Technical Assistance Response Plan - Terms of Reference

Country	**Sudan**
Request ID#	**AF-20160000016**
Title	Soil erosion valuation using advanced laboratory measurement methods to support climate resilient agriculture and food security
NDE	*Huyam Ahmed Abdalla* *Higher Council for Environment and Natural Resources* *CTCN focal point* *Khartoum- Sudan* *Mek Nimir Street* *E. hoyamahmed66@gmail.com-Phone:00249129030174* *WhatsApp: 00249908273803*
Proponent	*Natural Resources General Directorate of Ministry of Agriculture and Natural Resources(NRGD)* *Dr.Sawsan Khair Elsied Abdel Rahim Mustafa* *Director General* *Cellular 00249912559438* *sawsanatkh@yahoo.com* *skype: mustafasawasan@gmail.com*

Summary of Climate Technology Centre and Network (CTCN) technical assistance

The Sudanese Natural Resources General Directorate of Ministry of Agriculture and Natural Resources (NRGD) with the support from Climate Technology Centre and Network (CTCN) seeks to evaluate the soil erosion using advanced atomic absorption to support climate resilient agriculture and food security in Sudan. This method is expected to provide a basis over which new or different methods of development of soil- and climate-based systems can be compared and objectively evaluated. Earth Observation based monitoring systems complement the qualitative and quantitative analysis of micronutrients in the soil, enhancing the overall understanding of erosion. EO-based monitoring systems could play a significant role in improving soil information system and crop production assessments by validating soil analysis assessments identified through field soil surveys within a targeted area.

The technical assistance shall contribute to enhance technological capacities by filling information gaps, providing physical and human capacities and demonstration of application Earth Observation technologies. Besides, this technical assistance will support technology transfer mechanism in using atomic absorption and Earth Observation tools including the use of UAVs in monitoring the climate change variables on soil and their impacts on agricultural productivity, thereby strengthening soil monitoring systems and raising the resilience of the vulnerability of the agricultural sector.

Agreement:

(If possible, please use electronic signatures in Microsoft Word file format)

National Designated Entity to the United Nations Framework Convention on Climate Change (UNFCCC) Technology Mechanism

Name: Mrs. Huyam Ahmed Abdalla
Title: Higher Council for Environment and Natural Resources
CTCN focal point
Date: 16/03/2022
Signature:

Project Proponent

Name: Dr. Sawsan Khair Elsied Abdel Rahim Mustafa
Title:Director General
Date:15/03/2022
Signature:

Climate Technology Centre and Network (CTCN)

Name: Rose Mwebaza
Title: Director of CTCN
Date: 17.03.2022
Signature:

1. Background and context

The unreliable nature of rainfall, together with its concentration in short growing seasons, heightens the vulnerability of the grazing and rain-fed agricultural systems.
Measures and studies of Sudan's rainfall indicated that the frequency of climatic extremes, particularly drought is increasing HCENR (2007).
Rainfall patterns during the period starting from 1941 to 2000 showed a decline in average annual rainfall from about 425 mm/year to about 360 mm/year (a decrease of annual rainfall of about 0.5% per year). As well, the coefficient of variability of rainfall shows an overall increasing trend which is most serious in the arid northern parts of the country where the average variability now exceeds 100% (HCENR, 2007).
Sudan air temperatures have been steadily increasing over the period 1960-2009 (between 0.20 and 0.40 per decade) (HCENR, 2013).
The potential impact of these changes is on agricultural production and farming systems.

Both the SNC (2013) and (NAP, 2014) illustrated that the frequency of extreme climatic shocks is increasing, particularly drought and floods. Frequent drought threatens about 19 million hectares of rain-fed mechanized and traditional farms (INDCs,2015). More than 70% of Sudan's population's livelihood depends on these sectors. Floods in Sudan can either be locally caused by exceptionally heavy rainfall or more widespread, caused by the overflow of the River Nile and its tributaries.Further negative climatic related impacts on agriculture, includes, soil heath, disease outbreaks, water shortages and food crises are experienced from time to time and famine impose a threat at least once in each decade (HCNER, 2007).

Climate impacts on agricultural soil resulted in soil erosion which further impacted crop productivity.These impacts are still not well understood due to the complication of climate and ecosystem changes and lack of soil heath biophysical indicators.
In addition, lack of standardized methodology in evaluating soil erosion, and its effects on crops, interpretations may be attributed to differences in soil profile characteristics, nutrient status, type of crops grown, and prevailing climatic conditions.
The northern region of Sudan, which is harsh sandy soil with erratic rainfall, is usually subjected to high incidence of droughts which is aggravated by the high incidence of windstorms that occur at high velocity during long dry season.
Although the southerly wind prevailing in summer is of shorter duration, it had a profound effect on wind erosion subjecting in habitants to blowing winds and climate shocks, however, overuse of the natural resources and suboptimal land use practices threaten the long-term viability of the land and contribute to persistent poverty.

Recent study indicated that northern region of Sudan was vulnerable to climate change impacts and mainly on wind erosion, sand creping and sand dune movement. These are the most dangerous form of degradation that helped to prevail coarse texture (sand) and the loss of soft components and fertility materials, which negatively affected the productivity of lands manifested to a clear decline in the productivity of agricultural projects in the area(ACSAD ,2019).

The measurement of soil erosion is caused by a few processes running at different temporal and spatial scales that make it very difficult, hence, measures on soil properties that serve as indicators of soil health and can be used to guide management decisions is lacking., this aggravated by lack of applied technologies at national level to overcome these difficulties.

