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Development Suitability Maps for Rainwater Harvesting in the EN Basin

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Background:

RWH site selection is a complex activity as well, and it influences different factors, including both environmental and human-society factors. Meanwhile, RWH structures can be built for different purposes.

The EN basin has good experience in rainwater harvesting; the techniques that are used in the countries are somehow more or less the same.

Ethiopia uses household ponds, community ponds, and small dams for irrigation and livestock.

In Sudan and South Sudan, the purpose of RWH is to provide water for domestic use and livestock by using improved hafirs and small dams.

This study aimed to develop suitability maps for potential RWH in the EN basin by employing a GIS-based MCA approach. Moreover, this study aims to prepare an integrated RWH for all the selected techniques that are of high value for water decision-makers to properly identify suitable techniques that can be implemented in the area. This, in turn, will enhance sustainable water resources in the EN basin.

Study area:

The Eastern Nile River basin drains the eastern part of the Nile Basin, a region that covers much of Ethiopia, Sudan, South Sudan, and Egypt.

The Eastern Nile River basin includes the Blue Nile, the Baro-Akobo-Sobat, the Atbara, and the main Nile.

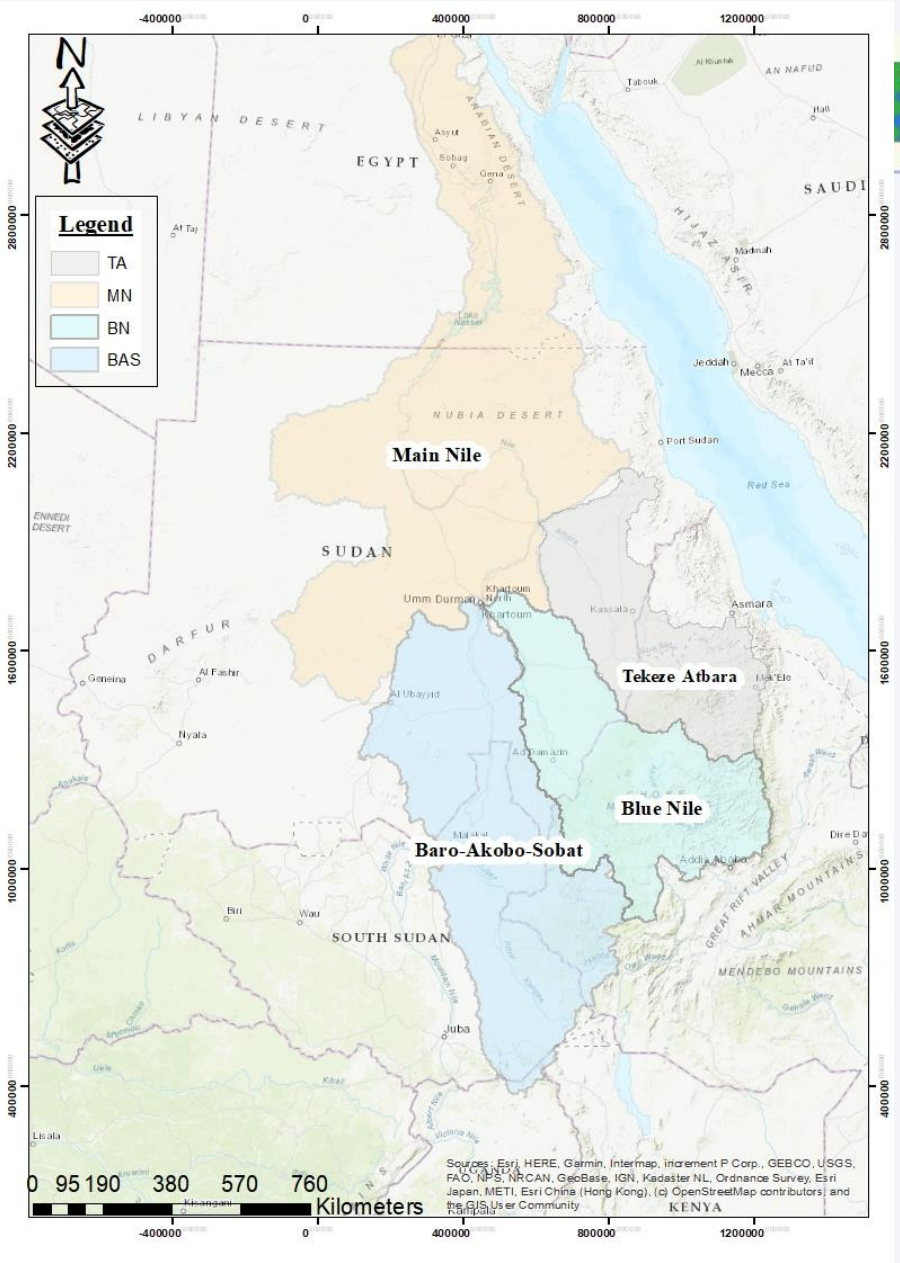


Figure 1 Location map – EN basin

Methodology

Based on the previous criteria and data available for the EN basin, the suitability model framework, which has adopted the analytic hierarchy process, is one of the spatial decision support systems (DSS) that can be integrated into a GIS environment using multi-criteria.

Then, a map of RWH availability was generated. This map will help decision-makers and water resources planners in the EN basin plan rainwater harvesting structures, such as the construction of small dams or ponds in high suitable & suitable areas, to reduce urban flooding in heavy rainfall areas and relieve pressure on available supplies to benefit ecosystems. Therefore, it will help to maintain a sustainable water environment in areas with scarcity potential.

To identify the suitable areas for RWH, the five criteria selected for the identification of potential sites for RWH are:

1) Slope (topography).
2) Land cover and land use (derived from available RS data)
3) Soil map.
4) Rainfall.
5) Runoff depth

Process Flow Chart in shows the model framework.

