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LAND EVALUATION AND SUSTAINABLE DEVELOPMENT OF SOME AREAS OF DAKHLA OASIS, EGYPT

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ABSTRACT

Dakhla Oasis represents one of the high priority regions for future development in Egypt. It is one of the major depressions in the western desert of Egypt. Dakhla oasis is located in the South Western Desert of Egypt between longitudes 28°15' - 29° 40' E and latitudes 25° 00' - 26° 00' N. Study area covers about120000 feddan and it is one of the main challenging regions for sustainable development. Thesoils were classified as Typic Haplargids, Typic Torriorthents, Typic Torripasamments, Typic Haplotorrerts and Vertic Torriorthents.Land capability assessment was done to define the suitable areas for agricultural production using Storie Index. Results indicate that more than 28080 feddan are good capable (grade 2) and about 91000 feddan are fair capable (grade 3) for agriculture production. Land Use Suitability Evaluation Tool (LUSET) was used to compare the soil characteristics and quality needed for 16 different types of crops. The results from the land suitability analysis indicated that, more than 84000 feddan are moderately suitable for wheat and sorghum; whereas 88560 feddan are highly suitable for barley; 93600 feddan are moderately suitable for alfaalfa, olive and groundnut; 59280 feddan are highly suitable for cotton; 71000 feddan are moderately suitable for mango and 51600 feddan are moderately suitable for potato. In the current study, we have used remote sensing and soil data in combination with GIS tools, for sustainable land use (SLU) analysis in El-Dakhla area. The SLU was established based on various factors such as: land capability and suitability, crop water requirement, economic return from water and financial return from land and water. The SLU was build based on two alternatives; (a) the most SLU in terms of irrigation water requirements are Barely and sorghum or groundnut against olive (as the irrigation requirements for these crops are low). (b) the most sustainable land use in terms of economic net return are wheat and potato or cotton against mango or alfaalfa (as the net return for this crops is high**).**

Keywords: Land evaluation • land sustainability • GIS • Remote Sensing • LUSET • Storie Index • Dakhla Oasis • Egypt.

INTRODUCTION

Nowadays, Sustainable management of limited land and water resources is urgently needed to meet the increasing demand for food and to protect the environment. Horizontal extension in the new areas in the western desert is necessary to meet the demand of food due to the growth of Egypt population. The suitable land and water resources in Egypt are very limited, the future plan for agriculture expansion demands that all the land resources be carefully studied.

The Oases of the western desert (Dakhla, Kharga, Bahariya and Farafra) represent promising areas for future agriculture expansion plans. Dakhla Oasis represents one of the major depressions in the western desert of Egypt. Arid regions are defined as areas where potential evaporation is much greater than precipitation. The area under investigation is located in the hyper arid belt because El-Dakhla oasis may be considered as rainless area.

Land evaluation is defined as the process of land performance assessment when the land is used for specific purposes (FAO, 1985) or as all methods to explain or predict the use potential of land (van Diepen *et al.,* 1991). Therefore, land evaluation is a tool for strategic land use planning. Sustainable Agriculture refers to a range of strategies for addressing many problems that effect agriculture. Furthermore, “Sustainable” implies a time dimension and the capacity of a farming system to endure indefinitely (Crosson, 1992).

In the present study, Sustainable land use was established based on: land capability and suitability, water resources availability, economic return from water and financial return from land and water. Soil map is an essential part of soil assessment framework (Lagacherie, 2008). The objectives of this study are to (1) Build up a geographic soil data base for Dakhla Oasis using GIS. (2) Create the current landuse map of Dakhla Oasis using satellite image, (3) Land suitability and capability evaluation of Dakhla Oasis and (4) build scenarios for sustainable landuse and development of Dakhla Oasis.

Study Area

Location: The Dakhla oasis is located South of the Western Desert of Egypt, about 120 km west of the Kharga oasis, about 300 km west of the Nile valley and about 300 km southeast of Farafra oasis, between longitudes 28°15' - 29° 40' E and latitudes 25° 00' - 26° 00' N (Fig. 1). The oasis is about 155 km long from southeast to northwest, with a maximum width of about 60 km. Study area covers an area of 500 square kilometers.

Geology: The geology of El-Dakhla oases have been studied by several geologists among them Said (1961 and 1962) and Abu El-Izz (1971), mentioned that El-Dakhla Oasis is occupied by different types of rocks varying between Quaternary to Cretaceous areas. The geological formations found in El-Dakhla Oasis from top to bottom belong as: Chalk, Dakhla shale, Phosphatic beds, variegated shales and Nubian sandstone.

Geomorphology: The geomorphology of Dakhla oases is characterized by various distinct geomorphological features (Shata, 1962). However, El-Dakhla area shows three main divisions a) The central portion, which includes the oasis depression and extends south of the escarpment of the lower plateau, b) The marginal portion, occupying the narrow area adjacent to the escarpment foot, c) The flat Nuba surface which is strongly barren and covered occasionally by drift sand deposits.

Climate: El-Dakhla Oases lies within the extremely arid belt. The mean annual temperature is 23.55 Cº with maximum of32.49 ºC and minimum temperature of 14.65 ºC. The mean monthly maximum wind velocity o wind is 4.50 m/s. The average relative humidity is 34.92 % with a minimum of 25.33 % in May and July and a maximum of 48 % in December. The maximum evaporation is noticed in the warmer and dryer months, where it reaches 24.8 mm/day in June, while the minimum value (7.7 mm/day)was noticed in the coldest months. i.e. December and January. The soil moisture regime is aridic, and the soil temperature regime is hyperthermic**.**

Water resources: Ground water is the only water resource in the area. In other words, water in the oasis area is derived from one single source, namely the western underground reservoir. The underground artesian water is stored in the Nubian sandstone formations with thickness that increases from south to north, 200m near the Sudan border and 800m at El-Kharga (Himida, 1966). Most of the wells of the Dakhla oasis are deep, water is found at varying depths in El-Dakhla oasis between 300 and 400m

MATERIALS AND METHODS

Landsat ETM+ (Enhanced Thematic Mapper) image of Feb 20, 2006, a scene (Path177 / Row42), covering the study area was used. Digital Elevation model (DEM) 30 m pixel size resolution, covers the study area, taken from The Shuttle Radar Topographic Mission (SRTM) images.