2. Problem statement

Sudan, like other developing countries, is yet to fully take advantage of advanced laboratory measurementmethods for soil analysis and EO-based monitoring systems.
Atomic Absorption Spectroscopy is one of the spectroscopic and analytical techniques, used for the qualitative and quantitative analysis of micronutrients in soil.
EO tools, used for soil sampling, that, can be adopted according to needs.
Unfortunately, Sudan in general and NRGD of Ministry of Agriculture and Natural Resources in particular, and has not however had the opportunity to fully benefit from these innovative technologies due to many types of barriers that can be summaries below*:*

1-Physical

Although NRGD, the institution responsible from soil conservation and land reclamation, has a Central Soil Laboratory for soil, plant, and fertilizers, it is not well-equipped with tools and systems for assessing degree of soil erosions, plant and fertilizers, some instruments are inoperative (Spectro photometer and Flame photo meter), others require replacement to cope with modern ones.

The laboratory was equipped with atomic absorption instrument, but it was not functioning due to the lack of accessories (computer, printers etc..) and lack of software to operate the tool for soil and plant analysis.

There was no fully equipped remote sensing laboratory (limited global positioning system, have no drones, maps printer, computer etc. for soil survey).

2- Technical

Insufficient specialized expertise in the field of soil properties measures.

- No national biophysical soil health indicators
- Low institutional capacities to address climate change adaptations needs in relation to sustainable soil management; inadequate monitoring framework to support climate resilient livelihoods regarding soil,
- Low levels of climate impacts information and communications, low levels of awareness on systematic observation and seasonal forecasting for soil conservation, early warning systems; and lack of skills/know-how in areas of vulnerability monitoring and mapping.

3- Financial

- Financial constrains due to the Sudan circumstances; High cost of capital and interest rates, High inflation rate and high price fluctuations; high cost of operational cost.
- Ineffective coordination between governmental organizations and lack of synergies may increase the cost of implementation.

NRGD seeks to evaluate soil erosion using advanced atomic absorption to support climate resilient agriculture and food security The specific advantage of atomic absorption is that it allows the development of soil- and climate-based interpretation and can also provide a standard starting point against which new or different methods can be compared and objectively evaluated.

Earth Observation-based monitoring systems different methods are mutually complementary, and their combination improves the overall understanding of erosion.

Earth Observation-based monitoring systems could play a significant role in improving soil information system and crop production assessment, which are priorities adaptation measures in agricultural sector.

The technical assistance will thus contribute to enhance the technological capacities by filling information gaps, provide physical and human capacities and demonstration of these technologies' application. The technical assistance will support technology transfer mechanism for using atomic absorption and Earth Observation tools includingdrones in monitoring the climate change variables on soil and their impacts on the agricultural productivity, that will lead to strengthen the soil monitoring systems and raise the resilience of the venerability of the sector and ecosystem.

3. Logical Framework for the CTCN Technical Assistance:

	Month[1]																	
Goal: Evaluate soil erosion using advanced atomic absorption to support climate resilient agriculture and food security in Sudan																		
Outcome: The Technical Assistance will determine the spatial extent of soil erosion hazard, quantify the annual soil loss rates, and delineate the priority areas for climate-smart and sustainable land management (CS-SLM). Additionally, the Project will assess the impact of the on-going soil erosion on the overall soil health and fertility status of the area and provide its conclusions.																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Mandatory Output: Develop communication documents and implementation work plan																		
Mandatory activities: *All implementers must undertake the following activities at the beginning and at the end of the CTCN technical assistance.* **Activity i**: A detailed implementation plan for all activities, deliverables, outputs, deadlines, and responsible persons/organizations, including a gender study and an itemized budget for implementing the Response Plan. The detailed implementation plan and budget must be based directly on this Response Plan. **Activity ii**: Based on the work plan, a monitoring and evaluation plan with specific, measurable, achievable, relevant, and time-bound indicators should be developed to evaluate the timeliness and appropriateness of implementation. The indicators selected in the monitoring and evaluation plan should be aligned with the Closure and Data Collection Report template. This will enable the implementer to complete the CTCN Closure and Data Collection Report at the end of the technical assistance (please refer to Activity 1.4 and Section 14 of the Response Plan). **Activity iii**: A two-page description of the expected impact of the CTCN technical assistance prepared at the start of the assistance, updated at the end of the technical assistance (a template will be provided). **Activity iv**: A CTCN Closure and Data Collection report completed at the end of the technical assistance (a template will be provided).																		
Mandatory Deliverables:																		
i) Implementation plan	X																	
ii) Monitoring and evaluation plan	X																	
iii) Impact description document (initial and final version)	X																	X

[1] The project timeline can be adjusted according to the level of development of the participating country.

iv) Closure and Data Collection Report																			X
Output 1: TA coordination mechanism established																			
Activity 1.1: Map relevant stakeholders and establish a stakeholder working group The activity will identify relevant stakeholders among governmental institutions at the national and sub-national levels, sector professionals, private sector, civil society, academic institutions, and beneficiaries. Based on this list of stakeholders, a limited working group will be created. This working group will oversee supervising the implementation of this Technical Assistance. It shall maintain a gender balance and an adequate representation from vulnerable groups. The working group will provide a technical overview and a high-level guidance at every stage of implementation.																			
Activity 1.2: Organize consultative meetings with the working group Consultative meetings will be held with each member of the working groups to understand previous initiatives that could have been developed, access existing maps, surveys, technical analysis that could have been done as well as to discuss possible sites in which the TA could be implemented based on the need of the drones.																			
Activity 1.3: Organize a multi-stakeholder inception workshop A 3-hours multi-stakeholder workshop will be organized at the beginning of the Technical Assistance, to inform the stakeholders of the start of this TA and ensure their adequate participation throughout the implementation process. This meeting will be held in person. It is expected that a maximum of 50 persons will participate.																			
Deliverable:																			
1.1 Stakeholder mapping report containing a complete stakeholder list.	X																		
1.2 Minutes of the consultative meetings.	X																		
1.3 Minute of the inception workshop with the list of participants, disaggregated by gender, materials used of the workshops and photos of the event.		X																	
Output 2: Selection of the site and data collection																			

