



Regional Centre for  
Mapping of Resources  
for Development



## INDICATORS FOR MONITORING THE EVOLUTION OF SOIL EROSION IN AL DAMAR, RIVER NILE STATE, SUDAN



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## **LIST OF ABBREVIATIONS**

CTCN	United Nations Climate Technology Centre and Network
DSM	Digital Soil Mapping
EO	Earth Observation
NRGD	Natural Resources General Directorate of the Ministry of Agriculture and Forests
RCMRD	Regional Centre for Mapping of Resources for Development
RNS	River Nile State
RUSLE	Revised Universal Soil Erosion Equation
SLM	Sustainable Land Management
TA	Technical Assistance



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## 1.0 INTRODUCTION

### 1.1 Background

Soil is a fundamental and irreplaceable natural resource, supporting the survival and socio-economic well-being of the inhabitants of Al Damar in the River Nile State (RNS) of Sudan. The support is mainly achieved through small-scale agricultural activities, which are majorly confined on the banks of the Nile River. The increasing frequency of climatic extremes, particularly droughts, high-velocity wind storms, erratic rainfall, and floods has exposed the soils of the northern parts of Sudan to erosion by both wind and water (Figure 1). Anthropogenic factors, such as inappropriate land use practices and over-exploitation of the natural resource base have also accelerated the rates of soil erosion. The widespread land degradation in the form of soil erosion underpins the low agricultural productivity and per capita income levels in the area. The erosive processes could also increase the vulnerability of communities in Al Damar to future climatic and economic shocks, culminating in human destitution, abandoned unproductive lands, conflicts and migration.



**Figure 1:** Absence of vegetation cover (left) and presence of armoured layer (right), illustrating the ongoing erosive processes in Al Damar

Restoring the degraded soils and averting further land degradation calls for concerted efforts towards Sustainable Land Management (SLM) involvements that will not only address the existing soil degradation issues, but also optimize productivity, incomes and livelihoods in a way that equitably meets the present needs of the communities, while conserving and advancing the various ecosystem services and functions offered by the soils of Al Damar.

To tackle the ongoing soil erosion, the Natural Resources General Directorate of the Ministry of Agriculture and Forests (NRGD) in Sudan sought and received Technical Assistance (TA) from the United Nations Climate Technology Centre and Network (CTCN). The TA was to evaluate soil erosion and the attendant effects on soil functional properties using advanced soil analysis, Earth Observation (EO) and Digital Soil Mapping (DSM) to support climate-resilient agriculture and food security in Sudan. With this TA, the NRGD with the support of Regional Centre for Mapping of Resources for Development (RCMRD) has, *inter alia*, mapped the spatial patterns of soil erosion risk and quantified the annual soil loss rates using the Revised Universal Soil Loss Equation (RUSLE). The resultant soil erosion risk map and estimates will be used as a baseline for future monitoring and reporting on soil erosion dynamics in Al Damar District.

