

**Terms of Reference**

**for**

**Water Smart Irrigation study in the Nile Basin**

(International Firm Consultant)

NCCR Project for Information Services and Platform Thematic Area

**March 2024**

**1. Background**

The Nile Basin Initiative (NBI) is a transitional cooperative mechanism of ten riparian countries to realize a jointly articulated Shared Vision: “To achieve sustainable socio-economic development through the equitable utilization and benefit from the common Nile Basin water resources”. NBI provides the only all-inclusive regional platform for multi stakeholder dialogue, information sharing as well as joint management and development of water and related resources in the Nile Basin Currently Burundi, DR Congo, Egypt, Ethiopia, Kenya, Rwanda, South Sudan, Sudan, Tanzania, and Uganda are members of the initiative. Eritrea participates as observer and Egypt temporarily freeze participation.

The Eastern Nile Subsidiary Action Program (ENSAP) and Nile Equatorial Lakes Subsidiary Action Program (NELSAP) are two NBI Subsidiary Action programs established in 1999. ENSAP and NELSAP focus on joint water resource investment preparation. The EN countries established Eastern Nile Technical Regional Office (ENTRO) to implement ENSAP. The NEL countries established NELSAP-CU in Kigali as coordination unit of NELSAP.

* 1. **Previous Irrigation and Drainage Implementation Efforts**

Overall, agriculture dominates all other water uses in the Nile basin, accounting for more than 80% of water withdrawals (Timmerman 2005, Karyabwite 2000, FAO 2011b). The total equipped area in the Nile Basin is estimated at 5.4 million hectares, while the actual cropped area is estimated at 6.4 million hectares. The cropped area varies depending on what percentage of the irrigation equipped areas is covered by crops in any given year and whether more than one crop is planted. In most Nile Basin countries, the cropped area is much less than the equipped for irrigation area.

**1.1.1 Eastern Nile sub-basin**

NBI/ENSAP (Eastern Nile Subsidiary Action Program) identified 7 projects under IDEN (Integrated Development of Eastern Nile) as a first round of projects to be implemented in the EN Region and Irrigation and Drainage is one of the seven programs identified for implementation.

The Main Purposes of IDEN project were to build Trust and Confidence, to enhance Knowledge Base and capacity to improved understanding of the Nile system, its potentials and threats and need for cooperation, preparation of Investment Projects (regional planning perspectives & trans-boundary solutions), to exchange and share Information and Experience, Stakeholders Participation, and Adoption and Dissemination of Good Practices in the institution and the program.

In October 2004, ENCOM (Easter Nile Council of Ministers) decided to fast-track the Irrigation and drainage project to achieve clear results of Nile Basin collaboration on the ground; and agreed for carrying out feasibility studies for 100,000 ha and investment for initial development of irrigation of around 20,000 to 50,000 ha in each of the EN country.

Following the agreements of EN Countries, World Bank agreed to finance projects in Ethiopia and Egypt. This WB financed Projects implemented by National Ministries of Water Resources of Ethiopia and Egypt. Under this support Projects were identified, Feasibility studies conducted, detail design and construction implemented in Egypt and Ethiopia.

In addition to the above, ENTRO simultaneously with the support of African Development Bank implemented Irrigation and Drainage Project study (ENIDS) as one of IDEN project from 2007 - 2010 in various phases. It has two components: An Engineering Sub-study under Phase 1: Diagnosis and planning of activities: to result in identification and proposal of 15,000 ha to be studied at feasibility level; Phase 2: Feasibility study of 7,500 ha in Ethiopia and 7,500 ha in Sudan. Cooperative Regional Assessment (CRA) Sub-study geared at enhancing the understanding of benefits and costs accruing to irrigation and drainage projects across the sub-basin’s countries. CRA conducted transboundary analysis which focuses on challenges, opportunities and institutional analysis related to irrigation in the region. The study prepared project profiles for the proposed projects to be implemented in the future and estimated distributive analysis of costs and benefits for the proposed projects.

Therefore, the objective of the Study is to assess comprehensive situation and develop a Database of the existing irrigated areas in EN and to assess a preliminary performance of existing irrigation schemes in the EN and basin wide schemes. In this case, ENTRO has a database of existing Irrigation Schemes in EN with preliminary information on the characteristics of the schemes.

Based on the above evidence, ENTRO and NELSAP have the mandate, experiences, and capacity to support member states in Irrigation Projects planning and implementation. From the outset, ENTRO and NELSAP were designed to support member countries in preparation of investment projects. Below are pilot irrigation projects identified for Eastern Nile (Table 1) and Equatorial Lakes (Table 2) sub-basins.

**Table 1**. List of irrigation projects identified in the EN region.

|  |  |  |
| --- | --- | --- |
| **SN** | **Description** | **Locations** |
| 1234567 | Tekeze small scale irrigation schemes (27061.36 ha)**Blue Nile** irrigation schemes:* Tana Beles (command area 12247 ha)
* Koga (command area 7004 ha)
* Arjo Didessa (1500 ha)
* Megech Seraba1 (4000 ha)
* Fincha (19548 ha)

Alwero irrigation scheme (2200 ha) in Baro Akobo basin | Ethiopia |
| 89 | Northern Upper Nile Irrigation Scheme (654700 ha)Aweil irrigation Rice Scheme (9240 ha) | South Sudan |
| 101112131415 | **Blue Nile** irrigation schemes:* Gezira and Managil schemes (Gezira state), with a total area of 882,400 ha (2.1 million feddan).
* Rahad I scheme (Gedaref and Gezira states), with a total area 147,100 ha (350,000 feddan).
* Sennar state schemes, (37) with a total area of 110,200 ha (262,000 feddan).