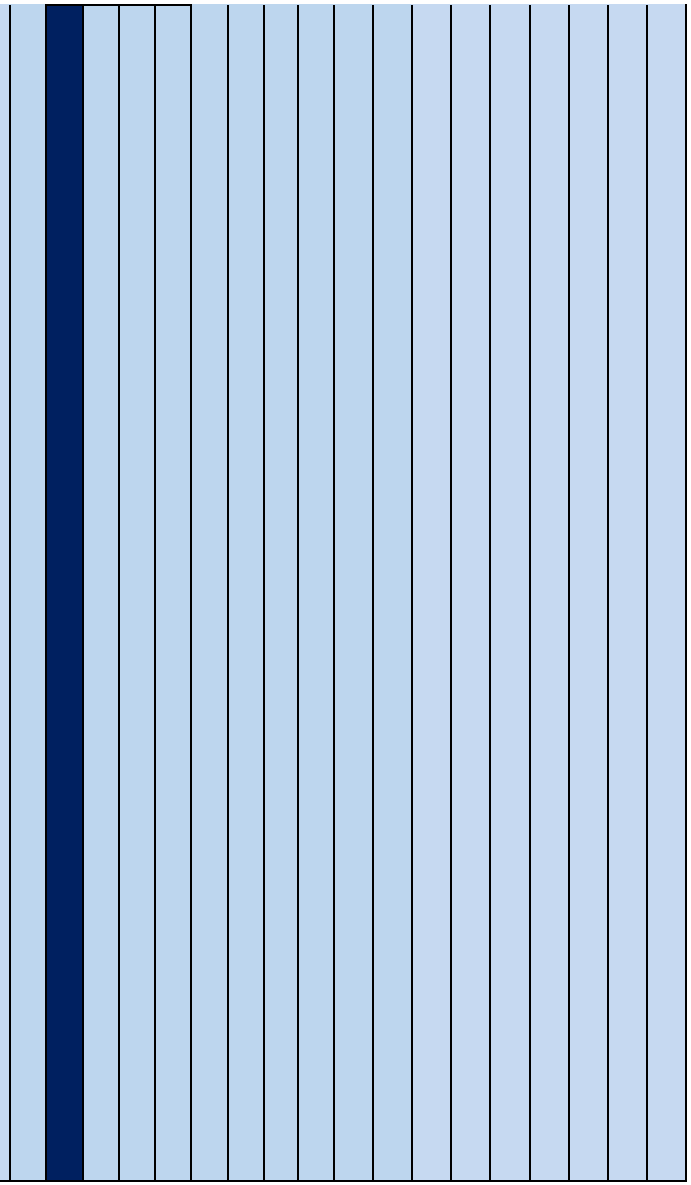
Activity 2.1 Identification of the sites and logistics.
This activity includes the identification of the sites, the planning for each site/area for UAV mapping - appropriate time for UAV acquisition. This activity will also focus on obtaining the clearance from Sudan civil aviation authority (SCAA) on the drone usage for the purpose of this TA.

To be in line with the acquisition dates and time for better UAV+ Satellite fusion, a total of 50 Km2 (tentatively) drone imagery is to be collected by the fixed-wing drone.
The following issues should be dealt with before or during flight mission planning:

- Adequate time should be allocated to test the fixed-wing drones. At least one tested backup drone should always be on standby in the event the primary drone develops technical issues.
- Travel time while in the field - A significant amount of time is lost due to traveling to mission sites. To address this challenge, the team should be set up close to areas where missions will be taking place and be flexible to change set up locations.
- Time for data acquisition - Mapping missions should be planned for when the sun would be directly overhead and hence shadows would be shorter. If images are captured too late in the day, the shadows tend to be longer and thus compromise the data quality captured. An option would be to follow acquisition plans for Sentinel 2. Missions to be undertaken between 11 am and 2 pm to avoid long shadows.
- Each flight to be within a 1-kilometre geo-fence i.e., within a visual line of sight (VLOS) as prescribed by most civil aviation authorities. As such each flight shall be able to capture at least 1 km2
- On a good day, 3 flights can be achieved therefore meaning 3 km2. Therefore, to cover 50 km2 it will take approximately 17 working days of drone survey missions. Weekends should be reserved for the UAV pilots to rest, recharge equipment and back up data.

While conducting the missions, the team should ensure the following are available on site to support coordination and safety, data capturing and storage:

- Radios - VHF and Airband,
- Modem/ WIFI connection,
- External hard disks,
- Pylon marking cones, Landing zone,
- Diesel powered generator to recharge drone batteries,
- laptops,
- mobile phones for data collection and GPS tracking,
- remote controller,
- drone tablet and radios,
- Tent as a temporary workstation,
- Electrical power cables.



