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Set of Agricultural Land Evaluation in El–Dakhla Oases Soils, Egypt

Soliman, M.M.
Soils, Water and Environment. Res. Inst., Agric. Res. Center

EL–DAKHLA Oases soils are located between longitudes 28^{O} 30^{-} and 29^{O} 04^{-} East and latitudes 25^{O} 20^{-} and 26^{O} 00^{-} North, covering about 2000 km^{2}.

Physiographic mapping units, soil taxonomy, statistical size parameters, water resources quality and its suitability for irrigation and crop water requirements were performed as a set of agricultural land capability and suitability evaluation of El- Dakhla Oases soils.

Land sat ETM image (2010), digital elevation model (DEM) and 3D –GIS techniques were used in ERDAS image 9.2 software to produce the physiographic map of the studied area. The main physiographic units and its soil taxonomic ; family levels could be classified as follows:

1- Soils of Playa:
a- Typic Haplosalids, fine loamy over sandy skeletal, mixed, hyperthermic.
b- Duric Haplosalids, sandy skeletal, mixed, hyperthermic.
2-Soils of Sabkha:
Lithic Gypsisalids, sandy skeletal, siliceous, hyperthermic, shallow.
3- Soils of Sand Sheets:
Calcic Haplosalids, sandy skeletal, mixed, hyperthermic, deep.
4- Soils of Peniplain:
Typic Haplosalids, clayey skeletal, hyperthermic.
5- Soils of Cultivated plain:
a- Typic Torriorthents, fine loamy, mixed, hyperthermic.
b-Typic Torriorthents, clayey over fine loamy skeletal, mixed, hyperthermic.
c-Typic Haplosalids, coarse loamy skeletal over clayey, mixed, hyperthermic .
d-Typic Haplosalids, fine loamy over coarse loamy, mixed, hyperthermic.

The statistical size distribution reveal that these soils have mainly poorly sorted sediments with near symmetrical to fine skewed materials and lepto kurtic to meso kurtic pattern. These parameters indicate that the studied area is formed under water or both water and wind action, forming of non- uniform parent materials.

Current suitability of the studied soils could be categorized into three suitable classes; moderately suitable (S_2) , marginally suitable

E-mail:mahmoudaldemelawi@hotmail.com
: mahmoudeldemelawi@yahoo.com

(S_3) and not suitable (N_1) with different intensity degree of soil limitations. By existing suitable improvement practices, the potential suitability classes assessed are two suitability classes; moderately suitable (S_2) and not suitable (N_2).

Data revealed that current suitability for some specific crops were not suitable (N), except for some scattered areas developed on cultivated plain which are suitable for all the studied crops. On the other hand, the potential suitability classes differed according to the satisfaction conditions between different properties of soils developed on the studied physiographic units and crop water requirements. However, soils of sabkha and cultivated plain are highly suitable (S_1) for groundnut. Also, soils of peniplain and cultivated plain are highly suitable (S_1) for potato and grapes. Whereas, soils of playa, peniplain and cultivated plain are moderately suitable (S_2) for olives.

Water of wells and springs are considered the main sources for irrigation in El- Dakhla Oases soils. Data revealed that the suitability of irrigation water had (C_1–S_1) class with non restriction at west El–Mowhob and Kalamon area , while it represented (C_4–S_4) class with very high salinity levels and very high alkalinity hazard at El- Zaiate well and Bathor spring waters, indicating severe restrictions in these soils.

Data revealed that the crop water requirement values of some specific crops are considered high, due to the highness of evapotranspiration values. It represented with an average of 500, 800 and 1800 mm/s for vegetable, field and fruit crops, respectively. So, it is very important to apply suitable irrigation systems such as trickle or sprinkler, under these conditions.

Keywords: GIS, Land evaluation, Soil taxonomy, and Crop water requirements.

El- Dakhla depression is natural excavation in the middle part of the Egyptian Western Desert and has an area of about 2000 km^2 . It is situated between latitudes 25^{o} 20^{-} and 26^{o} 00^{-} North and Longitudes 28^{o} 30^{-} and 29^{o} 04^{-} East, It is located at about 120 km west of El- Kharga Oases and about 300 km west the Nile Valley. The floor of El- Dakhla depression is bound from the north and north east by steep scarps of the Eocene limestone plateau, but gradually rises to the south where it merges with the plain of upper Cretaceous Nubian sandstone.

Geology

A number of geologists, among them Shata (1959), Said (1962), Hermina (1967), Attia (1970), Abu El- Izz (2000) and Said (2000) discussed the geological description of El- Dakhla Oases. They mentioned that the succession of its formation from the olders to the youngest, *i.e.* Cretaceous, Paleocene and Quaternary (Pleistocene and Holocene). It owes its orgin to the exposure of Nubian sediments which consist of alternation of clays, shales, sands and sandstones to erosion.

The overlying Cretaceous and Eocene formations consist essentially of limestone from the plateau which borders the Oasis from north and east, the elevation of this plateau indicates that erosion has removed about 200 m of this limestone to expose the underlying Nubian rocks. The latter group rocks contains the important water bearing horizon of which the oasis owes its existence.

Climate

According to Central Laboratory for Agriculture of Climate (CLAC 2010), the climatelogical data of El- Dakhla Oases is somewhat worm in summer and slightly cold in winter. The mean annual temperature ranges between 13.7^{o} C and 33^{o} C, the annual maximum temperature differs from 21.2^{o} C to 40.6 ^{o} C and the minimum from 6.2^{o} C to 25.7^{o} C. El- Dakhla Oases receives a very low amount of rainfall where the average rate is located between 0.1 and 1.2 mm/year. The mean annual relative humidity ranges from 28.0% to 66%. Wind velocity ranges from 5.2 Km/h in December to 19.2 Km/h in March. According to the Key of Soil Taxonomy System (USDA 2010) the soil temperature regime of the studied area could be defined as hyperthermic and soil moisture regime as torric.

Water resources

In El- Dakhla Oases there are two main sources of irrigation waters, water of springs and water of wells. Most wells of El- Dakhla Oases are deep, their sources is the Nubian Sandstone which is saturated with water originating from equatorial rainfall, water is found at varying depths, between 300 and 400 m. Some geologists think that ground water movement from Equatorial Africa to the Western Desert for about 500 years.

Material and Methods

Based on the interpretation of the remote sensing image of El- Daklla Oases, the following geomorphic aspects were distinguished:

1- Structural Plateau (SP)
2- Escarpment (ES)
3- Peniplain (Pe)
   3- 1- Cultivated area (Cu)
   3-2- Playa (Pe Pa)
   3-3- Sabkha (Pe sb)
4- Wind blown sand (W)
   4-1- Sand dunes (Wsd)
   4-2-Sand sheets (Wss)

Table 1 shows the geomorphic legend description of different mapping units. Figure 1 illustrates physiographic units of El- Dakhla Oases delineated on landsat, Thematic mapper hard copy (2010) produced by ERDAS imagine 9.3 image processing software. Topographic maps scale 1 : 100.000, produced by Egyptian General Survey Authority were used to check the delineated soil units of the study area.

TABLE 1. Physiographic legend and description of different geomorphological units.

Symbol	Geomorphological Units	Sub units	Description
(SP)	Structural Plateau		It is located in the north and eastern sides of El- Dakhla depression, and includes the very stony material (limestone), sandy material and sand sheets. Topography of the surface is gently sloping to undulating and occupies the more rolling slope.
(ES)	Escarpment		El- Dakhla Oases on the northern and western sides is bound by a precipitatous escarpment which rises some 300m. above the depression floor and which makes the edge of an extensive limestone plateau. The width of this escarpment ranges between three and six kilometers. The top portion of the escarpment is a steep weel of white chalk, while below comes a more gradual slope of dark colored clays, marls and sandstone white foot hills of considerable size
(Pe)	Periplain		It is located between the structural plateau in the north and escarpment in the south. The surface could be classified into two sub units, namely periplain slope and centeral periplain flat. periplain slope is characterized by undulating relief and almost barren, covered by gravels and stones and occupies the narrow area adjacent to the escarpment foot. Central periplain flat includes the Oases depression and extends from east to the west, it is divided into a cultivated area by a strip of barren desert.
(Pe Pa)		Playa	It is located in eastern parts of El- Dakhla Oases between the high plateaus and characterized by an almost flat surface. The playa deposits are composed of fine site beds of brown colour intercalated with sand and gravels. They are contain amounts of sandy silt, which includes the rock fragments.

TABLE 1. Cont.

Symbol	Geomorphological Units	Sub units	Description
(Pe sb)	Peniplain	Sabkha	It is located in the middle of El- Dakhla Oases and adjacent to sand dunes. The surface is almost flat and covered with thin crust.
(Cu)		(Plain) Cultivated	The cultivated area is located around Balat, Esmant, Tanida, Musara, Hindaw, Mawhoub and El-Gadida villages. These areas have been artificially modified in order to change the landscape into terraces to suite irrigated agriculture using the natural existing wells. Topography of the surface ranges between almost flat and slightly undulating.
(WSd)	Wind blown sand	Sand dunes	These are located in the western and southern parts of El- Dakhla depression, low to moderately high, and dominated by recent shaped barchans dunes and occasionally with sand dunes, they reach 10 - 15 meters. Their surfaces are barren of natural vegetation except in the relatively level area between them, and they are drift very slowly to the south - west direction.
(Wss)		Sand sheets	These are located in the western and middle parts of El- Dakhla Oases, The surface is mainly almost flat to slightly undulating and covered with aeolian deposits. The texture is mainly coarse and fine sand with fine gravels.