**Atbara** irrigation schemes:* New Halfa agricultural scheme (Kassala state), with a total area of 163,900 ha (390,000 feddan).

**White Nile** irrigation schemes:* White Nile state projects, with more than140 projects (equivalent to 1.35 million feddans or 570,000 hectares).
* White Nile Sugar project, with a total area of 90,000 feddan (37,800 ha).
 | Sudan |

**1.1.2 Equatorial Lakes sub-basin**

In the NEL basin, irrigation plays an important role in the life of millions of people and is a powerful engine for socio-economic development, food security and poverty alleviation through creation of employment opportunities, particularly for the rural poor. This is why some of the NEL countries invest large parts of their limited financial resources in irrigation developments. In spite large amount of water committed to irrigation, the performance of many irrigation systems in the NEL region is below expectations in terms of both waters use efficiency and agricultural productivity. Irrigation developments are also generating enormous environmental and health concerns.

Information on existing irrigation developments, at national and regional levels is also poor or limited. Despite the large amount of literature on irrigation systems in the NEL region, there is clear lack of agreement on the annual cropped areas and their annual water use and on the level of performance of different irrigation techniques adopted and the factors contributing to the current level of performance. Data sharing and exchange between countries is also a challenge; even in the same country, information on irrigation is scattered between different entities (central and regional government offices and private sector). It will be of great value if all scattered information at the national and regional level can be gathered together in a central data base which can be accessible at all level to inform irrigation policies and technology choices.

Several factors may be contributing to the low performance of irrigation systems. These include among others: Engineering factors, institutional setup; policies and legal framework. The engineering factors include; adequacy of available irrigation water, the use of outdated engineering technology and ageing hydraulic infrastructure. Institutional setup includes issues such as government, private sector and farmers’ roles in irrigation management, cost recovery and financing marketing of products. Policies and legal framework issues include; cost recovery, water allocation, land ownership, crop choice and farmers’ incentive for improved water use efficiency and productivity.

This project activity aims to enhance the knowledge of planners, irrigation managers, and researchers in the NEL region at national and more importantly at regional level on existing irrigation developments (cropped areas, annual water use, water efficiency and productivity, institutional setup among others). This knowledge is essential for running simulation of water-related investments scenarios by using deferent models and planning tools for improved planning and operation of water infrastructure at national and regional level.

The project will also contribute to enhanced dialogue amongst irrigation professionals by providing them with means and recommendations for improving the performance of existing and planned irrigation developments. In addition, exchange of lessons learned between the NEL countries can be an important input for improved planning of future irrigation developments in the NEL region.

**Table 2**. List of irrigation projects identified in the NEL region.

|  |  |  |
| --- | --- | --- |
| **SN** | **Description** | **Locations** |
| 12 | * Nyamuswaga Valley Irrigation and Water Supply Deployment Project (3,000 ha; 6,000 farmers)
* Ndurumu Valley Irrigation and Water Supply Deployment Project (4,000 ha; 8,000 farmers)
 | Burundi |
| 3 | Kitoba-Lubango Water Resources Projects (3,000 ha; 4,286 farmers) | DR Congo |
| 45 | * Lower Sio/ Maira irrigation Project (6,090 ha, Dam – 6.2 MCM, 11m High, 3000 people)
* Titsi Irrigation Development and Watershed Project (command area 403ha, Beneficiaries- 3100)
 | Kenya |
| 67 | * Bugwema Irrigation Development Project (2,030Ha of irrigation to benefit 755 HH and 9,500 people)
* Mara valley Irrigation and Watershed Management Project (Beneficiaries 20,000 people, Irrigation 8,340Ha in 13 villages of Serengeti and Butiama Districts, 2.85MW, water supply to 18 villages in Serengeti, Butiama and Tarime Districts)
 | Tanzania |
| 8910111213 | * Bigasha Water resources development Project (500 ha of irrigation and water supply for 118,000 people)
* Rwimi Irrigation Development and Watershed Management Project (3,000 ha; 4,286 farmers)
* Nyabanja Irrigation Development and Watershed Management Project (command area 3200 ha, Beneficiaries 12000)
* Lirima Irrigation Development & Watershed Management Project (command area 1137 ha, Beneficiaries 5,154)
* Bukhabusi Irrigation Development & Watershed Management Project (command area 480 ha, Beneficiaries 6,200)
* Nyamatunga Irrigation Development & Watershed Project (command area 412 ha, Beneficiaries 10,000)
 | Uganda |
| 14 | Nyimur/ Limur Multipurpose Water Resources Development (4,180 ha of irrigation areas in both Uganda and South Sudan; water supply for approximately 12,000 people; 14,300 ha of Sustainable Land use Management) | South Sudan/ Uganda |
| 15 | Aweil Irrigation Development and Watershed Management Project (12,000 ha; 24,000 farmers) | South Sudan |

**1.1.3 Context**

The Nile Basin, with an area of over 3.2 million square kilometers, is source of livelihoods to over 250 million people residing within the basin boundary. The basin area stretches over 11 countries and, thus, making the Nile one of the most shared river basins in the world; it is one of the world’s five rivers that are shared by 9 to 11 countries. The Nile Basin, compared to other large river basins, has relatively low runoff coefficient. Most of the 11 riparian countries are grappling with the task of meeting their population’s basic needs. Based on FAO’s world hunger statistics, a substantial proportion of the population in five Nile riparian states are undernourished.