Scanned topographic maps scale 1:50000 were used first for the image geo-referencing using image-to-image geometric module in ERDAS IMAGINE 9.1. Stretching radiometric enhancement and convolution and adaptive filtering were applied. The unsupervised classification was performed using Iso Cluster as a signature file followed by a Maximum Likelihood Classification, in GIS. The resulted enhanced false color composite and the enhanced natural like composite were used for the interpretation of land use units, whereas, the normalized difference vegetation index (NDVI) is used to distinguish the different land covers in the study area.

The digital elevation model (DEM) is used for soil map generation. An enhanced false color composite of LANDSAT image is overlaid on the created 3D model using ARC GIS 9.2. The same was done with the enhanced natural like composite LANDSAT image.

Twenty five soil profiles were dug to 120 cm depth then soil samples were collected for different analyses. These soil profiles were morphologically described according the FAO (2006), followed by 24 auger observations for checking the boundaries. The collected disturbed soil samples were air dried; ground gently; and sieved through a 2 mm sieve where the main physical and chemical properties were determined, (USDA, 2004). The soil survey staff (2006) was used to classify the different soils of the investigated area to the sub great group level.

After carrying out the ground truthing during the field work, re-interpretation was made to produce the final soil map. Soil attributes of the different mapping units were added from the analysis results of the modal soil profiles representing the main dominant soil.

Land evaluation was carried out through two steps;(1) Land capability classification: Modified Storie Index Rating, UCDVVIS (2008): The calculation was run and coded using Visual Basic for application under Microsoft Excel.(2) Land suitability classification: Land Use Suitability Evaluation Tool (LUSET), Yen et al. (2006) a computer- based program.

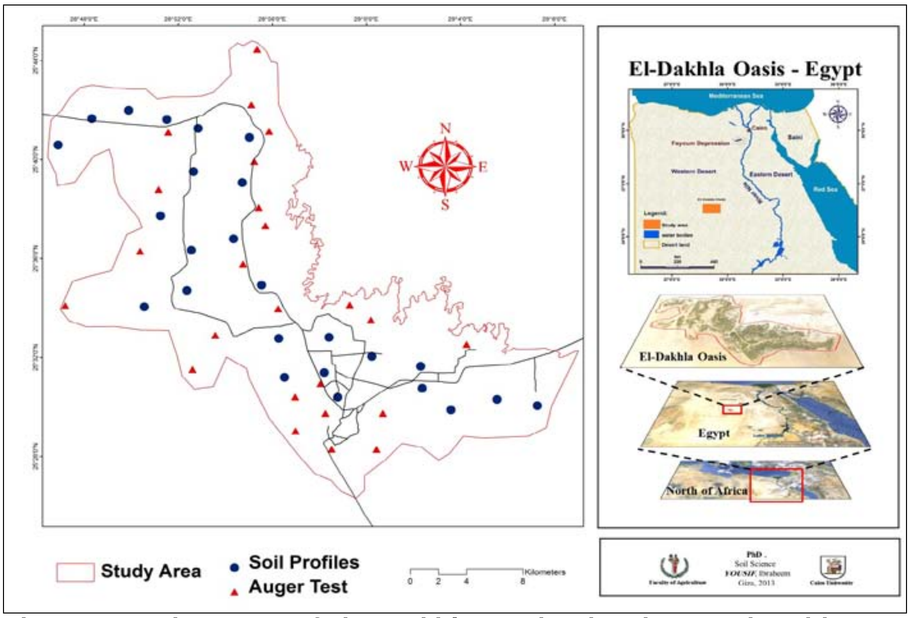


Fig. 1. Location map of the Dakhla Oasis showing roads, cities and villages.

RESULTS AND DISCUSSION

The use of data in digital format has become essential for many disciplines, especially those dealing large extent regions and large amount of data. Remote sensing and geographic information systems GIS proved to be powerful tools for such soil-water environment studies. Digital Elevation Model (DEM) of the study area showed that the elevations ranged from about 7 m above sea level to about 551 m above sea level.

Twenty five classes were resulted from unsupervised classification. These results were checked and verified in the field. Therefore, they were regrouped based on these field observations and laboratory analyses of soil profile samples, especially for the surface layers. This regrouping method called the supervised classification. The supervised classification was developed using map units' polygons representing the same spectral units. The different spectral soil mapping units covering the study area is representing by 6 classes (Fig. 2).

Physiographic soil map

An enhanced false color composite (bands 4, 3, 2) of LANDSAT ETM+7 image was made, and then overlayed on a 3D model. An enhanced false color is very popular and useful for vegetation studies; therefore we used this combination in order to delineate the cultivated areas. The same was made using a natural-like composite (bands 7, 4, 2) of LANDSAT ETM+7 image. The unsupervised classification, 3D map, supervised classification, and field survey data were used to extract, define, delineate, and mapping the main physiographic units in El-Dakhla Oasis depression as shown in Fig. 4 and Table 1.

T1

The area is covered by one landscape (El-Dakhla depression). The relief of this landscape includes four different landforms, namely Depression Edge, Depression floor, sand dunes, and pools. The information of physiographic units with soil taxonomy and soil field data (Table 2) were incorporated using Geographic Information System (GIS) to create the physiographic soil map. The produced data reveal that the soils of the main physiographic units in the area could be arranged under the landscape level in the following:

Depression Edge

Depression edge represents the external portion or the external border of the depression. This area occupies approximately 274.13 km^2; represent 53.12 % of the studied area. Based on the morphological description of soil profiles, physical and chemical analyses, the mapping unit is classified as association where it is covered by Typic Torriorthents (50 %) and Typic Haplotorrerts (50 %).

Depression Floor

Depression floor represents the lower portion or the internal portion of the depression. This area occupies approximately 173.19 km^2; represent 33.56 % of the studied area.. Based on the morphological description of soil profiles, physical and chemical analyses, the mapping unit is Complex includesTypic Haplargids (46.16 %), Typic Torriorthents (15.38 %), Typic Torripasamments (15.38 %), Typic Haplotorrerts (15.38 %) and Vertic Torriorthents (7.70 %).

Sand Dunes

This unit occupies approximately 64.40 km^2; represent 12.48 % of the studied area and is located mainly at the western part of the study area. The longitudinal sand dunes are common type and extend from North to South direction which corresponds to the prevailing wind direction. Based on the morphology description of soil profiles, physical and chemical analyses, the mapping unit is consociation as it covered by Typic Torripasamments (100 %).

