for MoWE experts involved in data collection, analysis, and reporting.
- Test and commission the developed tools and groundwater monitoring system.
- Develop standard operating procedures for data management, reporting, and maintenance of the groundwater monitoring system.
- Ensure compliance with relevant national and international standards and guidelines.
- Monitor and evaluate the performance of the groundwater monitoring system and tools, and make necessary improvements based on feedback and user requirements.

3. SCOPE OF SERVICES

The scope of the assignment includes, but is not limited to, the following:

- Conduct an assessment of the existing groundwater database and data management practices;
- Identify gaps, challenges, and opportunities of the existing system for improvement in groundwater information access, monitoring, and use;
- Design and develop user-friendly tools for accessing groundwater information,
- Design and develop mobile application for collecting ground water data's and synchronized with the existing database;
- Develop groundwater monitoring document;
- Establish mechanisms for real-time or regular data transmission from monitoring sites to a centralized database;
- Prepare comprehensive reports, bulletins, and publications that synthesize groundwater data and provide insights into the status and trends of groundwater resources; Develop user-friendly information products, such as fact sheets, infographics, and decision-support tools, to communicate groundwater information to different stakeholders;
- Develop training materials and conduct capacity building programs to enhance the understanding and use of groundwater data and information;
- Develop user manuals and training materials for the integrated system, including step-by-step instructions on system usage, data management, and troubleshooting;
- Provide technical assistance and support to strengthen groundwater database, including government agencies responsible for groundwater management;

- Identify capacity building needs and develop training programs to enhance the knowledge and skills of stakeholders involved in groundwater management and information systems;
- Establish a monitoring and evaluation framework to assess the implementation and effectiveness of the interventions; Develop indicators and targets to track progress towards achieving the objectives of enhancing groundwater database and information;
- Test and validate the functionality and performance of the integrated system, including data accuracy, reliability, and response time;
- Conduct training sessions for relevant stakeholders on the installation, operation, maintenance, and utilization of the sensor, logger and telemetry;
- Provide technical support and assistance during the commissioning phase and initial period of system operation;
- Collaborate with the project team and stakeholders to ensure that the developed tools and integrated system meet the required specifications and objectives.

4. EXPECTED OUTCOME

The implementation of the assignment can yield various expected outputs. These outputs are the specific results or outcomes achieved through the implementation process and some of the potential expected outputs include:

- Enhanced Data Collection and Management: Improved capabilities for data collection and management related to groundwater monitoring. This may include standardized data collection protocols, automated data entry processes, and efficient data storage and retrieval mechanisms.
- Integrated Monitoring System: Successful integration of the newly developed groundwater monitoring system with the existing web-based groundwater database. This integration allows for seamless data exchange and provides a unified platform for monitoring and managing groundwater resources.
- Improved Data Visualization and Reporting: Enhanced visualization and reporting functionalities that enable users to analyze and interpret groundwater data more effectively. This may include user-friendly dashboards, interactive graphs, and customized reports that provide insights into groundwater levels, quality, trends, and other relevant parameters.
- Real-time Monitoring Capabilities: Implementation of real-time monitoring capabilities that enable users to access up-to-date groundwater data in near real-time. This allows for better decision-making and timely response to changes in groundwater conditions.
- Enhanced Data Analysis and Modeling: Advanced data analysis and modeling capabilities that support better understanding and characterization of groundwater systems. This may include predictive modeling, trend analysis, and identification of potential risks or vulnerabilities.

- Strengthened Stakeholder Engagement: Increased stakeholder engagement and participation in groundwater monitoring and management efforts. The implementation of the groundwater monitoring promotes collaboration among users, regulators, and policymakers, leading to more informed decision-making and better resource allocation.
- Enhanced System Security and Data Protection: Implementation of robust security measures to safeguard groundwater data and protect the system against unauthorized access or cyber threats. This includes encryption protocols, access controls, and regular system audits.
- Documentation and Knowledge Transfer: Comprehensive documentation of the implemented system, including technical specifications, user manuals, and training materials. This facilitates knowledge transfer and enables system administrators and end-users to effectively utilize and maintain the groundwater monitoring system.

5. METHODOLOGY

The methodology for integration of groundwater monitoring system with existing web-based information system should be designed to enhance the management of groundwater resources. It encompasses various stages including desk review, stakeholder engagement, assessment and gap analysis, needs assessment, tool development, groundwater monitoring system design, data management system establishment, data consolidation, reporting and dissemination, capacity building and training, and monitoring and evaluation. By integrating additional features and functionalities into the existing web-based system, this methodology aims to optimize the overall performance and usability of the groundwater monitoring system and tools. The consulting firm will follow a comprehensive and systematic approach to the methodology applying three phases namely Study Phase, Design Phase and Implementation Phase in order to achieve the objectives of the assignment as detailed below:

5.1. Study Phase

In this phase of the assignment, the consultant has to undertake desk review and gap analysis of existing system, needs assessment and feasibility study of the Groundwater monitoring system and monitoring tools.

5.1.1. Desk Review and Gap Analysis

The consultancy firm will conduct a comprehensive desk review of existing literature, reports, and data related to groundwater database, information systems, and data management practices to provide a baseline understanding of the current state of groundwater information and identify gaps and challenges and determine the areas where the groundwater system can provide improvements and enhancements. Thus, the following information systems, data management practices, and data related to groundwater database are assessed and reviewed:

- Evaluate the methods and tools used for data collection, such as monitoring wells, sensors, or remote sensing technologies, identify any gaps in data collection coverage,

frequency, or quality control measures, lack of standardized data collection protocols, or limited use of advanced technologies for data collection.