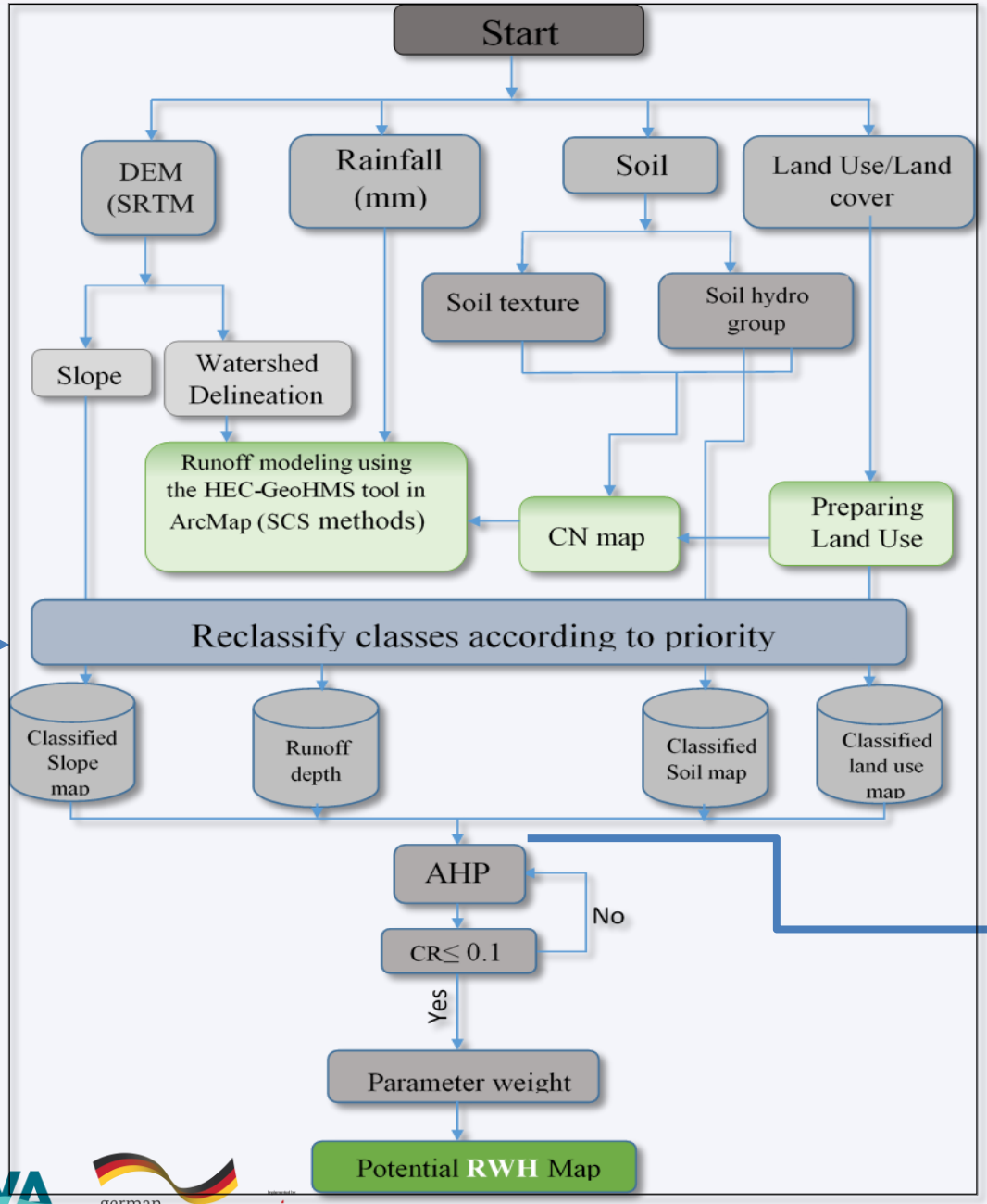


Figure 2 Model framework for identifying potential RWH Sites

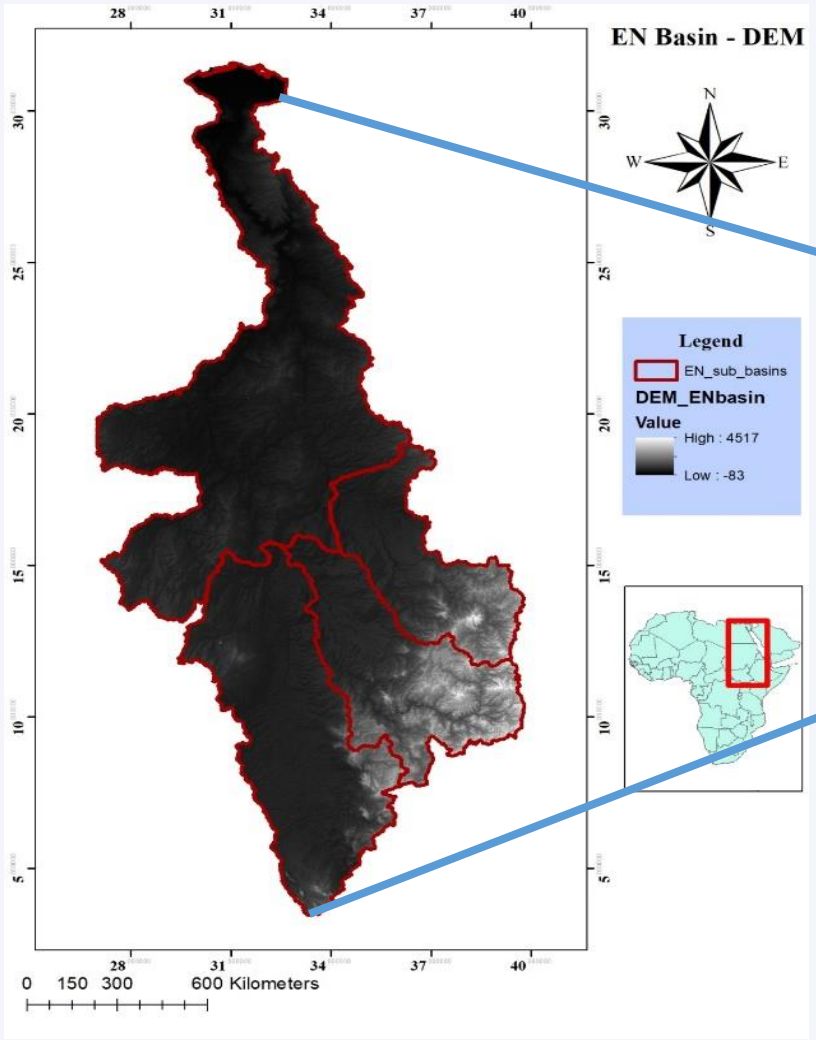
AHP Process.xlsx

Data Sources and Processing

Table (1): Dataset types and places obtained from

DATA	TYPE	CHARACTERISTIC	SOURCE	USE
DEM	Spatial (raster format)Datum,WGS 84	DEM 30m*30m	https://earthexplorer.usgs.gov/	Delineation of the catchment & slope
SHAPE FILES	Spatial	Soil (1:250 000)	ENTRO	Input into RWH potential site suitability framework and SCS CN for runoff computation)
		Land use/cover (1:250000)		
RAINFALL (MM)			ENTRO	Input into the SCS CN model to estimate potential runoff.