Strategic Water Resources Analysis (SWRA) study conducted by Nile Sec which is aimed at developing options of measures (water resources infrastructure and management options) to meet the growing water demand in the NB sustainably and reduce mounting stress on the river system and minimize water allocation related tensions among the riparian countries. SWRA assessment estimated existing equipped irrigation development area in the basin to be around 6.64 million hectares. According to the analysis, irrigated agriculture is expected to expand by approximately 60 percent during the projection period up to 2050. Implicitly, irrigated agriculture will remain the main water user in the Nile Basin and is estimated to consume up to 75-80% of the basin water in the foreseeable future.

Irrigation is projected to expand in the Basin: Country plans compiled and analyzed by NBI (Nile-SEC, strategic analysis, ENTRO CRA, ENMSIOA) that shows the total irrigation area planned in the entire Nile Basin.

To supply water for these irrigation schemes and power generation, dams with combined storage of over 200 BCM are planned basin-wide with over 95% in the Eastern Nile. The total area of the planned irrigation expansion projects in the EN basin alone amounts to 3.8 million hectares. The total irrigation water requirement of the planned expansion projects is estimated to be 49 BM3, making the total future water demand of 123.7 BM3 which is the main challenge.

**2. Rationale**

Irrigation consumes 78% of the water abstracted from the Nile and its tributaries (NBI EWUAP 2009). The agricultural sector (the broader production sector that includes animal husbandry and fisheries) is of immense importance to all Nile Basin countries in terms of contribution to GDP (between 12% to 45%), employment (between 32% and 94% of the labor force), and food production (State of the River Nile Basin Report 2012). For a water scarce basin like the Nile Basin where substantial growth in irrigated agriculture in the riparian countries is projected to steadily grow, investing in water saving technology is critically important for sustainable water resources management in the Nile Basin. For example, in the Lake Victoria basin of the Nile, the total drainage from runoff is about 5%, while most of the countries in this part of Nile basin are planning huge irrigation infrastructure according to their national irrigation master plans. Country plans compiled and analyzed by NBI (Nile-SEC, Strategic Water Resources Analysis, ENTRO CRA, ENMSIOA) show that out of the total irrigation area planned in the entire Nile Basin, nearly 98% is in the Eastern Nile. The total area of the planned irrigation expansion projects in the Eastern Nile basin alone amounts to 3.8 million hectares. The projected water demand for irrigated agriculture will therefore put strain on the available water.

The NBI is the only platform where Nile riparian Countries come together to discuss challenges facing the basin in relation to water resources management including efficient water use for agriculture. NBI therefore has a comparative advantage to support member countries to adopt modern emerging information/data collection technologies (e.g. remote sensing) for improving irrigation water management, water use efficiency and productivity.

Remote sensing technology offers relatively cheaper opportunity for collecting data over large area that can be used to improve irrigation performances. It is against this background that under this project, innovative approaches will be piloted on few schemes in the basin with the aim to expand it in the future based on assessment of its reliability and usefulness.

Demonstration and capacity building on the technology for further use by riparian countries to monitor their irrigation water use will have significant benefit for advising the water users and saving water that will have beneficial use. It is widely accepted that appropriately designed remote sensing technology can provide cost-effective and reliable method for irrigation performance assessment and provide information that can be used for improving irrigation performance; however, this is lacking in the Nile basin. The proposed project activity therefore intends to fill the gap using relevant smart irrigation technologies which can be applied to improve the agricultural/irrigation performances. Finally, the pilot irrigation schemes will be implemented by countries with the support of NBI centers for the benefits of the countries to improve the water use efficiency and improve productivity and scale up to other areas.

**3. Objective**

The main objective of this project is to leverage use of innovative information technology and EO data for improving water management (water smart irrigation) and productivity of irrigation developments in the Nile basin. To meet the objective, the water uses efficiency and optimization of cropping patterns and “virtual water” trade used in the production of goods between countries can offer tangible solutions to address future gaps in water availability.

**3.1 Specific objectives include**:

* To perform a diagnostic study on irrigation water use efficiency at the Nile Basin and select the best performing pilot schemes.
* To develop a smart irrigation system to enhance water use efficiency in the Nile Basin using Earth Observation (EO) data and programing incorporate a monitoring dashboard/toolkit. Its purpose is to facilitate decision-making during irrigation scheduling and water allocation activities.
* To develop database systems for water smart irrigation system to monitor and improve the irrigation performance in the basins.
* To enhance the capacity of NBI countries and stakeholders on the use of Remote Sensing technologies for irrigation water use monitoring and controlling performances.
* To develop guidelines for planning, design, and management of smart irrigation systems in the Nile basin.