- Review the database structure, data storage formats, and metadata standards used for storing groundwater data, identify any gaps in data storage capacity, data organization, or data security measures, lack of data standardization, or insufficient data backup and recovery mechanisms.
- Examine the software applications and tools used for data analysis and processing, evaluate their functionality, ease of use, and compatibility with different data formats and identify the gaps in terms of data processing capabilities, integration with other systems, or the availability of advanced analytical features.
- Analyze the tools and methods used for data visualization and reporting, evaluate the effectiveness of these tools in presenting groundwater data in a user-friendly and informative manner and identify the gaps of data visualization options, customization capabilities, or the ability to generate automated reports.
- Assess the interoperability and integration capabilities of the existing groundwater information systems, identify any gaps of data exchange protocols, compatibility with other systems, or the ability to integrate data from different sources.
- Evaluate the user interface and user experience of the existing systems and pinpoint any gaps in terms of usability, accessibility, or user training needs.
- Assess the security measures in position to protect groundwater data from unauthorized access or data breaches and identify any gaps with data security protocols, data backup procedures, or privacy considerations.
- Evaluate the processes and procedures in place to ensure the quality of groundwater data and identify any gaps related to data validation, quality control measures, or adherence to data standards.
- Analyze the integration of the existing groundwater information systems with other relevant systems, such as hydrological models or decision support tools and find out any gaps in terms of data exchange, compatibility, or the ability to provide seamless integration.

5.1.2. Needs Assessment

The consultant has to conduct need assessment in order to identify the requirements and challenges related to groundwater information and monitoring systems and to ensure that the subsequent phases of the project are aligned with the identified needs and objectives. Thus, the following needs should be considered:

- Assess the data requirements for groundwater monitoring and information management; identify the types of data needed, such as water levels, quality parameters, and geological information; determine the frequency, spatial coverage, and accuracy requirements for data collection.

- Identify the needs and expectations of different stakeholders involved in groundwater management, such as government agencies, water resource managers, researchers, and the public; understand their specific requirements for accessing, analyzing, and visualizing groundwater data.
- Determine the desired functionalities of the groundwater system, such as data collection, storage, analysis, visualization, reporting, and decision support; assess the specific tools and features required to meet the needs of different user groups.
- Evaluate the existing web-based groundwater information and monitoring systems that need to be integrated with the groundwater database; understand the data exchange requirements, interoperability challenges, and integration points between the systems.
- Assess the technical infrastructure required for implementing groundwater monitoring system, including hardware, software, and network requirements; consider factors such as scalability, security, data storage capacity, and computational capabilities.
- Understand the institutional and organizational context in which the monitoring system will be implemented; identify any legal, policy, or governance requirements that need to be considered; assess the capacity and resources available within the organization to support the implementation and operation of the monitoring system.
- Evaluate the existing data management practices and systems in place for groundwater data; assess the data quality, data governance, data sharing, and data security requirements; identify any gaps or challenges in the current data management processes.
- Understand the needs and preferences of the end-users who will interact with the groundwater monitoring system; consider their technical skills, knowledge level, and user experience expectations; identify any specific training or support needs for the users.
- Assess the financial resources required for maintaining the groundwater monitoring system; consider the costs associated with repairing hardware, software, licensing, personnel, training, and ongoing maintenance and support.

5.1.3. Feasibility Study

The feasibility study aims to assess the technical, financial, and operational viability of implementing the groundwater monitoring system, and it helps stakeholders make informed decisions and ensure the successful implementation of the assignment. The consulting firm has to evaluate the following aspects:

- Assess the available technologies and tools that can be utilized to evaluate the groundwater monitoring system compatibility with existing systems, scalability, performance, and ability to meet the identified requirements.
- Evaluate the technical infrastructure required to support the groundwater monitoring system, including hardware, software, and network resources; determine if the existing infrastructure is sufficient or if additional investments are needed.

- Conduct a cost-benefit analysis to determine the financial viability of the groundwater monitoring system; assess the costs associated with development, customization, integration, data migration, training, maintenance, and support; compare these costs with the potential benefits and expected returns on investment.
- Evaluate the availability of internal budgets, external grants, partnerships, or other financial resources required to support the long-term operation of the system.
- Assess the readiness of the organization to implement and manage the groundwater system in terms of availability of skilled personnel, capacity for change management, and willingness to adopt new technologies and processes.
- Evaluate the level of support and engagement from key stakeholders, including government agencies, water resource managers, and end-users; assess their willingness to participate in the project, provide data, and utilize the system for decision-making.
- Evaluate the legal and regulatory requirements related to groundwater management and data sharing; assess if the monitoring system can meet these requirements and ensure compliance with relevant policies and regulations.
- Identify potential risks and challenges associated with the implementation of the groundwater monitoring system; evaluate the probability and impact of each risk on the project's success.
- Develop risk mitigation strategies to address identified risks and minimize their potential negative impacts.
- Develop a realistic project schedule and timeline for the implementation of the groundwater monitoring system taking into consideration the complexity of the project, resource availability, and potential dependencies on other ongoing initiatives.