DEM data



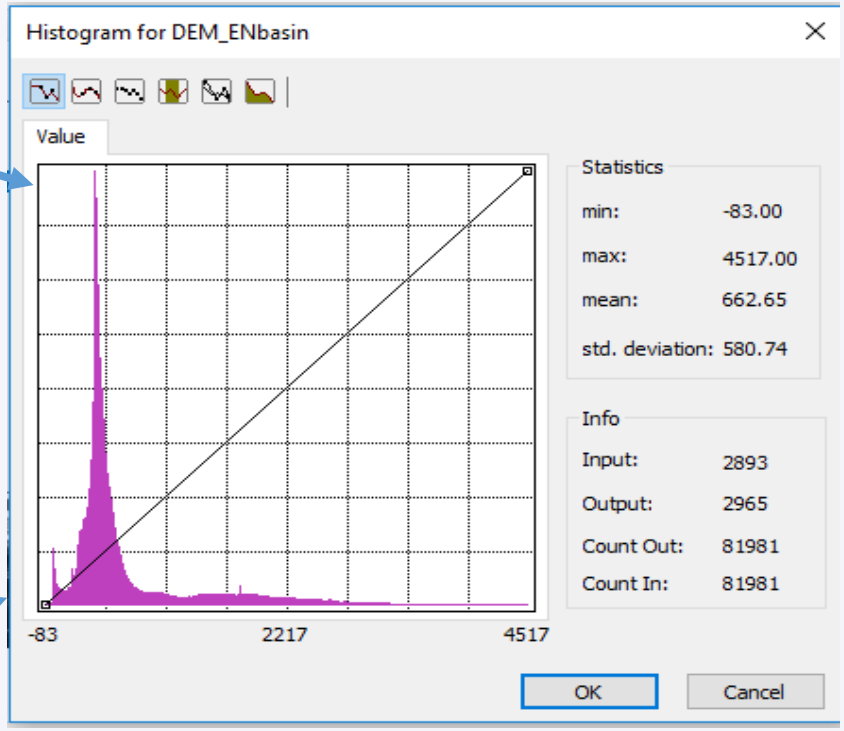


Figure 3 DEM – EN Basin

Slope Map

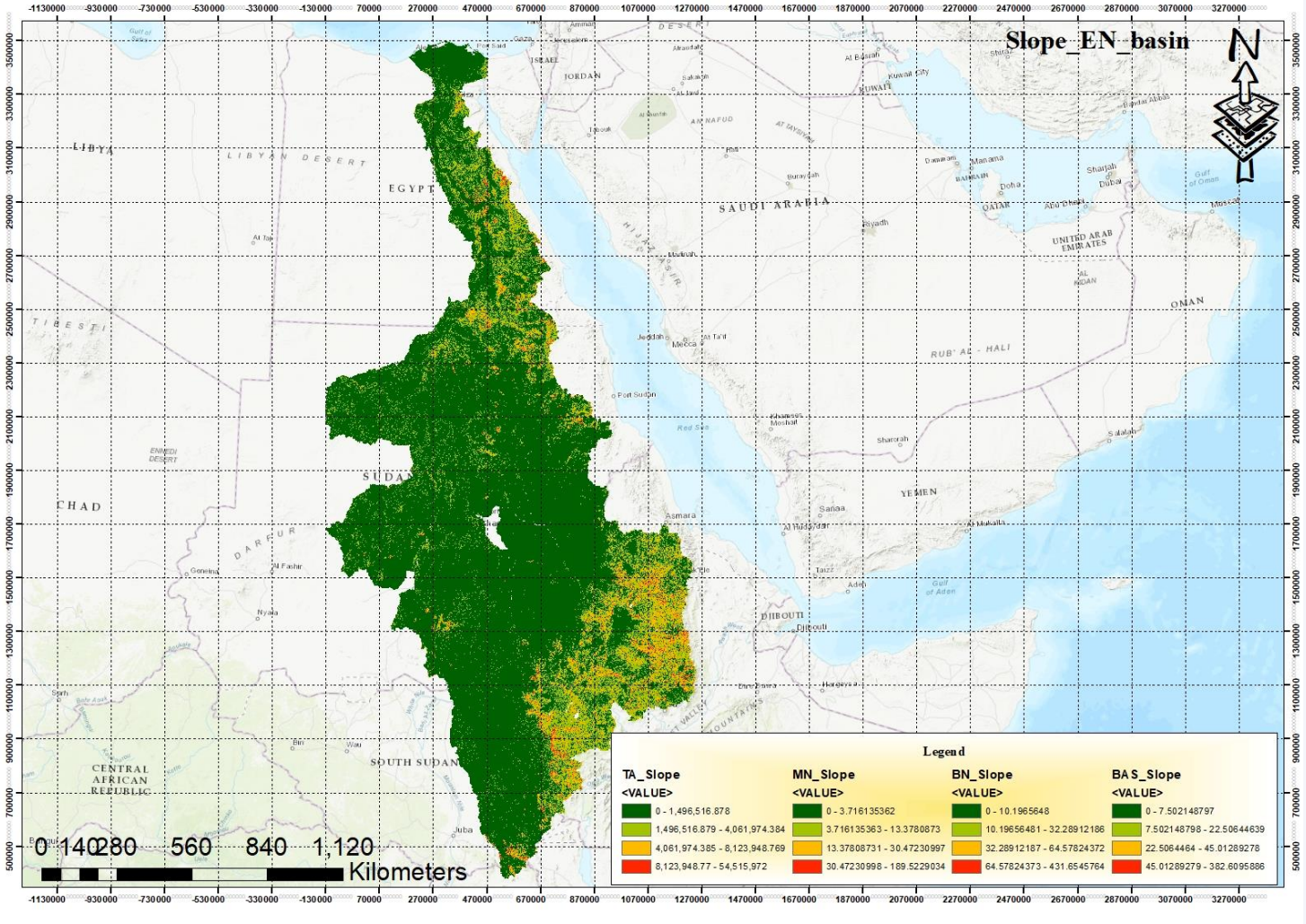


Figure 3 DEM – EN Basin

Land/Use & Soil type