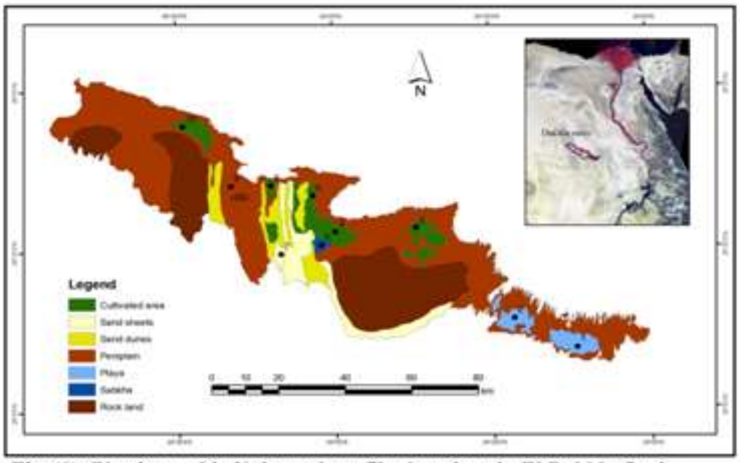

Fig. (1): Physiographic Units and profiles locations in El Dakhla Oasis.

Field work

A rapid reconnaissance soil survey was made throughout the investigated area of El- Dakhla Oases in order to identify the major landforms and gain appreciation of the broad soil patterns and landscape characteristics. The primary units were verified based on field interpretation and information gained during the reconnaissance survey. Ten soil profiles have been dug in each site to a depth of about 150 cm or to the depth of hard layers, parent material, or the water table. A detailed morphological description of soil profiles was carried out on basis outlined by FAO (2006), (Table 2). A number of 37 soil samples of the various layers have been collected for laboratory analyses. (Fig.1). Also, ten water samples representing the wells and springs were collected .

Laboratory Analyses

Physical analyses

Soil color (wet & dry) was identified with the aid of Munsell (2010). Mechanical analysis was carried out for fraction by pipette method and particle size distribution for sand fraction was determined by dry sieving USDA (2004), then the obtained data were statistically evaluated according to Folk and Ward (1957).

Chemical analyses

Electrical conductivity (EC), PH, soluble cations and anions, $CaCO_3$%, OM%, and gypsum contents were determined according to USDA (2004). Ten water samples were subjected to chemical analyses according to USDA (2004), where soluble cations and anions, total dissolved salts (TDS) and pH were determined. Sodium adsorption ratio (SAR) was calculated using the formula :

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{++} + Mg^{++}}{2}}}$$

TABLE 2. Morphological Description of the Studied Soil Profiles.

Profile No.	Depth (cm)	Soil colour				Soil texture	Soil structure	Consistence	Efferv-esce-nce	Boundary
		Dry		Moist						
Playa										
1	0-30 30-60 60-80 80-150	5YR 5YR 5YR 5YR	5/3 5/4 5/4 5/4	5YR 5YR 5YR 5YR	5/4 4/6 4/6 4/4	SCL SCL LS SL	w.c.s.ang m.c.ang b ma ma ma	soft nst npl soft nst npl soft nst npl soft nst npl	Non Non Non Non	c.s c.s c.s --
2	0-10 10-50	7.5YR 7.5YR	5/4 5/3	7.5YR 7.5YR	4/4 4/3	SCL LS	w.c.s.ang w.c.s.ang	soft ns np soft ns np	w w	c.s
Sabkha										
5	0-10 10-40	5YR 5YR	4/6 5/4	5YR 5YR	4/4 4/4	SCL S	w.c.s.ang ma	nst npl nst npl	w w	c.s --
Sand Sheets										
7	0-15 15-55 55-85 85-110	7.5YR 7.5YR 7.5YR 7.5YR 10YR	6/4 6/6 6/6 5/4 5/6	.5YR 7.5YR 7.5YR 7.5YR 10YR	5/4 5/6 5/6 4/3 4/6	S LS S S	Sg. Sg. ma. ma.	Lo n st. npl. Lo n st. npl. So. n st. npl. So. n st. npl.	w w Non Non W	c.s c.s c.s d.s --
Peniplain										
9	0-15 15-55 55-75 75-110	10YR 10YR 10YR 10YR	6/3 5/3 4/4 5/4	5YR 5YR 5YR 5YR	5/6 4/4 4/6 4/4	SC C SC SC	w.c.ang b m.f.ang b s.f.ang b w.c.ang b	n. st. st. pl. n. st. n. st.	mod w w w	c.s c.s d.s --
(Plain) Cultivated area										
3	0-10 10-35 35-65 65-100	7.5YR 7.5YR 5YR 5YR	4/6 5/6 4/4 4/4	7.5YR 7.5YR 5YR 5YR	4/6 4/4 4/4 5/6	SCL SCL SCL SCL	ma ma ma ma	st pl st pl st pl st pl	mod mod mod mod	d.s d.s d.s --
4	0-25 25-50 50-90 90-150	7.5YR 7.5YR 7.5YR 7.5YR	5/8 5/4 5/6 5/6	7.5YR 7.5YR 7.5YR 7.5YR	4/6 4/4 4/6 3/4	SCL SCL SCL SCL	w.c.s.ang b w.m.ang b mod.f.ang mod.f.ang	st pl st pl st pl st pl	mod mod mod mod	d.s d.s d.s --
6	0-25 25-65 65-100	10YR 10YR 10YR	5/6 5/8 5/6	10YR 10YR 10YR	4/6 4/6 4/6	SC SC SCL	w.c.s.ang mod.m.s.ang b mod.m.s.ang b	st pl st pl st pl	w w w	d.s c.s
8	0-15 15-45 45-70 70-100 100-120	10YR 10YR 10YR 10YR 10YR	6/6 6/4 5/4 5/6 5/4	10YR 10YR 10YR 10YR 10YR	4/6 5/4 5/3 5/4 5/3	C SL SC SCL SCL	w.c.s.ang ma ma ma ma	st pl slst slpl st pl st pl st pl	mod mod mod mod mod	c.s c.s d.s --
10	0-15 15-35 35-50 50-70 70-100	7.5YR 7.5YR 7.5YR 7.5YR 7.5YR	5/8 5/4 5/6 5/6 5/6	7.5YR 7.5YR 7.5YR 7.5YR 7.5YR	4/6 4/4 4/6 3/4 3/4	C SC SCL SL SL	w.c.s.ang b w.m.ang b mod.f.ang ma. Ma.	st pl st pll st pl so.sl.st. so.sl.st.	mod mod mod mod	d.s d.s d.s --

Soil Taxonomy

Based on the morphological, physical and chemical characteristics of the studied soil profiles as well as meteorological data, the studied soils were classified up to the family level according to the American System of Soil Taxonomy (USDA, 2010).

Land evaluation

The soil under investigation were evaluated using the two systems namely, land capability classification of Sys *et al.* (1991) and soil suitability classification of certain crops based on the concepts outlined by Sys *et al.* (1993). The main soil parameters used in this system are climate, soil depth, texture, gravel content, $CaCO_3$ percent, gypsum percent, salinity (ECe), alkalinity (SAR), slope pattern and different conditions. A suitability index of 12 crops for the studied soils was done according to this system.

Crop water requirement

The crop water requirements were calculated using crop wat. program. The program determines ETo using Penmon - Monteith method, (Allen, 1998). The climatic data of El- Dakhla Oases, Climatological Normals for Egypt (2010) and Central Laboratory for Agriculture of Climate (CLAC 2010) were used.

Results and Discussion

El- Dakhla Oases soils consists mainly of five dominant physiographic units. These are, Playa, Sabkha, Cultivated plain, Sand dunes, Sand sheets and Peniplain. A breif notes about the identified physiographic units were shown in Table 2. Soil characteristics of the physiograohic units could be discussed and classified according to USDA (2010) based on the data in Tables 3, 4 and 5. Some of these characteristics could be summarized in the following lines:-

TABLE 3. Particle Size Distribution, Texture class , $CaCO_3$ Content and OM% of the Studied Soil Profiles.

Prof. No.	Depth Cm	gravels %	Particale size distribution %				Text. Class	$CaCO_3$ %	OM %
			C.S	F.S	Silt	clay			
Playa									
1	0-30	37	38.15	25.22	8.12	28.51	SCL	2.83	0.003
	30-60	37	55.68	20.79	2.30	21.23	SCL	1.89	0.41
	60-80	36	71.62	14.37	0.13	13.88	LS	1.62	0.003
	80-150	39	66.40	15.36	2.73	15.51	SL	135	0.41
2	0-10	24	40.81	17.59	6.07	30.53	SCL	2.97	0.39
	10-50	38	56.78	32.61	0.46	10.15	LS	3.10	0.003
Sabkha									
5	0-10	27	37.68	21.47	10.47	30.38	SCL	4.19	0.02
	10-40	39	82.17	15.04	1.66	1.13	S	3.92	1.05
Sand Sheets									
7	0-15	27	68.46	27.93	1.37	2.24	S	13.50	0.28
	15-55	25	78.76	12.97	0.43	7.84	LS	10.13	1.48
	55-85	36	87.60	11.79	0.11	3.41	S	12.96	0.07
	85-110	37	93.68	4.68	0.45	1.19	S	11.50	0.39
Peniplain									
9	0-15	20	32.77	25.70	2.21	39.92	SC	6.48	0.003
	15-55	24	19.48	17.12	7.01	56.20	C	0.81	0.69
	55-75	39	23.35	27.72	0.92	48.01	SC	1.62	0.14
	75-110	39	33.33	13.37	0.92	52.38	SC	0.95	0.34

TABLE 3. Cont.

