

**THE RELATIONSHIP BETWEEN SOIL PROPERTIES AND
LANDSCAPE FOR SUSTAINABLE LANDUSE IN
WADI EL-TARFA, MINYA GOVERNORATE, EGYPT**

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Abstract

Egypt has limited cultivable land, its water resources are limited and its population is growing, which in turn is destroying the cultivable land. This issue can be solving by use of desert land. This study aims to identify the resources provided by the Egyptian deserts, their potential and how they can be utilized in sustainable development by study characteristics of Egyptian soil and how their composition changes over time. In this respect, the eastern desert is one of the promising areas in Egypt. Wadi El-Tarfa is one of semi-arid areas located in eastern Desert of Egypt composed of Cretaceous and Eocene limestone and Quaternary sediments. Samples were collected from 10 profile, about 25 representative soil samples from different depth were collected. Each sample was prepared by air-dried, crushed, sieved through a 2 mm sieve and chemical, physical properties and soil nutrient element level were analyzed. The data obtained from the soil survey indicates that, soils are generally sandy, moderately -alkaline, non-saline to slightly saline, and the percentage of organic matter less than 0.5%. The profile depth

are varied from very shallow (less than 30 cm) to moderately deep (ranging from 50 -100 cm) and deep (100-150 cm) with high amounts of gravels on the profiles surface. Obtained data indicated that, there are significant differences between profiles depths in gravels, EC, CaCO₃, Gypsum, particle size distribution fraction and contents of NPK, while no significant differences between profiles depths in pH and OM. On the other hand, there are a high positive correlation between N contents and O.M% and negative correlation with both of pH and CaCO₃ %. Data also showed a cleared negative correlation between P content and both of pH and gypsum and high negative correlation between K content and gypsum followed by CaCO₃ and positive correlation with both of pH and O.M. Morphologically described, classified according to soil taxonomy (USDA, 2014) and 24 soil samples were collected for lab analyses. Two soil orders are identified in the study area *i.e.* *Aridisols*, which are dominated in the study area, and *Entisols*. These orders are differentiated into suborders, great groups, and subgroups. The main soil sub-orders detected in the study area are *Gypsid*s, *Calcids*. The current suitability of the studied soil profiles was estimated by matching between the present land characteristics and their ratings outlined by FAO (1976). Suitability indices and classification of the studied soils revealed that there are three suitability classes, *i.e.*, moderately suitable, marginally suitable and actually unsuitable. The most limiting factors in the studied soils are topography of the terrain, profile depth, gravel, CaCO₃, salinity index (EC), Exchangeable sodium ratio (ESP), slope and gypsum content with differentiated to five classes according to their expected hazards very low, low, moderate, severe and very severe intensity. This current suitability can be more

profitable after executing the main growth limitations as agricultural mechanization to improve soil characteristics from depth and slope, in addition to using modern irrigation methods such as drip or sprinkler and using of good fertilizer program.

Key words: Egyptian eastern desert, Wadi El-Tarfa, sustainable development, soil characteristics and soil nutrient element

INTRODUCTION

Agriculture is one of the world's most important activities supporting human life. The population growth in Egypt is very fast that may be make Egypt in the long run faced a large scale food crisis. Desert reclamation one of the important solve to compensate for the loss of agricultural land and to minimize food supply shortage. The Eastern Desert lies between latitudes 22° and 29° N and longitudes 31° and 37° E, covering about 22% of the Egyptian territory (222,000 km²) and bounded by the Red Sea and Gulf of Suez on the East and Nile Valley on the West. The surface of the eastern desert is intensively dissected by a great number of dry drainage vallies which form two types the eastward type drainages to the Red Sea by numerous independent and short Wadi, while the westward type drainages to the Nile valley through a few number of great trunk channels such as in Wadi El-Tarfa which considered one of the largest basins in the north Eastern Desert of Egypt.

This study aims to identify the resources provided Egyptian Eastern deserts, their potential and how they can be utilized.

Climatic conditions: The climate of the study area is semi-arid to arid with an annual rainfall of 7.8 mm and mean monthly evaporation rate ranging from 170.5 mm to 603 mm. Soil temperature was defined as Thermic and the soil

moisture regime as Torric. The mean relative humidity ranges from 43% to 57%, while the mean daily temperature ranges from 12.2 0C to 29.1 0C (Aggour and Sadek, 2001 and Ahmed and Shabana 2020).

Geology: The study area is outcropped by three sedimentary successions: Cretaceous, Eocene and Quaternary. The Cretaceous rocks, occupies the upstream parts of the Wadi El-Tarfa area, consists of cross bedded sandstone, carbonate and shale embedded by sandstone and intercalations of chalk and shale ((Bishay, 1961; Boukhary and Abdulla, 1985; Said, 2017). while, the downstream parts of the study area are Eocene rocks comprise of chalky and marly limestone embedded by clay and shale. In the occupy the drainage channels and its main tributaries floor, the post-Eocene deposits which include the Quaternary deposits, which represented by the recent Wadi deposits which composed of gravel, sand and silt as a product from the weathering of the country rocks (El-Belasy, 1994 and Ahmed and Shabana 2020).