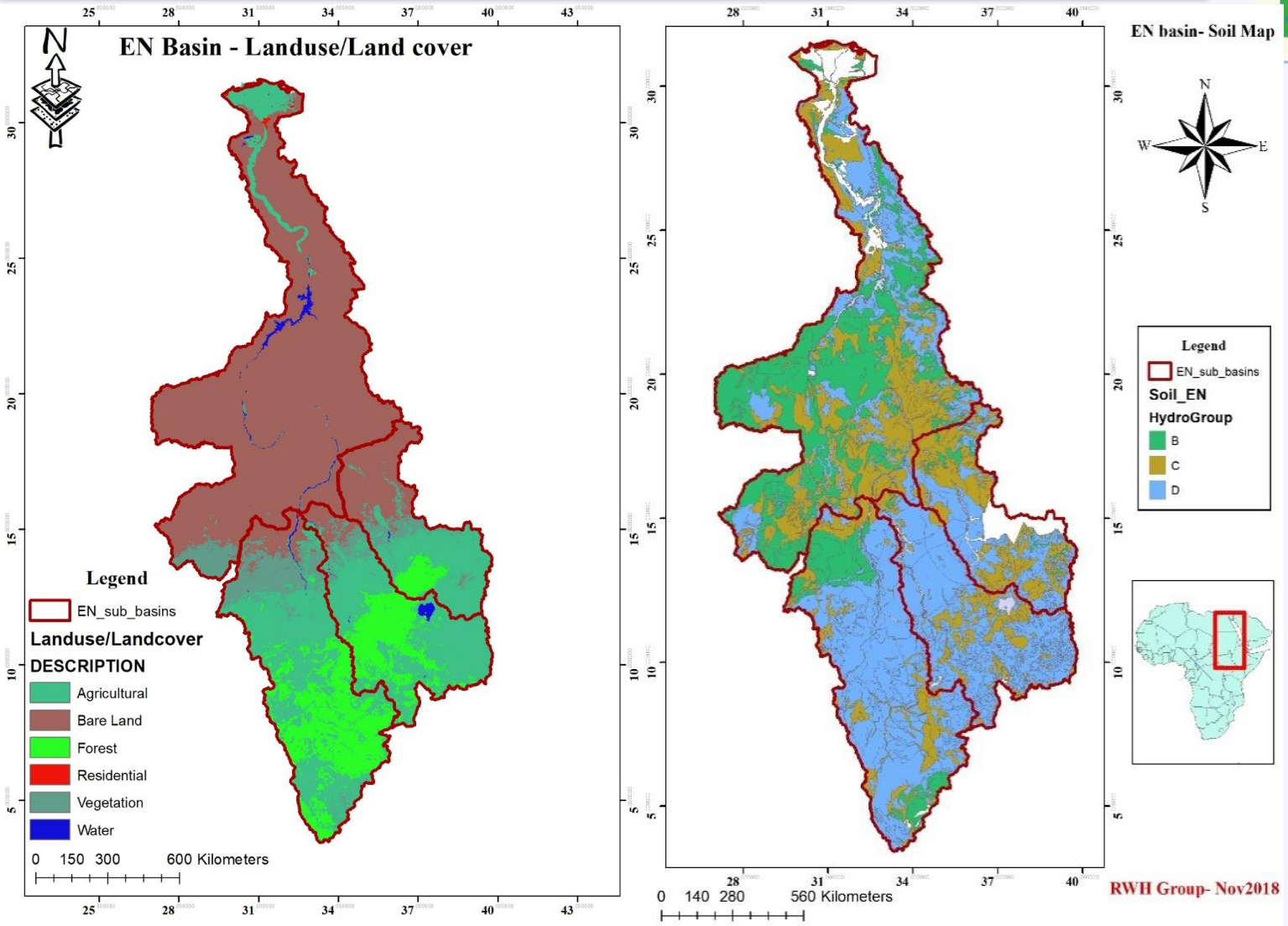


Figure 4 Land/Use & soil – Grid map

Generated CN

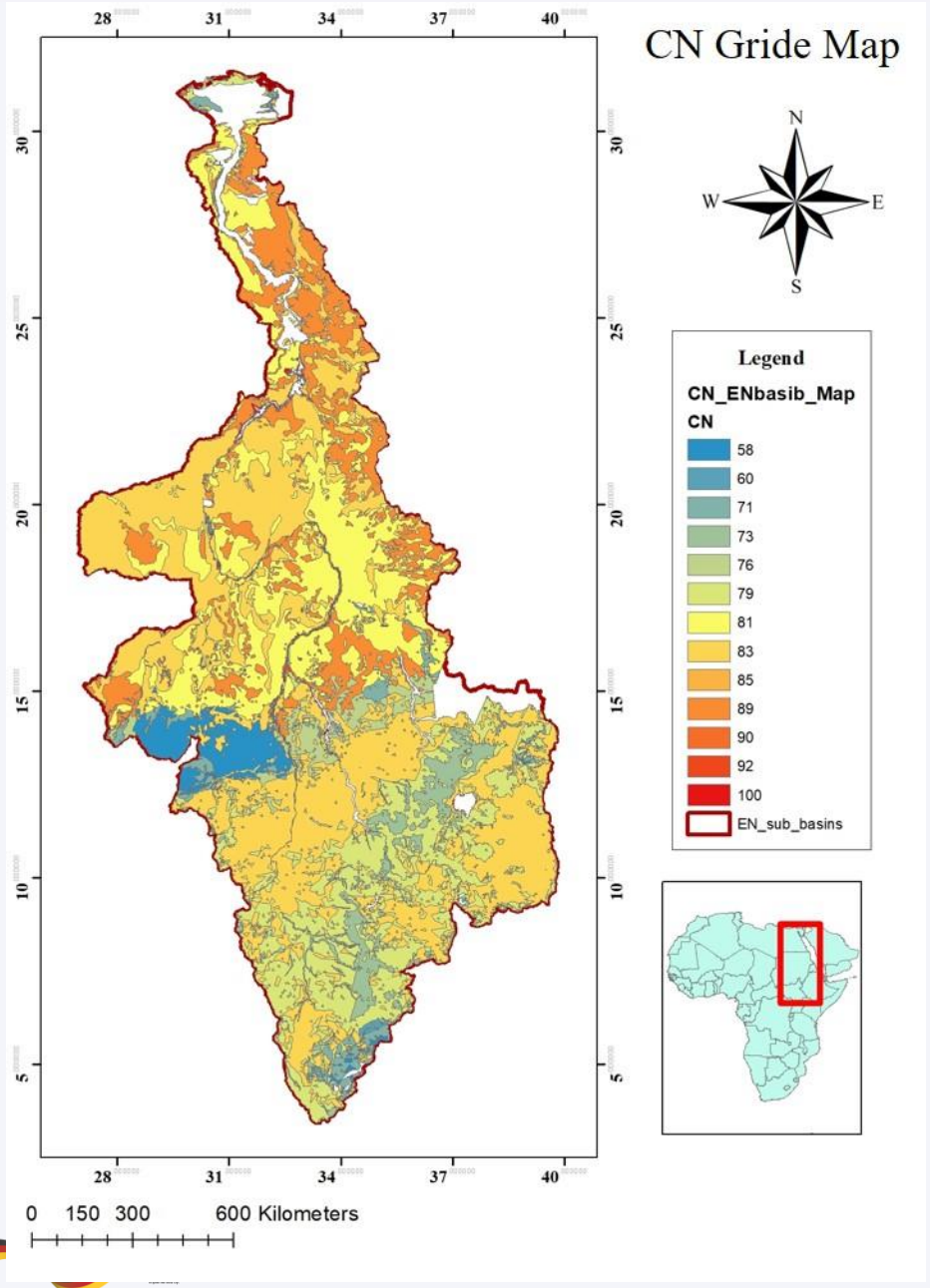
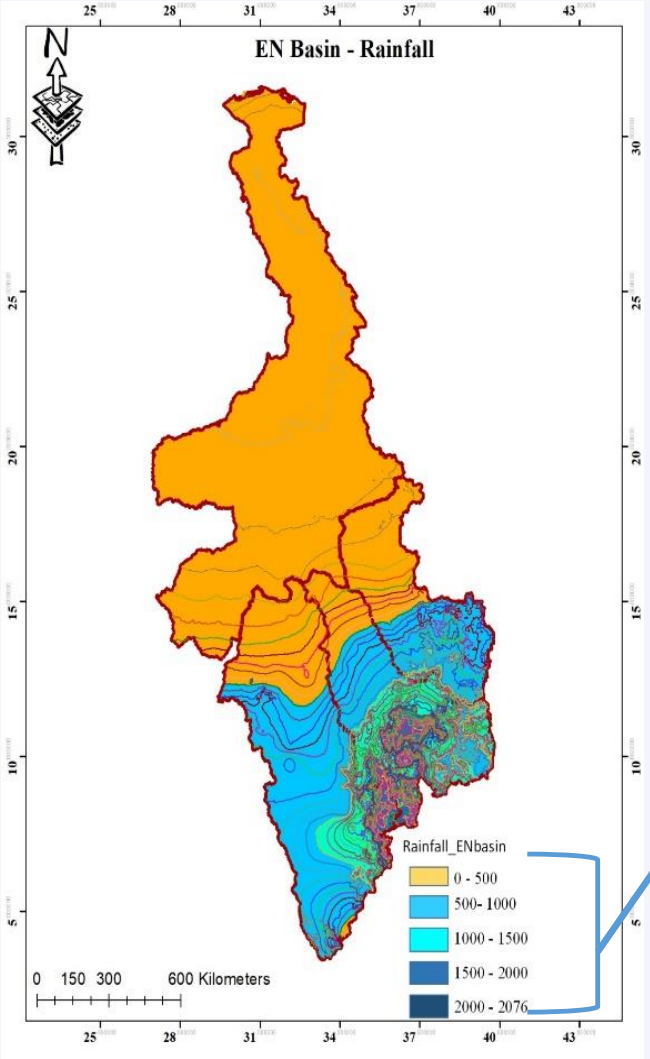