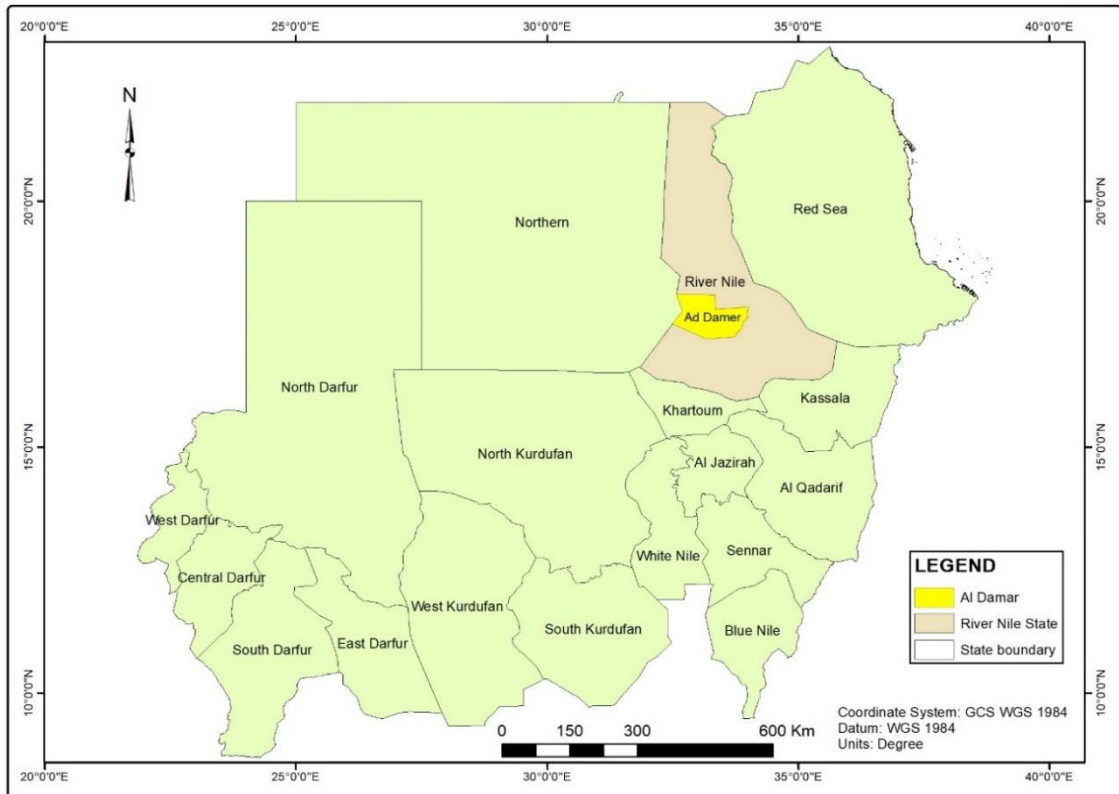
This document has been developed to guide the identification and selection of indicators that can be used to monitor regularly the evolution of topsoil loss in Al Damar, especially, at the hotspots. To prepare it, literature describing the indicators adopted by previous soil inventory and mapping projects were reviewed, and soil experts with years of accumulated knowledge were consulted.

## **2.0 METHODOLOGICAL APPROACH**

### **2.1 Description of Al Damar District**

Al Damar (Ad Damer, Ed Damer) District of the River Nile State lies between Latitudes 17° 11' 9.6" and 18° 6' 46.8" N, and Longitudes 32° 28' 12" and 33° 59' 45.6" E, at an altitude of 1,158 feet (353 m) above sea level (Figure 2). It covers an area of 10,866 km<sup>2</sup>, which is dominated by Aridisols (i.e., dry soils with CaCO<sub>3</sub> accumulations), semi-desert vegetation (i.e., scrubs and grasslands) and semi-arid climatic conditions. The mean annual rainfall is about 56 mm, most of which is received between July and September, relative humidity is less than 40 percent, and temperatures are as high as 43°C between April and June, and as low as 14°C in January. In addition, the shortwave solar radiation is as high as 659 calorie cm<sup>-2</sup> in May, while the mean maximum wind speed is about 17.6 km<sup>-hr</sup>. Owing to these extreme climatic conditions,

agricultural activities are majorly confined on the banks of the Nile River. In terms of physiography, the landform of Al Damar is characterized by flat to slightly undulating desert plains, rising from 100 to 600 feet above sea level, with *wadis*, sand dunes, and low ridges and hills appearing in some parts.



**Figure 2:** Location of Al Damar District in the River Nile State, Sudan

## 2.2 Determination of indicators for soil erosion monitoring

As mentioned earlier, the potential indicators to measure and observe at the hotspots of soil erosion and other selected sites were determined through desk study, whereby pertinent literature describing the indicators adopted by previous soil conservation projects were reviewed. In addition, expert knowledge was leveraged, whereby soil experts with years of accumulated knowledge were consulted, among the key stakeholders, to contribute what they thought were essential indicators for assessing soil erosion.

## 3.0 INDICATORS FOR MONITORING SOIL EROSION

Soil erosion is a complex biophysical process, which occurs at different spatial and time scales. This makes its evaluation difficult to perform in a cost-effective way and to summarize using simple measures. As such, a wide range

of indicators have been developed and used under different circumstances and spatial scales to detect and estimate the relative degree of soil loss. Soil erosion monitoring indicators *per se* are strategies, metrics, or properties that are used to assess both the spatial and temporal changes in soils, as well as other aspects of land. They are environmental variables whose characteristics describe the state of erosion. The indicators should be carefully selected and used in order to get relevant and important information rapidly and cheaply.