**4. Implementation Methods**

The mapping of the crop type and water use performance based on the purpose of the application and the data requirements should be categorized as follows:

1. High resolution datasets for mapping field and existing irrigation system, the satellite imageries to be procured and the analysis should be using the Artificial Intelligence (AI) methods (Machine and deep learning).
2. Medium resolution datasets which are freely available for mapping crop activities over time and monitoring the crop performance. These datasets and products should be downloaded in automatic way from different vendors and sources.
	* + - Apply atmospheric correction and reduce clouds on Sentinel-2A and LandSat images.
			- Filter image collection e.g. (of Sentinel-2A and Landsat 8 and 9) in Google Earth Engine using JavaScript or other platforms (e.g., Python and R) with temporal resolution of maximum of 10 days from the planting date of crop up to harvest.
			- Use crop calendar and NDVI time-series to identify different crops and identify Phenology parameters from NDVI time-series in growing days to discriminate crops from each other or other applicable methods. The computation of NDVI can be using the Google Earth Engine or other environment.
			- Detection of irrigation system water (losses) using remote sensing technology.
			- Crop growth (Biomass production (BP), Leaf area index (LAI) and Vegetation index (NDVI).
			- Use of Satellite Earth Observation images (e.g., Surface Energy Balance Algorithm for Land (SEBAL) approach) to measure key parameters (growth, moisture, minerals) to check the crop performance (Biomass water use efficiency):
			- Moisture (Actual Evapotranspiration, Evaporation Deficit, Crop Factor, Biomass Water Use Efficiency).
			- Minerals (Nitrogen in upper leaf and Total plant nitrogen), if applicable.
			- OpenET to access satellite-based evapotranspiration (ET) data for improved water management which can be applied as a readily available source for ET data (<https://openetdata.org/>).

In general, diagnose and identify common challenges among existing information on irrigation systems and practices in the EN and NEL countries, the data and information collected will be complied in one Diagnostic Report to establish an initial database for future expansion and update (irrigation performance assessment report). In addition, review of best practices in other parts of the world, preliminary options for improvement of irrigation performance in the Nile region will be developed. Approach and Methodology and workplan for the study will be presented in detail by the consultant as a part of Inception report and reviewed by Stakeholders/Working Group Members and way forward will be agreed upon.

Finally, the regional validation and consultation workshop(s) will be organized for stakeholders from the Nile countries with coordination of ENTRO (in collaboration of Nile-SEC and NELSAP). The workshop will involve irrigation and water, and ministries of finance experts and line ministries and stakeholders from the member countries and other regional and international institutions having interest in irrigation in the Nile basin for the review of the draft Diagnostic and Irrigation Database Reports. The workshop will also involve validation and getting feedback to enhancing the draft reports. The workshops are also expected to enhance regional awareness on the issue of irrigation system performance, the need for improvement and recommendations on how to deal with the issue.

**5. Main Activities of the Project**

**5.1 Component 1:** Conduct a diagnostic assessment of the current practices in irrigation and water management, technologies, policies, and existing information.

The assessment and identification of non-technical challenges affecting the performance of systems serve as a base for recommendation of capacity building activities and involvement of stakeholders to support the implementation strategies. In the Eastern Nile Irrigation System Performance assessment study conducted in 2019, for instance, produced an inventory of the existing and planned irrigation developments in each of the four Eastern Nile countries which included estimates of annual cropped areas, irrigation technology, crop mix, crop and water productivity, actual volume of irrigation water used and explained the institutional set-ups in which irrigation developments are operating including policies, legal frameworks, institutional structure, public/private role (including the role of farmers associations), human resources capacity, financing development. It also identifies factors that contribute to the current level of crop and water productivity, and which encompass, policies, legal framework, and institutional structure including the private sector.

ENTRO and NELSAP will create this database through the inventory and baseline study to examine the status of irrigation systems in the Nile Basin before/during the start of the assessment. The assessment will use the previous studies, database created and collects additional primary data to analyze and draw findings to complete the component assessment.

Key activities include:

* Identify, review, and select appropriate remote sensing technology to be used to assess irrigation water use and efficiency.
* Procure high resolution Satellite Earth Observation (EO) datasets and products and present in the existing NB-DAS/IKP system (Nile-SEC and ENTRO database) and access from the existing system for different uses, such as water management, flood and drought monitoring, etc.
* Identify and list the tools and ready to use environmental variables data that are relevant and available for the project activities.
* Collection, review and compiling, and analysis of existing/ secondary knowledge based on available data/ literatures at national, regional, and international levels.
* Prepare catalogue of remote sensing information products and their uses in irrigation performance management 🡪 catalogue of remote sensing data available, database of existing experiences, lessons, and available methods.
* Identify primary or secondary data required and collected to verify the accuracy of the technology.
* Review the status of the Nile basin socio-economic and environmental issues.
* Stakeholders’ consultation, technology selection and agree on type of information services to be monitored. In a stakeholder consultation process, identify and agree on type of information services, such as (i) timing and amount of field water application (ii) Detection of excess irrigation water use, etc.) based on the application of the technology.
* Consultation with key stakeholder and agree on capacity building needs assessments.

