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LAND EVALUATION OF PHYSIOGRAPHIC UNITS IN SOME WADIES IN THE EASTERN DESERT OF EGYPT USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

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ABSTRACT

Visual interpretation of Landsat-7 ETM-7 bands 4, 3 and 2 was depending on many elements such as tone, shape, size, pattern, texture, shadow, and association. The interpretation was done to extract all important landscape. A physiographic analysis using visual interpretation was carried out to delineate the different physiographic units of the studied area. The main physiographic units in the studied area extracted from visual interpretation and spectral classification are defined in soil maps and could be categorized into 7 units. i.e. Piedmont, Alluvial Terraces, Alluvial fans, Bajadas, Wadies, Coastal braided deltas and Marine sediments.

According to Soil Taxonomy System the studied area could be classified into two orders (Aridisols and Entisols), five suborders (Salids, Gypsids, Calcids, Fluvents and Orthents), and ten soil families. Six soil families belong to Aridisols and four Entisol families were identified.

Current land suitability refers to the suitability for a defined use of land in its present condition, without major improvements. Currently include two orders {suitable (S) and not suitable (N)}, two classes {marginally suitable (S3) and currently not suitable (N1)}, two subclasses (N1sn and N1wsn) and five units (S3sn-1, S3sn-2, N1tsn-1, N1tsn-2 and N1tsn-3)

Potential suitability term refers to the suitability of units, for a defined use, in their conditions at some future data, after specified major improvements have been completed where necessary (FAO, 1976). Land improvements are activities which cause beneficial

changes in the qualities of the land itself. The future land improvements are required to correct or reduce the severity of limitations exiting in the area under consideration. Such as a) leveling of undulating surface soils, construction of good drainage systems to lower the saline ground water table in the soils of marine sediments, leaching of salinity and reclamation of alkalinity existing in the soils of coastal braided delta, alluvial fans, piedmont and marine sediments, application of chemical and organic fertilizers, green manure and soil conditioners to increase soil fertility to improve the physical and chemical soil characteristics and application of modern irrigation systems, such as drip and sprinkler to save irrigation water. Potential suitability of the studied soils indicated the existing of two orders (S and N), three classes (S2, S3 and N1), three subclasses (S2s, S3s and N1ws) and three units (S3s-1, S3s-2 and S3s-3)

Key words: satellite data, GIS, Eastern Desert Area, Soil Taxonomy System and Land evaluation

INTRODUCTION

Egypt lies in the northeastern corner of the African continent and has a total area of about 1 million km^2. About 96% of its total area is desert, and only 4% is agricultural land of the Nile Valley and Delta.

Undoubtedly, the horizontal expansion in the cultivated area is one of the major aims of the agricultural policy of Egypt to increase the cultivated lands in order to face the serious over-population problem. The national strategy of Egypt for horizontal expansion of agricultural lands until year 2017 aims at adding about 4.32 million feddans in different regions, depending on land suitability and water resources

The Eastern Desert covers an area of about 223,000 km^2. It is bordered by the Nile Valley on the West and by the Suez Canal, the Gulf of Suez and the Red Sea on the East. The backbone of this desert is a series of mountain chains (Red Sea mountains), running parallel to the Red Sea and separated from it by a narrow coastal plain (DRC 2005).

The selection of the study area of wadies Ghwaiba, Bedaa, Hagol and Al-Naqah in the western side of Gulf of Suez in the Eastern Desert to be investigated is based on the concept, that areas selected for the agriculture development purposes, must receive water from

natural controlled water resources. Accordingly, the selected area is located within a land pattern of mega relief, which consists of watershed units as catchment areas and drainage systems in the upper slopes of the highland, both connecting to what are specified as the promising areas in the lowland.

Remote sensing techniques as well as geographic information systems offer numerous advantages over traditional methods of conducting agricultural, water and soil resources surveys. Satellite data, with aircraft and in conjunction with field observations, can provide valuable information on soil types, potential groundwater resources, mineral resources, and other parameters, which can be used, along with informations from other sources through GIS application. The main objective of this work is to determine suitability of other non-agricultural areas and establishing new communities away from the limited valuable agricultural lands.

MATERIALS AND METHODS

1. Materials used:

1.1. Remote Sensing and GIS Software

Erdas Imagine version 9.2 has been used as R.S software for Geometric Correction for Base Maps and ETM-7 image and ARC/GIS software version 9.3 for input data, delineation and output physiographic units map and capability map.