5.1.4. Study Phase Report Preparation

The consultant has to prepare and submit Study Phase Report that comprises of the desk review and gap analysis, needs assessment and feasibility study of the project. Thus, the study report shall include but not limited to the following:

- the existing groundwater information systems with other relevant systems,
- the methods and tools used for existing data collection.
- the existing database system, software applications, tools and methods used for data visualization and reporting,
- the interoperability and integration capabilities of the existing groundwater information systems.
- the user interface and user experience of the existing systems, mechanisms in place for data accessibility and sharing.
- the processes and procedures in place to ensure the quality of groundwater data and identify any gaps related to data validation, quality control measures, or adherence to data standards.

- the requirements and challenges related to groundwater information and monitoring systems
- the technical, financial, and operational viability of implementing the groundwater information system.

5.1.5. Validation Workshop of the Study Phase

Present findings of the study at a validation Workshop-1 in one of the cities or at Addis Ababa as appropriate in at least 3-star hotel. The cost of the Workshop (hall rent for 50 participants, refreshment and lunch) shall be covered by the PMCU.

Final report of the Study Phase shall be submitted after incorporating comments from the client, including updated model if any comments were given during study phase.

5.2. Design Phase

In the Design phase of the assignment, it is important that the consultant focuses on the technical aspects of the project. The following factors should be included in this phase:

- Describe the proposed system architecture and design for the groundwater monitoring system which includes outlining the overall structure, components, and modules of the system; and specify the technologies, frameworks, and programming languages to be used.
- Define the data model for the groundwater monitoring system, including the entities, attributes, and relationships necessary to store and manage groundwater data;
- Described proposed system architecture for the integrations of groundwater monitoring system with the existing groundwater database.
- Outline the design principles and guidelines for the user interface of the monitoring system; describe the intended user experience and consider usability, accessibility, and responsiveness including wireframes or mockups to visualize the proposed user interface.
- Specify the functional requirements of the groundwater monitoring system, detailing the features and functionalities that the system should provide which may include data collection, data storage, data analysis, data visualization, reporting, and integration capabilities.
- Identify the technical requirements for the groundwater monitoring system, such as hardware specifications, software dependencies, and compatibility with existing systems and consider scalability, performance, security, and data privacy requirements.
- Define the strategy for integrating the monitoring system with existing web-based groundwater information; specify the data exchange protocols, APIs, or other mechanisms to facilitate seamless integration.
- Outline the testing approach for the groundwater monitoring system, including unit testing, integration testing, and user acceptance testing; define the criteria for system

acceptance and specify the quality assurance measures to ensure the reliability, accuracy, and consistency of the system.

- Describe the documentation requirements for the groundwater monitoring system including the integration with the existing groundwater database, including user manuals, technical specifications, and system documentation; specify the training needs for users and administrators to effectively use and maintain the system.
- Describe the project management approach, including roles and responsibilities, communication channels, and reporting mechanisms; define the governance structure and decision-making processes to ensure effective project oversight.
- Identify potential risks and challenges related to the design and implementation of the groundwater monitoring system and develop strategies to mitigate these risks and ensure that contingency plans are in place.

5.2.1. Specifications of Tools

The consultant should identify appropriate tools for the Integration of Groundwater Monitoring System with Existing Web-Based Information System , and the following key specifications should be included on:

- Hardware requirements: Specify the minimum and recommended hardware specifications for servers, storage devices, networking equipment, and any other hardware components needed for the system.
- Software requirements: Specify the operating system, database management system, web server, and any other software dependencies required for the system.
- Development tools: Specify the programming languages, frameworks, and integrated development environments (IDEs) that should be used for developing the monitoring system.
- Testing tools: Specify the testing tools and frameworks that should be used for quality assurance and testing activities, such as test management tools, test automation tools, and performance testing tools.
- Documentation tools: Specify the tools and platforms that should be used for creating and managing documentation, such as Microsoft Word, Confluence, or SharePoint.
- Groundwater monitoring tools: Sensor, Data logger, Transmitter, Antenna, Power supply and Shelter

5.2.2. Bill of Quantities

Further, the consultant has to provide a detailed bill of quantities that includes the quantities and specifications of all the required equipment, materials and software as follows and ensure that the bill of quantities is comprehensive and accurately reflects the scope of the project:

- Hardware costs: Provide a detailed breakdown of the costs associated with purchasing or upgrading hardware components, including servers, storage devices, networking

equipment, and any other required hardware, Sensor, Data logger, Transmitter, Antenna, Power supply and Shelter

- Software costs: Provide a breakdown of the costs associated with purchasing or licensing software, including operating systems, database management systems, web servers, and any other required software.
- Development costs: Provide an estimate of the costs associated with software development, including the development team's salaries, consulting fees, and any other development-related expenses.
- Testing costs: Provide an estimate of the costs associated with quality assurance and testing activities, including testing tools, test environments, and any external testing services.
- Documentation costs: Provide an estimate of the costs associated with creating and managing documentation, including the documentation specialist's salary or fees, documentation tools, and any external documentation services.