Prof. No.	Depth Cm	gravels %	Particle size distribution %				Text. Class	$CaCO_3$ %	OM %
			C.S	F.S	Silt	Clay			
(Plain) Cultivated area									
3	0-10	40	30.94	39.57	3.47	26.03	SCL	5.67	0.48
	10-35	4	32.45	24.43	12.49	30.63	SCL	7.02	0.48
	35-65	7	46.0	23.15	2.91	27.94	SCL	6.34	0.28
	65-100	20	47.79	21.33	8.48	22.40	SCL	5.40	0.28
4	0-25	19	30.56	44.03	0.52	24.89	SCL	6.75	0.21
	25-50	18	18.88	45.91	2.99	32.22	SCL	6.21	0.21
	50-90	19	45.97	27.31	1.09	25.63	SCL	6.21	0.34
	90-150	15	49.68	19.47	1.77	29.08	SCL	5.94	0.34
6	0-25	36	13.44	43.76	1.93	40.87	SC	3.78	0.41
	25-65	27	12.85	45.30	1.42	40.43	SC	1.50	0.34
	65-100	39	35.51	36.73	1.51	26.25	SCL	3.78	0.69
8	0-15	39	11.41	22.54	6.75	59.30	C	11.07	0.69
	15-45	37	16.27	32.36	49.47	1.90	SL	5.13	0.14
	45-70	25	22.06	34.7	1.65	41.59	SC	4.59	0.48
	70-100	27	17.41	47.04	1.35	34.21	SCL	5.40	0.14
	100-120	29	29.14	47.34	2.65	20.87	SCL	4.32	0.21
10	0-15	12	4.74	23.44	15.72	56.10	C	4.32	0,69
	15-35	9	11.42	39.27	15.31	44.00	SC	2.56	0.14
	35-50	29	21.16	44.62	2.30	31.92	SCL	1.75	0.003
	50-70	9	28.74	50.43	1.95	18.88	SL	1.35	0.003
	70-100	15	25.82	54.24	3.98	15.96	SL	2.30	0.50

TABLE 4. Some chemical analyses of the studied soil profiles.

profile No.	Depth Cm	pH	ECe (dS/m)	Anions				Cations				Gyp. %	SAR
				$CO^{=}_{3}$	HCO^{-}_{3}	Cl^{-}	SO^{2-}_{4}	Ca^{2-}	Mg^{2+}	Na^{+}	K^{+}		
Playa													
1	0-30	7.78	61.13	-	7.69	2150.	377.4	641.02	1334.28	491.97	67.83	0.12	15.65
	30-60	8.20	27.39	-	3.08	220.0	178.5	46.15	32.86	317.4	5.18	1.42	50.54
	60-80	8.22	36.37	-	4.90	360.0	83.63	51.28	17.86	371.36	8.03	1.90	63.16
	80-150	8.29	19.04	-	3.69	88.0	160.9	46.28	37.8	163.46	5.18	1.09	25.23
2	0-10	7.64	23.22	-	2.46	301.0	42.05	135.89	22.13	184.1	3.39	0.82	20.71
	10-50	7.53	28.48	-	3.69	440.0	8.70	151.28	46.25	250.75	4.11	1.20	12.15
Sabkha													
5	0-10	6.95	14.72	-	6.15	130.0	48.67	56.41	5.34	120.39	2.68	15.99	21.69
	10-40	7.44	54.42	-	12.65	2930.	36049.9	256.41	317.66	38400.0	18.21	4.11	2266.8
Sand Sheets													
7	0-15	7.51	15.83	-	1.54	390.0	62.06	201.28	1.22	236.46	14.64	1.16	23.50
	15-55	7.54	32.92	-	2.66	420.0	281.8	394.87	91.55	803.31	11.78	0.90	13.03
	55-85	7.65	24.49	-	2.46	308.0	170.8	256.41	67.04	149.18	8.21	0.40	11.73
	85-110	7.63	16.88		3.08	156.0	136.7	115.38	82.15	93.63	4.64	0.34	9.42
Peniplain													
9	0-15	7.87	10.74	-	1.85	68.0	85.57	51.28	15.38	82.52	6.24	4.34	14.30
	15-55	8.06	39.27	-	2.32	240.0	265.6	56.41	27.54	412.62	11.42	2.19	63.67
	55-75	8.21	45.44	-	9.22	250.0	628.2	123.20	19.95	730.02	9.28	0.89	84.78
	75-110	8.22	28.21	-	4.32	176.0	276.1	66.66	61.69	323.75	4.28	3.98	40.42

TABLE 4. Cont.

profile No.	Depth Cm	pH	ECe (dS/m)	Anions				Cations				Gyp. %	SAR
				$CO^{=}_3$	HCO^-_3	Cl^-	SO^{2-}_4	Ca^{2-}	Mg^{2+}	Na^+	K^+		
(Plain) Cultivated area													
3	0-10	7.63	4.86	-	9.23	18.0	37.11	30.76	6.28	22.75	4.55	0.10	5.29
	10-35	7.44	9.29	-	8.46	59.0	39.13	45.51	29.8	24.50	6.78	0.35	3.99
	35-65	7.53	3.04	-	6.46	15.0	21.26	19.23	6.70	11.43	5.36	0.09	3.18
	65-100	7.56	2.58	-	3.38	3.0	11.85	8.97	3.90	4.13	1.23	0.14	1.63
4	0-25	7.71	2.82	-	4.61	16.0	6.49	10.89	1.45	13.65	1.11	0.14	5.50
	25-50	7.96	1.44	-	3.08	8.74	12.82	1.37	4.76	0.87	19.82	0.17	0.50
	50-90	8.30	4.34	-	3.08	14.0	43.8	44.87	8.21	10.16	1.64	0.34	1.97
	90-150	7.53	4.64	-	5.69	16.08	54.0	43.58	8.27	14.91	9.01	1.45	2.93
6	0-25	7.80	1.53	-	4.61	7.0	12.73	11.54	0.82	4.11	0.87	0.18	4.48
	25-65	7.81	0.93	-	3.99	3.0	3.03	5.13	2.28	2.16	0.45	0.13	1.125
	65-100	8.03	0.68	-	2.30	3.0	6.52	5.13	2.28	3.86	0.55	0.23	2.00
8	0-15	7.95	3.68	-	1.69	12.0	73.25	37.18	6.03	41.23	2.5.0	3.33	8.87
	15-45	8.08	37.09	-	4.32	102.1	360.0	51.25	7.98	390.4	16.78	3.47	71.76
	45-100	7.98	22.22	-	4.32	160.0	187.4	82.05	41.40	222.8	6.07	2.43	28.27
	100-120	8.06	17.68	-	3.99	90.0	110.6	49.38	4.94	144.42	5.89	1.59	27.72
10	0-15	7.97	5.17	-	2.31	14.38	53.0	338.46	1.04	26.98	3.21	1.47	60.8
	15-35	7.87	30.1	-	9.23	320.0	34.68	21.79	72.03	260.27	9.82	1.29	37.99
	35-50	7.85	26.0	-	6.10	236.0	88.03	92.30	6.46	225.35	6.07	1.38	32.06
	50--70	7.94	20.0	-	3.07	164.0	96.43	130.76	29.73	99.98	3.03	0.46	11.15
	70-100	7.83	8.52	-	1.84	64.0	35.03	38.46	32.26	38.08	1.07	0.14	6.86

TABLE 5. Soil classification categories of the studied profiles (according to USDA 2010).

Order	Suborder	Great group	Sub great group	Soil Families	Profile No.
Aridisols	Salids	Haplosalids	Calcic Haplosalids	Sandy skeletal, siliceous, hyperthermic, deep	7
			Duric Haplosalids	Sandy skeletal, mixed, hyperthermic, shallow	2
			Typic Haplosalids	Fine loamy skeletal over Sandy skeletal, mixed, hyperthermic, deep	1
				Clayey skeletal, mixed, hyperthermic, deep	9
				Coarse loamy skeletal over clayey, mixed, hyperthermic, deep	8
				Fine loamy over Coarse loamy, mixed, hyperthermic, moderately deep	10
			Lithic Gypsisalids	Sandy skeletal, siliceous, hyperthermic, shallow, lithic	5
Entisols	Fluvents	Torrifluvents	Typic Torrifluvents	Clayey over fine loamy skeletal, mixed, hyperthermic, moderately deep	6
	Orthents	Torriorthents	Typic Torriorthents	Fine loamy, mixed, hyperthermic, deep	3
					4

1- Soils of playa

This physiographic units represented by profiles No. 1 and 2 cover an area of about 84.5 km^2 (20280 feddens). The analytical data show that soil texture class varied from loamy sand to sandy clay loam. $CaCO_3$ content is very low and ranged from 1.35 to 3.10%. Gypsum content is generally less than 1.9%. Organic matter content is extremely low, not exceeding 0.41%. Soil pH values ranged between 7.53 and 8.29 indicating that these soils are slightly to moderately alkaline. Data presented in Table 4 revealed that the studied playa soils are highly to extremely saline and characterized by different salinity levels from 19.04 to 61.13 sm^{-1}. Sodium ions are the predominate soluble cations followed by Ca^{++} and Mg^{++}, while K^+ is rather low, except for the surface layer of profile No. 1. where Mg^{++} exceeds Na^+. Soluble anions are dominated by Cl^- followed $SO_4^=$ and then HCO_3^-. SAR varied from 12.15 to 63.16, indicating that these soils are sodic. The soils of this physiographic unit are classified as :

1- Typic Haplosalids, fine loamy over sand skeletal, mixed, hyperthermic (profile 1)

2- Duric Haplosalids, sand skeletal, mixed, hyperthermic (profile 2).