Land evaluation

The inwardness of land evaluation is a framework to compare or match the requirements of each potential land use with the characteristics of each type of land. Reliable knowledge of land characteristics is necessary to good land evaluation. Any area of land, no matter how its boundaries are defined, can be regarded as a land unit for purpose of land evaluation. So to carry out the land evaluation, the incoming part is going to concentrate on mapping the most limiting land characteristics and to evaluate the land capability and suitability classification.

Land capability

Capability is the potential of land for use in specified ways, or with specified management practices. The purpose of land capability classification systems is to study and record all data relevant to find the combination of agricultural and conservation measures which would permit the most intensive and appropriate agricultural use of the land without undue danger of soil degradation.

T2

The best known one of these systems is Modified Storie Index adopted by UCDAVIS (2008). Modified Storie Index predicts the general land capability. The final capability classes are calculated depending upon the Storie Index Rating as the following equation:

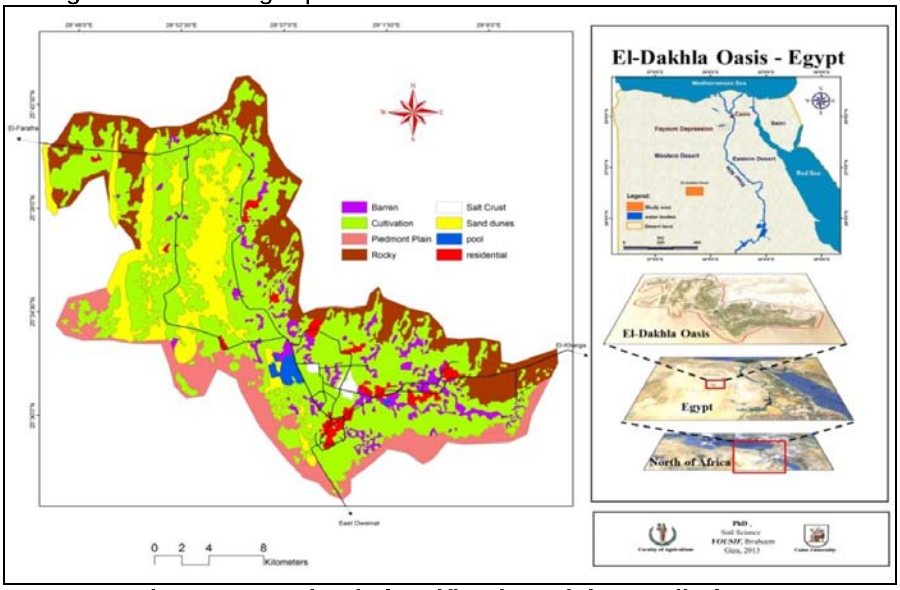


Fig. 2. Supervised classification of the studied area.

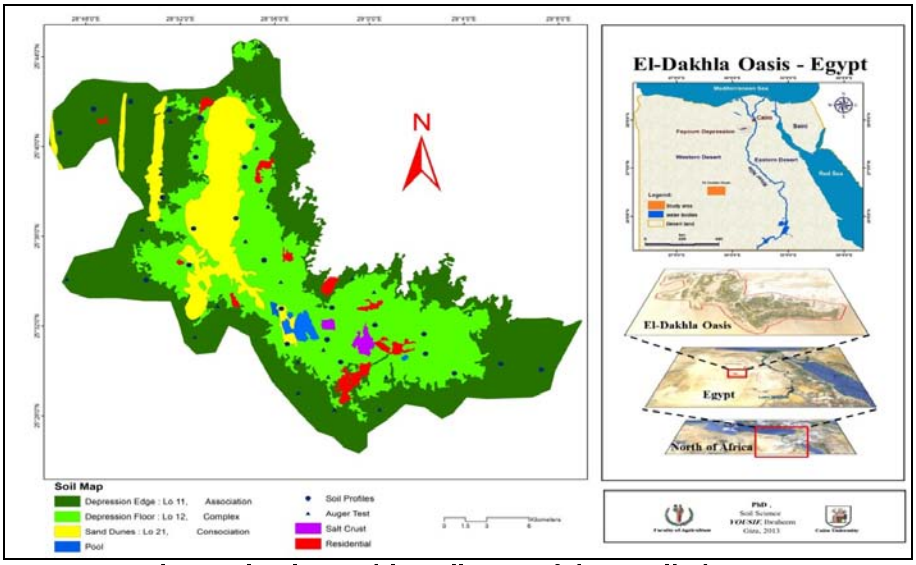


Fig. 3. Physiographic soil map of the studied area.

Through applying Storie Index equation, the soils of study area are Grade 2 and Grade 3 with very few exceptional cases that are Grade 4 as shown in Table 3, and Fig.4. From the land capability and land form maps, tabulate area was done between land capability and land form. The distribution of land capability grades in the different land form type is shown in Fig. 5.Selected soil physical and chemical properties of the study area are shown in Table 2. The dominant textural class of the studied soils is Clay and Sand texture. The spatial distribution of lime indicates that the slightly calcareous soils (less than 10 %) represent the largest portion of the studied area. The obtained data show that the EC values were generally less than 4 dS/m. As for the sodicity, the soils in general have ESP less than 15%.

1. Land suitability classification

The suitability of a given area of land is its natural ability to support a specific purpose. Land Use Suitability Evaluation Tool (LUSET) was used to assess the soil suitability for specific types of crops. These crops were grouped into three groups as shown in Table 4.There are four methods for computing the overall suitability (maximum, minimum, average, or exponent) and types of overall suitability (rated by 1 to 100 or classified as S1, S2, S3, and N). The requirements of the most commonly grown crops provided by Sys, *et al* (1993) are recorded in this program. LUSET was used to evaluate the land suitability of the study area using the exponent equation for all the selected crops, Table 4.