Geomorphology: The study area comprised two geomorphic units; the water collectors (lowlands) and the watershed areas (uplands). The water collectors are represented by the drainage network occupying a surface area of 4436 km² and consisting mainly of small sub-basins. Whilst, the inland depressions are elongated and occupied by the Quaternary deposits consisting mainly of sand, gravels and rock fragments. On the other hand, the water collectors are repressing. The watershed areas are high topographic plateau (El Maaza plateau) which is built of the carbonate Eocene rocks (Ahmed and Shabana 2020).

Regarding to agriculture resources, the soils of the investigated area consist principally of unconsolidated deposits formed from alluvial, aeolian, or lacustrine deposits and developed

primarily under arid conditions. Soils of the study area have very low organic matter content and low water retention capacity as well (Attia et al., 2002). Arid regions have certain climatic conditions, such as low humidity, high temperature and scanty rainfall, which lead to barren conditions. The Egyptian deserts are not completely devoid of rain, but rainfall is sporadic and usually torrential, where the mountain channels are intermittently filled with water in winter and descend steep slopes (Darwish and Wahba, 2010)

MATERIALS AND METHODS

1. Study location:

Area under investigation was surveyed using soil profiles in different locations covering parts of the Wadi to represent the different soil mapping units which bounded by latitudes

28° 20' - 28° 30' N and longitudes 30° 45' - 31° 5' E. Ten soil profiles were chosen and examined in different locations covering the Wadi to represent the different soil. Samples of soil were taken (Fig.1). The exact locations of the soil profiles were precisely defined in field by using the "GPS" System, and plotted on maps. Detailed morphological description were recorded for each of the studied soil profiles on the bases outlined by FAO guideline for soil profile description (2006) and classified according to USDA (2006).

The Digital Elevation Model (DEM) of the study area (Fig.2) was extracted from the SRTM data (30 m resolution). DEM was employed to offer varieties of data that assist in produced landforms map, where the results indicated that elevations of the study area ranged between less 30 to more than 150 m above Sea level.

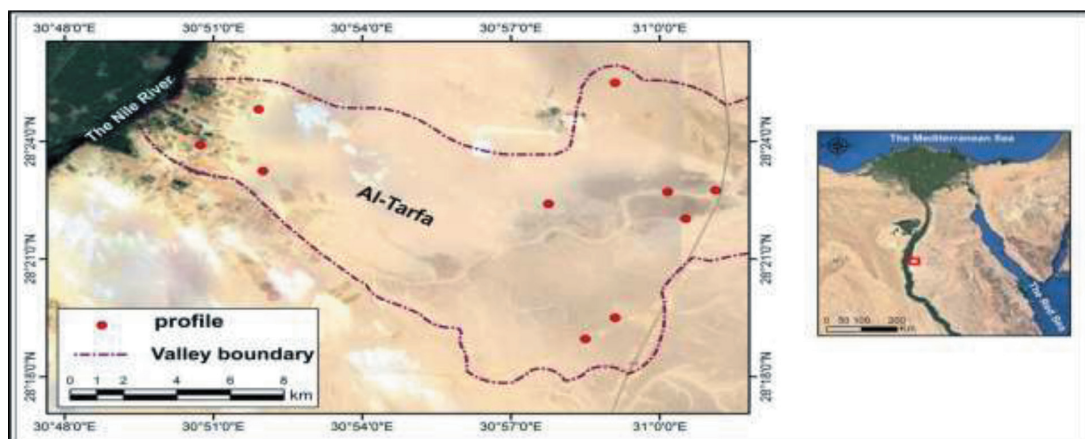


Fig.1: Location of the investigation area

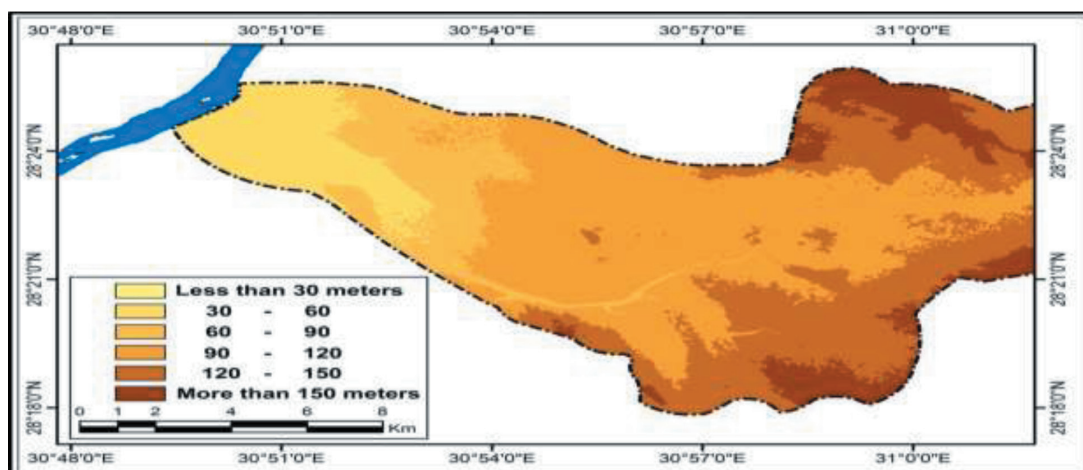


Fig.2: Digital elevation model (DEM)

2. Drainage Basin Analysis:

Investigated area has three water resources, the Nile River water, the ground water, the transported water and the rainfall water (Attia et al., 2002). The ground water is less than about 8 to 10 mm. Most of the rainfall water either evaporates or percolates into the subsoil. Nevertheless, runoff may occur, when rainfall exceeds 10 mm, and wadibeds will begin to carry water depending on the amount and duration of rainfall, the intake capacity of basin's soils and their moisture content (Fig. 3).