Activity 2.2 Validate baseline data, develop field data collection protocols and map soils The implementer will validate the baseline data with the working group and define a field data protocol that will also be discussed approved by the working group. The advent of light Unmanned Aerial Vehicles (UAVs) has pushed the frontiers of data acquisition and phenomena monitoring. The use of UAV has greatly increased in all fields of earth observation due to their flexibility during field operations and sub-meter spatial resolution datasets provided by a wide range of sensors such as RGB, multi- and hyperspectral optical sensors or lightweight lidar scanners. UAVs have also been used to aid collection of ground reference data for feature extraction such as image classification, spectral indices, extraction of physical quantities and specific features. In recent years, UAVs have been used to collect data on soils. The ideal UAV for soil mapping will be a fixed-wing drone. A fixed-wing drone is often more suitable and beneficial for agricultural applications, where mapped areas are usually large, and take-off and landing space is not limited. Its endurance and high cruising speed allow a greater area of land to be mapped up to 2.6x faster, with an object resolution of cm/inch per pixel, and users also benefit from its ability to withstand high wind resistance – _an important factor when mapping large areas of open land – _as well as reduced labour costs. The drone needs to be fitted with a multi-spectral sensor and thus able to capture R, G, B and NIR as the bare minimum. Most preferably, a fixed-wing with Vertical take-off and landing (VTOL) capabilities that can conduct small- & large-scale drone surveys, designed to cover long distances with a maximum flight time of above 55 minutes. Institutions that own and operate UAV mapping drones will be considered for this consultancy. They should be certified by the Kenya Civil Aviation Authority (KCAA) or any international civil aviation authority and have recent experience conducting small scale mapping surveys using fixed-wing drones both in-country and out of the country. An institution with a back-up UAV is most preferred. The institution should also be able to possess other drone operation ancillary equipment such as extra drone spare parts, radio communication equipment, pylons, anemometer, compass et cetera that are pivotal in any drone survey mission. Proven experience of drone pilots. Authorisation from the Sudan Civil Aviation Authority (SCAA). Fixed-wing UAV exportation.	
Activity 2.3 Formulate a gender analysis study The impact of the consequences of Climate Change on women and youth, along with the role that women play in the management of the land will be analysed, and the needs of the vulnerable population will be described in a gender assessment study.	
Activity 2.4: Data pre-processing and collection of pilot baseline data. Soil is used in agriculture, where it serves as the primary nutrient base for plants. Land degradation is a human-induced or natural process which impairs the capacity of land to function. Soils are the critical component in land degradation when it involves acidification, contamination, and other parameters.	

The analysis of soils is an excellent measure of soil fertility. It is a very inexpensive way of maintaining good plant health and maximum crop productivity. The analysis of soils will determine the current fertility status and provides the necessary information needed to maintain the optimum fertility year after year.

A recent study indicated that northern region of Sudan is vulnerable to climate change impacts which include wind erosion, sand creping and sand dune movement, these are the most dangerous form of degradation that helped to prevail coarse texture (sand) and the loss of soft components and fertility materials, which negatively affected the productivity of lands manifested to a clear decline in the productivity of agricultural projects in the area (ACSAD ,2019).

Representative soil samples randomly/systematically from different locations within the study area will be collected and use the Atomic Absorption Spectrophotometer to give an indication about the number of extractable micronutrients in soils.

Soils will be subject to analysis and classification based on the US Soil Classification System and its modification, while physical characteristics of climate changes in the study area will be analysed.

In this activity the implement will

- Prepare the procurement of Mapping and Data Preprocessing Services of the UAV data
- Collectof pilot baseline data and development of case study/
- Piloting of technologies for collection of a baseline dataset

Activity 2.5 DevelopEarth observation techniques

Earth observation techniques offer an effective and efficient platform for mapping due to improved temporal and spatial resolutions. This capability provides a reliable system with near-term potential to provide stakeholders with timely information on mapping natural resources such as soil.

UAV spectral information has always been supplemented using earth observation satellites such as Sentinel~2 (S2) optical through image fusion experiments. S2 data is available freely with a revisit period of at least 5 days worldwide through the COPERNICUS Earth observation project. The availability of such data at a low cost has spurred development of machine-learning models for mapping and predicting soil. Exploiting the synergy between UAV and satellite data (UAV/Satellite synergy) is essential for understanding the dynamics of the Earth´s surfaces (Künzer, Dech & Wagner, 2015). For instance, UAV can quickly acquire data with high spatial resolution, short revisit period (temporal resolution) and minimal atmospheric effects compared to spaceborne systems (Zhao et al., 2019).

This methodological framework proposes the use of innovative approaches for the multi-sensor assessment and mapping of various soil characteristics based on fused earth observation and UAV to generate information such as vegetation cover types, soil spectral indices and digital surface models (DSMs) - as covariates in investigating soil erosion susceptibility.

Vegetation cover types will be derived to spectrally delineate soil masks from other cover types such as cropland, forestland, open water, and grassland. Soil spectral indices to be generated within the soil masks shall include the Normalized Soil Moisture Index (NSMI), Normalized Difference Soil Index (NDSI), Desertification Soil Index (DSI), Soil Adjusted Vegetation Index (SAVI) and Normalized Difference Vegetation Index (NDVI) to evaluate the soil erosivity. High resolution DSMs will be acquired from UAVs to derive slope and aspect as factors contributing to soil erosion. All the soil erosion covariates would be stacked together to predict soil erosion susceptibility based on ground data collected over sampled areas using android mobile-based handheld GPS fitted data collection equipment. Data derived from UAVs is going to be used for validation.																
Activity 2.6Organize a long field data collection on UAV data It is expected that the implementer will spend an average of 28 days to gather field UAV data, make soil analysis.																	
Deliverable:																	
2.1 Selection of sites on which the assessment will be done along with a clear planning		X															
2.2 a. Validation of the baseline data 2.2b. definition of a field data protocol and map soil					X	X	X										
2.3 Gender assessment					X												
2.4 Collection of pilot baseline data							X										
2.5 Earth observation report							X										
2.6 Photos and explanations of the field data collection on UAV data, soil analysis.																	
Output 3: Soil erosion assessment																	
Activity 3.1: Develop Russle modelling RUSLE modelling approach will be used to determine the spatial extent of soil erosion risk, quantify the annual soil loss rates, and delineate the priority areas for climate-smart and sustainable soil management. The technical assistance will assess soil erosion by water. It will provide a detailed and rapid spatial assessment for land susceptibility to water erosion at minimal cost. This will be transferable across any erosion-prone areas for better land and water conservation practices. Different datasets will be employed in this study including: - Remote sensing TRMM precipitation, - Soil Grids datasets from the International Soil Reference and Information Centre (ISRIC), - Normalized Difference Vegetation Index (NDVI) dataset from the Moderate Resolution Imaging Spectroradiometer (MODIS), - Copernicus land cover layers, - and Shuttle Radar Topographic Mission (SRTM) - Digital Elevation Model (DEM).																	