5.2.3. Design Phase Report Preparation

The consultant has to prepare and submit Design Phase Report that focuses on technical aspects of the project. Thus, the design report shall include but not limited to the following:

- The proposed system architecture and design for the groundwater monitoring system and integrating with the existing groundwater database.
- The database management system of groundwater monitoring system.
- The design principles and guidelines for the user interface of the groundwater monitoring system.
- The functional and technical requirements of the groundwater monitoring system, the features and functionalities that the system should provide, hardware specifications, software dependencies, and compatibility with existing systems.
- The strategy for integrating the groundwater monitoring system with existing web-based groundwater database.
- The testing approach for the groundwater monitoring system,
- The documentation requirements for the groundwater monitoring system.
- The project management approaches, including roles and responsibilities, communication channels, and reporting mechanisms.
- Potential risks and challenges related to the design and implementation of the monitoring system, strategies to mitigate these risks.
- Detailed specifications of tools and bill of quantities.

5.2.4. Validation Workshop of the Design Phase

Present findings of the design at a validation Workshop-2 in one of the cities or at Addis Ababa as appropriate in at least 3-star hotel. The cost of the Workshop (hall rent for 50 participants, refreshment and lunch) shall be covered by the PMCU.

Final report of the Design Phase shall be submitted after incorporating comments from the client, including updated model if any comments were given during the design phase.

5.3. Implementation and Installation Phase

In the Implementation phase of the assignment, the consultant needs to focus on executing the planned activities and tasks by providing a clear roadmap for executing the activities required to implement the developing groundwater monitoring system and integrate it with existing web-based groundwater database. This phase of the project is when the actual construction, coding, and programming will be implemented.

5.3.1. Monitoring System Installation and Integration

The consultant should deal with this phase of the project for effective and efficient use of the system as follows:

- Describe the use strategy for the groundwater monitoring system, including hardware setup, software installation, and system configuration. Specify the technical requirements for the use of the system and outline the steps to ensure a smooth implementing process.
- Focus on implementing the server-side logic and functionality of the monitoring system which includes writing the code to handle data processing, analysis algorithms, database interactions and any other backend requirements ensuring that the code is modular, well-structured, and follows best practices for maintainability and scalability.
- The development team of the consultant should build the software components of the groundwater monitoring system based on the design specifications to create the necessary modules, functions, and features required for data collection, analysis, visualization, and reporting.
- Work on the client-side or front-end development of the groundwater monitoring system which involves creating the user interface (UI) components using technologies like HTML, CSS, and JavaScript making sure that the UI is intuitive, responsive, and aligned with the design specifications provided; consideration should be given to accessibility and usability principles to create a user-friendly experience.
- Develop a user-friendly and intuitive experience including creating screens, forms, menus, and navigation elements that allow users to interact with the system easily.
- Establish the necessary connections, interfaces for seamless data exchange if there is a need to integrate the groundwater monitoring system with existing web-based groundwater database working closely with the team responsible for the existing system

to understand and data formats ensuring that the integration is robust, reliable, and adheres to any security or authentication requirements.

- Detail the steps and processes involved in integrating the groundwater monitoring system with the existing web-based groundwater database which may include data mapping, data transformation, and establishing data exchange protocols.
- Prioritize security during the development of the groundwater monitoring system and implement appropriate security measures, such as access controls, user authentication, data encryption, and secure communication protocols following best practices for secure coding and ensure that potential vulnerabilities are addressed to protect the system and the sensitive groundwater data it handles.
- Conduct thorough testing and quality assurance procedures throughout the development phase including unit testing, integration testing, and system testing to verify the functionality, performance, and reliability of the system address any identified issues or bugs promptly and ensure that the system meets the specified requirements.
- Maintain open and effective communication with the project team, stakeholders, and any other involved parties actively engaging them in discussions, provide regular progress updates, seek clarification on design specifications when needed, and address any concerns or feedback promptly.

5.3.2. Testing and Validation

The following testing and validation activities should be done, and the consultant should provide regular progress reports and a final testing and validation report summarizing the findings and recommendations from the testing and validation activities:

- Comprehensive testing of the groundwater monitoring system to ensure that all system components are functioning correctly (functional testing, performance testing, security testing, and usability testing).
- Integration testing to ensure that the monitoring system is seamlessly integrated with the existing web-based groundwater database (testing data transfer, data synchronization, and interoperability between the systems).
- Involve end-users in the testing process to ensure that the system meets their requirements and expectations.
- Validate the accuracy and integrity of the data being collected and stored in the groundwater database (comparing the data with known sources, conducting data consistency checks, and verifying data quality against predefined criteria).
- Test the performance of the monitoring system to ensure that it can handle the expected workload and provide timely responses (stress testing, load testing, and scalability testing to assess the system's performance under different scenarios).
- Security testing to identify vulnerabilities and ensure the protection of sensitive data.

- Review the documentation related to the existing groundwater database, including system requirements, design documents, and test plans.

5.3.3. Customized Reports and Dashboards

A customized report in a groundwater monitoring system is a document generated from the system that presents specific data, analysis, and insights tailored to the needs of the user or stakeholder which allows users to generate reports with selected parameters, data ranges, and formatting options to meet their specific requirements; while a customized dashboard is a visual interface that allows users to personalize their view of the data by selecting and arranging specific charts, graphs, maps, and other visual elements. Users can customize the dashboard to display the data and metrics that are most relevant to their needs and preferences.