3. Soil analyses:

Collected soil samples were analyzed to determine (a) physical properties such as soil texture, gravels percentage, saturation percentage (Page et al., 1982); (b) chemical properties such as electrical conductivity (EC), soluble cations – anions, soil reaction (pH) (Page et al., 1982) and total calcium carbonate (Jackson, 1973); (c) fertility properties such as organic matter (Jackson, 1973), total nitrogen (Black, 1983), available phosphorus and potassium (Soltanpour, 1985).

4. Land capability classification:

Land capability classification summarized by Klingebiel and Montgomery (1969) has been the most widely used one and adapted. It is basically a system that leads to an aggregation of soil mapping units into groups (capability units) of soils with comparable responses to management and of similarities in hazards, limitations or risks in use. Land capability assessment is based on a broader range of characteristics of soil properties i.e. slope angle, climate, flood and erosion risk. According to USDA, 1962 system classification structure namely capability classes which are the broadest category and includes eight classes from I to VIII.

5. Land suitability:

Land suitability is classified according to FAO (1976) as shown in the following Table three degrees were used in this study S2 (moderately suitable), S3 (marginally suitable) and N1 (actually unsuitable) (Table 1).

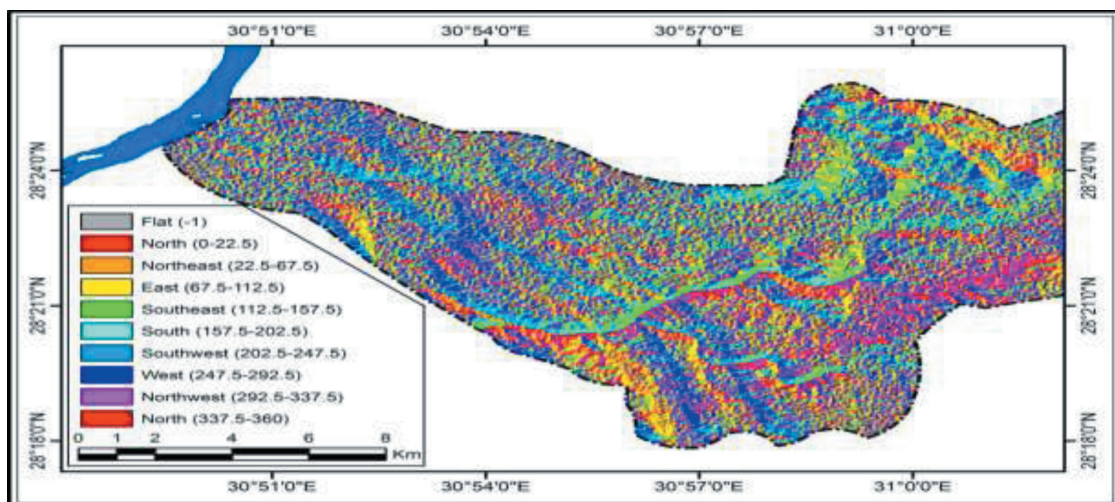


Fig.3: Aspect map of investigation area

Table (1): Land suitability is classes of the investigation area

Class	Soil limitations
S2 (moderately suitable)	Land units without or with only 2:3 slight limitations and no more than 2/3 moderate limitations
S3 (marginally suitable)	Land units with more than 3 moderate limitations and/or no more than severe limitations
N1 (actually unsuitable)	Land units with very severe limitations which can be corrected.

The most limiting factors in the studied soils are topography of the terrain, profile depth, gravel, CaCO₃, salinity index (EC), Exchangeable sodium ratio (ESP), slope and gypsum content, while land suitability subclasses reflect kinds of limitations. The limitation were differentiated to five classes according to their expected hazards e.g., very low, low, moderate, severe and very severe.

RESULTS AND DISCUSSION

1. Physical and chemical properties of the studies soil:-

1.1. Physical properties:-

Regard to physical properties of the studies soil data in Table (2) indicated that, topographically of these soils surface is gently sloping (2-5%) in profiles No., 1,2,6,9 and 10 to sloping (5-10%) in profile No., 3, 4, 5, 7 and 8.