1.2. Maps

1: Six topographic maps are covered at scale 1:50.000. Four maps Sheets NH36-F4b "Bir al-Ajramiyyah", NH36-F4d "Jabal al-qattamiyyah", NH36-F5a "Jabal Umm-risyas", NH36-F5c "Jabal al-Kihaliyyah" produced by the Egyptian General Survey Authority, EGSA (1997) and two maps Sheets NH36-F5d "Jabal ataqah", NH36-F5b "Alaeen alsokhna" produced by Military Survey Authority (1995).

2: Geological map at scale 1:500.000, sheet NH 36 Beni Suef produced by the produced by the Egyptian Geological Survey and Mining Authority, (EGSMA, 1987)

3: Hydrological map of Egypt at scale 1:2.000.000 produced by the Research Institute for Groundwater (RIGW), National Water Research Center (NWRC, 1999)

1.3. Satellite Image:

One LANDSAT-7 "ETM-7" multispectral scene Path 176/ Row 39 acquired in 2006 which composite of bands 4, 3, 2. and pixel size is a mixture of 28.5 and 30 meters.

2. Methodology:

2.1.: The Rectification:

Geometric Correction for topographic, Geological and Hydrological maps are corrected by using grid system and Correction from Image to Image: of raw data of LANDSAT-7 image is carried out using ground control points GCPs which represent features of known ground locations. These GCPs can be accurately located on the digital imagery. Erdas Imagine software (version 9.1) is used in Geometric correction processes for topographic, Geological, and Hydrological maps and image with specifications Egyptian Transverse Mercator ETM as following: Projection type is Transverse Mercator; Spheroid Name is Helmert; Datum Name is Old Egyptian 1907; Scale factor at central meridian is 1.00000; Longitude of central meridian is 31:00:00.000000E; Latitude of origin of projection is 30:00:00.000000N; False Easting is 615000.000000 meters and False Northing is 810000.000000 meters.

2. 2: Visual interpretation of Landsat-7 (TM-7):

The image of Landsat-7 thematic mapper (TM-7) is considered as a basic for the visual analysis. The overall view which is a result of the spectral signature of an ortho rectified Landsat Thematic Mapper is used for delineating the promising areas. The different units are characterized by their special reflectance. It is a composite of bands 4, 3, 2. The pixel size is a mixture of 28.5 and 30 meters.

2.3. Field Work:

The preliminary photo-interpretation map was checked in the field by different ground observations to confirm the boundaries of the physiographic units or to revise what were shifted.

Sixteen soil profiles were chosen to represent the different physiographic units on the image interpretation map and their coordinates were recorded with help of topographic maps (1:50.000) Soil profiles, representing different physiographic units of the study area were taken in sites representing the predominant characteristics of each unit. The profile sites are detected in the field by means of the

Global Positioning System (G.P.S). The soil profile is dug to 150cm depth or water table level which is first, described morphologically according to FAO (1973**)**, and classified on basis of Soil Survey Division Staff Manual (USDA, 2003). The different soil layers are sampled, air-dried, sieved through a 2 mm sieve and kept for physical and chemical analyses.

2.4. Laboratory Analyses:

2.4.1. Physical Analysis:

Soil color, (wet and dry) of the soil samples is determined according to the Munsell soil color charts (1990)**;** Mechanical analysis is carried out by dry sieving for the coarse textured samples, and gravel metrically the pipette method for the fine textured samples using Na-hexametaphosphate as a dispersing agent without the removal of calcium carbonate (Piper, 1950)**;** Calcium Carbonate content using the calcimeter (Black, 1965); Organic matter is determined by using the modified Walkley and Black method (Jackson, 1973) and Gypsum content is determined by precipitation with acetone (USDA, 1954).

2.4.2. Chemical Analysis:

Soil paste extract is prepared for each soil sample, where the following determinations are carried out according to **(Jackson,** 1973); Total salinity by measurement of electrical conductivity (ECe) of the soil paste extracts (Black, 1965); Soluble cations and anions were determined according to (Jackson, 1973); Soil water extract 1:1 (for the purpose of salic horizon identification). Conversion of EC to contents of soluble salts being on the basis of 1 dS/m = “640 mg/L”; Soil pH was determined in the soil saturation paste.

2.5. Soil classification and land evaluation:

Soils were categorized to the level or soil family according to the Soil Taxonomy System USDA, (1975), and its 2nd edition USDA, (1999), using the keys to Soil Taxonomy (USDA, 2003). Land evaluation for the purpose of the agricultural use was assessed according to Sys et al (1991).