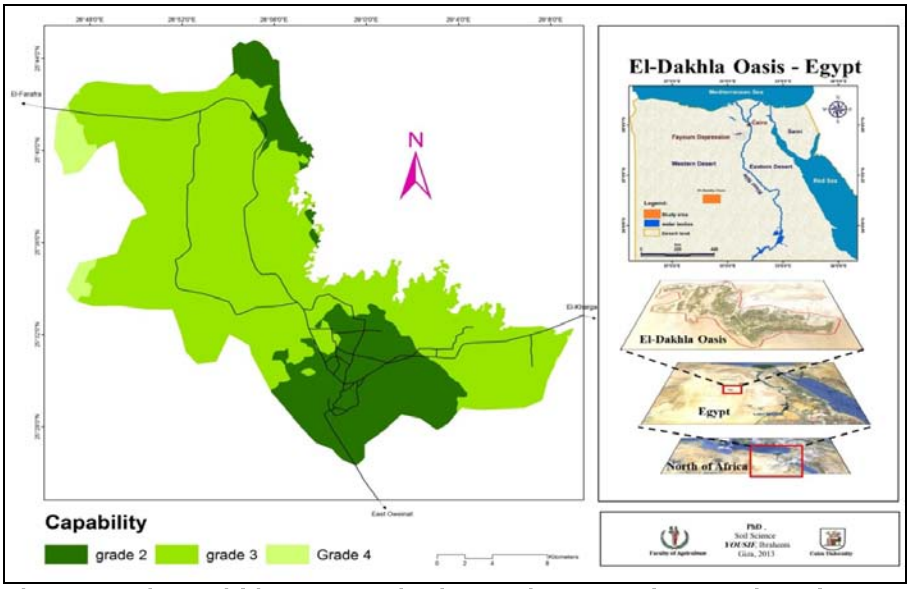
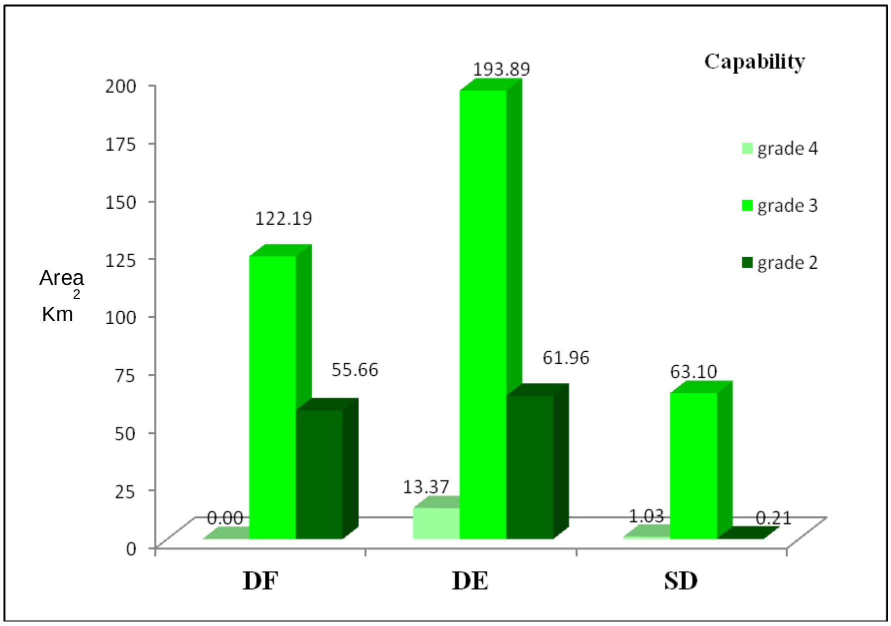


Fig. 4. Land capability classes in the study area using Storie Index.



* DF: Depression Floor, DE: Depression Edge, SD: Sand Dunes

Fig. 5. Distribution of the land capability classes in the studied area.

Table 3. Land capability rating using modified Storie Index.

Unit	P_No	Depth Rate	Gravel Rate	Slope Rate	pH Rate	SAR Rate	EC Rate	Texture Rate	Final Rate	Class
Depression Edge	1	93.3	100.0	97.6	100.0	95.6	67.9	50.0	29.57	**Grade 4**
	2	93.3	100.0	98.6	100.0	97.0	84.1	95.0	71.28	**Grade 2**
	7	93.3	100.0	97.0	100.0	95.4	86.9	50.0	37.51	**Grade 4**
	17	93.3	100.0	99.1	100.0	94.8	95.4	50.0	41.83	**Grade 3**
	18	93.3	100.0	95.7	100.0	94.5	90.1	50.0	38.02	**Grade 4**
	19	93.3	100.0	96.5	100.0	95.0	97.4	50.0	41.63	**Grade 3**
	23	93.3	100.0	97.5	100.0	94.3	95.4	50.0	40.92	**Grade 3**
Depression Floor	3	93.3	100.0	97.0	100.0	95.1	78.8	50.0	33.93	**Grade 4**
	4	93.3	100.0	93.2	100.0	98.7	98.7	60.0	50.82	**Grade 3**
	5	93.3	100.0	92.9	100.0	97.2	88.3	95.0	70.66	**Grade 2**
	6	93.3	100.0	97.6	100.0	97.7	99.1	60.0	52.95	**Grade 3**
	8	93.3	100.0	97.6	100.0	96.0	84.8	95.0	70.46	**Grade 2**
	9	93.3	100.0	97.2	100.0	95.4	74.2	50.0	32.10	**Grade 4**
	13	93.3	100.0	99.4	100.0	95.5	97.1	65.0	55.89	**Grade 3**
	14	93.3	100.0	93.6	100.0	95.7	97.9	65.0	53.22	**Grade 3**
	15	93.3	100.0	98.0	100.0	96.0	98.6	95.0	82.24	**Grade 1**
	16	93.3	100.0	98.0	100.0	95.1	78.1	65.0	44.20	**Grade 3**
	20	93.3	100.0	94.9	100.0	95.7	91.1	50.0	38.62	**Grade 4**
	24	93.3	100.0	97.5	100.0	93.6	97.9	65.0	54.21	**Grade 3**
	25	93.3	100.0	98.8	100.0	93.7	94.0	50.0	40.59	**Grade 3**
Sand Dunes	10	93.3	100.0	89.5	100.0	98.5	96.5	60.0	47.64	**Grade 3**
	11	93.3	100.0	95.2	100.0	98.5	91.8	60.0	48.21	**Grade 3**
	12	93.3	100.0	92.4	100.0	98.5	99.2	60.0	50.55	**Grade 3**
	21	93.3	100.0	96.7	100.0	97.6	92.2	95.0	77.06	**Grade 2**
	22	93.3	100.0	94.5	100.0	98.6	99.1	60.0	51.67	**Grade 3**

Building Scenarios for Sustainable Landuse

The main limited factor for land use in the study area is irrigation requirement. Ground water is the only water resource in the area. To assess the most sustainable land use in the study area, three factors were taken into consideration, namely; physical land use suitability, irrigation requirements economic criteria (NR & WP). In the study area, the actual extraction rate from the Aquifer is about 3 $*10^8$ m^3/year. On the other hand, the Safe extraction from the aquifer is about $9*10^8$ m^3 /year. The results showed five different possible scenarios.