Here, an inventory (long list) of the potential soil erosion monitoring indicators for Al Damar is presented (Table 1). This is the outcome of both a scan of pertinent literature and a consultative process whereby people contributed what they think are essential soil erosion monitoring indicators. However, as a next step, soil experts, local communities and land users in Al Damar can reduce the long list, or select a minimum set of indicators to monitor regularly by teasing out what they deem to be the key indicators, or by assigning attributes (and scores) to each indicator in terms of their cost-effectiveness, reproducibility, user-friendliness, and so forth.

### **3.1 Criteria for selecting suitable soil erosion indicators**

The following are some of the attributes that soil experts, local communities and land users in Al Damar should consider and score while identifying and selecting the final soil erosion indicators from the long list to monitor regularly (Table 1; Annex 1). An indicator should be:

- ✚ Cost-effective/ efficient (e.g., data collection should not be too costly)
- ✚ Easy to use/ simple (e.g., data collection should not be too difficult or time-consuming)
- ✚ Based on stakeholder's perception and local conditions
- ✚ Able to be used in combination with other indicators (i.e., an indicator should be selected on its own merit, as well as in relation to other indicators)
- ✚ Able to provide tangible, easily measurable data about changes that occur (i.e., data availability)
- ✚ Able to allow the local people assist in data collection. Therefore, the indicators should focus on practical aspects, be straightforward and make sense to the local people

- ✚ Able to show causal relationship with soil erosion (i.e., ranks highly in the causal process of soil erosion)
- ✚ Relevant

### 3.2 Potential indicators of soil erosion

Table 1 presents the array of indicators that can be used to monitor soil erosion by water and wind in Al Damar.

**Table 1:** Potential indicators for monitoring soil erosion in Al Damar

<b>Indicators</b>	
<b>Water erosion</b>	<b>Wind erosion</b>
▪ Crusting of the topsoil	▪ Presence and amount of suspended particles in the air
▪ Occurrence of compacted soil layers (hard soil surface)	▪ Presence and extent of sand deposits
▪ Sealing of soil pores	▪ Frequency and duration of sand winds and dust events
▪ Absence of vegetation cover (bare soil)	▪ Changes in soil texture
▪ Formation of soil pedestals (pillars)	▪ Density of vegetation cover
▪ Building up of small channels (rills)	▪ Surface crust cover
▪ Building up of deep channels (gullies)	▪ Surface roughness
▪ Presence of sheet wash/ sheet erosion	▪ Presence of wind scouring/ blowouts and sediment depositions
▪ Changes in soil colour	▪ Degradation/ reduction of soil surface horizon
▪ Exposure of plant/ tree roots	
▪ Exposure of rocks	
▪ Exposure of fragipan, or armoured soil layer (stoniness)	
▪ Changes in soil rooting depth	
▪ Presence of tree mounds	
▪ Presence of sediments in drains, river banks, etc.	
▪ Building up of soils/ sediments against barriers (e.g., fences)	
▪ Decolourization of river water (muddy water)	
▪ Changes in soil texture	

▪ Changes in land use systems and practices	
▪ Presence of indicator plants (e.g.,)	
▪ Reduction in the thickness of topsoil (thin topsoil)	
▪ Reduction in crop yields and productivity	
▪ Decline in soil organic matter levels	



**Figure 3:** Crusting of the topsoil



**Figure 4:** Presence of sand depositions



**Figure 5:** Building up of deep channels (gullies)

#### **4.0 CONCLUDING REMARKS AND OUTLOOK**

In a nutshell, soil erosion monitoring indicators are important because they provide a way to measure and track progress towards restoration of soils in a landscape. This document has provided an inventory of indicators that can be used to monitor soil erosion in Al Damar. This is the outcome of both desktop study and a consultative process, whereby specific people shared their perspectives on essential soil erosion monitoring indicators. It is recommended that, as a next step, soil experts, local communities and land users in Al Damar should select a minimum set of indicators from the long list that can be monitored regularly. This can be achieved by teasing out what they deem to be the key indicators based on their cost-effectiveness, reproducibility, user-friendliness, and so forth.