2- Soils of sabkha

This physiographic unit is represented by profile No.5. and covers an area of about 12.34 km^2 (2962 feddans). Data in Table 3 show that the depth of these soils is around 40 cm. It is limited by a lithic contact. Soil texture class is sandy clay loam in the surface layer changed into sand in the 10-40 cm depth. Calcium carbonate content is very low and varied within narrow limit (3.92-4.19%), while organic matter content is extremely low, not exceeding 1.05%, soil reaction ranges from 6.95 to 7.44 (neutral to slightly alkaline). Electrical conductivity (ECe) ranges from 14.72 to 54.42 dSm^{-1} indicating that these soils are moderately saline in the surface layer and extremely saline in the deepest layer. Soluble cations follow the order $Na^+ > Ca^{++} > Mg^{++} > K^+$, while soluble anions follow the order $SO_4^= > Cl^- > HCO^-$. Gypsum content varied from 4.11 to 15.99% and tends to decrease within the depth. The soils of this physiographic unit are sodic soils , where SAR values ranged from 21.69 to 2266.8. Soils of this unit are classified as Lithic Gypsisalids, sandy skeletal, siliceous, hyperthermic, shallow (profile 5).

3- Soils of sand sheets

This unit is represented by soil profile No.7 and occupied about 188.8 km^2 (45312 feddans). Data show that the soils of this unit are more than 100 cm depth (deep). The analytical data reveal that soil texture class is sand or loamy sand in the different layers of the representative soil profile. $CaCO_3$ content ranges between 10.13 and 13.5% with an irregular distribution pattern within the depth. Organic matter is extremely low and varied from 0.07 to 1.48%. Soil reaction is slightly alkaline (pH values are 7.51- 7.65). Soluble salts content ranged between 15.83 and 32.92 dSm^{-1} showing that these soils are moderately to extremely saline. Soluble cations are dominated by Na^+ and / or Ca^{++} followed by Mg^{++}, while soluble K^+ is the least abundant. On the other hand, soluble anions are dominated by Cl^- followed by $SO_4^=$ and HCO_3^-. Gypsum content is very low, not exceeding 1.16%. SAR values ranged from 9.42 to 23.5.

Soil characteristics of the second horizon meet the requirement of both salic and calcic horizons. Soils of this unit are classified as Calcic Haplosalids, sandy skeletal, mixed, hyperthermic, deep. (profile 7).

Soils of peniplain

This physiographic unit is represented by profile No. 9. Its area occupied about 156.4 km^2 (37536 feddans). The obtained data show that the soils are deep (> 100cm). The soil texture class is sandy clay in the surface and deepest layers, mean while it is clay in the subsurface layer. $CaCO_3$ content varies from 0.81 to 6.48%. The distribution pattern of $CaCO_3$ content does not portray any specific pattern within the depth. Organic matter content is very low, not exceeding 0.69%. Soil reaction is between 7.87 and 8.22 showing that these soils are strongly alkaline. Soluble salts content vary between 10.74 and 45.44 dSm^{-1} (moderately to extremely saline). Sodium is the dominant soluble cation followed by Ca^{++}, Mg^{++} and K^+. $SO4^=$ is the dominant soluble anion followed by Cl^- and HCO^-_3. Gypsum content ranged from 0.89 to 4.34% with an irregular distribution pattern within the depth. SAR values are more than 13 indicating that the soils of peniplain are sodic soils. These soils have a salic horizon in the soil depth from 25-100 cm (Control section). Soils of this unit are classified as:
Typic Haplosalids, clayey skeletal, hyperthermic (profile 9).

Soils of cultivated plain

This unit is represented by profiles No. 3, 4, 6.8 and 10 and covers an area about 933.3 km^2 (223992 feddans). The obtained results reveal that depth of these soils is between 95 and 150 cm. Soil texture varied from sandy loam to clay. Both representative profiles (No. 3 and 4) have the same pattern of sedimentation in all profile layers, where texture class is sandy clay loam. Calcium carbonate content ranges from 1.35 to 11.07% with an irregular distribution pattern within soil profile depth. Organic matter content is very low, 0.69%. The soil reaction ranges from 7.44 to 8.30 indicating that these soils are slightly to moderately alkaline, soluble salts content varies from 0.68 to 37.09 dSm-1 (non to extremely saline). Soluble cations are dominated with Ca^{++} and / or Na^+ followed by Mg^{++} and K^+, while soluble anions are dominated by $SO_4^=$ and Cl^- followed by HCO_3^-. Gypsum content varies from 0.09 to 3.47%, SAR values ranged between 1.63 and 71.76 indicating that these soils are non sodic to strongly sodic soils. The soils of this unit are classified as:

1- Typic Torriorthents, fine loamy, mixed, hyperthermic (profiles 3 and 4)

2- Typic Torriorthents, clayey over fine loamy skeletal, mixed, hyperthermic (profile 6).

3- Typic Haplosalids, coarse loamy skeletal over clay, mixed, hyperthermic, (profile 8).

4- Typic Haplosalids, fine loamy over coarse loamy, mixed, hyperthermic (profile10).

Statistical size parameters

Statistical measures (Folk and Ward, 1957) serve a guide in the explanation of the environment of deposition and agents of transportation. Data in Table 6 reveal that, the soils of playa, represented by profiles 1 and 2 have sorting values that ranged between 1.1 and 1.7 Q, indicating that the sediments are poorly sorted throughout the entire profile depths. This indictates that their sediments are transported and deposited under water action. Values of skewness indicate that all layers of the representative profiles are strong fine skewed and near symmetry in the top layer of profile 1.

These soils have a tail towards fineness. The kurtosis values ranged from 0.45 and 1.35Q, indicating that the sediments are meso kurtic, extremely lepto kurtic and platy kurtic. This leads to the suggestion that the soils are mainly formed under water action.

With regard to the soils of sabkha (profile 5), these soils constitute poorly sorted sediments in the surface layer and moderately sorted in the subsurface layer, this indicates that the surface layer is transported and deposited by water action, while the subsurface layer is transported and deposited under combined action of both water and wind. The sediments constituting profile 5 is fine and very fine skewed in the surface and subsurface layers, respectively. Graphic kurtosis indicates that the sediments constituting profile 5 is meso kurtic in the top layer and extremely leptokurtic in the subsurface layers.

Sorting values of the sand sheets showed that the sediments constituting profile 7 are well sorted in the top and deepest layers, sandwish a pair of poorly and moderately sorted in the middle layers. The well sorted sediments suggest that the surface and deepest layers are mainly transported and deposited by wind action, while poorly and moderately sorted sediments are transported and deposited by water or water and wind actions. Graphic skewness values in the sandy soils are coarse skewed in the surface layer and fine skewed in the subsurface and deepest layers, kurtosis of these sediments is extremely leptokurtic throughout the entire profile depths.

The obtained results of the peniplain soils (profile 9), show that the sorting values varied from 1.4 to 1.71 ø indicating that the sediments of the studied soil profiles are poorly sorted sediments throughout the entire depth. This leads to suggestion that the sediments of these soils are transported and deposited by water action or weathered in situ. Values of skewness indicate that the uppermost surface layer is fine and strong fine skewed, while the deepest layer are coarse and strong coarse skewed. The kurtosis values indicate that the sediments of profile 9 are meso kurtic in the surface layer and leptok urtic in the deepest layers.

TABLE 6. Q values read from the cumulative frequency curves and grain size parameters of sand fraction in the studied soil profiles.

Prof. No.	Depth Cm	ø5	ø 16	ø 25	ø 50	ø 75	ø 84	ø 95	MZ	Sorting		Skewness		Kurtosis	
										6ᵢ	class	SKi	class	Kg	class
Playa															
1	0-30	-	-	0.4	2.0	4.1	4.2	4.3	2.07	1.7	P.S	0.06	N.symm	0.48	MK
	30-60	-	-	-	0.8	4.0	4.0	4.4	1.60	1.67	P.S	0.62	s.f.sk	0.45	PK
	60-80	-	-	-	0.7	1.3	1.8	4.3	0.83	1.10	P.S	0.45	s.f.sk	1.35	E.L.K
	80-150	-	-	-	0.5	1.3	4.0	4.3	1.77	1.65	P.S	0.76	s.f.sk	1.35	E.L.K
2	0-10	-	-	0.1	1.4	3.9	4.1	4.3	1.83	1.68	P.S	0.33	s.f.sk	0.46	PK
	10-30		-	0.5	4.0	4.2	4.3	4.5	2.77	1.7	P.S	-0.82	s.c.sk	0.50	MK
Sabkha															
5	0-10	-	-	0.5	1.7	4.2	4.3	4.4	2.0	1.74	P.S	0.22	f.sk	0.49	MK
	10-40	-	-	-	-	0.3	1.1	4.1	0.37	0.9	M.S	0.53	s.f.sk	5.60	E.L.K
Sand Sheets															
7	0-15	-0.1	0.6	1.1	1.8	2.5	3.0	4.1	0.7	0.25	w.s	-0.12	-c.sk	1.53	E.L.K
	15-55	-	-	0.1	0.7	1.20	1.60	4.2	0.77	1.04	P.S	0.4	s.f.sk	1.56	E.L.K
	55-85	-	-	0.2	0.6	0.8	1.0	1.9	0.43	0.54	M.S	0.8	N.symm	1.30	E.L.K
	85-110	-	-	0.1	0.4	0.7	0.8	1.2	0.40	0.38	W.S	0.17	f.sk	0.82	E.L.K
Peniplain															
9	0-15	-	-	0.5	1.6	4.0	4.1	4.4	1.90	1.69	P.S	0.25	f.sk	0.52	MK
	15-55	-	-	0.3	1.2	1.7	3.0	4.3	1.40	1.40	P.S	0.32	s.f.sk	1.26	E.L.K
	55-75	-	0.3	1.1	2.5	4.2	4.4	4.5	7.20	1.71	P.S	-0.16	c.sk	0.60	LK
	75-110	-	0.3	1.0	4.0	4.3	4.4	4.5	2.90	1.71	P.S	-0.79	s.c.sk	0.56	LK