We shall address this challenge by ingesting RUSLE factors in the Google Earth Engine (GEE) environment to simulate the long-term mean annual soil loss rate through pixel-based estimation and cloud-based processing. This cloud-based computing can rapidly and directly develop refined spatial maps and automate extraction of summary statistics, and hence becoming a transferrable model to assess soil erosion rate. The RUSLE model will be developed to estimate the long-term mean annual soil loss rate due to water erosion based on major soil erosion factors: pedological (soil erodibility: K-factor), climatological (rainfall erosivity: R-factor), topographic (slope length and steepness: T-factor), and anthropogenic (cover management: C-factor; support practice: P-factor).																	
Activity 3.2: Implement Digital Soil Mapping techniques Digital Soil Mapping techniques will be applied to create spatially explicit digital maps of soil functional properties, such as NPK, SOC and pH to assess the impact of erosion on the health of soils of the Project area. This activity will focus on predicting and producing digital maps showing the spatial variability of functional soil properties in the Project area. The functional soil properties will be those that indicate soil health, fertility, and quality. Similarly, the output digital soil maps will aim at answering the following questions: a) What are the spatial patterns of the different functional soil properties? b) Where are the hotspots of soil fertility, health, and quality decline for targeting CS-SLM interventions? To perform these, auxiliary data (environmental covariates) will be retrieved from satellite imagery and existing geodatabases based on the SCORPAN conceptual model of soil development. These data (e.g., Landsat TM spectral reflectance bands, vegetation indices, land cover, climate (rainfall and temperature), topography (elevation, slope, aspect, curvature, topographic wetness index, stream power index, length-slope factor, topographic position index, and upslope area), soil properties, and lithology) will be prepared in a GIS and a spatially enabled database developed. Soil sampling campaign will be conducted to collect samples in a completely randomized design across the study area and analysed for chemical and physical properties (e.g., NPK, pH, SOC and soil texture). Prior to the soil sampling campaign, standard protocols and workflows for soil mapping and soil sampling, including equipment, number of samples, sampling depth, handling, packing, preparation, and analysis will be developed. Functional relationships between the environmental covariates and soil observations will be modelled, and the spatial patterns mapped using appropriate statistical and machine learning algorithms e.g., regression-kriging, support vector regression and random forests). The uncertainty associated with the resultant prediction maps will also be assessed and quantified.																	
Activity 3.3 Develop soil erosion mapping framework- (RUSSLE-GEE framework) The implementer will develop a soil erosion mapping framework that will be discussed and presented to the working group during a meeting. Any changes or amendments will be reflected in the framework and the revised copy will be shared to the working group for review. Up to 3 rounds of comments will be done until the final document is approved**.**																	
Activity 3.4 Soil Based Sampling & Analysis of Micronutrients in Soil This activity will be used by using Atomic Absorption Spectrophotometer/testing logistics.																	

Deliverable:																	
3.1 Russle modelling report and conclusions									X								
3.2 Digital Soil Mapping report and conclusions												X					
3.3 Soil erosion mapping framework (draft, revised and final version)												X					
3.4 Soil based sampling and analysis of micronutrients in soil												X					
Output 4: Monitor the evolution of the erosion overtime and plan actions																	
Activity 4.1: Develop criteria and indicators to monitor the evolution overtime The implementer will define a clear set of indicators as well as criteria that will enable to monitor the evolution (positive of negative) of the erosion of the soil in Sudan**.**																	
Activity 4.2: Develop guidance for Soil erosion modelling The implementer will describe the methodology to be used to control soil erosion through modelling**.** It will include a step-by-step explanation, a list of equipment required, the description of the methodology to be used to collect the data as well as to analyse the results obtained.																	
Activity 4.3: Production of policy briefs on Criteria and indicators and Guidance to develop local soil erosion modelling Finally, policy briefs will be made, both on the criteria and indicators than on the guidance to develop local soil erosion modelling. These policy briefs will be targeting governmental institutions that will be responsible for the follow-up of this Technical Assistance once finalized.																	
Activity 4.4: Identify adaptation measures to address soil degradation and development of strategic action plan The implementer will propose some strategic actions that could be implemented to limit the erosion of the soil and increase the resilience of the region. This plan will be classified from immediate actions to long-terms actions. It will also include the indicators to be used, the impact expended of the action, as well as a cost-analysis of the action. For each action a responsible entity, as well as an estimated budget and timeline should be provided, along with clear indicators for its monitoring and evaluation.																	
Activity 4.5 Consultative and validation workshops to present the action plan, the indicators, the policy briefs, the guidance A workshop in presence of the working group will be organized to present the indicators, the policy briefs, the guidance and to discuss potential improvements. The improvements, comments or corrections received during the consultation workshops will be reflected in the final versions of the products.																	
Deliverable:																	
4.1Definition of thecriteria and indicators to monitor the evolution overtime								X									
4.2 Guidance for Soil erosion modelling								X									
4.3 Policy briefs on Criteria and indicators and Guidance to develop local soil erosion modelling									X								

4.4 Technical analytical report including methods for improving the properties of land productivity and adaptationactions for sustainable soil management										X							
4.5 Minute of the consultative and validation workshops with list of participants, photos, material used for the workshop													X			X		
Output 5: Train stakeholders and disseminate information about the results of the TA																		
Activity 5.1: Organize a 3-day capacity building A 3-day capacity building will be organized. One day will be targeting policy makers, another day will be targeting governmental administrators of the results, and the last day will be used to rain the stakeholders. These workshops will be limited to 25 persons.																		
Activity 5.2 Disseminate information on climate adaptation The implementer will disseminate the results of the TA through collaborative networks and media specialised in climate change adaptation. Before its publication online, the implementer will request the internal approval of the NDE, the project proponent and the CTCN.																		
Deliverables																		
5.1 Minute of the workshops (3 minutes) including a list of participants disaggregated by gender, photos, a d material used.																	X	
5.2 Report on the dissemination of the products with a list of the websites / network partners and climate change platforms in which the Technical Assistance has been disseminated.																		X