Table (2): Some chemical and physical properties of the soil derived from Wadi El-Tarfa

Profile No.	Depth (cm)	CaCO ₃ %	Gypsum	Gravel %	Particle size distribution %						Texture class	pH	EcdS/m	Soluble cations (m. eq/L)				Soluble anion (m.eq/L)		
					3-1	1-0.5	0.5-0.25	0.25-0.125	0.125-0.063	<0.063				Na ⁺	K ⁺	Ca ²⁺	Mg ²⁺	Cl ⁻	Hco ₃ ⁻	so ₄ ⁻
					1	0-20	33.85	nil	38.83	18.32				41.62	33.64	4.33	0.65	1.44	c.s	8.0
	20-35	36.41	nil	30.33	11.08	45.13	37.81	4.02	1.45	0.51	c.s	7.9	0.22	0.25	0.09	0.58	0.16	0.27	0.46	0.35
2	0-15	35.12	nil	56.70	17.04	51.06	29.09	1.76	0.25	0.80	c.s	8.3	1.60	6.64	0.08	0.65	0.47	0.26	0.56	7.02
3	0-20	23.99	nil	22.22	15.74	40.74	34.37	7.21	1.38	0.56	c.s	8.4	1.99	8.74	0.08	0.50	0.43	0.18	0.28	9.29
4	0-20	31.73	nil	66.37	47.89	23.31	11.82	7.92	8.13	0.93	c.s	7.9	0.40	0.6	0.16	0.90	0.3	0.44	0.38	1.14
	20-25	33.00	nil	76.0	27.17	23.74	19.90	13.21	10.88	5.10	c.s	8.1	0.38	0.81	0.12	0.60	0.33	0.53	0.28	1.05
5	0-20	38.54	nil	74.83	39.45	32.08	15.44	6.16	6.25	0.62	c.s	8.0	0.20	0.59	.012	0.40	0.16	0.26	0.38	0.63
6	0-20	18.93	nil	46.00	9.52	25.54	28.38	15.94	13.97	6.65	c.s	7.8	0.99	1.09	0.14	2.50	1.12	0.62	0.19	4.04
7	0-30	13.46	nil	5.15	11.81	21.64	30.94	26.00	7.40	2.21	c.s	8.0	0.27	0.50	0.11	0.50	0.24	0.35	0.28	0.72
	30-45	12.53	nil	18.86	25.34	38.74	22.45	10.28	2.98	0.21	c.s	8.4	1.34	5.63	0.10	0.50	0.34	0.26	0.38	5.93
	45-60	21.06	nil	25.0	17.51	28.13	27.29	21.70	3.52	1.85	c.s	8.3	1.12	4.77	0.07	0.40	0.25	0.18	0.28	5.03
	60-75	22.86	nil	17.54	8.26	15.06	33.93	33.55	8.64	0.56	c.s	8.3	1.11	4.16	0.26	0.60	0.42	0.35	0.47	4.62
8	0-30	24.33	10.40	25.0	19.26	28.75	27.73	15.20	7.67	1.39	m.s	8.0	1.84	3.66	0.24	3.50	1.62	3.96	0.38	4.68
	30-50	30.47	15.50	26.59	27.35	32.75	22.97	10.95	3.29	2.69	c.s	8.2	1.78	5.33	0.23	2.00	1.16	3.17	0.28	4.57
	50-70	36.84	11.52	34.72	28.98	27.10	24.98	12.19	5.79	0.96	c.s	8.1	2.60	6.50	0.36	4.5	1.6	5.8	0.20	6.96
9	0-25	16.79	13.66	36.58	22.27	37.19	22.87	9.61	4.08	3.98	c.s	8.4	3.40	13.4	0.28	1.7	1.6	8.0	0.52	8.46
	25-50	20.21	10.60	35.08	19.24	33.59	25.27	11.01	5.45	5.44	c.s	8.3	4.00	14.0	0.35	3.4	2.2	9.1	0.59	10.26
	50-75	30.32	15.72	46.72	22.50	36.56	22.93	9.25	4.09	4.67	c.s	8.4	5.10	19.25	0.33	3.4	2.5	12.6	0.39	12.49
	75-100	18.93	10.80	41.17	20.40	32.66	26.54	10.44	5.59	4.37	c.s	8.2	3.60	12.0	0.38	4.5	1.1	8.0	0.65	9.33
10	0-25	20.72	9.40	29.78	20.34	26.51	25.07	14.97	8.25	4.86	c.s	8.1	1.07	2.85	0.18	1.3	1.0	2.2	0.52	2.61
	25-50	19.78	10.60	28.57	15.95	23.57	25.97	17.23	14.52	2.76	c.s	8.1	1.30	3.45	0.22	1.8	1.0	2.6	0.52	3.35
	50-75	21.72	15.22	33.33	21.06	21.68	22.50	16.09	15.50	3.17	c.s	8.1	1.30	3.77	0.22	2.0	0.5	2.8	0.39	3.3
	75-100	13.81	7.30	21.42	18.29	22.44	18.64	16.28	17.34	7.01	c.s	8.2	1.48	4.10	0.27	2.4	0.6	3.6	0.52	3.25
	100-125	29.93	8.30	29.06	15.62	17.75	21.88	20.48	17.75	6.52	c.s	8.2	2.30	6.55	0.64	3.0	1.3	6.4	0.52	4.57
	125-150	12.53	10.20	22.93	4.43	4.33	7.0	2.57	46.42	11.25	v.f.s	8.1	1.80	4.15	0.32	3.3	1.2	4.5	0.39	4.08

The depth of soil profile varied within four classes are varies from very shallow where the depth less than 30 cm (profile No., 2,3,4,5 and 6), shallow where the depth 30-50 cm (profile No.,1), moderately deep where the depth 50-100 cm (profile No.,7 and 8), and deep where the depth 150 -100 cm (profile No.,9 and 10). Mostly of the texture in study profile and their depths is coarse sand except in profile No. 8 in depth 0-30 was medium sand and profile No. 10 in depth 125-150 was very fine sand. Regard to the gravels content through the entire depth of soil profile divided into 3 partitions gravelly (profile No.1, 3, 7 and10), very gravelly (profile No. 2, 6 and 9) and extremely gravelly (profile No. 4 and 5).