2.6. Data Output:

1. Physiographic soil map of the study area.
2. Current land Capability map of the study area.
3. Potential land Capability map of the study area.

RESULTS AND DISCUSSION

1. Location of the studied area

The study area is located on the western side of the Gulf of Suez 45 km east of Cairo and 5 km west of Suez city. It measures about 48 km from north to south and 45 km from west to east equal 2160 km2. It commences at the foot of jabal Ataqah of northern to jabal al-jalalah al-Bahariyyah southern and Gulf of Suez eastern to jabal al-qattamiyyah of west direction. It is bounded by Latitudes 29° 30′ 19″ and 29° 56′ 07″ N and Longitudes 31° 57′ 55″ and 32° 25′ 25″ E. It includes four major Wadies from south to north are (W. Ghwaiba, W. Bedaa, W. Hagol and W. Al-Naqah) as shown in Fig. (1).

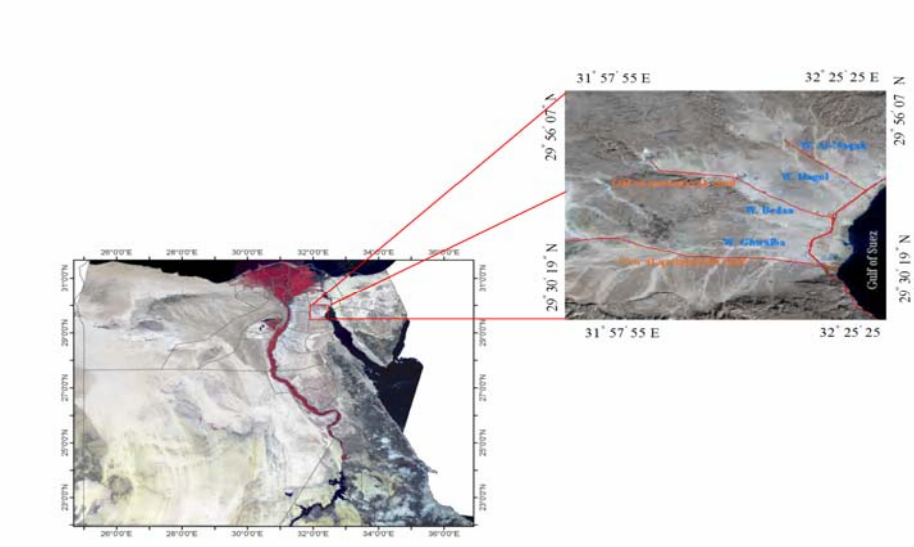

Figure (1) Location of study area

2. Physiographic units of the study area:

Physiography is defined as the study and description of physical earth surface features or landscapes, including the causes and processes responsible for their formation and evolution. It is of particular importance when using satellite data (Sleen, 1984). Physiography is based on geomorphology and can provide good basis for explanations through image interpretation, which identifies certain physiographic processes and provides an important element clues for delineating soil patterns after predicting some certain soil properties (Goosen, 1967).

In the current study, the area is interpreted geomorphologically using Landsat-7 image produced in 2006, Fig.(2). The physiographic units are identified on bases of the detected geomorphic units which reflect most of the landscape forms and their genesis as well as features of the essential information about topography and geology. The physiographic units are differentiated into two main classes; highland and lowland, Fig. (3) described as follows;

2.1. The highland of parent rock structures:

These parent rock structures are considered the origin of the soil parent materials and have no potentiality for agriculture. This unit covers about 106700 ha. (254067 fed.) of the study area and was delineated in the north through jabal Ataqah, northwest jabal al-kihayliyyah, west jabal al-Akhaydir and jabal Ar-Ramliyyah, southwest jabal Minaydrah, and in the south jabal al-jalalah al-Bahariyyah and jabal Umm Risays which comprises a sedimentary rocks (limestone) of the study area.