4 Resources required and itemized budget:

BUDGET					
Activity	**Sub-activity**	**No. of staff**	**Days**	**Cost/day**	**Total**
Development of implementation planning and communication documents	Prepare and finalize detailed workplan	1	6	250	**1,500.00**
	Develop a monitoring and evaluation plan and impact statement form	1	6	250	**1,500.00**
TA coordination mechanism established	Map relevant stakeholders and establish a stakeholder working group	3	6	300	**5,400.00**
Structured stakeholder engagement	Identification and outreach to key stakeholders for engagement	3	5	250	**3,750.00**
	Staff facilitation to attend engagements meeting (flights. Covid test, airport transfer, Airfare)	3	5	800	**12,000.00**
	Facilitation of 5-day stakeholder engagement meeting (Conference, Allowance)	18	4	90	**6,480.00**
Selection of the site and data collection	Identification of the sites and logistics/Identifying areas of eroded soil that are particularly vulnerable to climate change	1	5	350	**1,750.00**
	Validate baseline data, develop field data collection protocols and map soils - (Soil Scientist)	1	9	350	**3,150.00**
	Gender analysis/Study	1	10	250	**2,500.00**
	Procurement of Mapping and Data Preprocessing Services of the UAV data/Collection of pilot baseline data and development of case study/Piloting of technologies for collection of a baseline dataset	1	42	1200	**50,400.00**

	Developing Earth observation techniques	2	5	250	**2,500.00**
	28 days Field Data Collection on UAV data, soil analysis (DSA for 3 staff for 28 days, Airfare, Car hire for 25 days, Airport transfer, Covid test, Local field Allowances)	3	28	715	**60,000.00**
Soil erosion assessment	Develop - Russle model - RUSLE modelling approach will be used to determine the spatial extent of soil erosion risk, quantify the annual soil loss rates, and delineate the priority areas for climate-smart and sustainable soil management (Soil Scientist)	1	8	350	**2,800.00**
	Digital Soil Mapping techniques - Digital Soil Mapping techniques will be applied to create spatially explicit digital maps of soil functional properties, such as NPK, SOC and pH to assess the impact of (Soil Scientist)	1	10	350	**3,500.00**
	Develop soil erosion mapping framework-(Proposed_RUSSLE-GEE framework) - (Soil Scientist)	1	10	350	**3,500.00**
	NRGD Budget (Soil Based Sampling & Analysis of Micronutrients in Soil by Using Atomic Absorption Spectrophotometer/testing logistics) -	1	1	30000	**30,000.00**
Monitor the evolution of the erosion overtime and plan actions	Develop criteria and indicators to monitor the evolution overtime - (Soil Scientist)	1	5	350	**1,750.00**
	Develop guidance for Soil erosion modelling - (Soil Scientist)	1	5	350	**1,750.00**
	Production of policy briefs on Criteria and indicators and Guidance to develop local soil erosion modelling - (Soil Scientist)	1	5	350	**1,750.00**
	Identify adaptation measures to address soil degradation and development of strategic action plan - (Soil Scientist)	1	10	350	**3,500.00**

	Facilitation of a 3-day validation workshop on products (Conference & participants allowance)	15	3	90	**4,050.00**
	Facilitation of a 3-day validation workshop on products (Staff DSA, Covid test, Airport transfer, Airfare)	3	5	600	**9,000.00**
Training on UAV and remote sensing technologies	Identification of training participants and development of training materials (Staff DSA, Covid test, Airport transfer, Airfare)	3	7	450	**9,450.00**
	Facilitation of a 5-day training on UAV and remote sensing technologies (Conference & participants allowance)	18	5	70	**6,300.00**
	Procurement of Computers &Tuition fee of one staff for UAV pilot license	1	1	3000	**3,000.00**
	Web site, Media and publicity, Creation of Policy briefs & Communication plans	1	1	9000	**9,000.00**
	Action plan/synthesized report	1	1	5000	**5,000.00**
Technical Assistance Close out	Submission of the final technical report and deliverables	1	9.5	500	**4,750.00**
Total Budget					**250,030.00**

5 Profile and experience of experts

Experts required	Brief description of required profile
International experts	
Team leader and expert in Soil mapping I1	PhD or master's degree in GIS, Forestry, Soil mapping, agriculture, or affiliate.At least 12 years of experience in a lead role in mapping and assessing soils.Experience with coordinating and liaising with multiple national and international agencies. Experience of preparing policy briefs Experience in defining action plans to increase the resilience of the country to climate change. Experience with African countries is highly desirable Qualified women candidates are highly encouraged to apply.
GIS, Web and tools developer, database management expert – I2	Master's degree or above in database management, GIS, Web development. At least 10 years of experience in using and treating GIS data, creating web pages, and developing internet tools. Qualified women candidates are highly encouraged to apply.
Soil expert /Scientist - I3	PhD or master's degree in science, forestry, Soil mapping, water, agriculture, or affiliate. At least 12 years of experience in a lead role in mapping and assessing soils. Experience in dealing with data generated by UAV, Earth observation techniques, Digital Soil Mapping techniques, Russle. Experience in developing guidelines, develop criteria and indicators to monitor the impactof future actions.
National experts	
UAV soil mapping team– N1	Master's degree in the use of Drone, Forestry, soil mapping. At least 10 years of experience mapping soils and using drones in Africa. Strong familiarity with the context, challenges, and opportunities of mapping soils in Africa. Qualified women candidates are highly encouraged to apply.
Gender Expert – N2	A Master's or bachelor's degree specialising in gender studies or other related field from a recognized university.At least 8 years of experience in mainstreaming gender benefits in development programs. Knowledge of climate change and forestry / water sectors. Qualified women candidates are highly encouraged to apply.