Data in Table(3) showed the summary of some morphometric characteristics of the investigation area which indicated that, The Drainage Density was 0.92, which is a low value due mainly to the dry and semi-arid climate to which the study basin belongs. The Bifurcation Ratio is one of the most important factors that control the drainage rate which was 1.965, it is a low ratio, which indicates a lack of the basin splitting by its streams. While, the value of stream frequency in the basin is 0.84. As for constant channel maintenance, which shows the extent of flow density in the basin, it was 1.09 km/km², which indicates the medium of basin area. Relief degree was 7.5, which is considered a high value, and it indicates the difference in height relative to the perimeter of the basin, and this value also indicates the variation in rock formations and the geological structure of the basin. The Ruggedness value was 6.93, which is a high value indicating the severity of the

basin ruggedness and the heterogeneity of the basin rock formations.

1.2. Chemical properties:-

Most of the investigated soils considered to be moderately alkaline except profile No. 6 it was slightly alkaline. Regard to salinity (electric conductivity EC dS/m.) most of study profiles was non saline except profile No. 8 (depth 30-70), profile No. 9 (all depths except 50-75) and profile No. 10 (depth 75-100) were very slightly saline, while profile No. 9 (depth 50-75) was slightly saline (Table 3). However, the studies soil in calcium carbonates (CaCO₃) showed two classes, strongly calcareous (profile No. 3, 6, 7, 9 and 10) and extremely calcareous (profile No. 1, 4, 7 and 8). While the values of gypsum content data in Table (2) illustrated that, the studies soil divided into slightly gypsic (profile No. 1 to 7) and moderately gypsic (profile No. 8, 9 and 10). As for soluble cations, Na⁺ recorded slightly values in profiles No.1, 4, 5 and 6 while was moderately in profiles No. 7 and 10, whereas it gives high values in profiles No. 3 and 9. On the other hand, K⁺ and Mg²⁺ their distribution was approximately uniform in most profiles. While, Ca²⁺ recorded higher values in profiles No. 6, 8, 9 and 10 than rest of profiles (Table 3). Regard to soluble anion HCO⁻³ showed uniform distribution in all profiles whereas Cl⁻ recorded higher values in profiles No. 8, 9 and 10 than profiles No. 1 to7. While SO₄⁻⁻ showed Irregular distribution in all profiles, while it was slightly in profile No. 1, 4 and 5 it was moderately in profile No. 6,7,8 and 10 and high in profile No. 2, 3 and 9 (Table2).

Table (3): Summary of some morphometric characteristics of the investigation area

Drainage Density	Bifurcation Ratio	Relief Degree	Constant Chanel Maintenance	Ruggedness Value	Stream Frequency
0.92 km/km ²	1.965	7.5	1.09 km/km ²	6.93	0.84

1.3. NPK contents and organic matter percentage of the studies soil:-

Data in Table (4) indicated that, most of the investigated soils have low percentage of organic matter and showed similar values in all profiles from 0.25 to 0.44%. At the same trend, total N in all profiles recorded low values (10.11 to 31.36 ppm). On the other hand, available P (ppm) in the studies soils divide into 3 classes, very low in profile No. 5,7,8,9 and 10, low in profile No. 1, 2, 3 and 4 whereas profile No.

6 gave high values. Regard to available K (ppm) showed four classes, very low (profile No.3), moderately (profile No. 1, 2 and 7), high (profile No.4, 5, 6 and 8) and very high in profile No.9. While profile No. showed high values in K (ppm) on depth 0-75 and very high on depth 75-150. and extremely calcareous (profile No.1, 4, 7 and 8).

Table (4): NPK content (ppm) and organic matter (O.M%) of the soil derived from Wadi El-Tarfa

Profile No.	Depth (cm)	O.M %	Total N (ppm)	Available P (ppm)	Available K (ppm)
1	0-20	0.43	25.09	7.77	139.92
	20-35	0.27	10.98	7.71	149.57
2	0-15	0.29	10.98	7.54	133.49
3	0-20	0.31	12.54	9.08	82.02
4	0-20	0.38	18.82	7.71	247.68
	20-25	0.25	14.70	8.24	220.34
5	0-20	0.35	15.68	5.89	236.42
6	0-20	0.45	31.36	11.30	228.38
7	0-30	0.39	21.95	3.30	180.17
	30-45	0.30	12.54	6.12	131.88
	45-60	0.28	10.98	6.59	162.44
	60-75	0.26	10.98	4.24	157.62
8	0-30	0.34	23.52	4.95	300.97
	30-50	0.26	14.49	2.59	284.67
	50-70	0.30	10.11	7.07	255.72
9	0-25	0.28	10.98	2.83	315.23
	25-50	0.31	12.54	7.30	337.75
	50-75	0.42	25.09	1.41	357.05
	75-100	0.44	31.36	5.42	352.22
10	0-25	0.36	17.25	4.47	226.77
	25-50	0.33	17.25	3.77	284.67
	50-75	0.30	12.54	6.61	287.89
	75-100	0.31	12.54	3.77	303.97
	100-125	0.32	12.54	5.18	323.27
	125-150	0.40	20.38	3.77	427.25

1.4. ANOVA analysis to depths category of profiles of the studies soil:-

Data in Table (5) indicated that, there are a significant differences between profiles depths in gravels, EC, CaCO₃, Gypsum, particle size distribution fraction and contents of NPK.