First Scenario:

In this scenario three field crops are suggested namely; wheat, alfaalfa and barley. As shown in Figure 6, wheat is suitable for 64080 feddan, alfaalfa is suitable for 7156 feddan and, barley is suitable for 24000 feddan. The total water requirement for this scenario is 266.78 million m^3. These crops are already cultivated in some areas in the studied area.

Table 4. Land suitability classes resulting from LUSET.

Unit	No	Field Crops												Fruit Crops			
		Co.	Wh.	Ri.	Su.	So.	Ba.	Ma.	Se.	Cw.	Sy.	Gr.	Al.	Ci.	Mn.	Ol.	Pe.
Depression Edge	**1**	S1	S2	S2	S2	S1	S1	S2	S3	S2	S2	S2	S2	S3	S3	S2	S3
	2	S2	S2	S2	S2	S2	S2	S2	S3	S2	S2	S2	S3	S3	S2	S2	S2
	7	S3	S2	N	S3	S2	S2	S3	N	N	N	N	S3	N	N	S3	N
	17	S3	S2	S3	S3	S2	S2	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3
	18	S1	S2	S2	S2	S1	S1	S2	S2	S2	S2	S2	S2	S3	S2	S2	S3
	19	S3	S2	N	S3	S2	S2	S3	S3	S3	N	S3	S3	S3	S3	S3	N
	23	S1	S2	N	S2	S1	S1	S2	S2	S2	S2	S2	S2	S3	S2	S2	S3
Depression Floor	**3**	S1	S2	S2	S2	S1	S1	S2	S3	S2	S2	S2	S2	S3	S2	S2	S3
	4	S2	S2	S2	S2	S2	S2	S2	S3	S2	S2	S2	S3	S2	S2	S1	S2
	5	S3	S2	N	S3	S2	S2	S3	N	N	N	N	S3	S2	S1	S1	S2
	6	S3	S2	S3	S3	S2	S2	S3	S3	S3	S3	S3	S3	S2	S2	S2	S3
	8	S1	S2	S2	S2	S1	S1	S2	S2	S2	S2	S2	S2	S1	S1	S1	S2
	9	S3	S2	N	S3	S2	S2	S3	S3	S3	N	S3	S3	S3	S3	S3	S3
	13	S1	S2	N	S2	S1	S1	S2	S2	S2	S2	S2	S2	S3	S2	S2	S2
	14	S1	S2	S2	S2	S1	S1	S2	S3	S2	S2	S2	S2	S2	S2	S2	S2
	15	S2	S2	S2	S2	S2	S2	S2	S3	S2	S2	S2	S3	S2	S1	S2	S2
	16	S1	S2	S2	S2	S1	S1	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2
	20	S3	S2	N	S2	S2	S2	S3	S3	S3	N	S3	S3	S3	S3	S3	S3
	24	S3	S3	N	S3	S2	S2	S3	N	N	N	N	S3	N	N	S3	N
	25	S1	S2	S2	S2	S1	S1	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2
Sand Dunes	**10**	S3	S2	S3	S3	S2	S2	S3	S3	S3	S3	S3	S3	S3	S3	S3	S3
	11	S1	S1	S2	S1	S1	S1	S1	S1	S1	S1	S2	S2	S2	S1	S1	S2
	12	S1	S2	S2	S2	S1	S1	S2	S2	S2	S2	S2	S2	S3	S2	S1	S2
	21	S1	S2	N	S2	S1	S1	S3	S2	S3	S3	S3	S2	N	S3	S3	S3
	22	S1	S2	N	S2	S1	S1	S2	S2	S2	S2	S2	S2	S2	S2	S2	S2

Crops: Co.; Cotton, Wh.; Wheat, Ri.; Rice, Su.; Sunflower, So.; Sorghum, Ba.; Barley, Ma.; Maize, Se.; Sesame, Cw.; Cowpea, Sy.; Soya bean, Gr.; Groundnuts, Al.; Alfalfa, Ci.; Citrus, Mn.; Mango, Ol.; Olive., Pe.; Peach,

Capability classes: S1: Highly suitable, S2: Moderately suitable, S3: Marginal suitable, N: Not Suitable.

Second Scenario

In this scenario four field crops are suggested namely; cotton, sorghum, maize and sunflower. As shown in Figure 7, cotton is suitable for 50880 feddan, sorghum is suitable for 19900 feddan, maize is suitable for 1100 feddan and sunflower is suitable for 23280 feddan. The total water requirement for this scenario is 454.29 million m^3. Sorghum and maize are already cultivated in some areas in the study area but cotton and sunflower are not cultivated.

Third Scenario

In this scenario five field crops are suggested namely; Groundnut, Soya, Cowpea, Sesame and alfaalfa. As shown in Figure 8, groundnut is suitable for 40000 feddan, soya is suitable for 6860 feddan, cowpea is suitable for 7600 feddan, sesame is suitable for 24000 feddan and alfaalfa is suitable for 16800 feddan. The total water requirement for this scenario is 191.26 million m^3.

Fourth Scenario

In this scenario four crops are suggested namely; citrus, olive, mango and peach. As shown in Figure 9, citrus is suitable for 7920 feddan, olive is suitable for 44400 feddan, mango is suitable for 37200 feddan and peach is suitable for 5520 feddan. The total water requirement for this scenario is 414.96 million m3.

Herein, the comparison between the five scenarios in crop water requirement and as shown in Table 5 the total water requirements for all scenarios are within the safe extraction rate from the aquifer ($9*10^8$ m^3/year)

Table 5. Total water requirements for the five scenarios.