Figure 5 Curve Number(CN)– Grid map

Rainfall data



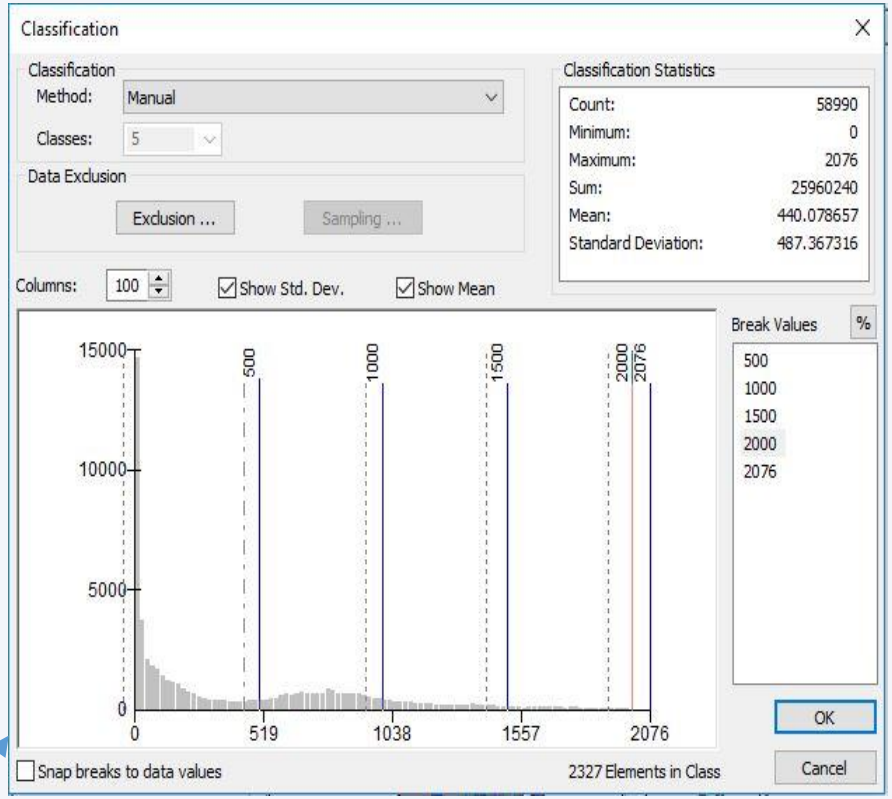


Figure 6 Rainfall – EN Basin

Runoff Depth Estimation

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S}$$

Where:
Q= Runoff (mm)
P= Rainfall (mm)
I_a= Initial abstraction (mm)
S= Potential maximum retention after runoff begins (in)

$$I_a = 0.2S$$

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$

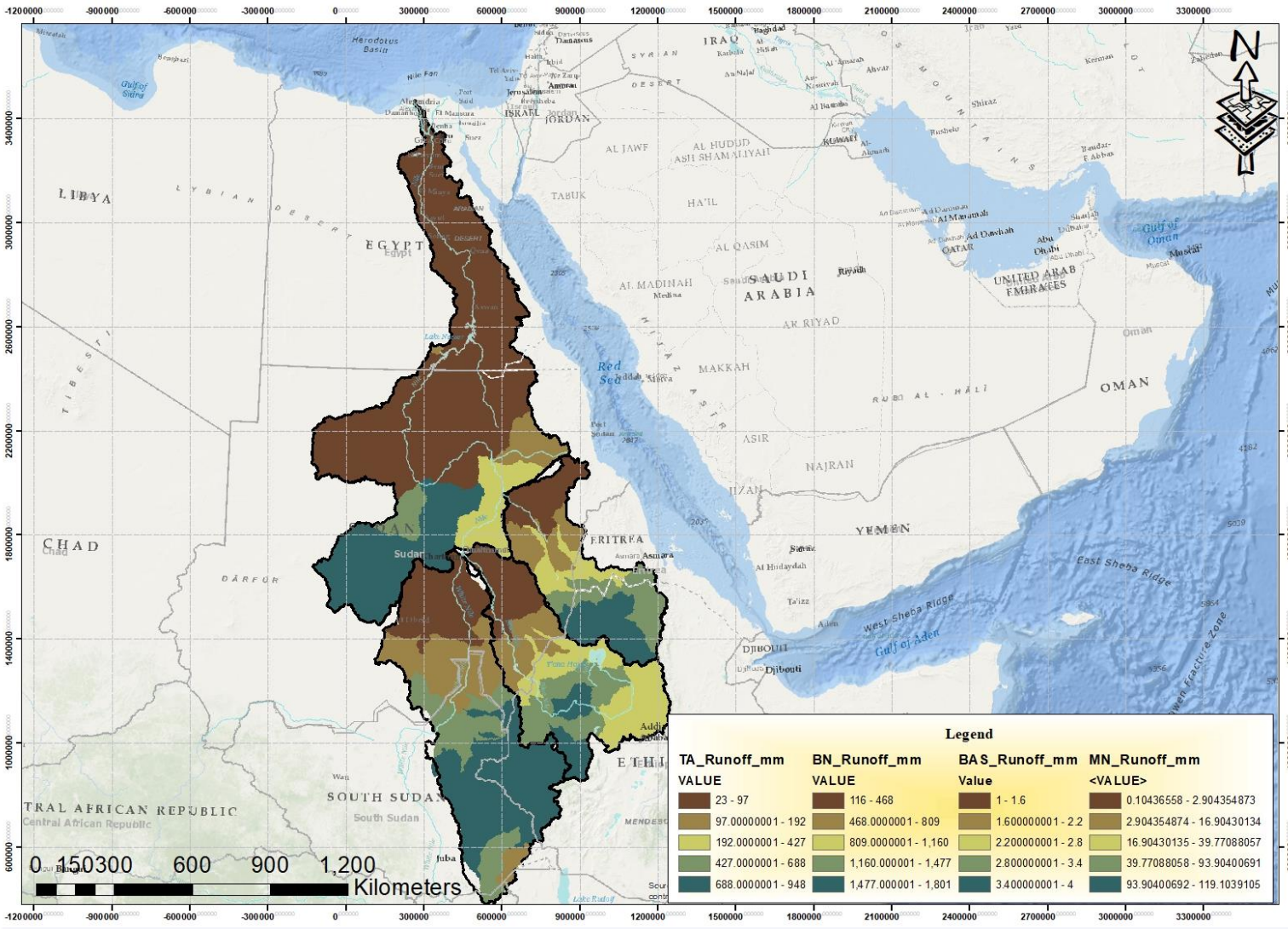
$$S = \frac{25400}{CN} - 254$$

$$Q = \frac{\left[P - 0.2\left(\frac{25400}{CN} - 254\right)\right]^2}{P + 0.8\left(\frac{25400}{CN} - 254\right)}$$