While data clearly showed that, there are no significant differences between profiles depths in pH and O.M. In this respect, depth 0-30 recorded the highest value of gravel, C.S, M.S, and contents of P, and depth 30-50 gave the highest value of pH and N contents while, depth 50-75 gave the highest value of EC, CaCO₃ %, and Gypsum, however depth 75< recorded the highest value of F.S, O.M % and K contents.

1.5. Correlation and contribution of soil variables to the contents of NPK of the studies soil:-

Illustrated Data in Tables (6&7) showed that, there are a high positive correlation between N contents and O.M% (92.2%) with contribution 86.3%, while there are a negative correlation between N contents and both of pH and CaCO₃% (-39.3% & -20.3%) with contribution -15.44 &

-4.12. This results in agreement with Gihan-Ebied (2010) and Kenneth et al., (2019), who's illustrated that, there are an important role of O.M% in soil and increase N contents while increase of pH and CaCO₃ % led to decrease of N content in soil.

Data also in Tables (6&7) showed that, there are cleared negative correlation between P content and both of pH and gypsum with contribution (-5.71 & -3.31). This results in agreement with De Smet et al., (2008) and Gihan-Ebied (2010), who stated that, available P in soil decrease by increasing of pH and gypsum.

On the other hand there are high negative correlation between K content and gypsum followed by CaCO₃ with contribution (- 44.09& -9.80) while there are a positive correlation between K content and both of pH and O.M.(Tables 6&7). This results harmony with Abaslon and Abtahi, (2008) and Gihan-Ebied (2010), who's stated that, available K in soil affected with increase of gypsum and CaCO₃ while is increase with increasing of pH and O.M.

Table (5): ANOVA analysis to depths category of profiles which derived from the soil of Wadi El-Tarfa

Depth (cm)	Gravel	pH	EC	CaCo3	Gypsum	C.S	M.S	F.S	O.M	N	P	K
0-30	42.32a	8.08a	1.05c	27.49a	11.15ab	54.77a	26.42a	18.81c	0.33a	16.99b	13.15a	206.00b
30-50	26.82c	8.26a	1.91b	20.81b	12.23ab	52.43ab	24.79b	22.78b	0.30a	31.36a	5.28c	240.28b
50-75	33.08b	8.23a	2.53a	27.93a	14.15a	45.30b	26.09ab	28.62b	0.32a	15.68b	9.83b	264.57b
75<	28.65c	8.18a	2.30ab	18.80c	9.15b	33.98c	18.52c	47.51a	0.37a	19.21ab	4.53c	401.68a

Table (6): Correlation coefficients between the contents of NPK and some soil variables of the soil derived from Wadi El-Tarfa

Treatments	pH	EC	CaCO ₃ %	Gypsum	O.M %
N	-39.3	17.0	-20.3	9.4	92.9
P	-23.9	5.0	-1.4	-18.2	-7.7
K	-3.10	45.6	-31.3	- 66.4	29.0

Table (7): Contribution of soil variables to the contents of NPK of the soil derived from Wadi El-Tarfa

Treatments	pH	EC	CaCo %	Gypsum	O.M %
N	-15.44	2.89	-4.12	0.88	86.30
P	-5.71	0.25	-0.02	-3.31	-0.59
K	-0.10	20.79	-9.80	- 44.09	8.41

2. Soil Classification:-

Soil taxonomy is the standard reference used in organizing and communicating knowledge about soils. The classification of soil under investigation is carried out according to USDA (2014). This system is based on the following:

1. Soil moisture and temperature regime.
2. Morphological characteristics.
3. Chemical and mineralogical composition.
4. Presence or absence of diagnostic horizons.

According to this system, two soil orders are identified in the study area i.e. Aridisols and Entisols. These orders are differentiated into suborders, great groups and subgroups based on criteria outlined in the U.S. Soil Taxonomy System (2014). Subgroups are further differentiated into families.

a- Order Aridisols: -

These soils were developed under the aridic moisture regime and hyperthermic temperature regime. They include one or more of the diagnostic horizons as calcic, gypsic. The soils of this order are spread in profile No. 8, 9 and 10. Follow one suborders Gypsid under two great group Haplogypsid under sub great group Typic haplogypsid in profile No.8. The other great group is Calcigypsid and under sub great group Typic calcigypsid in profile No. 9 and 10.

b- Order Entisols:-

Entisols are the recent soils that are not exhibiting any sign of parent material maturity under the prevailing arid climate. However, according to Smith (1986) Entisols lack the subsurface

diagnostic horizons. In the study area there are one suborder under Entisols is Psammentlie lie under great group Torripsamments identified in profile No.1,2,3,4,5,6 and 7 which follow tow sub great group, Lithic torripsamment in profile No.1,2,3,4,5,6 and Typic torripsamments in profile No. 7.