6 Intended contribution to the expected impact of the technical assistance

The technical assistance will contribute to enhance the technological capacities by filling information gaps, provide physical and human capacities and demonstration of these technologies' application. The technical assistance will support technology transfer mechanism for using atomic absorption and EO tools including drones in monitoring the climate change variables on soil and their impacts on the agricultural productivity, that will lead to strengthen the soil monitoring systems and raise the resilience of the venerability of the sector and ecosystem.

7 Relevance to NDCs and other national priorities

- Sudan's INDCs2013 was based on the Sudan's strategy to integrate climate mitigation and adaptation into its national sustainable development process to achieve low-carbon and resilience development objectives.
- Updating Sudan's NDC under process. Agricultural Adaptation Contribution Priorities builds upon national Agricultural Triple Programme for Stability and Economic Development (2021-2023). The programme priority interventions were identified based increase of contribution of agriculture GDP; increase socio-economic growth; addressing sector specific vulnerabilities and achieving the SDGs (Goal 1,2,3,8,13 15, &17). similarly updating Sudan's NDC focusses on development of stakeholder consensus on priority interventions, baselines, and targets on adaptation mainly climate resilient cultivation for agricultural sector; develop indicators of prioritized adaptation interventions; develop monitoring and evaluation framework for adaptation actions which coincides with adoption of EO technology to monitor soil heath and condition for sustained agriculture
- TNA,2013 presented a systematic approach to identify, evaluate, and prioritize technologies for adaptation and achieving sustainable development objectives. agriculture sector was selected as the most important one however, two technologies were selected from the agricultural sector which are Improved crop varieties and conservation agriculture (zero tillage) which characterized by improvement of soil characteristics.
- Sudan Country Programming Paper: Consolidating the Path to Resilience and Sustainability 2019 – 2024. In which drought disaster resilience sustainably is one of its eight priority investment areas. link between drought resilience, adaptive measures and sustainable development supposed to be achieved through soil efficiency improvement practices (Soil conservation - zero tillage).

8 Links to relevant parallel activities:

- One of the on-going efforts on monitoring is Sudan Crop Monitor is a part of GEOGLAM, a GEO global initiative. www.cropmonitor.org,it is an open, timely, and science-driven information on crop conditions in support of market transparency and early warning of production shortfalls. GEOGLAM declared by state parties to strengthen global agricultural monitoring by improving the use of remote sensing tools for crop production projections and weather forecasting". This ensured the importance of developing Earth observation systems. Sudan has not however had the opportunity to fully develop these systems mainly due to technology and financial barriers
- Active technical support project tilted: Developing Methodology and Capacity for Monitoring Climate Change and its Impacts on Agriculture in Sudan through Earth Observations, funded by climate technology center and network. The project aimed to articulates changes in the institutional and behavioral capacities for climate technology development.
- Natural resources geo-databases based on EO for Land Cover Mapping and Land Use Change Detection, focusing mainly on trends, and consequences of the changes. The land cover information was used intensively as a base for food security status assessment in Sudan.
- Recently Drones tool were introduced to strength small scale farms on monitoring and crop assessment within the framework of the Climate Risk finance for Sustainable and climate Resilient Rain-fed Farming

and Pastoral Systems project (2014–2018), to achieve project target on increase in coverage for climate/weather monitoring and access to improved EWS/CI.

- FAO in-2016- 2019 provided technical assistance to Sudan for soil information system(SUSIS) and digital soil mapping, the project identified and described the soil resources in Sudan, ensuring their sustainable and productive use for food security, environmental protection, and the development of strategies to adapt to climate change over the medium to long term. The study recommended that further soil mapping be conducted to produce more refined maps and efforts should also be made to collect feedback from end-users to assess the extent to which their needs are met by the information provided by SUSIS. however, therefore there is still information gap regarding the soil that, vulnerable to the climate change impacts especially in the arid and semi-arid ecological zones. Therefore, a necessity further assessment was needed to provide time-series soil erosion condition, to demonstrate its implications on land productivity and food security in the face of climate change.
- Application of remote sensing on soil erosion has gained substantial consideration, with considerable scientific research work having been conducted in the past. However, soil loss due to soil erosion by water has been identified by ACSAD 2019, as the primary threat to crop production, and food security across the Sudan arid and semi-arid ecological zones

At field practices a conservative agriculture (zero tillage) was prioritized for agriculture sector. it improves the soil, increases production, and decreases the cost of production(TNA,2013)

9 Anticipated follow-up activities after this technical assistance is completed:

Following the implementation of this TA, it is planned that the country will start implementing some of the actions that will be identified in the plan of actions defined to increase the resilience of the country.

10 Benefits in terms of gender and co-benefits:

Imbedded into the design of the activities:	❖ All activities will design to be gender-sensitive and benefit for all. Ministry of Agriculture and Natural Resources, usually create opportunities for discussion and learning, for both
Gender and co-benefits of the activities:	❖ For this proposed action the gender mainstreaming will planned to facilitate integration of gender equality in the design, planning and execution of activities. Gender equality is alsorecognized as an integral part of the stakeholder engagement and capacity building process, essential for achieving social justice, and for ensuring equitable and sustainable human development for all, reports will be gender-disaggregated data and monitoring progress towards gender equality ❖ Technical staff will participate equitably in decision-making related to climate technology implementation and use, so both they will be benefit equitably from technical assistance and project-related training

11 Main national stakeholders in the implementation of the technical assistance activities:

Key stakeholders:

Please list the stakeholders who will be involved in the implementation of the micro-grants project and describe their role during the implementation (for example, government agencies and ministries, academic institutions and universities, private sector, community organizations, civil society, etc.).