Scenario	Total water requirements 1000 m^3	Total water requirements million m^3
First Scenario	266779.31	266.78
Second Scenario	454290.22	454.29
Third Scenario	191260.16	191.26
Fourth Scenario	414961.27	414.96

Sustainable land use assessment

In order to plan the most sustainable land use, there are three LUT groups; winter crops, summer crops and orchards or perennial crops. Therefore, there are two choices; either planting field crops (winter and summer) or orchards and perennial crops. In this study three criteria were used in order to make a decision; the physical land suitability, net return (NR) and water requirement. If the LUT has the highest suitability among its group; then it will be the most sustainable LUT. If the physical land suitability is the same for LUTs; then the water requirement (WR) factor that comes into consideration will depend on its priority. If the water requirement is the same for LUTs; then the net return (NR) factor that comes into consideration will depend on its priority

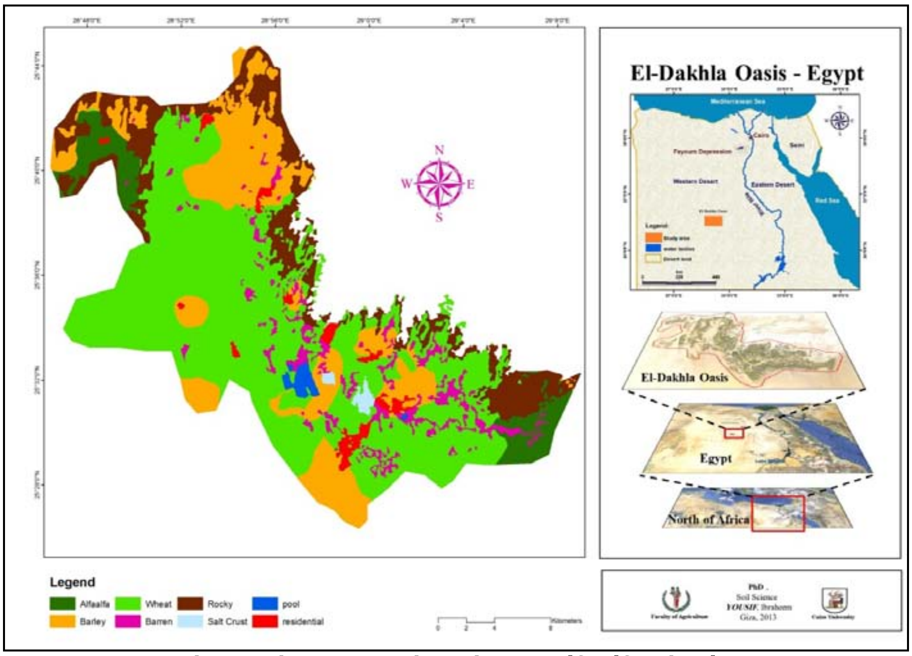


Fig. 6. First scenario: wheat - alfaalfa - barley

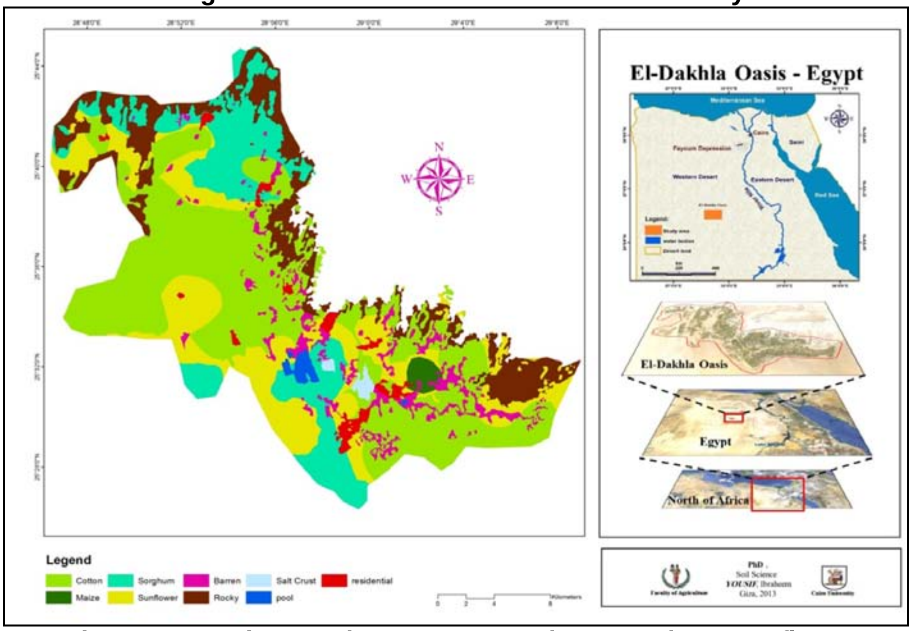


Fig. 7. Second scenario: cotton - sorghum - maize – sunflower

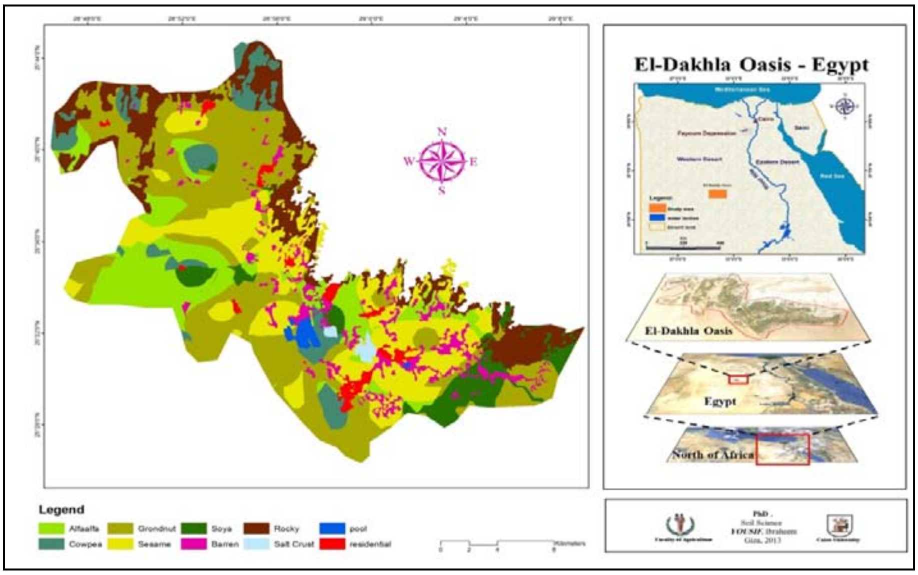


Fig. 8. Third scenario: groundnut, soya, cowpea, sesame and alfalfa

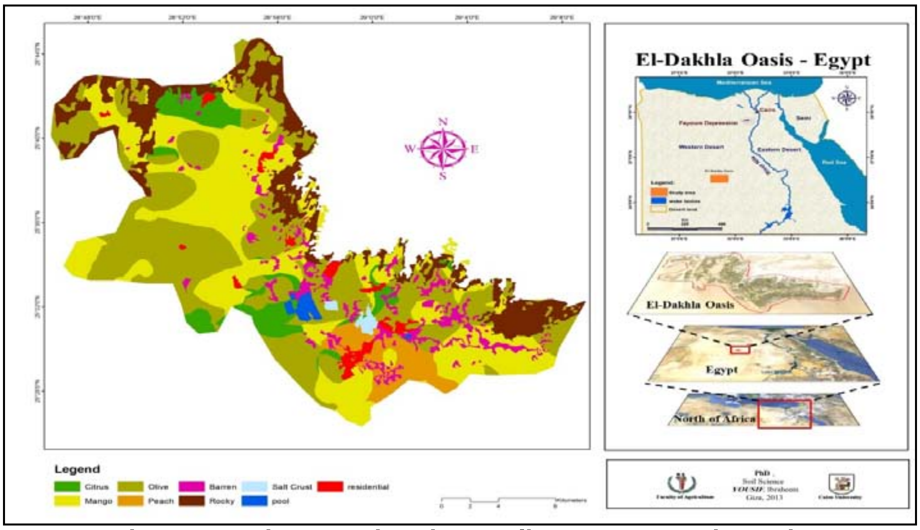


Fig. 9. Fourth scenario: citrus, olive, mango and peach.

As shown in Table 6 two alternatives were built for each land mapping unit. First alternative was built depend on the crop water requirement; In other words, choose crops that consume a little amount of irrigation water. Second alternative was built depend on the economic criteria such as net return (NR) and water productivity (WP); In other words, choose crops that give the highest net return (NR) and water productivity (WP).

Table 6. The most sustainable land use for the proposed alternative.

Unit	Alternative	Criteria	Most sustainable land use
Depression Edge	1	WR *	barely and sorghum or against olive
	2	NR & WP *	wheat and cotton against mango
Depression Floor	1	WR *	barely and sorghum against olive
	2	NR & WP *	wheat and cotton against mango
Sand Dunes	1	WR *	barely and groundnut against olive
	2	NR & WP *	wheat and alfaalfa against mango

* **WR : water requirements m^3/fed * NR: Net Return L.E./Fed * WP : Water productivity (Kg/m^3)**

CONCLUSION