3. Land capability:-

Data in Fig (4) showed that soils of the study area are classified their capability according to USDA (1962) into two classes III to VIII. Soils in class III (profiles Nos. 7, 8, 9, and 10) have moderate limitations and conservation practices are usually more difficult to apply and maintain. These soils may be used for cultivated crops, pasture, range, woodland or wildlife food and cover. The soils have one or more limitations: moderate hazard of wind or water erosion; frequent damaging overflow; wetness; moderately shallow rooting depth; moderately low moisture holding capacity; low fertility not easily corrected and moderate slopes, while soils in class VIII (profiles Nos. 1, 2, 3, 4, 5, and 6) have limitations that preclude their use for commercial plant production. Limitations that cannot be overcome consist of one or more of the following: erosion or erosion hazard; wetness; stones and rocks; and very low moisture capacity.

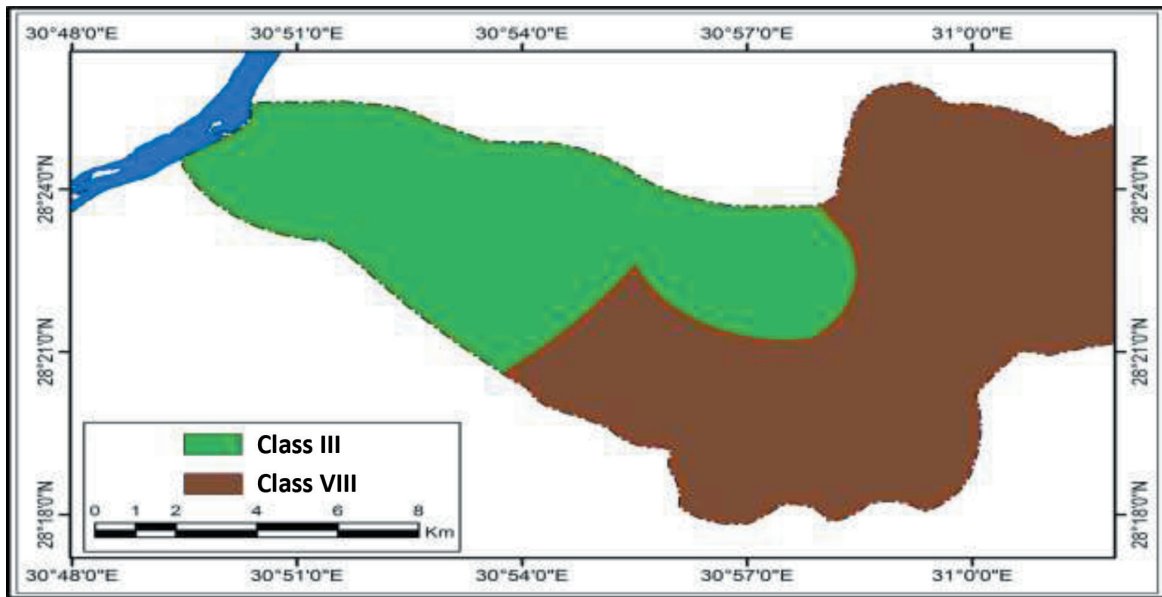


Fig. 4: Land capability of investigation area

4. Land suitability: -

A) Current land suitability:-

Applying the land suitability is classified according to FAO (1976) to the soils of the study area, Data in Fig. (5) reveals that, the current suitability of these soils can be placed at the following classes; class S2 (moderately suitable) included subclass S2p which represented by profiles No. 7, 8, 9 and 10. These soils have moderately limitations that differ in their kind and degree. The second class S3 (marginally suitable) which input in two subclasses S3d

and S3d represented by profiles 1, 3 and 6 . The soils of this class are affected by moderate and severe limitations that differ in their kind and degree. N1 (actually unsuitable) was the last degree of suitability which represented by profiles No. 2, 4 & 5 and included one subclass N1p. This class of soil is affected by severe limitations that differ in their kind and degree. The most limiting factors in the studied soils are profile depth, slope and gravel however the rest limitation factors represent minor limitations.