**5.2 Component 2:** Develop guideline on the implementation of Smart Irrigation System

Water-smart irrigation involves using efficient and sustainable methods to minimize water usage and maximize irrigation efficiency. In some water stress areas, it is important to propose and apply water harvesting techniques to improve water availability. In essence, the guideline for the implementation of smart irrigation in the Nile basin will be developed with some technologies. The guideline will support operators in remote controlling and monitoring the irrigation systems including the following, but not limited to:

* Near real-time monitoring:  To monitor irrigation activities in near real-time in providing valuable insights into water usage, soil moisture levels, and weather conditions among others.
* Alerts and notifications: It can be linked with river flow and drought forecast systems to give countries that can be used the information with river flow or drought forecasts.
* Irrigation efficiency: By analyzing near real-time data, users can tailor irrigation schedules to improve land and water productivity based on the types of soil and crops. For instance, (i) in Surface irrigation method, the application efficiency is 50–70% and Conveyance Efficiency is 40–70%, (ii) in Sprinkler irrigation method, the application efficiency is 55–75% and Conveyance Efficiency is 60–90%, and (iii) in Drip irrigation method, the application efficiency is 70–95% and Conveyance Efficiency is 70–95% (Source: NBI baseline dataset of 2015).

**5.3 Component 3**: Develop a smart irrigation system incorporate a dashboard/data processing toolkits that includes to identify EO products and integrate it into the NB-DAS/IKP at the Nile Basin

Developing detailed design of measures for smart irrigation development schemes. Such measures can include improved information management for better irrigation scheduling, irrigation technology improvements, policy frameworks for enhancing performance of irrigated agriculture, etc. Identification of social, economic, environmental, and other barriers for developing and enhancing the capacities of Water User Associations and Irrigation users and operators would recommend in addition to technical and engineering measures. Recommendation of suitable regional irrigation development strategy, Public, Private Partnership arrangements, cost recovery mechanisms and irrigation management transfer policies will be implemented as part of strengthening institutional capacity for enhancing smart irrigation.

Key activities include:

* Establish Remote Sensing based irrigation performance assessment methods in Nile basin level. Remote Sensing based irrigation performance assessment process established (datasets, tools, methodologies).
* Develop methods and road map for assessing the selected performance indicators based on available Remote Sensing data and methods.
* Present the remote sensing EO data and products with the existing NB-DAS/IKP system (Nile-SEC and ENTRO Ge-database) and access from the existing system.
* Organize regional training for professionals from NBI Centers and member states to enable them apply RS in irrigation water management and performance assessment. The contents of the regional trainings will be identified on the assessment of NBI centers capacities in application of technology and provision of monitoring results to stakeholders.
* Carry out an assessment on the reliability and accuracy of the technology and devise mechanisms and/ or refine methodology to expand the use of technology and information service to the wider scale in the Nile basin. Once, capacity created at NBI level and would be further applied by ENTRO and NELSAP at sub-basin level to monitor irrigation performance which is varying over time and space.
* SAPs disseminate the monitoring results and national government, or schemes owners use this information for their decision making on the use of water like flood and drought forecast.
* Prepare draft and final reports including guidance and policy recommendations.

**5.4 Component 4:** Implementing cross-cutting activities related to capacity building

The capacity building activities will focus on planning, implementation, and management of smart irrigation systems. For instance, the operation and management of the existing irrigation systems in a form of training and practical observation and irrigation performances will be provided.

Key activities include:

* Review and validation of training modules, and other capacity building activities.
* Long term National Focal institutions will build their capacity and apply the technology to monitor their irrigation developments.
* Organize regular side events (e.g., NBDF) dedicated to use of modern technologies and assessment results of monitoring of irrigation performance for experience sharing between Nile Basin countries and beyond.
* Organize workshops to evaluate the deliverables at various milestones.
* Conduct at least two training/Capacity building on the developed system within the Nile Basin Centers cities targeting around 30 participants (for each training) from member states and centers. The training duration will be at least 3 days per training. ENTRO will cover the cost of the venue and participants travelling and accommodation. The cost of the consultant’s participation on the training will be covered by themselves.

**6. Expected Results**

* Baseline assessment report/ Diagnostic Report
* Guideline on the water smart irrigation system for the Nile basin to support operators in monitoring and controlling the implementation and irrigation performances.
* Database for different uses, such as for the analysis of water use efficiency linked with existing NB-DAS/IKP system, and integrated water data, crop water requirements and irrigation infrastructure with NB-DSS to assist making optimal irrigation in the Nile basin wide.
* Smart irrigation management application Dashboard (or Toolkits) to provide information on irrigation scheduling, water allocation and best practice of water efficient irrigation techniques.
* Research results on the applicability and accuracy of innovative Earth Observation (EO) data on sample irrigation areas in Nile basin (if applicable) for monitoring irrigation water use efficiency.
* Awareness and capacities enhanced on the use of innovative EO use for irrigation water use monitoring.
* Capacity building for NBI Centers and Stakeholders in the Nile basin to enhance the application of the Remote Sensing technologies in irrigation performance and applications.
* Draft final and final reports on water smart irrigation system for the Nile basin.

# 7. Beneficiaries and Key Stakeholders

The beneficiaries/stakeholders are professionals working in irrigation sectors, national institutions working on irrigation, governance, planners, policy advisers/ makers, local communities using irrigation infrastructures, experts working at government and private firms, consultants, construction firms, basin organizations, academia, and research institutes, etc.

**8. Duration of the Project**

The project implementation period will be to the maximum 7 months of effective implementation including the procurement activities (supply & delivery) of satellite EO datasets and products, analysis and stakeholders’ consultation and validation workshops. In addition, implementation and development of smart irrigation systems, capacity building, presentation of results and dissemination of deliverables.