The consultant should consider the following steps to include customized reports and dashboards in assignment:

- Conduct a thorough needs assessment to understand the specific reporting and visualization requirements of the user.
- Ensure that the necessary data from the groundwater monitoring system is integrated into the existing web-based groundwater database.
- Design and develop report templates and dashboard layouts that meet users' specific requirements.
- Provide users with the ability to select specific parameters, data ranges, and formatting options for their reports and dashboards.
- Develop tools and algorithms that allow users to perform data analysis and generate visualizations within the reports and dashboards (statistical analysis, trend analysis, and the ability to create charts, graphs, maps, and other visual elements).
- Enable users to customize the layout and arrangement of visual elements in their dashboards.
- Provide users with the ability to generate reports in various formats, such as PDF, Excel, or CSV.

5.3.4. Monitoring and Evaluation

The consultant should facilitate regular monitoring and evaluation with the client following a collaborative approach during the implementation period of the project and here are the steps the consultant can take:

- Jointly develop a detailed plan outlining the monitoring and evaluation activities, including the objectives, indicators, methodologies, and timelines.
- Provide regular progress reports to the client, highlighting the status of the implementation, key milestones achieved, and any challenges or issues encountered.

- Actively engage with system users and stakeholders to gather their feedback on the groundwater monitoring system through surveys, interviews, focus group discussions, or workshops.
- Work with the client to establish data quality assurance processes for the monitoring system involving regular data validation checks, data verification against known sources, and data consistency assessments.
- Assess the impact of the monitoring system on groundwater management and decision-making processes through quantitative and qualitative analysis.
- Regularly monitor the performance of the system, including system response times, data accuracy, and system uptime.
- Document and regularly report all monitoring and evaluation activities, including methodologies, findings, and recommendations.

5.3.5. Implementation Phase Report Preparation

The consultant has to prepare and submit Implementation Phase Report that emphasizes on executing the planned activities and tasks to implement the groundwater monitoring system and integrate it with existing web-based groundwater database. Thus, the implementation report shall include but not limited to the following:

- The deployment strategy for the groundwater monitoring system (hardware setup, software installation, and system configuration with the technical requirements for the deployment environment.
- The code to handle data processing, analysis algorithms, database interactions.
- The client-side or front-end development of the groundwater monitoring system.
- Interfaces for seamless data exchange with existing web-based groundwater database.
- Review of the design specifications.
- Security measures, such as access controls, user authentication, data encryption, and secure communication protocols.
- System testing of the functionality, performance, and reliability of the groundwater monitoring system.
- The development process, code structure, system architecture, and any other relevant technical details.

5.3.6. Validation Workshop of the Implementation Phase

Present findings of the implementation at a validation Workshop-3 in one of the cities or at Addis Ababa as appropriate in at least 3-star hotel. The cost of the Workshop (hall rent for 50 participants, refreshment and lunch) shall be covered by the PMCU.

Final report of the Implementation Phase shall be submitted after incorporating comments from the client, including updated model if any comments were given during the implementation phase.

5.4. Capacity Building Training Workshop

Twenty (20) days capacity building training workshop shall be prepared by the consultant for 20-participants from relevant stakeholders (including the MoWE experts) on but not limited to system design, functionalities, technical aspect, data analysis and interpretation, system usage and maintenance.

The consultant will provide all material and software for the training and it has to provide capacity building trainings on the following subjects:

System Training

- Provide training on the overall architecture and design of the system and the integration process with the existing web-based groundwater database and the training should cover the technical aspects of the system, including data management, user interface, and system integration.
- Provide training on data collection, validation, storage, and retrieval processes within the developed system.
- Provide training on system monitoring, troubleshooting, and maintenance tasks, including backups, updates, and troubleshooting to ensure the smooth operation of the monitoring system.
- Provide training on the integration of the groundwater monitoring instruments with the existing groundwater database.
- Provide training on system testing methodologies and quality assurance practices including training on test planning, test execution, bug tracking, and overall system quality assurance processes.

Technical Training

- Provide training on the specific software development tools and technologies used in the implementation of the groundwater monitoring system including programming languages and frameworks used in the development of the system, ensuring that the development team has the necessary skills to maintain and enhance the system.

Data Analysis and Interpretation Training – focusing on:

- Techniques and tools for analyzing groundwater data, including statistical analysis, trend analysis, and spatial analysis.
- Groundwater modeling techniques and tools to interpret and predict groundwater behavior using the developed system outputs.
- Provide training on the real time groundwater data analysis.
- Data management and analysis techniques specific to groundwater monitoring systems including training on data collection, data validation, data visualization, and data analysis techniques.

Stakeholder Engagement and System Usage Training - focusing on:

- Effective stakeholder engagement strategies to ensure that stakeholders understand the purpose, benefits, and usage of the system.
- Provide training to stakeholders, such as groundwater managers, policymakers, and decision-makers, on how to effectively use the monitoring system for groundwater management and decision-making.
- Provide training for end-users on how to use the system, input data, generate reports, and interpret the results provided by the system.

