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Evaluation of Land Suitability for Agriculture under Irrigation at Khartoum North, Sudan

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Abstract- This study focused on genesis, classification, land suitability and land suitability evaluation for agriculture under irrigation and crop suitability of some soils of the River Nile terraces at Khartoum North, Sudan. Three river terraces comprising nine profiles were selected to cover the physiographic positions. Qualitative evaluation was carried out by means of parametric method. The capability index (Ci) was calculated by a weighted average for the upper 100 cm of the soil profile for slope class, texture, soil depth, calcium carbonate status, salinity/alkalinity, and drainage. The results revealed that the soil of the physiographic unit 1(first terrace) was suitable for agriculture (S2) due to limitations of soil texture and moderately drainage, while the unit 2 and 3(second and third terraces respectively) were slightly suitable (S3) due to limitations of poorly drainage (low infiltration rate) and texture (clay). The slope, soil depth, $CaCO_3$ and salinity and alkalinity were not considered as limiting factors in all study area.

Index Terms- Land suitability, River Nile terraces, qualitative evaluation, parametric method, capability index.

I. INTRODUCTION

The Sudan located within the zone where the hazards of land degradation are great. Total area of 65 million hectares, located between latitude and longitude (32° 52' 16.48"E, 14° 24' 05.65"N) and latitude and longitude (32° 8' 1.48"E, 15° 9' 33.48"N), extending across the Country from east to west has been decertified or degraded land (DECARP, 1974). Availability of irrigation leads to land use change as well as intensive cropping system. Improper use of irrigation water has resulted in environmental degradation of natural resources that leads to decline in the productivity of land resources and deterioration of land quality for its future use (Suresh et al., 2002). With the increase of demand for land, land evaluation has become more important as people strive to make better use of the limited land resources. Land evaluation is the process of assessment land performance for specified purposes (Rossiter, 1996).

Sys et al., (1991) suggested a parametric system in order to evaluate land suitability for irrigation. The system was based on the standard granulometrical and soil physio-chemical properties. According to their system, the factors influencing the soil suitability for irrigation can therefore be subdivided in the following four groups: physical properties determining the soil-water relationship in the soil such as permeability and available water content; chemical properties interfering with the salinity/alkalinity status such as soluble salts and exchangeable Na; drainage properties and environmental factors such as slope.
In Sudan limited number of studies and fulfillments were made to assess the irrigation potential based on the physical land and water resources (Kevie and El-Tom, 2004). Small scale studies conducted on soils of the country seem to be inappropriate in providing basic soil information that can help to make decision on proper utilization of resources. The soils of the River Nile terraces are used for agricultural production to meet the demands of the densely population capital. However, the selection of crops cultivated is erratic and traditional. Therefore, there is a real need for scientific and sound strategy to put these soils in their optimal use to the best interest of the farmers as well as the population of the capital. Therefore, the objective of this study was to determine the land suitability of the study area for irrigation purpose by using the parametric evaluation system.

II. MATERIALS AND METHODS

Study area and soil sampling:

The study area is located in the northeastern part of Khartoum North, Sudan between the River Nile at El Khogalab village and extending eastwards till the piedmont plain (Fig. 1). According to Van der Kevie (1973), the study area falls within the semi desert zone. The average annual rainfall varies from 100-225 mm. Mean maximum temperature of the hottest months May and June is 40 and 42˚C, respectively. Mean minimum temperature of the coldest month (January) is 13-16˚C. The dominant vegetation of the study area are *Capparis deciduas* and *Acacia seyal*. According to the Soil Taxonomy (2014), the soils of the study area belong within Entisols and Aridisols orders.

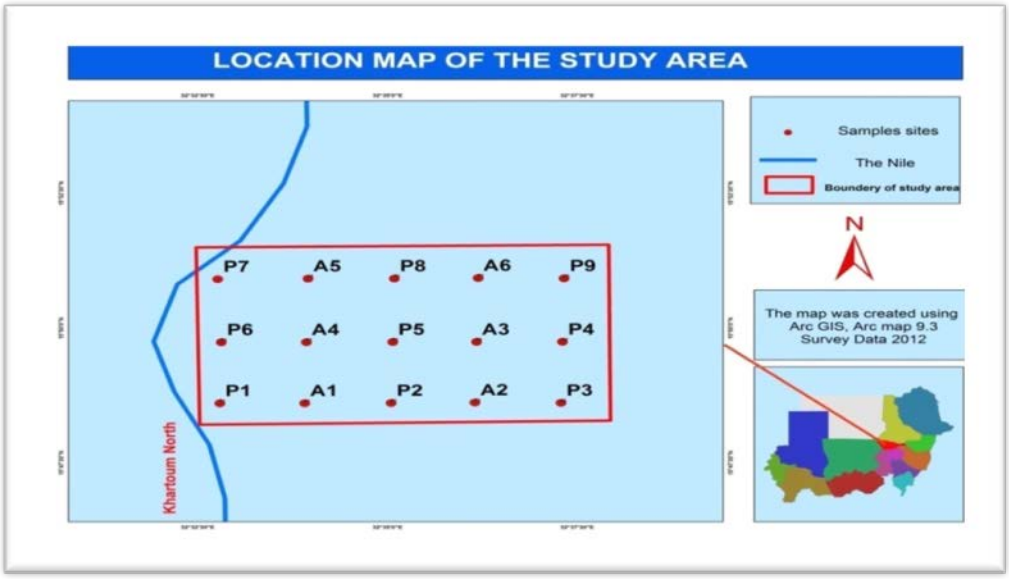

Figure (.1): The study area and sites of the soil samples.