The purpose of our study was to determine the soil suitability of El-Dakhla depression and to identify the factors that hinder the cultivation process. In this research, land capability, evaluation and sustainability were conducted with the aid of remotely sensed data and GIS. The results showed that more than 91000 feddan are fair capable (grade 3) for agriculture and about 28080 are good capable (grade 2). Using land evaluation program (LUSET), showed that the use of the study area for agricultural production was very promising. It is found that, the most sustainable land use recommended under the limited water resources in case of water requirement are barely, sorghum, groundnut and olive. Whereas the most sustainable land use in case of net return and water productivity are wheat, cotton, mango and afaalfa. On the other hand, there are some limitations for agricultural use. Therefore, proper soil management is required to increase the soil suitability for different crops. Finally, the present study proved that integration between remote sensing and GIS is a powerful tool for sustainable land use planning**.**

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تقييم الأراضي والتنمية المستدامة لبعض المناطق بواحة الداخلة – مصر

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أراضي الواحات الداخلة في صحراء مصر الغربية تعتبر من اكثر المناطق الملائمة للتوسع الزراعي ، وتمثل احد المنخفضات الرئيسية في الصحراء الغربية. و تهدف هذه الدراسة إلى عمل قاعدة بيانات جغرافية للتربة في منطقة الدراسة باستخدام نظام المعلومات الجغرافية ،عمل تقسيم و تقييم للأراضي بمنطقة الدراسة، وكذلك اقتراح سياسات للوصول للاستخدام الأمثل للأرض والتنمية المستدامة. تتميز منطقة الدراسة بالمناخ الجاف لعدم سقوط الأمطار بها. تقع منطقة الدراسة بين خطي طول 28 ° 15 '- 29 ° 40'شرقاًدائرتي عرض 25 ° 00 '- 26 ° 00' شمالاً . تغطي منطقة الدراسة مساحة قدرها حوالي120000 فدان وهى من أكثر المناطق تحديا للتنمية المستدامة. وفي هذه الدراسة قد تم استخدام بيانات الاستشعار عن بعد وبيانات التربة بالتكامل مع نظام المعلومات الجغرافية لتحليل الاستخدام المستدام للأراضي (SLU). تم اقتراح الـSLU على أساس عوامل مختلفة مثل: القدرة الإنتاجية للأرض ، وصلاحيتها للاستخدام ، الاحتياجات المائية للمحاصيل، العائد الاقتصادي من الأرض ومن وحدة المياه.تم إجراء الحصر الحقلي وحفر القطاعات الأرضية الممثلة للوحدات الفيزيوجرافية المختلفة ووصفها مورفولوجياً وجمع المعلومات الحقلية اللازمة للدراسة. تم إجراء التحليلات المعملية الطبيعية والكيميائية لعينات التربة المأخوذة من القطاعات الأرضية. ومن ثم تم بناء قاعدة البيانات الجغرافية للتربة وربطها بالوحدات الخرائطية المختلفة. وبناءً على الوصف الحقلي والتحليل المعملي تم تصنيف التربة إلى: Typic Haplargids, Typic Torriorthents, Typic Torripasamments, Typic Haplotorrerts and Vertic Torriorthents.وبالإضافة لذلك، تم تقييم القدرة الإنتاجية للأرض لتحديد المناطق الصالحة للإنتاج الزراعي باستخدام دليل ستوري (Storie)وأظهرت نتائج الدراسة أن أكثر من 28080 فدان جيدة (grade 2) وحوالي 91000 فدان (grade 3)