6. TEAM COMPOSITION AND QUALIFICATION REQUIREMENTS

6.1. Team Composition

Table 1: Proposed Positions the Firm's staff with maximum man-month for the service

SN	Proposed Position	Person	Person-Month (PM)		Total Man-month	Remark
			Office	Field		
1	Project Manager	1	5	1	6	**6 Months**
2	Technical Architect	1	5	1	6	
3	Database Administrator	1	5	1	6	
4	Software Developers/Programmers	1	6	-	6	
5	User Interface/User Experience (UI/UX) Designer	1	6	-	6	
6	Data Analyst	1	6	-	6	
7	Quality Assurance/Test Engineer	1	6	-	6	
8	Hydrogeologist	1	5	1	6	
9	Groundwater Monitoring Specialist	1	5	1	6	
10	Integration Specialist	1	6	-	6	
11	Documentation Specialist	1	6	-	6	

6.2. Qualification Requirements

The assignment typically involves a team of professionals with diverse expertise. The following are key professionals who could be involved in such a project:

Table 2: Qualification requirement (key staff requirement)

SN	Job Title	#	Qualification and Education	Experiences
1	Project Manager	1	MSc Degree in project management or a related field	At least 17 years general experience in managing similar IT projects, preferably with expertise in water resource management or groundwater systems; should possess strong project management skills, including planning, coordination, budgeting, and risk management of which 8 years in management
				At least 13 years of specific experiences in managing similar IT projects, preferably with expertise in water resource management or groundwater systems; strong project management skills, including planning,

SN	Job Title	#	Qualification and Education	Experiences
				coordination, budgeting, and risk management; overseeing the development and commissioning of complex software systems; knowledge of water resource management principles and practices, particularly related to groundwater monitoring and information systems; ability to effectively communicate and collaborate with stakeholders, including technical teams, subject matter experts, and project sponsors; familiarity with project management methodologies and tools to ensure successful project delivery; experience in managing project timelines, resources, and deliverables; problem-solving and decision-making skills to address any challenges or issues that may arise during the project implementation.
2	Technical Architect	1	MSc Degree in Computer Science, Software Engineering, or a related field	At least 15 years of specific experiences in software development and system architecture design; should have experience in designing and implementing web-based systems, preferably with expertise in groundwater information and monitoring systems.
				At least 13 years of specific experiences in system architecture design for web-based applications; web application development using relevant technologies and frameworks; database management including designing efficient schemas and optimizing performance; integration and interoperability of different systems, including existing web-based groundwater information and monitoring systems; security and data privacy measures including authentication, authorization, encryption, and secure data transmission; performance optimization of web applications, identifying and addressing bottlenecks; project management and collaboration skills, working effectively in a team; domain knowledge in groundwater systems, hydrology, or water resource management.
3	Database Administrator	1	MSc Degree in Computer Science or a related field	At least 13 years general experience in database management systems, preferably with experience in managing large-scale data systems; proficient in designing and optimizing databases, ensuring data integrity, and implementing data security measures.
				At least 10 years of specific experiences in Database management and administration including designing, implementing, and maintaining databases for web applications; expertise in database technologies such as SQL, NoSQL, or NewSQL, and proficiency in relevant database management systems; optimizing database performance, including query optimization, indexing, and data caching; knowledge of data modeling and database design principles to ensure efficient and scalable database schemas; familiarity with data integration and migration techniques to seamlessly integrate existing groundwater information and monitoring systems; ability to ensure data integrity, security, and privacy measures within the database system; database backup and recovery strategies to minimize data loss and ensure system reliability
4	Software Developers/Programmers	1	MSc Degree in Computer Science or a related field	At least 13 years general experiences in web application development, preferably using relevant technologies such as Java, .NET, or Python; possess strong coding skills,

SN	Job Title	#	Qualification and Education	Experiences
				knowledge of software development methodologies, and experience in working with databases. A degree in computer science or a related field is typically required
				At least 10 years specific experiences in relevant programming languages (such as Java, Python, or C#) and frameworks for web application development; developing scalable and robust web-based applications; knowledge of software development methodologies and best practices, including agile development and version control; expertise in front-end development, including HTML, CSS, and JavaScript, to create user-friendly interfaces; understanding of back-end development, including server-side programming, database integration, and API development; familiarity with web services and APIs for integrating existing groundwater information and monitoring systems; ability to write clean, maintainable, and efficient code, following coding standards and guidelines; troubleshooting and debugging skills to identify and resolve technical issues during the development and testing phases.
5	User Interface/User Experience (UI/UX) Designer	1	MSc Degree in Graphic Design, Human-Computer Interaction, or a related field	At least 13 years general experiences in designing intuitive and user-friendly interfaces for web applications, in conducting user research, creating wireframes and prototypes, and ensuring a seamless user experience.
				At least 10 years specific experiences in UI/UX design principles and best practices, including user research, wireframing, prototyping, and usability testing; designing intuitive and user-friendly interfaces for web applications; knowledge of information architecture and interaction design to create effective navigation and user flows; understanding of visual design principles, including typography, color theory, and layout, to create visually appealing interfaces; familiarity with responsive design techniques to ensure optimal user experience across different devices and screen sizes; ability to conduct user research and gather feedback to inform the design process and make data-driven design decisions.
6	Data Analyst	1	MSc Degree in Hydrogeology, Hydrology, Environmental Science or a related field	At least 13 years general experiences in analyzing and interpreting groundwater data. They should possess strong data analysis skills, proficiency in statistical analysis tools, and knowledge of groundwater monitoring techniques.
				At least 10 years specific experiences in data analysis techniques and tools, such as statistical analysis, data visualization, and data mining; working with large datasets and databases, including data cleaning, transformation, and integration; knowledge of groundwater monitoring and information systems, including data collection methods, quality control, and data validation; familiarity with data modeling and database design principles to ensure efficient storage and retrieval of groundwater data; ability to analyze and interpret complex data sets to identify patterns, trends, and anomalies; creating meaningful and actionable insights from data to inform decision-making processes; data visualization tools, such as Tableau or Power BI, to present data in a clear and visually appealing manner.