Where:
Q= Runoff (mm)
P= Rainfall (mm)
CN= Curve Number

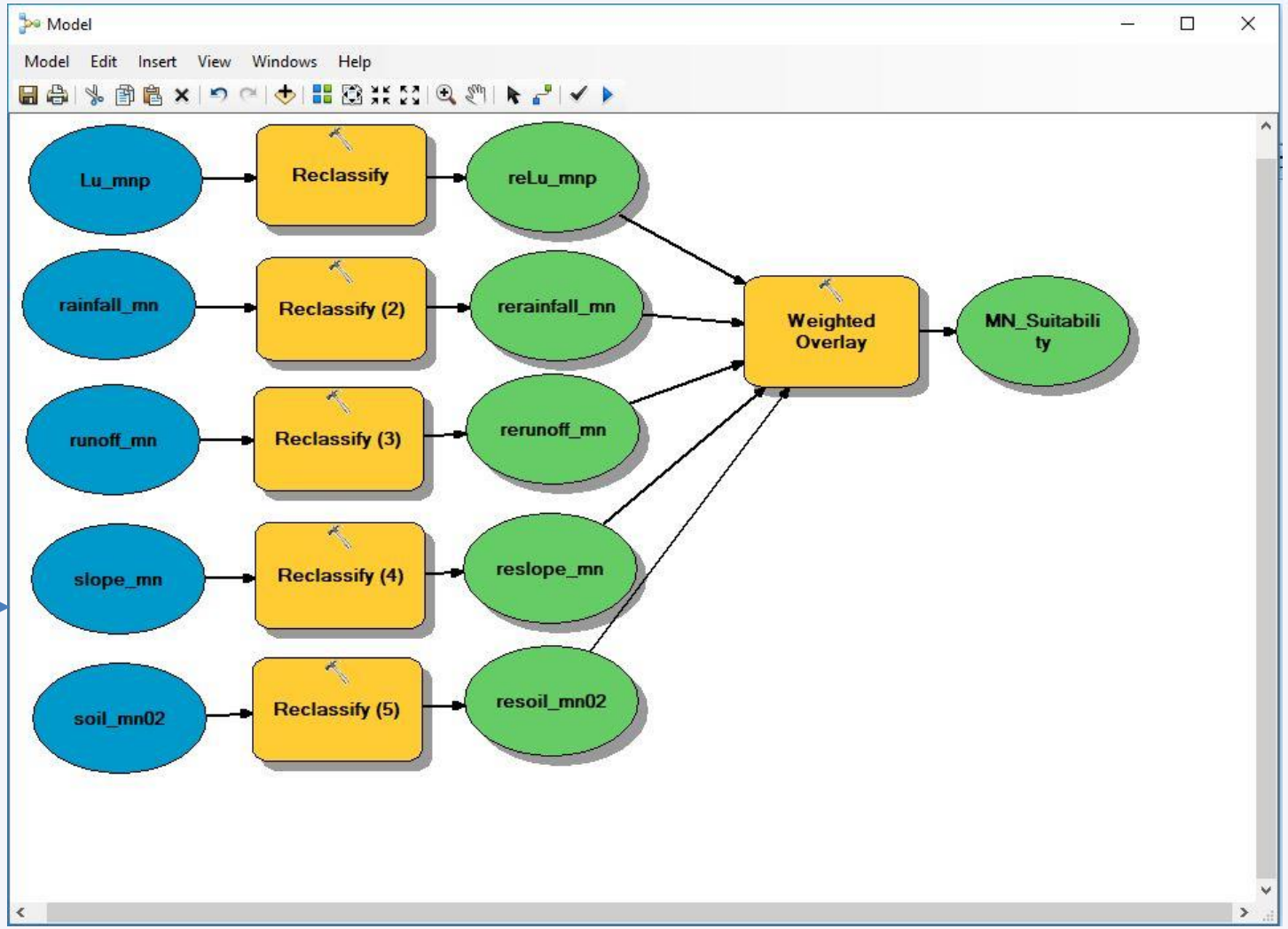
Figure 7 Rainfall – EN Basin

Runoff Depth Results



Weighted Analysis

AHP Process.xlsx



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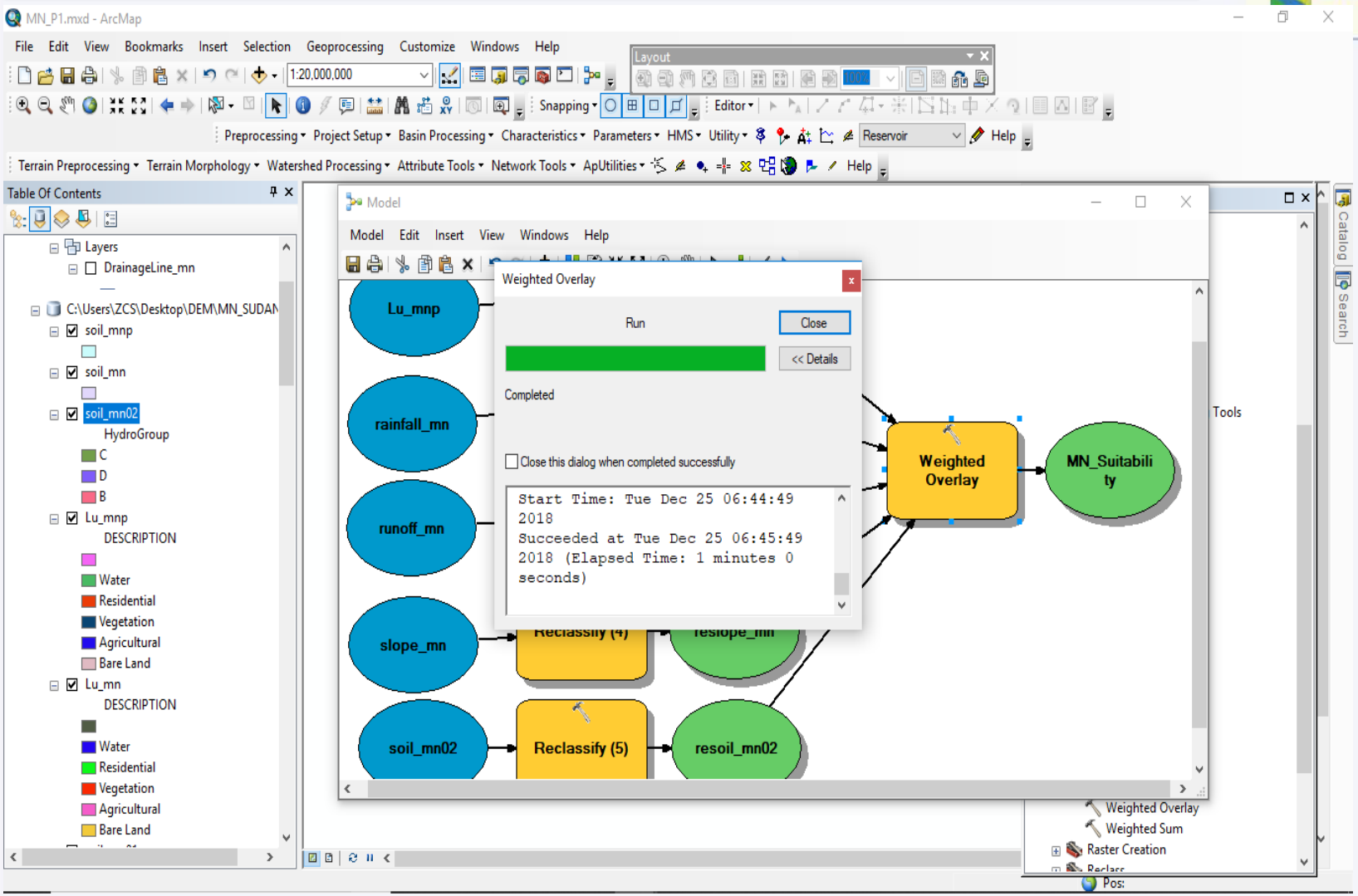
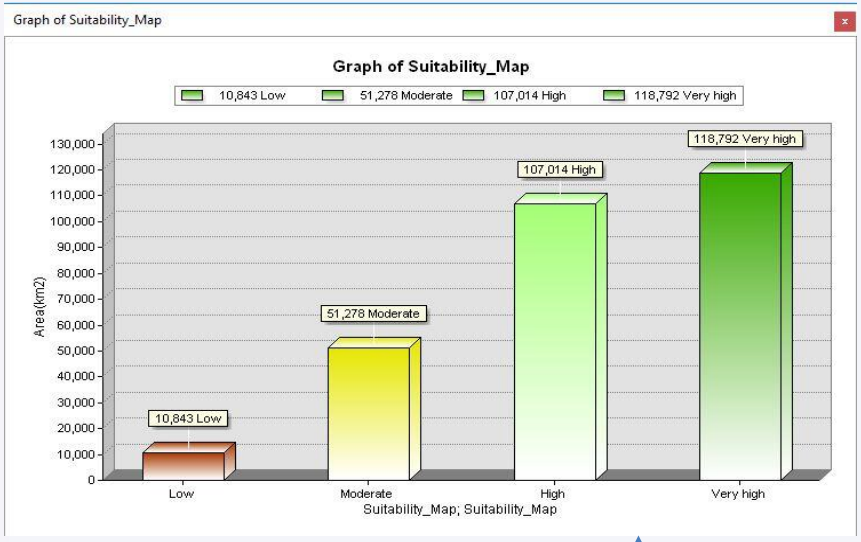
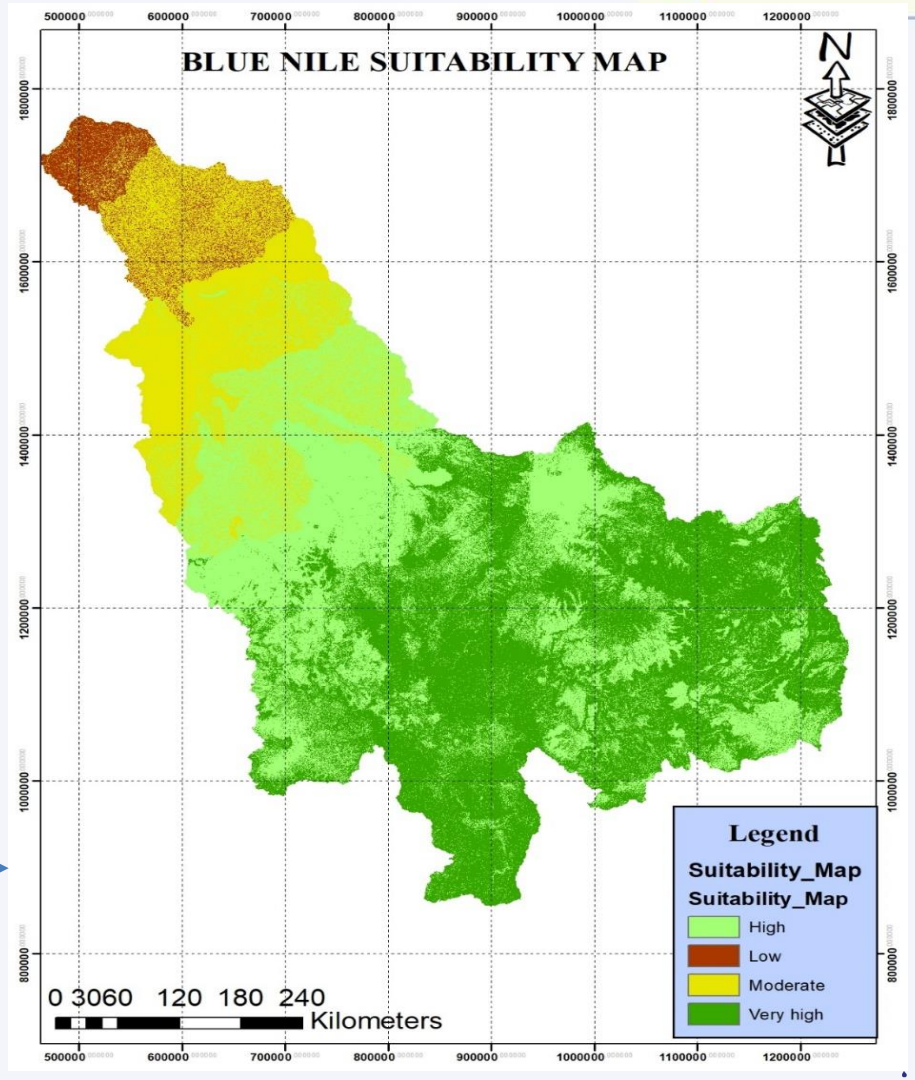


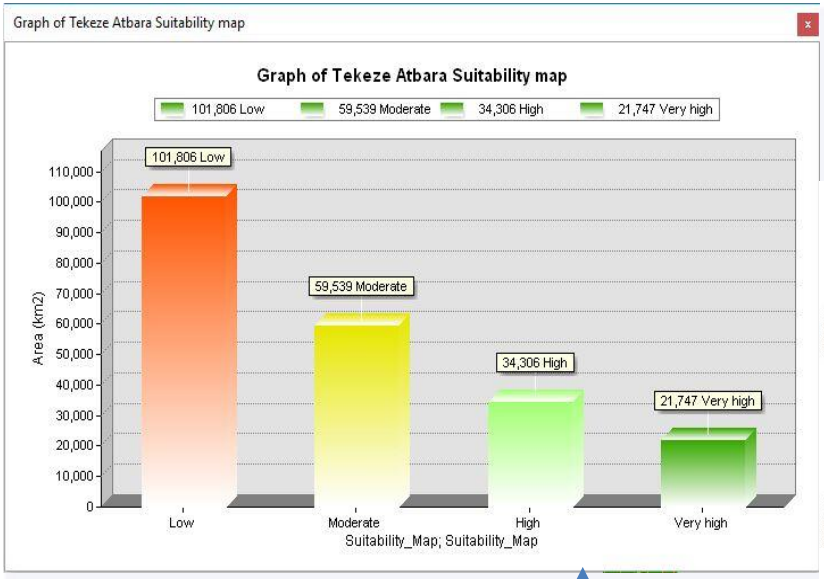
Results

- The integration of factors for suitable areas of RWH was done in Arc GIS based platform in order to generate suitability maps by using the Arc GIS 10.5 model builder. This model used a multi-criteria evaluation that combines different factors such rainfall, soil, slope, land use/cover, runoff depth through a weighted overlaying process. The model generated a suitability map for RWH sites for ENB. The model results indicated that the majority of the land was very high suitable (41 %) and highly suitable (37 %) in Blue Nile sub-basin, also indicated the land was moderately suitable (42 %) and highly suitable (15 %) in Baro akoba Soubat sub-basin. These results show the reliability of the developed RWH model because most of the sites are appropriately located. Therefore the accuracy of the model is found to be satisfactory.
- From the total area of Tekeze Atbara sub-basin, only 52% is suitable for rainwater harvesting.
- A Suitability map for RWH in EN basin, show in figure (4) to figure (6), below.