6ᵢ = sorting coefficient
(MZ)= mean size
(Ski)= skewness
(KG)= kurtosis

MZ= (ø 16+ ø 50+ ø 84)/3
6I=[(ø 84- ø 16)/4] + [ø 95- ø 5)/6.6)
Ski= [(ø 16+Q84)- 2 ø 50/[2(ø 84- ø 16)]+[(Q5+Q95)-2 ø 50/[2(ø 95-Q5)]
KG= (Q95-Q5)/ [2.44(Q75-2Q25)]

TABLE 6. Cont.

Prof. No.	Depth Cm	ø 5	ø 16	ø 25	ø 50	ø 75	ø 84	ø 95	MZ	Sorting		Shewinees		Kurtosis	
										6i	class	SKi	class	Kg	class
(Plain) Cultivated area															
3	0-10	0.5	0.8	0.9	1.8	4.0	4.1	4.3	0.23	1.40	PS	0.35	s.f.sk	0.50	MK
	10-3	0.2	0.7	0.8	1.7	4.1	4.3	4.4	2.20	1.54	PS	0.37	s.f.sk	0.52	MK
	35-65	0.4	0.6	0.9	1.7	4.1	4.2	4.4	1.97	1.51	PS	0.37	s.f.sk	0.51	MK
	65-95	0.4	0.6	0.7	1.2	3.7	4.1	4.3	1.97	0.94	M.S	0.62	s.f.sk	0.53	LK
4	0-25	0.1	0.7	0.8	1.5	3.5	4.1	4.4	2.1	1.50	PS	0.44	s.f.sk	0.65	V.L.K
	2-50	0.4	1.0	1.2	1.7	4.0	4.1	4.3	2.27	1.37	PS	0.44	s.f.sk	0.57	LK
	50-90	-	-	0.2	1.1	4.0	4.1	4.3	1.73	1.67	PS	0.47	s.f.sk	0.46	PK
	90-150	-	-	-	1.5	4.0	4.2	4.4	1.90	1.72	PS	0.30	s.f.sk	0.45	PK
6	0-25	0.3	1.2	1.4	4.0	4.2	4.3	4.4	3.17	1.40	PS	-0.81	s.c.sk	0.60	LK
	25-65	0.5	1.2	1.3	1.6	4.0	4.3	4.4	2.37	1.37	PS	0.59	s.f.sk	0.59	LK
	65-100	-	0.5	0.6	1.5	4.0	4.1	4.4	2.03	1.57	PS	0.59	s.f.sk	0.49	MK
8	0-15	-	1.2	1.5	4.1	4.2	4.3	4.4	3.20	1.44	PS	-0.87	s.c.sk	0.67	V.L.K
	15-45	-	1.1	1.4	3.1	3.5	3.7	4.1	2.63	1.27	PS	-0.53	s.c.sk	0.86	E.L.K
	45-70	-	0.8	1.4	1.8	4.2	4.3	4.4	2.30	1.54	PS	0.31	s.f.sk	0.64	V.L.K
	70-100	-	1.0	1.2	1.6	4.0	4.2	4.4	2.27	1.47	PS	0.45	s.f.sk	0.64	V.L.K
	100-120	-	0.6	1.2	1.9	2.5	4.2	4.4	2.23	1.57	PS	0.21	f.sk	1.38	E.L.K
10	0-15	1.0	1.6	1.9	4.1	4.3	4.4	4.5	3.37	1.23	PS	-0.78	s.f.sk	0.59	LK
	15-35	0.5	1.2	1.3	1.8	4.1	4.2	4.4	2.40	1.34	PS	0.47	s.f.sk	0.57	LK
	35-50	-	-	1.1	1.7	4.1	4.2	4.4	1.97	1.72	PS	0.21	f.sk	0.60	LK
	50-70	-	0.4	0.9	1.5	2.0	4.0	4.3	1.97	1.55	PS	0.35	s.f.sk	1.60	E.L.K
	70-100	-	0.7	1.0	1.5	1.9	2.6	4.2	1.60	1.11	PS	0.22	f.sk	1.91	E.L.K

6i
V.W.S= Very well sorted
W.S= Well sorted
M.s= Moderately sorted
M.W.s= Moderately well sorted
Ps= Poorly sorted
V.P.S= Very poorly sorted

SK
E.c.s= Extremely coarse skewed
S.C.s= strongly coarse skewed
C.S= Coarse skewed
N.S= Near symmetrical
F.S= Fine Skewed
E.F.s= Strongly fine skewed

KG
V.P.K= very platy kurtic
P.K= Platy kurtic
M.K= Meso Kurtic
L.K= Lepto Kurtic
E.L.K= Extremely lepto kurtic

Regarding the cultivated plain soils which are represented by profiles 3, 4, 6, 8 and 10, data in Table 6 reveal that the standard deviation (sorting) values are in the range of 0.94 to 1.72 ϕ, the distribution of sorting of these values is almost bimodal representing the poorly sorted sediment, except for the deepest layer of profile 3, which is moderately sorted. The poorly sorted nature of sediments suggests that the soils are mainly transported and deposited by water action. Data in Table 6 reveal that skewness values are widely different and ranged from -0.87 to 0.62 ϕ representing bimodal distribution of skewness values indicating mixing of two modal fractions, *i.e.,* fine and coarse sand in this case. The kurtosis (KG) is distributed between values of 0.45 and 1.91 ϕ representing lepto and very leptokurtic, meso kurtic and platy kurtic. The somewhat normal distribution of (KG) values corresponds to very low-energy environment and very high modification of grain size. In conclusion, it is clear that the sediments forming the studied soils are mostly deposited under aqueous or both water and wind actions. Furthermore, the available data of the statistical size parameters reveal that the studied soil profiles are formed of non- uniform parent materials. However, the stratified condition observed in these profiles is mostly attributed to depositional variations and / or to depositional regime.

Land suitability for irrigated agriculture

a) Current land suitability

By matching between the present land properties and their rating outlined by Sys *et al.* (1991), the current suitability of the studied area was estimated. This aims to provide a method for suitability evaluation of irrigation water based on the standard physical and chemical chcrateristies of soil properties and their symbols used as follows : Topography (t), wetness (w), soil texture (S_1), soil depth (S_2), $CaCO_3$ (S_3), gypsum (S_4) and salinity and sodicity (n).

The irrigation suitability index (Ci) is calculated as :

$$Ci = t \times \frac{w}{100} \times \frac{S1}{100} \times \frac{S2}{100} \times \frac{S3}{100} \times \frac{S4}{100} \frac{n}{100}$$

the order S: suitable for irrigation (Ci is more than 25).
classes S_1: Ci is more than 75
S_2: Ci is between 50 and 75
S_3; Ci is between 25 and 50
Order N: suitable for irrigation (Ci is leas than 25)
classes N_1: with limitations which can be corrected
N_2: with limitations which cannot be corrected.

Capability index for the studied soil profiles are presented in Table 7 and Fig. 2. The obtained results reveal that estimated current land suitability sub classes are given as follows:

Soils of grade (S_2) (moderately suitable)

The soils of this grade are represented by three soil profiles (3, 4 and 6) which belong to cultivated plain soils. Suitability index (Ci) values ranged from 56.97 to 72.68. These values indicate a moderately suitable class. the soils have a moderate intensity of texture.

Soils of grade (S_3) (marginally suitable)

This subclass represents the soils of playa (profile 1), peidmont soils (profile 9) and cultivated plain soils (profiles 8 and 10). Suitability index values (Ci) varied from 25.97 to 43.5. These soils are affected by moderate intensity of texture class, and moderate to severe intensity of salinity and alkalinity.

Soils of non suitable (N_1)

The soils of this grade are represented by profiles 2 (playa), 5 (sabkha) and 7 (sand sheets). These soils have suitability index values less than 25 and affected by severe to very severe texture classes; moderate to severe salinity and alkalinity , soil depth and calcium carbonate contents.

As a general, three different limitations are recognized. The dominant limitation is texture class, the minor limitations are salinity and alkalinity levels and calcium carbonate contents.