Nine soil profiles were chosen to represent the different terraces of the River Nile at Khartoum North, Sudan. Profiles 1, 6 and 7 represent the very recent (first terrace) Nile terrace soils. Profiles 2, 5 and 8 represent the succeeding terrace soils (second terrace), while profiles 3, 4 and 9 are the intermixing of the alluvial plain and the piedmont.

Soil analysis and land evaluation procedure:

The particles-size distribution of the soil samples as refer to soil texture was determined by the hydrometer method (Soil Survey Staff, 2004). The electrical conductivity was determined in the saturated soil paste extract using a conductivity meter Model (Jenway 4510 U.S. Salinity Lab Staff, 1954). The exchangeable sodium percentage was calculated according to the formula: % ESP = {Exch Na^+}*100/CEC. Soil calcium carbonate was measured by the calcimeter method, according to Nelson (1982). The effective soil depth, drainage, and the slope were measured directly at the field. To evaluate the land suitability for irrigation the parametric evaluation system of Sys *et al.*, (1991) was applied, using soil and land characteristics. These characteristics concern environmental factors, drainage properties, soil physical and chemical properties. They are rated and used to calculate the capability index for irrigation by the formula: A*B/100*C/100*D/100*E/100*F/100

Where: Ci: capability index for irrigation, A: rating of soil texture, B: rating of soil depth C: rating of CaCO3 status, D: salinity/alkalinity rating, E: drainage rating, and F: slope rating. According to the results of measured land index in parametric method suggested by Sys et al. (1991) lands having indexes >80 are in S1 (very suitable); 60-80 are in S2 (moderate suitable); 40-60 are in S3 (marginal suitable); 30-45 are in N1 (currently not suitable); and <30 are in N2 (permanently not suitable).

III. RESULTS AND DISCUSSION

Table 1 summarizes the classification of some soils of the study area. According to the American system of soil classification (Soil Survey Staff, 1975), the soils of the first terrace (unit 1) belong to the order Entisols due to absence of pedogenic horizons. While the soils of unit 2 and 3 (second and third terraces respectively) belong to the order Aridisols due to lack available water of most time for plant growth and presence of cambic subsurface horizon.

Table 1: Classification of some soils of the study area

Unit No.	Profile No.	Coordinates (UTM)		Classification
		X	Y	
1	1	451437	1747982	Fine loamy, mixed, active (non calcareous), hyperthermic, Typic, Torrifluvents
2	5	457440	1747997	Fine, mixed, active (non calcareous), hyperthermic, Entic, Haplocambids
3	7	453478	1750070	Fine, mixed, superactive (non calcareous), hyperthermic, Typic, Haplocambids

The definitive evaluation of land suitability for agriculture under irrigation by using parametric methods is given in Tables 2 and 3. According to the capability (or suitability) index (Ci), it is evident that the unit 1 which covered about 25% of the total area is considered to be suitable for irrigation, while the large portion of the study area –

Table 2: Capability index value and suitability classes of the study area

Unit	Profile	Slope	Texture	Soil depth	$CaCO_3$	Salinity & alkalinity	Drainage	Capability index	Suitability classes
1	1,6,7	100	90	100	100	100	80	76.00	S2
2	2,5,8	95	85	100	95	95	75	54.66	S3
3	3,4,9	95	85	100	85	95	70	45.64	S3

Table 3: Area coverage and percentage of the three land units

Land unit	Location	Suitability classes	Area (ha)	(%)
1	First terrace	S2	400	25.00
2	Second terrace	S3	700	43.75
3	Third terrace	S3	500	31.25
Total			1600	100

(unit 2 and 3) which covered about 1200 ha (75% of the total area) is considered as being slightly suitable. This might be due to limitation of texture (clay) and drainage (low infiltration rate). These results agreed with Mustafa *et al.*, (2013) who studied the land evaluation of University of Khartoum. They found that factors such as slope, soil depth, drainage and salinity and alkalinity were not considered as limiting factors for land suitability evaluation for irrigation.

Kevie and El-Tom (2004) developed a manual for land suitability evaluation for agriculture with practices in Sudan. They reported that there was no highly suitable (S1) area for irrigation. And most of the areas were classified as almost unsuitable (N1) for irrigation purposes. The most limiting factors were physical parameters such as slope, soil texture and soil depth.

IV. CONCLUSION

The study revealed that the soil of the three units of the study area were deep, non saline (with exception of few pockets in the second and third terraces which were saline), non alkaline and slightly calcareous. Applied of parametric evaluation system revealed that 75% of the study area found as slightly suitable, while 25% considered as suitable for agriculture under irrigation. The most important factors that considered as limiting factors in the study area included soil texture and drainage.

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