متوسطة القدرة للإنتاج الزراعي. تم استخدام LUSET لمقارنة خصائص التربة وعمل تقييم ملائمة الأرض لأنواع مختلفة من المحاصيل (16 محصول) ، وأظهرت النتائج أن أكثر من 84000 فدان متوسطة صلاحية (S2)للقمح والذرة الرفيعة ، في حين أن هناك حوالى 88560 فدان عالية الصلاحية (S1) للشعير و 93600 فدان متوسطة الصلاحية (S2) للبرسيم الحجازي،الزيتون والفول السوداني و59280 فدان عالية الصلاحية (S1) للقطن و71000 فدان متوسطة الصلاحية (S2) للمانجو و51600 فدانمتوسطة الصلاحية (S2) للبطاطس. وفى نهاية الدراسة تم تحديد الاستخدام المستدام للأرض (SLU) على أساس بديلين (أ) الاستخدام الأكثر استدامة للأرض من حيث الاحتياجات المائية: الشعير ، الذرة الرفيعة ، الفول السوداني و الزيتون، حيث أن الاحتياجات المائية لهذه المحاصيل قليلة. (ب) الاستخدام الأكثر استدامة للأرض من حيث صافي العائد الاقتصادي: القمح،القطن ، البرسيم الحجازي و المانجو حيث أن العائد الصافي لهذه المحاصيل مرتفع.تؤكد نتائج هذه الدراسة أن نظام المعلومات الجغرافية إلى جانب المصادر الأخرى للبيانات يعتبر وسيلة قوية جداً وفعالة في الإدارة والتخطيط وبالتالي دعم عملية صنع القرار.

قام بتحكيم البحث

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Table 1. Legend of the physiographic soil map of the studied area.

Landscape	Relief	Lithology	Landform	Area Km^2	%	Main Soils	% of Mapping unit	Kind of Mapping Unit
Lowland Lo	Depression Lo 1	Clay Shall	Depression Edge Lo 11	274.13	53.12	Typic Torriorthents	50	Association
						Typic Haplotorrerts	50	
			Depression Floor Lo 12	173.19	33.56	Typic Haplargids	46.16	Complex
						Typic Torriorthents	15.38	
						Typic Torripasamments	15.38	
						Typic Haplotorrerts	15.38	
						Vertic Torriorthents	7.70	
	Dune Field Lo 2	Sand stone	Sand dunes Lo 21	64.40	12.48	Typic Torripasamments	100.00	Consociation
	Water body		Pools	4.34	0.84	Water body		
Highland	Plateau	Lime stone	Summit			Rocky Area		
			Escarpment					

Storie Index Rating = [(Factor A/100) x (Factor B/100) x (Factor C/100) x (Factor X/100)] x 100
Where; Factor A: Soil depth (cm), Factor B: Surface Texture, Factor C: Slope and Factor X: includes; Drainage, Alkalinity. Capability Classes; Grade 1 (Excellent): 100-80%, Grade 2 (Good):79-60%, Grade 3 (Fair): 59-40%, Grade 4 (poor): 39-20%, Grade 5 (nonagricultural):< 20%

Table 2. Some chemical characteristics of some studied soils and their textural classes.

Unit	P_No	Depth cm	EC dS/m	pH	CaCO3 %	CEC meq/ 100 g soil	ESP %	SAR	Active $CaCO_3$ %	OM %	Texture*
Depression Edge	1	0-25	8.41	7.74	8.45	23.14	10.79	2.56	3	0.97	**C**
		25-50	6.31	7.89	12.87	20.52	7.18	3.15	2	0.73	**SC**
		50-100+	9.58	7.88	8.45	24.1	8.13	2.68	1.8	0.00	**C**
	2	0-30	1.88	7.79	6.84	2	4.66	0.97	0.8	0.00	S
		30-60	2.78	7.8	11.67	2.35	5.51	0.84	1.4	0.00	S
		60-100+	6.73	8.02	8.85	24.02	14.44	3.39	1.6	0.00	C
	17	0-35	0.32	7.08	9.65	28.48	18.15	3.18	2	0.46	C
		35-70	0.77	7.96	10.06	26.94	13.7	3.37	2	0.24	C
		70-100+	2.57	7.66	6.84	28.41	24.25	3.40	3	0.00	C
Depression Floor	3	0-30	2.12	7.85	13.28	24.09	14.92	2.97	2.4	0.97	SC
		30-70	6.09	7.91	6.44	30.12	13.92	3.41	2.6	0.48	C
		70-100+	8.09	8.02	11.26	30.94	17.1	2.77	2	0.00	C
	4	0-35	0.25	8.24	7.64	1.492	8.642	0.68	1	0.61	S
		35-70	0.39	8.26	9.65	2	7.319	0.99	1.6	0.00	S
		70-100+	0.37	8.31	10.46	1.7	13.61	0.70	1.4	0.00	S
	5	0-30	0.74	8.04	8.05	1.3	6.617	0.64	0.8	0.00	S
		30-55	2.12	7.82	9.65	2.5	1.237	1.30	1.2	0.00	S
		55-100+	4.99	7.83	11.67	19.85	13.43	2.81	1.6	0.00	SC
	6	0-30	0.29	7.87	5.63	12.52	8.427	2.91	0.8	1.16	SCL
		30-100+	0.2	8.07	6.84	1.6	9.456	0.86	1.2	0.00	S
	9	0-25	7.06	7.46	8.85	20.74	13.25	2.56	2.4	1.28	SC
		25-50	5.32	7.63	7.64	20.61	14.52	2.81	2.4	0.73	SC
		50-100+	7.29	7.88	6.03	30.5	17.98	3.12	2	0.00	C
	15	0-40	0.25	7.86	9.65	11.32	13.78	2.05	1.6	0.90	SL
		40-80	0.4	8.29	16.90	21.66	12.45	2.66	3.4	0.56	SC
		80-100+	0.44	8.49	13.68	19.54	12.51	3.32	2.8	0.00	SC
	20	0-30	3.2	8.09	6.84	27.19	12.14	2.76	0.6	0.48	C
		30-80	1.48	7.81	6.03	20.5	11.04	2.43	0.4	0.00	C
		80-100+	4.36	8.12	6.44	26.46	14.24	3.02	1	0.00	C
Sand Dunes	10	0-30	0.5	8.08	7.24	2.06	11.08	0.78	1	0.97	S
		30-60	0.66	8.09	6.03	1.8	10.40	0.88	1	0.00	S
		60-100+	1.32	7.85	8.85	2	10.53	1.17	1.2	0.00	S
	21	0-30	1.03	7.51	6.44	2	8.055	0.90	0	0.24	S
		30-60	0.71	7.95	6.03	3	11.19	1.08	0.6	0.00	S
		60-90	2.41	7.96	6.03	2.2	12.31	1.08	1	0.00	S

*** SL: Sandy Loam , SCL: Sandy Clay Loam, CL: Clay Loam, C: Clay, SC: Sandy Clay, SC: Sandy Clay, S: Sandy, L: Loam,**