Output Suitability Map





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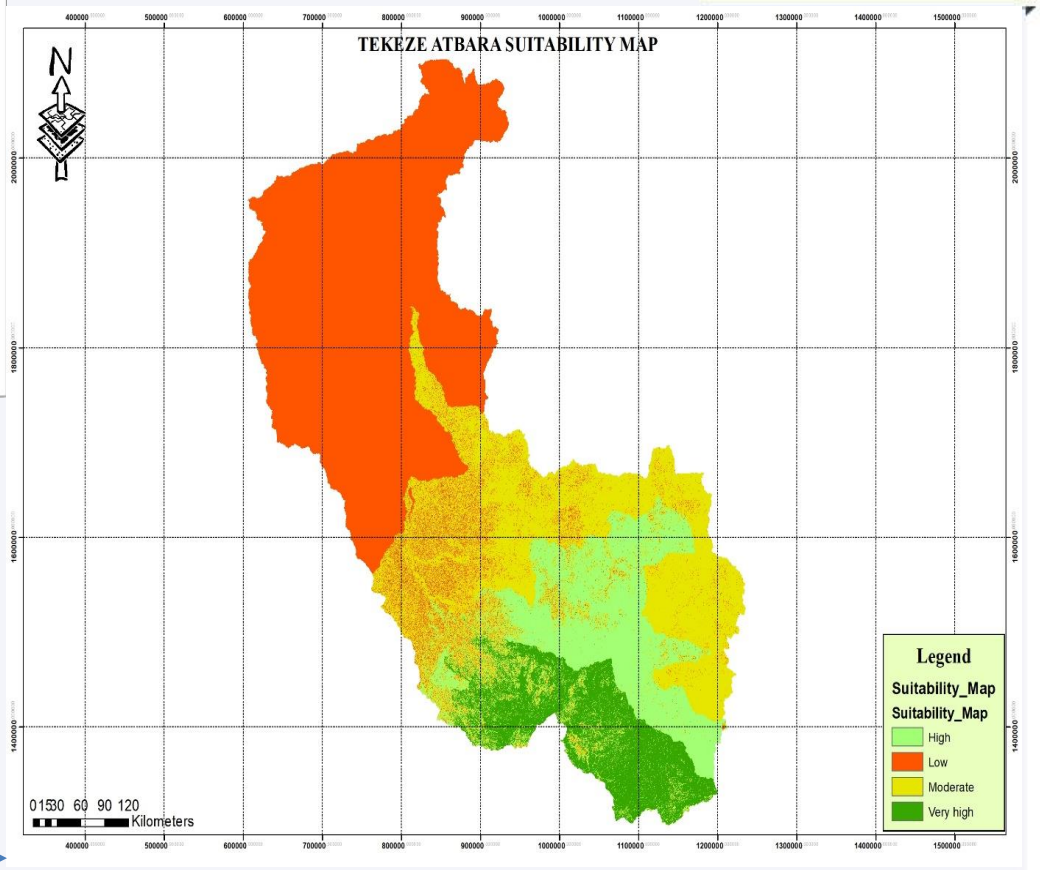

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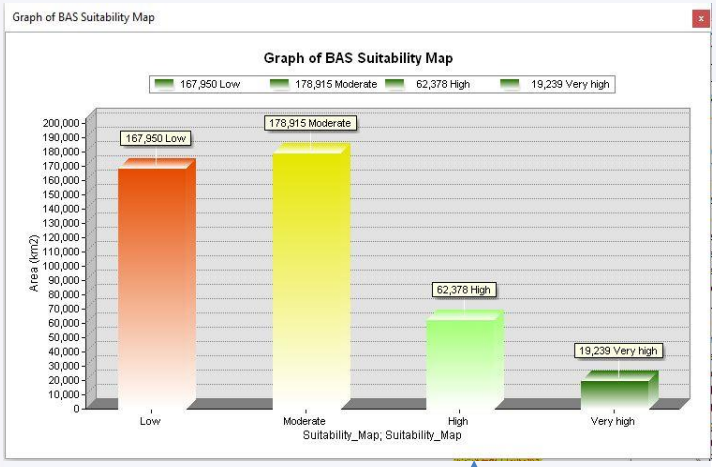

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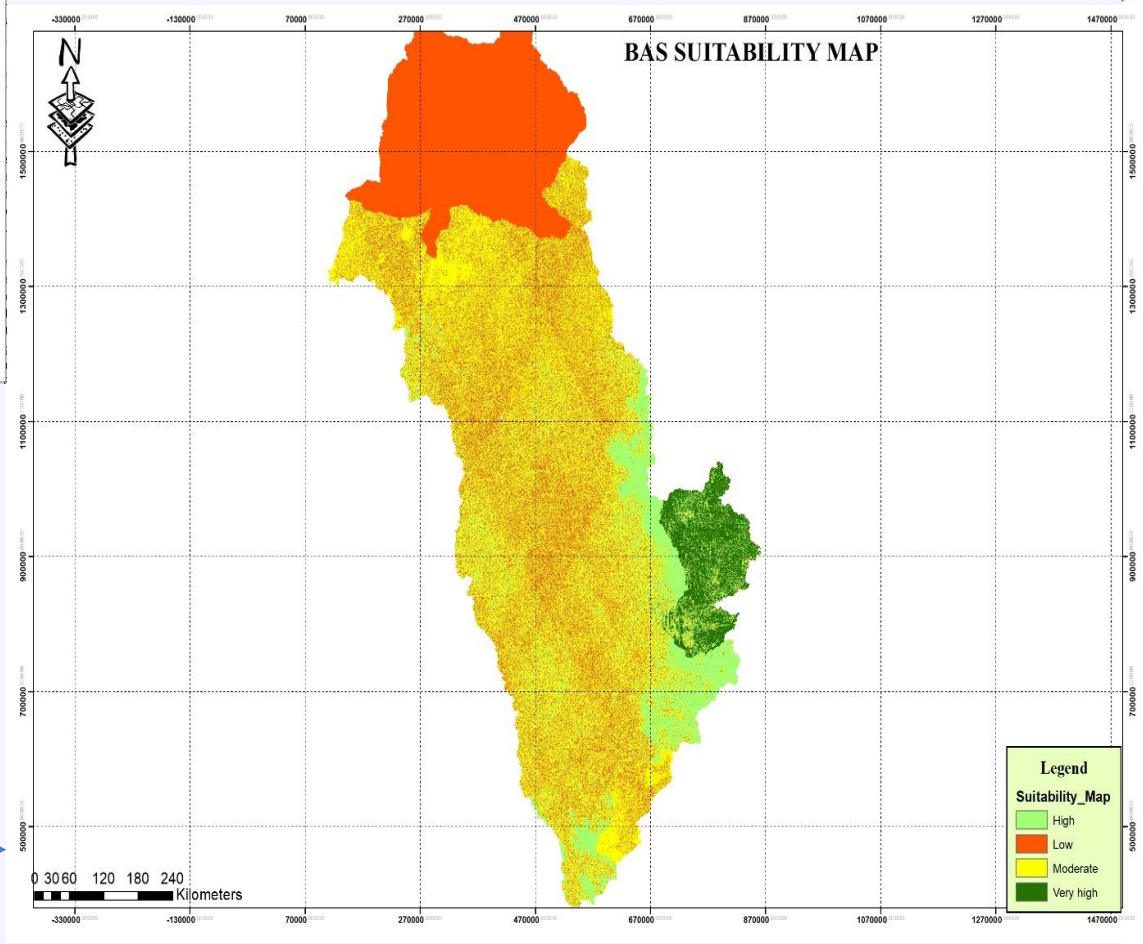