Stakeholders	**Role to support the implementation of the micro-grants project**
National Designated Entity	○ Responsible from endorsement of the application to national focal points to the Adaptation Fund Facilitator. ○ coordinate the process of the call organization and finalization

Designated Authority	○ Revise the application prior to official submission via the programme webpage, ○ Confirm statement included in the application template ○ Sign the application before online submission to UNEP-CTCN. ○ Made initial scoping assessment (adaptation needs & gaps in the sector, feasibility of the proposed technologies) ○ Stakeholder consultations (including youth and gender representatives) on the proposed technologies
NRGDNational	○ Development of the draft project concept note ○ implementing entity, host formal meetings, planning, programmes, knowledge sharing, Capacity building (workshops and training) Networking and coordination ○ Make available offices space and facilities ○ Identify and release officers entitled for the fieldwork ○ make available Venues for meetings ○ Evaluation missions Monitoring plan and proposed solutions ○ Reporting documents studies, Exchange visits, Templates ○ Supervising all project activities
Ministry of Agriculture and Natural Resources	○ facilities necessary for the successful implementation. It will: Pay basic salaries for staff, ○ Share knowledge relevant to this technical assistant and perform the operational products. ○ Work closely with the NRGD to ensure ownership of the process ○ Contribute to monitoring and evaluation
Agriculture research corporation	○ Provide information on soil Information and digital soil mapping ○ Part of teamwork and products utilization
Remote Sensing and Seismology Authority /National Centre for Research Ministry of Science and Communications	○ Contribute to process development and products utilization
Sub national Ministry of Production and Economic Resources River Nile State	Formal meetings, planning and coordination's Contribute to monitoring and evaluation:
Relevant funded projects	Networking media and coordination synergies
NDC-Partnership	Operation and management process of the programme
NGO's, private sector	Networking, media, and training

12 Contribution to the SDGs:

Goal:	Sustainable Development Goal	Direct contribution from CTCN TA
1	End poverty in all its forms everywhere	
2	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	The TA will map the soils using climate technologies to increase the resilience of the country to erosion.
3	Ensure healthy lives and promote well-being for all at all ages	
4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	
5	Achieve gender equality and empower all women and girls	
6	Ensure availability and sustainable management of water and sanitation for all	Sudan is facing a strong erosion problem. Erosion is directly connected to water.
7	Ensure access to affordable, reliable, sustainable, and modern energy for all (consider adding targets for 7)	

	7.1 - By 2030, ensure universal access to affordable, reliable, and modern energy services	
	7.2 - By 2030, increase substantially the share of renewable energy in the global energy mix	
	7.3 - By 2030, double the global rate of improvement in energy efficiency	
	7.a - By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology	
	7.b - By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programmes of support	
8	Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all	
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	
10	Reduce inequality within and among countries	
11	Make cities and human settlements inclusive, safe, resilient, and sustainable	
12	Ensure sustainable consumption and production patterns	
13	Take urgent action to combat climate change and its impacts	*All technical assistance should indicate relevance to SDG 13 and at least one of the following targets (13.1 to 13.b).*
	13.1 - Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries	The mapping of Sudanese soils will help defining a plan of actions to increase the resilience of the country to erosion.
	13.2 - Integrate climate change measures into national policies, strategies, and planning	Frameworks, policy briefs, guidance on soil mapping will be delivered.
	13.3 - Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	Governmental institutions will be trained to soil mapping and will be able to comment the deliverables before their final approval
	13.a - Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly $100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible	
	13.b - Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth, and local and marginalized communities	Mapping the soils will enable Sudan to make a better planning and a better use of its resources.
14	Conserve and sustainably use the oceans, seas, and marine resources for sustainable development	
15	Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat	

	desertification, and halt and reverse land degradation and halt biodiversity loss	
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable, and inclusive institutions at all levels	
17	Strengthen the means of implementation and revitalize the global partnership for sustainable development	

13 Classification of technical assistance:

Please tick the relevant boxes below	Primary	Secondary
☐ 1. Decision-making tools and/or information provision	X	
☐ 2. Sectoral roadmaps and strategies		
☐ 3. Recommendations for legal reforms, policies, and regulations		
☐ 4. Financing facilitation		
☐ 5. Private sector engagement and market creation		
☐ 6. Research and development of new technologies		
☐ 7. Feasibility of technology options		
☐ 8. Piloting and deployment of technologies in local conditions	X	
☐ 9. Technology identification and prioritization		

Please note that all CTCN technical assistance contributes to strengthening the capacity of in-country actors.

14 Monitoring and evaluation process

Upon contracting the implementing partners to implement this Response Plan, the lead implementer will produce a monitoring and evaluation plan for the technical assistance.This monitoring and evaluation plan must include specific, measurable, achievable, relevant, and time-bound indicators that will be used to monitor and evaluate the timeliness and appropriateness of the implementation.The CTCN Technology Manager responsible for the technical assistance will monitor the timeliness and appropriateness of the Response Plan implementation.Upon completion of all activities and outputs, evaluation forms will be completed by the (i) THE COUNTRY on overall satisfaction level with the technical assistance service provided;(ii) the Lead Implementer on the experience and knowledge gained through the technical assistance;and (iii) the CTCN Director on the timeliness and appropriateness of the activities and outputs.

Abbreviations and acronyms

CFC	Climate Finance Centre
CIS	Commonwealth of Independent States
CTCN	Climate Technology Centre and Network
EBRD	European Bank for Reconstruction and Development
EU	European Union
GCF	Green Climate Fund
GHG	Greenhouse Gases
HVAC	Heating, Ventilation and Air Conditioning
NDA	National Designated Authority
NDC	Nationally Determined Contribution
NDE	National Designated Entity
SNiP	Construction Norms andRegulations of the Soviet Union
TA	Technical Assistance