**9. Coordination/ Implementation Arrangements**

ENTRO is the primary entity responsible for leading the coordination and implementation arrangements of the project and is responsible for recruiting consulting firms. The consultant will be signing an agreement with ENTRO and report directly to ENTRO. ENTRO will be responsible for coordinating the activities of the project as it is implemented all over the Basin. ENTRO’s project implementation team is headed by SRPC. M&E officer, contract administration and Procurement Officer, GIS and Remote sensing and Modeling and Knowledge Management experts will be the key team members during implementation of the project.

NBI/ENTRO/NELSAP will:

* Facilitate in establishing communication with the relevant institutions and governance members in the Nile basin countries.
* Liaise and assist consultants in obtaining information on irrigation, data collection, etc.
* In collaboration with governance and national institutions supports to obtain primary and secondary data of piloted schemes (These piloted schemes will be implemented in at least five pilot irrigation schemes across the Nile Basin countries, and their identification will occur during the consultation workshop).
* Facilitate the travel arrangements of consultant team.
* In collaboration with consultant team, arrange workshop/ training/Working Group meeting and ensure linkage with relevant regional authorities.
* Cater for the logistical requirements of regional training/ workshop and all related activities.
* The consultant will use his own facility for Office and other logistics for the study.
* The reports and deliverables of the study is reviewed by Working Group Members/Stakeholders. The cost of Working Group meeting is covered by ENTRO. The consultant participates on review workshops and training sessions by covering his own cost.
* Selection of trainees and facilitating/organizing the training in coordination with the consultant. ENTRO will cover the cost of training for all participants except the Consultant.

**10. Selection Method and Evaluation Criteria**

In accordance with the project requirements, the selection method for this procurement process shall be Quality and Cost Based Selection (QCBS). The QCBS approach aims to assess both technical quality and cost considerations. The evaluation weight for each criterion is as follows: Technical Quality: 70% and Cost is 30%.

**11. Firm Consultants and Team Composition**

The International Firm Consultants conducting this study will have the following Key Staff Composition (1) Irrigation and Drainage Expert (Team Leader) with the minimum level of effort required to perform the required service is 3 man-months, (2) GIS and Remote Sensing Expert with an input equal to 70 man-days and (3) Information Management System (or Software) Expert) will be mobilized to conduct and package the research assessment with have an input of 2 man-months. The roles and deliverables of the consultant are presented in Table 3 below.

The Firm consultant is responsible for supplying the remote sensing and satellite data related to the piloted schemes. During the inception phase the consultant will provide the required satellite data with the optimum resolution and to be approved by ENTRO. Five pilot schemes to be studied for water smart irrigation assessment will be proposed and agreed upon on by Working Group members/Stakeholder during Inception Review phase.

**11. Staffing of Firm Consultant’s Team**

The consultancy firm shall have a minimum of 10 years of experience with water smart irrigation system and technologies in the Nile basin or similar basins. General expertise shall include irrigation, hydrological/hydraulic modeling and water resources planning, data management information system development and related aspects. The consultant should have the following interdisciplinary experts available to conduct the project. Positions can be filled flexibly by one or more experts, combining expertise.

**11.1** **Irrigation and Drainage Expert (Team leader)**

Team Leader with a strong background in irrigation and transboundary water resources planning and management, data management, water resources modeling, hydrological and hydraulic modeling in the Nile basin, minimum of 10 years work experience in the Nile basin.

The minimum master’s degree holders with experience required is at least ten years (10) of related work experience, with recognized technical expertise in Irrigation and Drainage system with the following experiences but not limited to:

* Advanced degree in agricultural/irrigation engineering, water resources management, or a related field.
* Proven experience in the design and implementation of irrigation and drainage projects with good experiences in smart irrigation technologies and development.
* Experiences in modern irrigation technologies, including sensor-based irrigation, data analytics, drip and sprinkler and floppy technologies and automation processes, etc.
* Experiences and familiarity in implementing projects related to water resources management and developments in the Nile Basin or similar developing basins.
* Strong knowledge in hydrological/water resources modeling and skills in GIS and Remote Sensing tools.
* Strong communication and capacity building/training skills.
* Good in report writing and presentation skills.
* Ability to work collaboratively with diverse stakeholders.

**11.2** **GIS and RS Expert**

At least master’s degree in GIS and/or Remote Sensing with good IT knowledge or related fields with strong background in remote sensing in addition to water resources management/engineering and development. The GIS/RS expert should have at least 7 years of experiences, but not limited to, involved in the use of remote sensing and GIS in planning development, monitoring, and management of natural resources systems. Particularly, in the retrieval, storage, archiving, processing and interpretation of geodatabases, spatial and RS data.