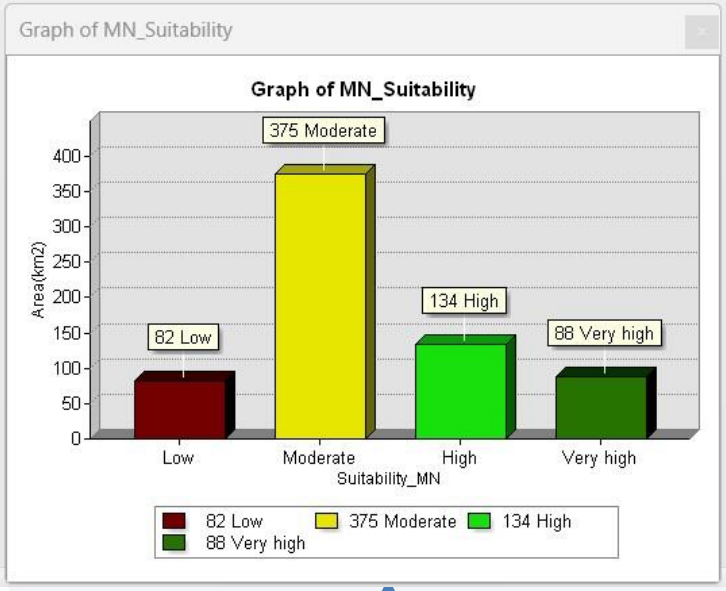

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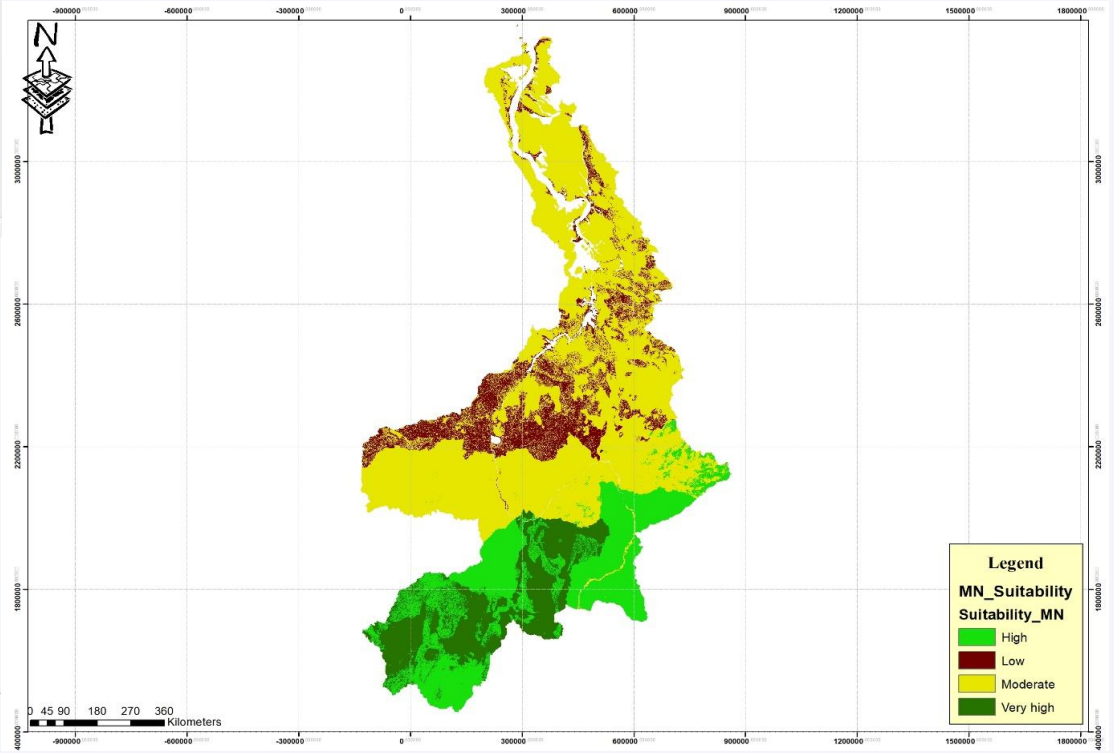

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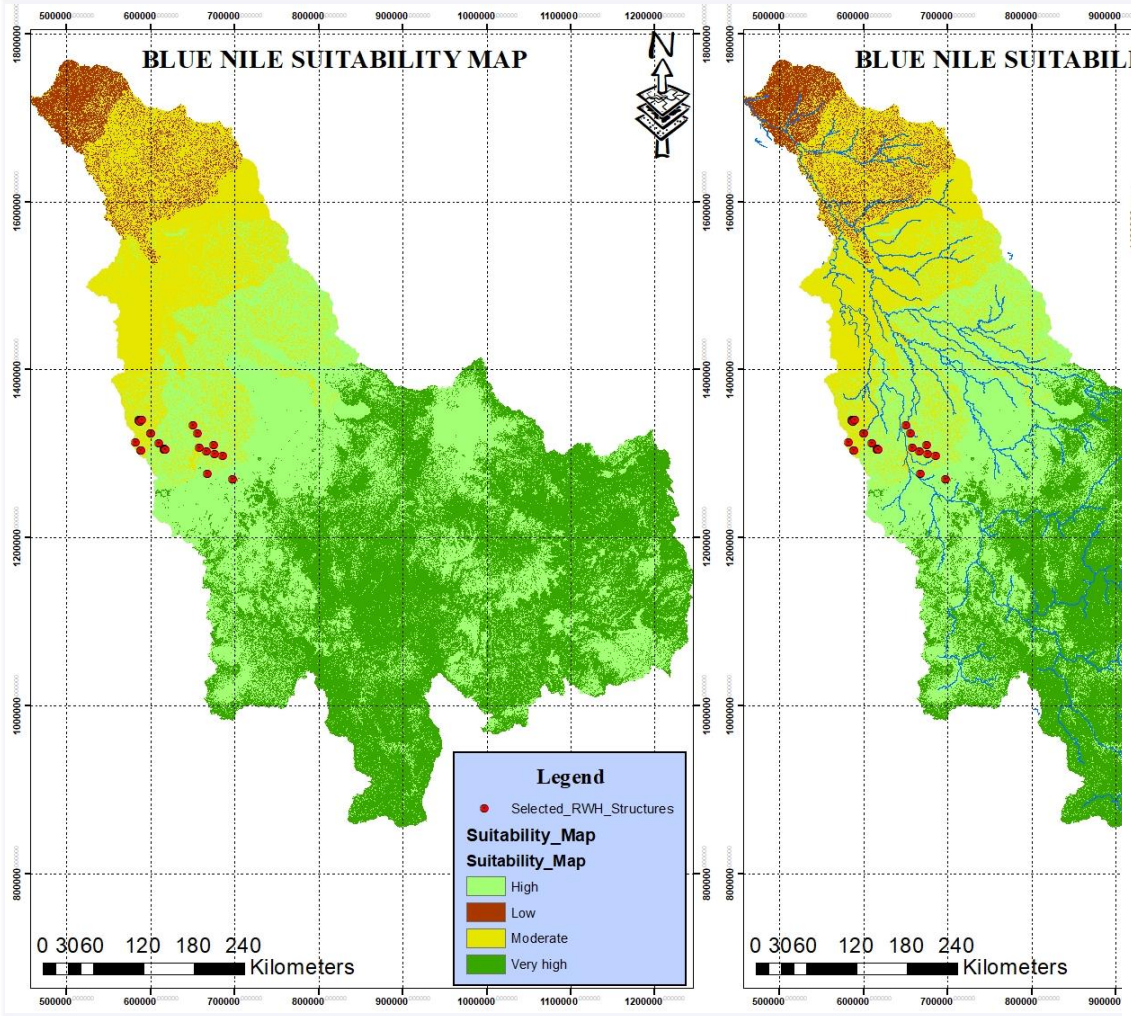

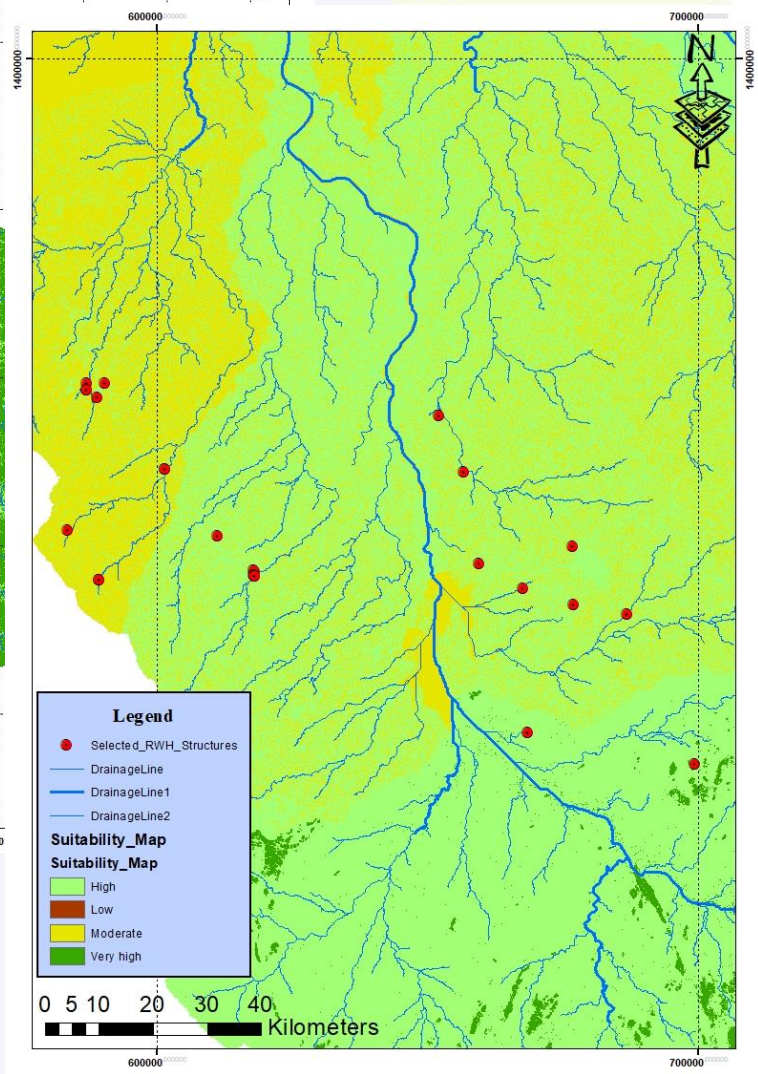

Site suitability map for Selected Hafirs & Dam

Recommendation

Based on results, it is recommended that;

1) For better, accurate and precise identification of potential surface runoff harvesting sites, spatial data with fine scale should be used.
2) The socio-economic constraints were not considered in this study and need to be studied first in more detail for a realistic implementation of RWH system.
3) further research is recommended to validate the combined map over different locations.
4) The location of the water harvesting structures should be such that, it should get enough quantity of water and should be neither very near nor too far from settlements and agricultural areas.


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THANK YOU!