Potential land suitability

Potential suitability of the studied soils as illustrated in Table 7 and Fig. 3 indicates that the existing two orders (S) and (N) and two classes S_2 and N_2. The detailed description of these classes is as follows :

S_2: Moderately suitable class represents soils of playa soils (profile 1), peniplain (profile 9) and cultivated plain soils (profiles 3,4,6,8 and 10). The increase in such value is due to the leaching process of salinity and reclamation of alkalinity limitations. Suitability index (Ci) of this class varies from 64.13 to 75.0. Soils of this class have a slight to moderate intensity of texture and slight intensity of calcium carbonate percent. The cost of these land improvements should be taken into account during economic analysis.

N_2: Not suitable

This suitability class represents the soils of playa (profile 2), Sabkha (profile 5) and sand sheets (profile 7). The suitability index (Ci) of this class is less than 25. soils of this class have very severe to severe intensity of texture class and slight to severe intensity of soil depth.

The application of chemical and organic fertilizers, green and organic manures and soil conditioners increase the values of capability index.

TABLE 7. Land suitability classes for the studied soil profiles.

Profile No.	Topography (t)		Wetness (w)		Physical Soil characteristics				Salinity& Alkalinity (n)		Suitability index (Ci)		Suitability class (Si)	
	Cs	**Ps**	**Cs**	**Ps**	**S1**	**S2**	**S3**	**S4**	**Cs**	**Ps**	**Cs**	**Ps**	**Cs**	**Ps**
							Playa							
1	100	100	100	100	75	100	95	100	40	100	28.5	71.25	S3	S2
2	100	100	100	100	25	55	95	85	80	100	8.88	11.10	N1	N2
							Sabkha							
5	100	100	50	100	50	55	95	80	100	100	16.36	20.9	N1	N2
							Sand Sheets							
7	100	100	100	100	25	90	100	100	58	100	16.98	22.5	N1	N2
							Peniplain							
9	90	100	100	100	75	90	95	100	45	100	25.97	64.13	S3	S2
							(Plain) Cultivated area							
3	100	100	100	100	85	90	95	100	98	100	71.22	72.67	S2	S2
4	80	100	100	100	85	100	95	90	98	100	56.97	72.68	S2	S2
6	100	100	100	100	85	90	95	100	100	100	72.62	72.68	S2	S2
8	100	100	100	100	75	100	100	100	58	100	43.5	75.0	S3	S2
10	80	100	100	100	75	90	95	80	80	100	29.75	64.13	S3	S2

S1 = Texture, S2 = Soil depth (cm), S3 = Calcium carbonate status and S4 = Gypsum status.

N = suitable, S1 = High suitability, S2=Moderate suitability and S3 = Limitation suitability.

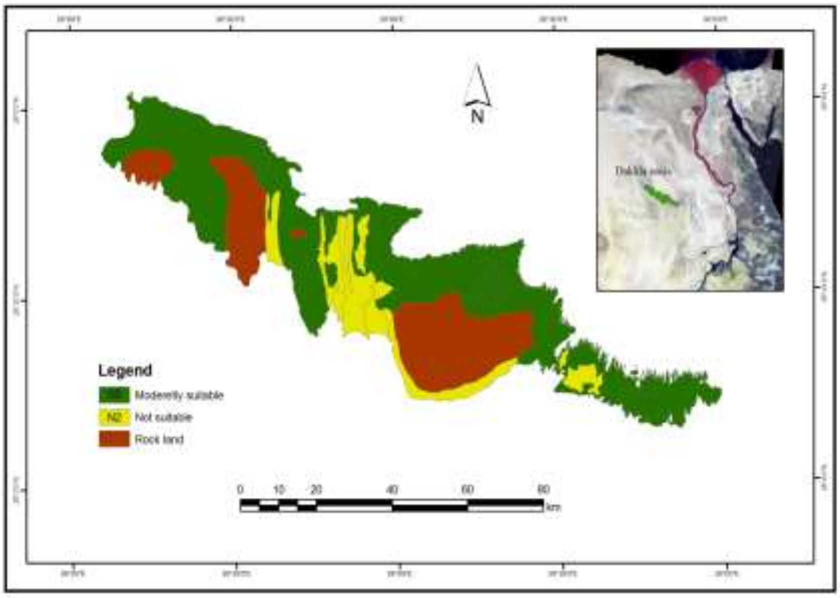

Fig. 2. Current Soil suitability of studied area.

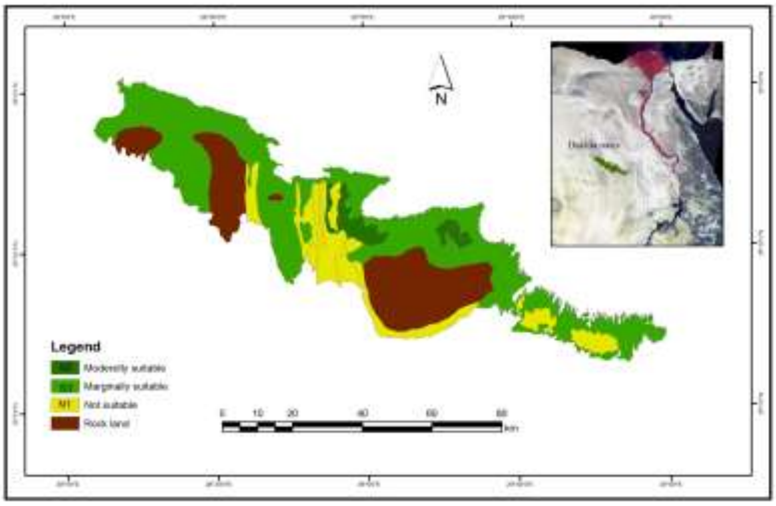

Fig. 3. Potential suitability of the studied area.

Land suitability for specific crops

Land suitability classes for several crops were predicted on the bases of matching land qualities and characteristics and crop standard requirements using the parametric land index as mentioned by Sys *et al.* (1991 and 1993). The land suitability for selected crops (field crops, vegetables and fruit trees) were investigated. The results of current and potential land suitability are shown in Table 8.

Current suitability

The results indicate that all the studied soils of playa, sabkha, sand sheet, peniplain and cultivated area (profile 8 and 10) are not suitable for all the studied crops, except for some scattered areas developed on cultivated plain (profile 3,4 and 6) for all the studied crops.

Potential suitability

1- Playa is moderately suitable (S_2) for olives and grapes; marginally suitable (S_3) for wheat, sunflower, groundnut, barley, tomato, potato, green pepper, citrus and palm.

2- Sabkha is highly suitable (S_1) for groundnut, and not suitable (N_2) for the rest of crops.

3- Sand sheets are marginally suitable (S_3) for wheat, tomato, potato, green pepper and citrus; while being not suitable (N_2) for sunflower, groundnut, barley, onion and palm.

4- Peniplain is highly suitable (S_1) for potato and grapes; moderately suitable (S_2) for wheat, sunflower, groundnut and olives; marginally suitable (S_3) for barley, onion, tomato, green pepper, citrus and palm.

5- Cultivated plain is highly suitable (S_1) for groundnut, potato and grapes; moderately suitable (S_2) for wheat, sunflower, barley, onion, tomato, green pepper, olives and palm; marginally suitable (S_3) for grapes.

TABLE 8. Suitability classes of the studied soil profiles for specific crops.

Profile No.	Field crops					Vegetable crops					Fruit crops				
	Crop	Suitability index		Suitability class		Crop	Suitability index		Suitability class		Crop	Suitability index		Suitability class	
		C	P	C	P		C	P	C	P		C	P	C	P
Playa															
1	Wheat	7.48	85.0	N	S1	Onion	8.07	95.0	N	S1	Olives	19.4	100.	N	S1
	Sunflower	5.05	80.7	N	S1	Tomato	5.76	72.0	N	S2	Grapes	16.2	95.0	N	S1
	Groundnut	15.5	83.9	N	S1	Potato	12.8	95.0	N	S1	Citrus	5.27	65.8	N	S2
	Barley	10.7	76.9	N	S2	G. pepper	8.64	72.0	N	S2	Palm	6.5	48.0	N	S3
2	Wheat	3.83	21.2	N1	N2	Onion	5.80	34.2	N	S3	Olives	28.5	60.0	S3	S2
	Sunflower	3.20	16.0	N1	N2	Tomato	1.92	12.0	N1	N2	Grapes	7.13	30.0	N	S2
	Groundnut	4.54	21.6	N1	N2	Potato	2.88	16.0	N1	N2	Citrus	4.08	24.0	N1	N2
	Barley	15.3	20.2	N1	N2	G. pepper	18.4	36.0	N	S3	Palm	3.60	18.0	N1	N2
Sabkha															
5	Wheat	1.90	10.0	N1	N2	Onion	1.36	7.19	N1	N2	Olives	3.36	10.8	N1	N2
	Sunflower	0.85	4.5	N1	N2	Tomato	1.72	2.20	N1	N2	Grapes	7.85	15.0	N1	N2
	Groundnut	1.96	75.0	N	S1	Potato	3.53	18.0	N1	N2	Citrus	0.39	2.06	N1	N2
	Barley	12.5	19.0	N1	N2	G. pepper	0.75	3.71	N1	N2	Palm	2.35	13.1	N1	N2
Sand sheets															
7	Wheat	2.37	25.0	N1	S3	Onion	2.43	18.0	N1	N2	Olives	28.5	60.0	S3	S2
	Sunflower	2.06	16.2	N1	N2	Tomato	4.32	32.0	N	S3	Grapes	9.50	50.0	N	S2
	Groundnut	4.79	37.6	N	S3	Potato	3.41	26.7	N	S3	Citrus	4.51	25.1	N	S3
	Barley	7.89	23.7	N1	N2	G. pepper	2.82	31.3	N	S3	Palm	3.27	16.4	N1	N2