**11.3** **Information Management System (Software) Expert**

The minimum of master’s degree holders with experience at least eight years (8) of related work experience, with recognized technical expertise in information management and software in addition to the following experiences but not limited to:

* An advanced degree in Information Technology or Computer Sciences, engineering, knowledge management systems or any other related fields.
* At least 5 years’ experience in trouble shooting, networking, hardware and software maintenance, data management systems.
* Hands on experience in trouble shooting, networking, basic programming languages, and relevant software applications.
* Strong previous working experience or knowledge of in developing and transition countries preferably in Nile basin trans-boundary water resources issues.
* Experience in developing and managing information technology and knowledge management systems.
* Good experience with big data and analytics platforms.
* Experience with cloud computing platforms such as AWS, Azure, or GCP.
* Knowledge of security best practices for IoT and Smart Irrigation devices and networks.
* Experience with machine learning and artificial intelligence.
* Good experience with SQL and relational databases systems and implementations mainly PostgreSQL with PostGIS.
* Experience with data analysis and reporting tools.
* Experience with agricultural data or smart irrigation systems is a strong preference.
* Working knowledge of Geodata Structure.
* Good command of English language, excellent communication, and interpersonal skills, and should have high standard of written and oral presentations.
* Demonstrated writing, analytical, presentation and reporting skills.
* Experiences working under challenging circumstances and in a multi-disciplinary team with minimum supervision and under pressure.
* Extensive experience in conducting and facilitating training and-or workshops.

The role and responsibilities of the team are illustrated in Table 3.

 **Table 3.** Roles, Responsibilities and Deliverables

|  |  |
| --- | --- |
| **Consultant**  | **Roles and Responsibilities** |
| **Irrigation and Drainage Expert:** The input will be 3 man-months. | * Coordination roles and responsibilities in leading the project team members.
* Conduct a comprehensive assessment of current irrigation and drainage practices in the Nile Basin, identifying challenges and opportunities for improvement.
* Collaborate with relevant stakeholders, including government agencies, NGOs, and local communities, to promote the adoption of smart irrigation and drainage practices.
* Provide capacity building trainings for professionals from NBI Centers and member states and stakeholders, scheme owners and operators to enable them apply RS in irrigation water management and performance assessment.
* Review the economic, social, and environmental impacts of smart irrigation and drainage interventions in the Nile Basin.
* Collaborate with research institutions to contribute to the development of innovative solutions for sustainable water management in agriculture.
* Monitor and evaluate the performance, reliability, and accuracy of smart irrigation projects, making recommendations for continuous improvement.
* Organize regular side events (probably with NBDF) dedicated to use of modern technologies and assessment results of monitoring of irrigation performance for experience sharing between Nile Basin countries and beyond.
* Responsible for organizing and leading the procurement of the Satellite EO datasets and products together with GIS and RS experts and ENTRO Procurement officer (the satellite EO data and products will be the properties of ENTRO).
 |
| **GIS and Remote Sensing Expert:** The input will be 70 man-days | * Contribute to establishment of the Dashboard in collaboration with Information Management System (or Software) Expert.
* Provide Spatial Analysis and Mapping Services:
	+ Utilize a comprehensive range of methods, including Artificial Intelligence (AI) among others, to extract valuable insights from Earth Observation (EO) data. Additionally, engage in geomodelling activities to enhance understanding and analysis of geological features and processes.
	+ Support Nile Basin Multi-Sectoral Investment Opportunity Analysis.
	+ Undertake cartographic modeling/spatial analysis and support the assessment of potential environmental, socioeconomic impacts of various investment options, with the aim to identify investments that spatially optimize water use at a Nile basin level.
	+ Perform spatial analysis that supports a study on environmental benefits of the Nile basin floodplains (in line with the NCCR project thematic areas) and the impact of regulation on recession agriculture and livelihood on the downstream floodplains.
	+ Develop optimized color and symbol schemes for different mapping needs that could be used to facilitate production of maps for various purposes (such as atlases, maps to be published on both internal and external web portals, etc.); and carryout baseline mapping of the physical resource base (climatic, hydrologic, hydro-geological, socioeconomics and environmental, etc.).
	+ Support the development of socio-economic and environmental baseline information for the Nile basin.
	+ Upgrade and enhance web mapping application.
	+ Configure, maintain, and upgrade enterprise web mapping, spatial and non-spatial database server applications.
	+ Geodatabase hosted on the external web server contains sample data from FFEWS and watershed projects.
	+ Provide information on the bio-physical and socio-economic situations and publish map services (geometry, map, feature, KML, WMS, etc.) on both internal and external servers.
	+ Upgrade and enhance the web mapping application in terms of graphic user interface and functionality (interactive map display, query features and feature attributes and different geo-processing tools as per needs).
	+ Support the enhancement and the conversion of different toolkits from Excel to html format and publish on web portal-based application using open-source JavaScript framework for interactivity.
	+ Migrate folder and file-based project knowledge bases and knowledge products into SharePoint which will be hosted on both internal and external web portals.
	+ Work closely with ENTRO/NBI communication specialist and IT unit to update web portal contents.
 |
| **Information Management System (or Software) Expert:** The input will be contracted for 2 Man-months. | * Establishment of the Dashboard and building the required toolkit.
* Information Technology (IT):
	+ Ensure the RS EO data and products, information, files, and documents are up to date.
	+ Indexing the ports in/outlets of the data centers (at NBI centers) for the data exchange and communication between the databases and IKP platform accessories.
	+ Support the implementation of ICT strategies and plans in the Nile basin countries and NBI caters. Provide computer training as well ad-hoc technical assistance to users and stakeholders.
	+ Maintain documentation of processes, procedures and troubleshooting guides including tracking EO data/information service requests through completion of the Smart Irrigation project.
	+ Conduct Nile basin-wide information management and knowledge base infrastructures, this shall include sharing of Satellite Earth Observation data and information database and website platforms in line with the existing NBI/IKP and future conditions under different scenarios.
	+ Responsible in generating information that needs to be simulated from the water smart irrigation toolkits and knowledge products.
	+ Work closely with each Nile basin center (ENTRO, Nile-SEC and NELSAP-CU) in IT activities, data-information, and knowledge base development.
	+ Provide training on the use of the EO database management, links and access in the existing network system how to archive and retrieve official data/information and documents.
	+ Supporting the procurement of the Satellite EO datasets and products with GIS/RS expert and ENTRO procurement officer. The satellite EO data and products will be the properties of ENTRO.
* Information/Knowledge Management (KM):
	+ Ensure knowledge management team (comprising at least of the GIS Specialist, Natural Resources Management Specialist, Librarian, IT Officer, Communications Specialist, etc.) and provide leadership to the team to strengthen and sustain knowledge management system.
	+ Manage a process that aims at establishing working routines and attribution of tasks within ENTRO and NBI member countries that assure that relevant information and knowledge shall be readily available to support all ENTRO/NBI tasks and activities.
	+ Ensure assessment of information/knowledge needs management tools for comprehensive information and knowledge exchange and procedures; and develop an integrated database system for data sharing, documentation, and information functions of ENTRO/NBI.
	+ Support interns assigned to assist different activities and generate knowledge product of ENTRO/NBI.
	+ Collect information about physical characteristics and infrastructure within the whole Nile basin region which involves processing, updating and documenting data which is stored in the larger knowledge management system for the NBI (NB-DAS).
	+ IMS expert works with Senior Regional Project Coordinator, Water Resources Management Unit, GIS Specialist, IT Officers, Communications and Social Development Specialist, and Modeling and KM system officers.
	+ Design and implement the smart irrigation database schema including geo-database.
	+ Develop data quality control procedures.
	+ Import and export data from various sources.
	+ Develop queries and reports to analyze data and maintain data visualizations.
	+ Train and support other staff on the use of the database.
	+ Check and up to date on the latest trends in smart irrigation and agricultural data management system.
	+ Package the products and design further use of technology in friendly manner by centers and national offices
 |