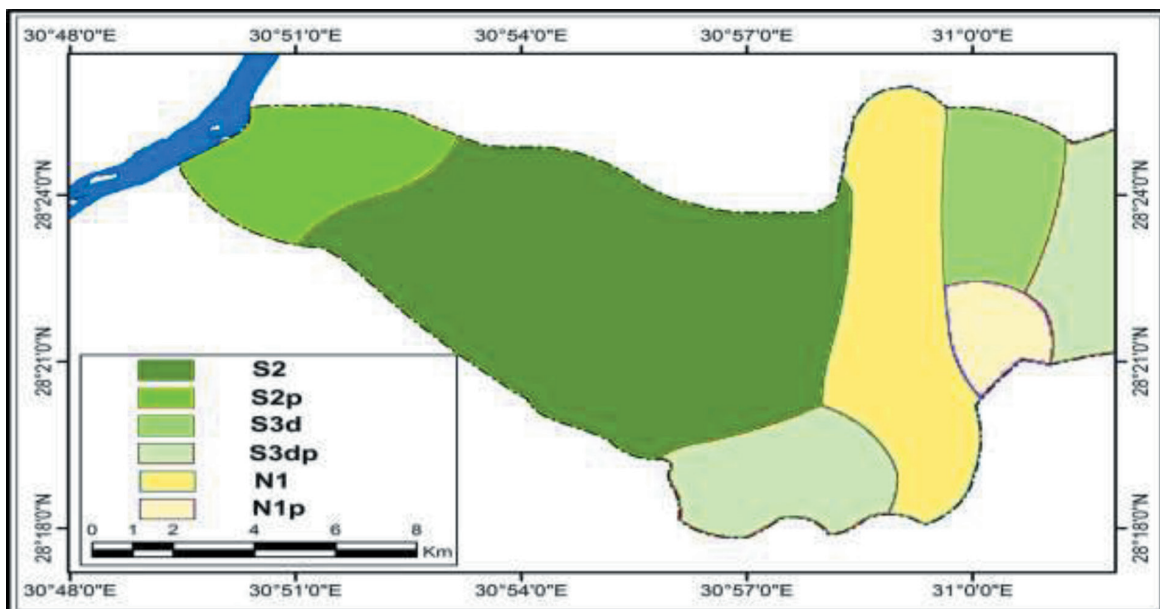


Fig.5: Degree of soil limitations and suitability classes of investigation area.

B) Potential land suitability: -

This current suitability can be more profitable after executing the main growth limitations as agricultural mechanization to improve soil characteristics from depth and slope, in addition continuous application of organic manure to improve soil properties and fertility status, and application of drip and sprinkler irrigation system.

Data in Table (8) showed that, profiles No.3, 7 and 10 are moderately suitable (S2) for Alfalfa and profiles No.1, 4, 6, 8 and 9 are marginally suitable (S3) while profiles No. 2 and 5 are actually unsuitable (N1) for Alfalfa. For Barley crop data showed that, profiles No.1,7, 8, 9, 8 and 10 are S2 and profiles No. 3 and 6 are S3 while profiles No. 2, 4 and 5 are N1. Wheat crop showed S2 for soil profiles No.1, 7, & 8 and S3 for soil profiles No.3, 6, 9 and 10 while profiles No. 2, 4 and 5 showed N1. For Maize crop profiles No.1, 3, 7, 8, 9 and 10 are S3 while profiles No.2, 4, 5 and 6 are N1. Sorghum is considered one of the crops that

gave promising results in terms of its suitability as profiles No.1,3,4,5,6,7,8 and 10 are S2 and profiles No. 9 is S3 while only profiles No.2 is N1. Quite the contrary, peanuts have not shown promising results in their suitability, as profiles No.1, 7,8 and 10 are S3 while the rest profiles give actually unsuitable N1 and N2. The same trend showed with Cabbage, Tomato and Green pepper, in this respect, Cabbage, only showed S3 for soil profiles No. 1,6,7,8 and 9, while Tomato and Green pepper, only showed S3 for soil profiles No. 7 and the rest profiles give unsuitable N1 and N2. In the same time, the trees did not show promising results in suitability for the study soils, regard to that, Oil palm with all study profile did not give any of degree of S2 and S3 while Olive showed only three profiles S3 and Citrus showed two profiles S3, while Guava tree give the best result in this regard whereas, profiles No.7 and 8 are S2 and profiles No.1, 6 and 10 are S3 while the rest profiles give unsuitable N1 and N2.

Table (8): Gross current and potential land suitability for seasonal crops and trees

Profile No.	Suitability Status	Alfalfa	Barley	wheat	Maize	Sorghum	Groundnut	Cabbage	Tomato	Green pepper	Oil palm	Olive	Citrus	Guava
1	S3dp	S3	S2	S2	S3	S2	S3	S3	N2	N1	N2	S3	N2	S3
2	N1p	N1	N1	N1	N2	N1	N2	N2	N2	N2	N2	N1	N2	N2
3	S3d	S2	S3	S3	S3	S2	N2	N1	N2	N2	N2	N1	N2	N1
4	N1	S3	N1	N1	N1	S2	N1	N1	N2	N2	N2	N1	N2	N1
5	N1	N1	N1	N1	N1	S2	N2	N2	N2	N2	N2	N1	N2	N1
6	S3dp	S3	S3	S3	N1	S2	N2	S3	N1	N1	N2	N1	N1	S3
7	S2	S2	S2	S2	S3	S2	S3	S3	S3	S3	N2	N1	S3	S2
8	S2	S3	S2	S2	S3	S2	S3	S3	N2	N2	N2	N1	N2	S2
9	S2p	S3	S2	S3	S3	S3	N2	N1	N2	N2	N2	S3	N2	N1
10	S2p	S2	S2	S3	S3	S2	S3	S3	N1	N1	N2	S3	S3	S3

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**THE RELATIONSHIP BETWEEN SOIL PROPERTIES AND LANDSCAPE FOR SUSTAINABLE LANDUSE
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