Peniplain															
9	Wheat	10.7	76.9	N	S2	Onion	6.73	39.6	N	S3	Olives	8.64	72.0	N	S2
	Sunflower	6.52	62.1	N	S2	Tomato	3.18	39.7	N	S3	Grapes	14.1	88.0	N	S1
	Groundnut	8.29	62.0	N	S2	Potato	12.3	79.5	N	S1	Citrus	3.12	27.6	N	S3
	Barley	10.7	58.3	N	S3	G. pepper	4.42	36.8	N	S3	Palm	4.44	32.9	N	S3
Cultivated plain															
3	Wheat	68.8	85.0	S2	S1	Onion	17.7	78.8	N	S1	Olives	57.0	60.0	S2	S2
	Sunflower	54.9	68.6	S2	S2	Tomato	48.5	61.8	S3	S2	Grapes	68.4	95.0	S2	S1
	Groundnut	56.4	94.0	S2	S1	Potato	37.6	94.0	S3	S1	Citrus	16.	44.5	N	S3
	Barley	8.16	83.3	N	S1	G. pepper	38.3	70.9	S3	S2	Palm	21.6	65.1	N	S2
4	Wheat	46.3	68.0	S3	S2	Onion	57.6	64.0	S2	S2	Olives	68.0	80.0	S2	S1
	Sunflower	43.9	64.6	S3	S2	Tomato	52.1	74.7	S2	S2	Grapes	58.1	76.0	S2	S1
	Groundnut	68.0	80.0	S2	S1	Potato	59.5	74.4	S2	S2	Citrus	28.9	53.6	S3	S2
	Barley	61.9	66.6	S2	S2	G. pepper	55.1	66.4	S2	S2	Palm	46.5	51.5	S3	S2
6	Wheat	--	--	--	--	Onion	76.6	90.2	S1	S1	Olives	38.4	60.0	S3	S3
	Sunflower	50.6	72.3	S2	S2	Tomato	55.7	61.9	S2	S2	Grapes	57.0	95.0	S2	S1
	Groundnut	60.0	100.	S2	S1	Potato	72.0	100.	S2	S1	Citrus	45.3	47.6	S3	S3
	Barley	72.3	85.0	S2	S1	G. pepper	66.4	83.0	S2	S1	Palm	63.1	66.5	S2	S2
8	Wheat	11.3	68.0	N	S2	Onion	1.76	11.0	N1	N2	Olives	9.48	76.5	N	S1
	Sunflower	5.37	55.0	N	S2	Tomato	2.85	17.8	N1	N2	Grapes	13.3	95.0	N	S1
	Groundnut	9.72	78.4	N	S1	Potato	13.3	63.0	N	S1	Citrus	0.86	8.82	N1	N2
	Barley	11.9	66.6	N	S2	G. pepper	1.35	11.6	N1	N2	Palm	1.82	13.5	N1	N2
10	Wheat	9.57	68.4	N	S2	Onion	11.9	74.5	N	S2	Olives	14.4	48.0	N	S3
	Sunflower	15.5	64.6	N	S2	Tomato	8.11	65.4	N	S2	Grapes	12.9	76.0	N	S1
	Groundnut	10.0	8.0	N	S3	Potato	9.12	76.0	N	S1	Citrus	4.17	37.9	N	S3
	Barley	25.1	68.0	S3	S2	G. pepper	6.87	57.3	N	S2	Palm	5.95	41.8	N	S3

Crop Water requirements

Table 9 reveals that, the crop water requirements of some selective crops, which are calculated by using climatic data and Crop Wat program. The ETo (evapotranspiration) was estimated using Penman- Monteith equation, after Allen (1998). The crop water requirements were 701.1, 921.0, 740.4, 834.3, 669.0 570.0 640.5, 2085.0, 625.2, 387.6, 1722.0, 1346.1, 373.0, 702.3, 505.2, 595.8, 645.3, 606.1, 466.4, and 602.1 mm/s. for tomato (135 day), tomato (180 day) maize grin (125 day), cotton, sorghum, egg plant, peper, banana, flax, barley, citrus 1, citrus 2, pea, peanut, lentil, cucumber, sunflower, onion/ dry, wheat and suger beet, respectively.

Data obtained reveal that consumptive use of crops is considered high, due to the highness of evaporation. It represented with an average of 500, 800 and 1800 mm/s for vegetable, field and fruit crops, respectively. So, it is very important to apply suitable irrigation systems such as trickle or sprinkler, where the soil physical properties of the studied physiographic units have good correlation with micron – relief (Zayed and Ashoub , 2000).

Evaluation of irrigation waters sources

In El- Dakhla Oases, the wells and springs are the main sources for irrigation purposes where the water of the springs that flow to the surface under hydrostatic pressure. Table 10 illustrates irrigation water classification of some ten selected springs and wells at El- Dakhla Oases according to USDA (1991), where (C_1-S_1) class represents water of West El Mowhob area, El- Kalamon and El- Mowhob village this class of can be used to irrigate most crops in most soils and there are no limiting factors. Water of class (C_2-S_1) represents the wells and springs of El- Zaiate village, Mut, El- Bashandy Village, and El- Mowhob. The class of water is moderately saline and non alkaline. Water of El- Zaiate well (No.10) which is classified as (C_3-S_1) has high salinity non alkalinity hazards. On the other hand, water of Bathor and El- Zaiate well (No.2) which is classified as (C_4-S_4) has very high salinity levels and very high alkalinity hazard. This water cannot be used for irrigation of the soils, due to increasing problems of salinity and sodicity in these soils. It is advised to mix the water of El- Zaiate well (No.2) and Bathor spring water with other low salinity and alkalinity values to get over these constraints.

TABLE 9. Crop water requirements for specific crops in El Dakhla Oases.

Months	Jan.	Feb.	Mar	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	W/S
ETo (mm/day)	3.51	3.79	4.50	5.40	6.27	7.01	6.90	6.64	5.96	5.29	4.54	3.98	
Tomato (135 day)-1													
KC per month		0.45	0.75	0.95	1.15	0.85							
ET crop mm/day		1.70	3.37	5.13	7.21	5.96							
ET crop per month		51.0	101.1	153.9	216.3	178.8							701.1
Tomato (180 day)-2													
		0.45	0.69	0.88	1.15	1.15	0.85						
		1.70	3.11	4.75	7.21	8.06	5.87						
		51.0	93.3	142.5	216.3	241.8	176.1						921.0
Maize grain (125 day)													
KC per month							0.54	1.29	1.15	0.85	0.23		
ET crop mm/day							3.73	8.56	6.85	4.50	1.04		
ET crop per month							111.9	256.8	205.5	135.0	31.20		740.40
Cotton													
KC per month						0.45	0.75	0.8	0.90	0.83	0.75	0.25	
ET crop mm/day						3.15	5.18	5.31	5.36	4.4	3.41	1.00	
ET crop per month						94.5	155.4	159.3	160.8	132.0	102.3	30.0	834.3
Sorghum													
KC per month				0.48	0.80	1.10	0.80	0.22					
ET crop mm/day				2.59	5.02	7.71	5.52	1.46					
ET crop per month				77.7	150.6	231.3	165.6	43.8					669.0
Eggplant													
KC per month		0.45	0.75	1.02	1.04	0.27							
ET crop mm/day		1.71	3.38	5.51	6.52	1.89							
ET crop per month		51.3	101.4	165.3	195.6	56.7							570.3
Pepper													
KC per month			0.50	0.80	1.15	1.08							
ET crop mm/day			2.25	4.32	7.21	7.57							
ET crop per month			67.5	129.6	216.3	227.1							640.5

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TABLE 9. Cont.

Months	Jan.	Fep.	Mar	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	W/S
ETo (mm/day)	3.51	3.79	4.50	5.40	6.27	7.01	6.90	6.64	5.96	5.29	4.54	3.98	
Banana													
KC per month	0.70	0.75	0.80	0.75	0.90	1.00	1.10	1.20	1.30	1.40	1.50	1.60	
ET crop mm/day	2.46	2.84	3.60	4.05	5.64	7.01	7.59	7.97	7.75	7.41	6.81	6.37	
ET crop per month	73.8	85.2	108.0	121.5	169.2	210.3	227.7	239.1	232.5	222.3	204.3	191.1	2085.0
Flax													
KC per month	0.88	1.15	0.96	0.75							0.45	0.75	
ET crop mm/day	3.09	4.36	4.32	4.05							2.04	2.98	
ET crop per month	92.7	130.8	129.6	121.5							61.2	89.4	625.2
Barley													
KC per month	o.81	o.23								0.18	0.81	1.15	
ET crop mm/day	2.84	0.87								0.95	3.68	4.58	
ET crop per month	85.2	26.1								28.5	110.4	137.4	387.6
Citrus – 1													
KC per month	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
ET crop mm/day	3.16	3.41	4.05	4.86	5.64	6.31	6.21	5.97	5.36	4.76	4.09	3.58	
ET crop per month	94.8	102.3	121.5	145.8	169.2	189.3	186.3	179.1	160.8	142.8	122.7	107.4	1722.0
Citrus – 2													
KC per month	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	
ET crop mm/day	2.46	2.65	3.15	3.78	4.40	4.91	4.83	4.65	4.17	3.70	3.18	2.79	
ET crop per month	73.8	79.5	94.5	113.4	132.0	147.3	144.9	139.5	125.1	117.0	95.4	83.7	1346.1
Pea													
KC per month										0.63	1.04	1.10	
ET crop mm/day										3.33	4.72	4.38	
ET crop per month										100.0	141.6	131.4	373.0

TABLE 9. Cont.