**12. Implementation Schedule**

**Table 4.** Implementation schedule for 7 months of effective implementation of the major activities and deliverables.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **SN** | **Millstone**  | **Activities** | **Deliverables** | **Months** |
| **M1** | **M2** | **M3** | **M4** | **M5** | **M6** | **M7** |
| **1** | **Inception Phase** | **Comprehensive literature review** | **Inception Report** |  |  |  |  |  |  |  |
| **Stakeholder mapping**  |  |  |  |  |  |  |  |
| **Inception workshop** |  |  |  |  |  |  |  |
| **Inception Report** |  **●** |  |  |  |  |  |  |
| **2** | **Diagnostic assessment, and guideline Development** | **Diagnostic report identifies common challenges among existing information on irrigation systems and practices in the EN and NEL countries as well as socio-economic and environmental issues related to irrigation.** | **Diagnostic report and guidelines** |  |  |  |  |  |  |  |
| **Guidelines on smart irrigation technologies** |  |  | **●** |  |  |  |  |
| **3** | **Development of system for improved irrigation water use efficiency including Monitoring Dashboard** | **Procurement of EO datasets and maps and establish RS based assessment methods and indicators** | **Dashboard toolkit and Guidelines**  |  |  |  |  |  |  |  |
| **Develop mapping and monitoring processes** |  |  |  |  |  |  |  |
| **integrate RS data and products into NBI/ENTRO database** |  |  |  |  |  | **●** |  |
| **4** | **Capacity building training and result dissemination**  | **Training on application of the developed system for monitoring irrigation** | **Training Materials** |  |  |  |  | **●** |  | **●** |
| **Validation workshop** |  |  |  |  |  |  |  |
| **5** | **Final Phase** | **Submission of final research results, software packages, documents, and final reports** | **Final Report and Project closeout**  |  |  |  |  |  |  | **●** |
|  |  | Activities |  |  |  |  |  |  |  |  |  |
| **●** |  | Deliverables |  |  |  |  |  |  |  |  |

**13. Deliverables of the Project and Payment**

**Table 5:** Deliverable and targeted schedule payment

|  |  |  |
| --- | --- | --- |
| **Deliverable** | **Description** | **Payment** |
| **Task 1** | Inception report and consultation workshop | 20% |
| **Task 2** | * Diagnostic assessment. System establishment, and guideline development
 | 30% |
| * Download and organize all required datasets and update the existing Geodatabase, in addition to acquisition of high-resolution Satellite data for Irrigation schemes mapping.
* Collect measured data to validate model results.
 |
| * Develop databases and installation of software and tools.
* Information management infrastructure and testing of user interfaces, etc.
 |
| **Task 3** | * Establishment of the dashboard /toolkit and testing of user interfaces and data processing toolkits, etc.
 | 30% |
| * Establish a Geodatabase (water balance Geodatabase) using SEPAL, utilizing historical and current satellite data, and installation of required software and tools, etc. for targeted irrigation schemes in NBI countries.
* Integrate sensor data storage with the project geodatabase together with the IT officer.
 |
| * Build a web mapping platform for the smart irrigation project using open-source technologies (Postgres, GeoServer, OpenLayers, Leaflet, etc.) and integrate with the proposed dashboard and the NBI-IKP platform.
 |
| **Task 4** | Draft report and validation workshop and trainings. | 20% |
| Final report, user manual, software packages, geodatabase and tools. |