SN	Job Title	#	Qualification and Education	Experiences
7	Quality Assurance/Test Engineer	1	MSc Degree in Computer Science or a related field	At least 13 years of experience in software testing and quality assurance processes. They should be proficient in creating test plans, executing test cases, and identifying and documenting software defects. A degree in computer science or a related field is typically required.
				At least 10 years specific experiences in software testing methodologies, including test planning, test case creation, and test execution; conducting functional, integration, and regression testing to ensure the reliability and accuracy of the system; knowledge of test automation tools and frameworks; familiarity with performance testing techniques to assess system responsiveness, scalability, and stability; understanding of usability testing principles to evaluate the user-friendliness and effectiveness of the system; ability to identify and document software defects, track their resolution, and verify fixes; proficiency in test management tools, such as JIRA or TestRail, to track and report testing progress and results.
8	Hydrogeologist	1	MSc Degree in Hydrogeology or a related field	At least 15 years of professional and in-depth knowledge of groundwater systems, hydrology, water resource management, or related domains.
				At least 13 years specific experiences in interpreting and analyzing groundwater data; knowledge of relevant environmental and hydrological factors that impact groundwater resources; familiarity with existing groundwater information and monitoring systems and their functionalities; collaboration skills to work closely with the technical team, stakeholders, and end-users; in-depth knowledge of groundwater management principles, regulations, and best practices; in groundwater monitoring techniques, including data collection methods, sensor technologies, and quality control procedures; familiarity with groundwater modeling and simulation tools to analyze and predict groundwater behavior; understanding of data requirements and information needs for effective groundwater management and decision-making
9	Groundwater Monitoring Specialist	1	BSc/MSc Degree in hydrogeology, geology or a related field	At least 10/12 years of professional and in-depth knowledge of groundwater systems, hydrology, water resource management, or related domains.
				At least 8/10 years specific experiences in groundwater monitoring and data management, designing and implementing groundwater monitoring programs, conducting field measurements, analyzing data, and interpreting results, web-based databases and data integration; in-depth knowledge of groundwater monitoring techniques, including the selection and installation of monitoring wells, data collection methods, and quality assurance/quality control procedures is necessary. Familiarity with various groundwater monitoring equipment, such as water level loggers, data loggers, and sensors, is also important; knowledge of programming languages such as SQL or Python for data manipulation and automation tasks.
10	Integration Specialist	1	MSc Degree in Computer Science,	At least 13 years general experiences in in integrating systems, knowledge of data exchange protocols and

SN	Job Title	#	Qualification and Education	Experiences
			Information Technology, or a related field	familiarity with web services and ETL (Extract, Transform and Load) processes
				At least 10 years specific experiences in system integration techniques and technologies, including API integration, data synchronization, and middleware platforms; integrating different software systems and databases to ensure seamless data flow and interoperability; knowledge of web services and protocols for exchanging data between systems; familiarity with data mapping and transformation techniques to align data structures and formats during integration; understanding of security and authentication protocols to ensure secure and authorized access to integrated systems; ability to troubleshoot and resolve integration issues, such as data inconsistencies or system compatibility problems; proficiency in integration tools and platforms.
11	Documentation Specialist	1	BSc Degree in Computer Science, Information Technology, technical writing, communication, or a related field	At least 12 years general experiences with strong writing skills, attention to detail, and the ability to effectively document project requirements, design specifications, and user manuals
				At least 10 years specific experiences in technical writing and documentation standards to create clear, concise, and comprehensive documentation; documenting software requirements, design specifications, user manuals, and system documentation; knowledge of documentation tools; familiarity with version control systems to track changes and maintain document versions; understanding of information architecture and organization; ability to collaborate with the development team, subject matter experts, and stakeholders to gather information and validate documentation accuracy; proficient in visual communication tools (diagrams or flowcharts); attention to detail and quality assurance skills to review and edit documentation for accuracy, consistency, and adherence to standards.

7. REPORTING REQUIRMENTS AND DELIVERABLES

The implementation of Integration of Groundwater Monitoring System with Existing Web-Based Information System can result in several deliverables which are tangible outcomes that are generated throughout the implementation process. Thus, in accordance with the implementation schedule, the Consulting Firm shall submit the following reports (study, design and implementation) at different stages to the Client as shown in Table 3:

Table 3: Reporting Types and Submission Time-Frame

Item No.	Deliverable (Report)	Deliverable Contents to be included but not limited to	Number of Copies	Time frame (M-Month)	Payment Schedule
1	Draft Study Report	The report includes the desk review and gap analysis, needs assessment and feasibility study of the project	5	M+2	-