Months	Jan.	Fep.	Mar	Apr.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.	W/S
ETo (mm/day)	3.51	3.79	4.50	5.40	6.27	7.01	6.90	6.64	5.96	5.29	4.54	3.98	
Peanut													
KC per month				0.23	0.75	0.91	1.05	0.58					
ET crop mm/day				1.24	4.70	6.38	7.24	3.85					
ET crop per month				37.2	141.0	191.4	217.2	115.5					702.3
Lentil													
KC per month	1.1	0.6	0.25							0.23	0.92	1.05	
ET crop mm/day	3.86	2.27	1.13							1.22	4.18	4.18	
ET crop per month	115.8	68.1	33.9							36.6	125.4	125.4	505.2
Cucumber													
KC per month		0.49	0.75	1.15	1.04	0.27							
ET crop mm/day		1.86	3.38	6.21	6.52	1.89							
ET crop per month		55.8	101.4	186.3	195.6	56.7							595.8
Sunflower													
KC per month						0.29	0.75	1.08	0.95	0.28			
ET crop mm/day						2.03	5.17	7.17	5.66	1.48			
ET crop per month						60.9	155.1	215.1	169.8	44.4			645.3
Onion/dry													
KC per month	1.05	0.88	0.43							1.05	0.88	0.43	
ET crop mm/day	3.68	3.33	1.93							5.55	4.00	1.71	
ET crop per month	110.4	100.0	57.9							166.5	120.0	51.3	606.1
Wheat													
KC per month	0.8	0.23								0.55	0.95	1.15	
ET crop mm/day	2.81	0.87								2.91	4.31	4.58	
ET crop per month	84.3	26.1								87.3	129.3	137.4	464.4
Suger beet													
	0.74	0.75							0.23	0.8	0.98	1.15	

	2.60	2.84							1.37	4.23	4.45	4.58	
	78.0	85.2							41.1	126.9	133.5	137.4	602.1

TABLE 10. Chemical composition of irrigation waters and its classes of some selected wells and springs.

Location	Prof.	Fe	SAR	Soluble Cations (meq/l)				(meq/l) Soluble Anions				TDS (ppm)	EC dS/m	pH	I.W.C*
				Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4				
West El-Mowhob	1	0.025	1.12	1.56	0.52	1.14	0.27	-	1.23		0.26	217.6	0.34	6.42	C1 - S1
El-Zaiat	2	0.031	26.65	51.28	343.7	374.5	1.53	-	6.15		674.9	37952	59.3	7.14	C4 - S4
El- Mowhob & El-Zaiat	3	0.019	1.83	6.41	2.23	3.81	1.14	-	0.92		13.09	748.8	1.17	6.50	C2 - S1
Mut	4	0.044	1.58	5.13	1.04	2.79	0.41	-	1.84		9.37	428.8	0.67	6.66	C2 - S1
El- Kalamon	5	0.025	0.30	5.12	1.05	0.50	0.55	-	1.23		2.99	140.8	0.22	7.70	C1 - S1
El- Bashandy	6	0.31	0.35	33.45	1.49	1.68	0.50	-	1.38		1.77	339.2	0.53	6.70	C2 - S1
El-Mowhob	7	0.019	0.63	5.12	1.05	1.11	0.52	-	1.54		2.28	204.8	0.32	6.69	C1 - S1
Bathor spring	8	0.13	10.4	129.2	11.82	36.5	1.96	-	1.54		10.56	4390.4	6.86	4.22	C4 - S2
El- Mowhob	9	0.18	0.96	2.13	1.04	1.21	0.50	-	1.69		0.19	300.8	0.47	6.34	C2 - S1
El- Zaiat	10	0.15	2.80	7.69	7.12	1.80	1.86	-	1.99		6.30	1408.0	2.20	5.26	C3 - S1

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دالة تقييم صلاحية أراضي الواحات الداخله للزراعه – مصر

محمود سليمان محمد
معهد بحوث الأراضي والمياه والبيئه - مركز البحوث الزراعية
E-mail:mahmoudaldemelawi@hotmail.com
:mahmoudeldemelawi@yahoo.com

تقع أراضي الواحات الداخله بين خطي طول 30- O 28 –04- O29 شرقاً، ودائرتي عــرض -20 O25 -00- O 26 شمالاً، وتمثل مساحاتــها حوالـــي 2000 كم^2.

وتشمل داله التقييم للمنطقه دراسة الوحدات الفيزيوجرافية للأرض، وتقسيــم الأراضي، قياسات التوزيع الحجمي الأحصائي ، نوعية وصلاحية مصادرالمياة للري ، الأحتياجات المائية للمحاصيل المختاره والقدره الحالية والمتوقعه للأرض وصلاحياتها للزراعة.

وقد إستخدمت صورة القمر الصناعي (2010) مع النموزج الرقمي للإرتفاعات وتقنية المعلومات الجغرافية ثلاثية الأبعاد لإنتاج خريطة الوحدات الفيزيوجرافيه لمنطقة الدراسه. وتشمل الوحدات الفيزيوجرافيه السائده وتقسيمها حتي مستوي العائله مايلي:

1) - أراضي البلايا: Playa

a-Typic Haplosalids, fine loamy over sandy skeletal, mixed, hyperthermic.

b-Duric Haplosalids, sandy skeletal, mixed, hyperthermic.

2) - أراضي السبخات: Sabkha

Lithic Gypsisalids, sandy skeletal, siliceous, Hyperthermic, shallow.

3) – أراضي الفراشات الرمليه: Sand Sheets

Calcic Haplosalids, sandy skeletal, mixed, hyperthermic, deep.

4) – أراضي أشباه السهول: Peniplain

Typic Haplosalids, clayey skeletal, hyperthermic.

5) – أراضي الوديان المنزرعه : Cultivated plain

a- Typic Torriorthents, fine loamy, mixed, hyperthermic.

b-Typic Torriorthents, clayey over fine loamy skeletal, mixed, hyperthermic.

c-Typic Haplosalids, coarse loamy skeletal over clayey, mixed, hyperthermic .

d-Typic Haplosalids, fine loamy over coarse loamy, mixed, hyperthermic.

وتوضح نتائج دراسة التوزيع الحجمي الإحصائي للحبيبات أن تلك الأراضي يسود بها التصنيف الرديء بدرجه كبيره مما يدل علي أن أراضي تلك المنطقه قد تكونت بفعل المياه أو بفعل المياه والرياح معاً ومن ثم عدم تجانس لمكونات مادة الأصل.

وقد أمكن تحديد القدرة الحاليه لصلاحية الأرض للزراعه الي ثلاث درجات وهي متوسطة الصلاحيه (S_2) – حدية الصلاحية (S_3) - وغير صالحه (N_1) وذلك بدرجات شده مختلفه لمحددات التربة. وبإجراء عمليات تحسين التربة المناسبة فقد تبين أن درجات الصلاحيه المتوقعه للأرض تنتمي الي متوسطة الصلاحية (S_2) وغير صالحه دائماً (N_2).

وتشير النتائج الي درجة عدم الملائمه الحاليه (N) لزراعة بعض المحاصيل المختاره لتلك الوحدات الفيزيوجرافيه ما عدا بعض المناطق المتفرقه في الوديان المنزرعه حيث تؤكد صلاحيتها لزراعة تلك المحاصيل. ومن ناحيه أخري فإن نتائج درجات الصلاحيه المتوقعه لزراعة المحاصيل تختلف بناءاً علي مدي ملائمة الظروف المتوفره بين خواص التربة للوحدات الفيزيوجرافيه والإحتياجات المائيه للمحاصيل – حيث تمثل أراضي السبخات والوديان المنزرعه درجة صلاحيه عاليه (S_1) لزراعة الفول السوداني – كذلك تمثل أراضي أشباه السهول والوديان المنزرعه درجات صلاحيه عاليه (S_1) لزراعة البطاطا والعنب – أما أراضي البلايا وأشباه السهول والوديان المنزرعه فإنها تمثل درجه صلاحيه متوسطه (S_2) لزراعة الزيتون .

وتعتبرمياه الأبار والعيون الطبيعيه هي المصدر الرئيسي لمياة الري لأراضي الواحات الداخله- حيث تشير النتائج الي درجة صلاحيه عاليه (C_1-S_1) لمياه الري دون تسبب في أي أضرار للأرض والنبات في مناطق غرب الموهوب والكلامون – بينما تمثل درجة صلاحيه منخفضه جداً (C_4-S_4) مع وجود تأثيرات عاليه للملوحة والقلويه ضاره في مياه أبار الزيات وعيون الباثور مما يتسبب عنه أضرار بالغه لتلك الأراضي .

وتشير النتائج إلي إرتفاع قيم النتح والتبخر بتلك المنطقه حيث يمثل متوسط تلك القيم 500 ، 800 ، 1800 مم/الموسم لمحاصيل الخضراوات والحقل والفاكهه علي الترتيب . لذلك فإن من الأهميه بمكان تطبيق إستخدام أنظمة الري المناسبه مثل الري بالرش والتنقيط تحت تلك الظروف .