Item No.	Deliverable (Report)	Deliverable Contents to be included but not limited to	Number of Copies	Time frame (M-Month)	Payment Schedule
2	Final Study Report	Final study report submission after incorporating comments/feedbacks of Workshop-1	5	M+3	20%
3	Implementation schedule	Detailed schedule for the design, implementation and commissioning the groundwater monitoring system and integrating with the existing groundwater database	5	M+3	
4	Draft Design Report	The report includes technical aspects of the project such as proposed system architecture and design, data model, system for integrating with the existing groundwater database, testing approach, documentation requirements, the project management approach, potential risks and challenges	5	M+8	-
5	Final Design Report	Final Draft Design Report after incorporating comments/feedbacks from Workshop-2	5	M+10	20%
6	Capacity Building Session	Capacity building on System Training, Technical Training, Data Analysis and Interpretation Training, Stakeholder Engagement and System Usage Training		M+10	
7	Draft Implementation Report	The report includes integrating the new developed system with the existing groundwater database	5, 20-training manuals, user manuals	M+30	30
8	Final Implementation Report	Final Implementation Report after incorporating comments and suggestions from Workshop-3	5	M+38	30%
9	3 Workshops and	At the end of Draft Study Work, Draft Design and Draft Implementation	-	M+2, M+12 and M+14	

All reports shall be submitted in both soft (MS Word, PDF) and hard copy. The hard copies will be prepared in A4 format, except for plans and drawings which should be prepared in A3 format. The reports should be clearly labelled, i.e., title of the study indicated, for easy identification and documentation purposes. All reports shall be prepared in English. Please note that the consultant will be expected within one (1) week of submission of draft reports to make presentations to the respected stakeholders. At each workshop, the consultant shall make PowerPoint presentations, provide concise background documents for discussion and prepare workshop reports to document the proceedings.

In addition, to the above, the consultant should prepare and submit the following reports and deliverables at different stages:

- Initial Assessment Report including the existing groundwater information and monitoring system, stakeholder requirements, and system integration needs to provide an overview of the project scope, objectives, and proposed approach.
- Progress Reports to update the client on the implementation status that should include information on key milestones achieved, tasks completed, challenges faced, and any deviations from the project plan.
- User Manuals and Training Materials - that guide system administrators and end-users on how to operate the system and utilize the groundwater tools effectively to enhance user understanding and proficiency in utilizing the system for data management, analysis, and reporting.
- User Feedback and Satisfaction Reports summarizing the feedback received from system users and stakeholders.
- Data Quality Assurance Reports outlining the data validation checks performed, data verification results, and any data quality issues identified; recommendations for improving data quality and ensuring the accuracy and integrity of the collected data.
- System Performance Monitoring Reports that include information on system response times, data accuracy, system uptime, and any performance issues identified; recommendations for optimizing system performance and addressing any identified performance bottlenecks.
- Integrated the newly developed groundwater monitoring system with the existing web-based groundwater database.
- Enhanced Data Collection and Management Tools that enable efficient data collection, storage, management, and analysis including data entry forms, automated data validation processes, data visualization interfaces, and reporting functionalities.
- Customized Reports and Dashboards that offer visual representations of groundwater monitoring data.
- Data Integration Framework for integrating different data sources into the groundwater database which allows seamless synchronization of data from various monitoring devices ensuring a comprehensive and up-to-date picture of groundwater resources.
- Implementation Documentation outlining the technical specifications, system architecture, and integration methodology used for the implementation of the monitoring system which enables effective system maintenance, troubleshooting, and future enhancements or upgrades.
- System Testing and Quality Assurance Reports detailing the testing methodologies employed and the outcomes of testing procedures which provide evidence of system functionality, performance, and reliability, ensuring that the groundwater monitoring system meet specified requirements.
- Change Management Plan that outlines strategies for user adoption and organizational integration of the new groundwater monitoring system which addresses training needs,

communication strategies, and the establishment of feedback mechanisms to facilitate a smooth transition to the enhanced system.

- Impact Assessment Reports on groundwater management and decision-making processes which should include an analysis of the system's impact, such as improved data availability, data-driven decision-making, and enhanced groundwater management practices; recommendations for further enhancing the system's impact.
- Final Evaluation Report that should summarize the overall project implementation, including achievements, challenges, and lessons learned; include recommendations for future improvements and sustainability of the system.

8. ORGANIZATION SETUP

8.1. Contractual Arrangements

The contractual arrangements for the specified activities are under lump sum contract payment schedule. The Consulting Firm shall show the cost of the proposed service in accordance with these contractual arrangements.

8.2. Services and Facilities to be provided by the Consulting Firm

The Project manager acting for the Consulting Firm as Engineer's Representative will undertake and retain the powers and authorities.

The site office shall be equipped with the basic equipment, latest computers and software, materials and engineering and office programs necessary to carry out the assignments (desk top, printer, shelves, tables, chairs and etc...).

8.3. Liaison with MoWE

MoWE for purposes of this assignment will nominate a member of staff from the Authority as Counterpart staff. It will be the Consulting Firm's duty to maintain close contact with the Counterpart staff on all aspects of work. All formal communications related to changes in site, scope of works, substantial volumes, new orders, new drawings, and any similar to these, the work will be directed to the attention of the Counterpart staff prior to the issuing of the instruction to the Contractor.

8.4. Logistical Setup and Staffing

Within the technical proposal, the Consulting Firm shall elaborate on the envisaged logistical setup and deployment of appropriate skills for the execution of the assignment.

The Consulting Firm shall present the project staffing schedule in a manner that clearly shows the stage and duration where each of the proposed team members is planned to be involved in the Project. An organization reflecting the responsibilities of each staff member and line management setup of the proposed team shall be part of the proposal.