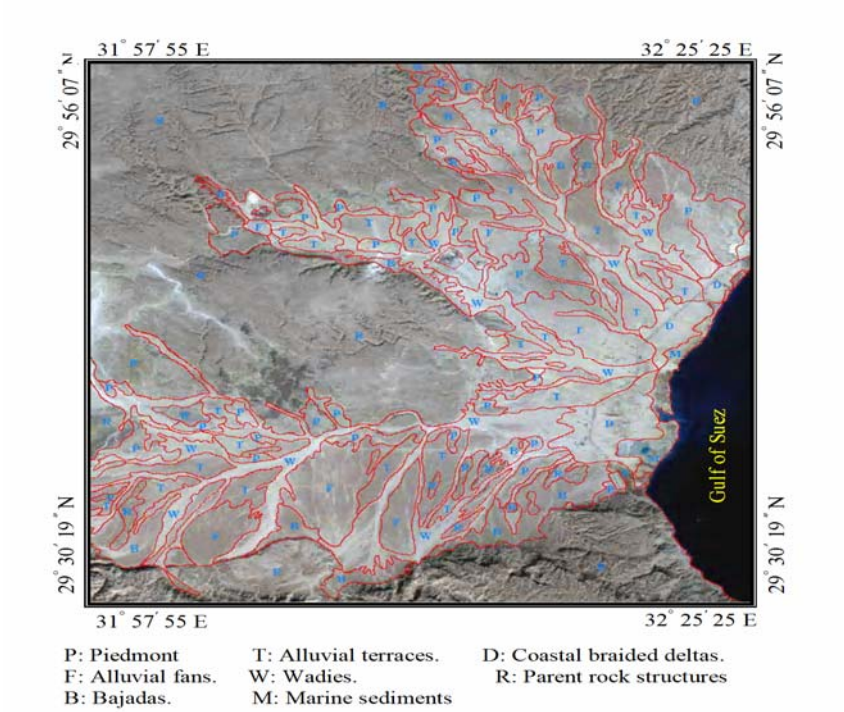

Fig. (2):The physiographic features characterized by the spectral signatures of Landsat-7 image of the study area dated in 2006.

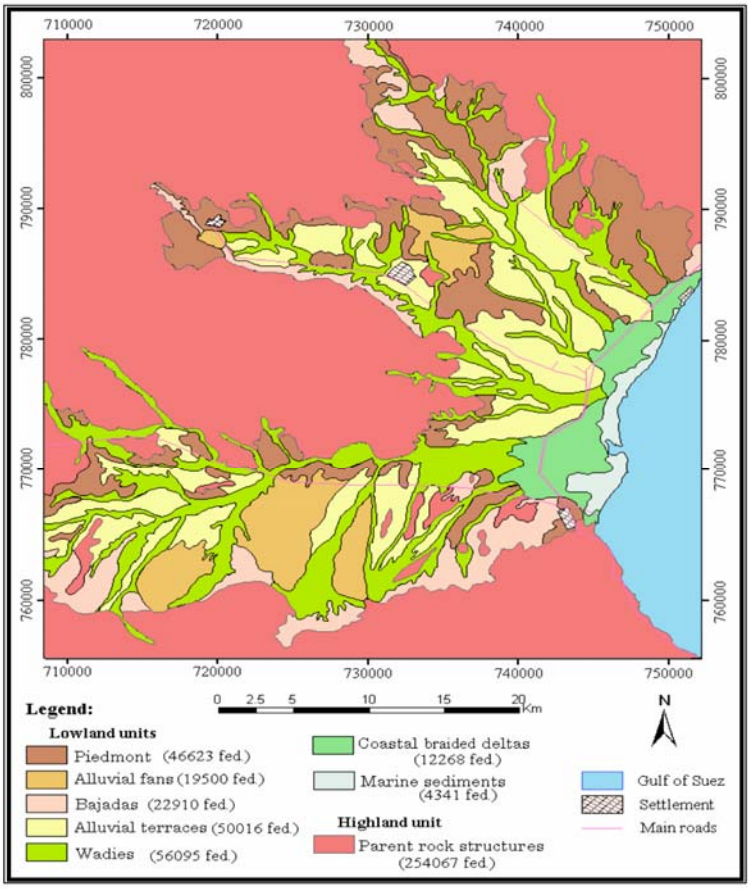

Fig. (3): Physiographic units of the study area.

2.2. The lowland of peneplanation and sedimentation:

These are seven units and covers about 88900 ha. (211753 fed.). They represent promising areas for the agriculture development and border the outskirts of the highland of the rocky structures. They are characterized as follows:

2.2. 1-Piedmont:

These sediments were transported and deposited by gravity and water forces (Colluvial alluvial foot slopes). The unit is situated along the mountainous escarpments, with stony surfaces of rolling through gently undulating complex slopes, dissected by narrow channels and

gullies. Piedmont covers about 19581 ha. (46623 fed.), with 22.1% of the lowland area and represented by soil profile 7.

2.2. 2-Alluvial Terraces:

The parent material of these terraces is alluvium, derived from the basement calcareous rocks. The surface of these terraces is gravelly, stony and gently undulating as a result of gully erosion. The alluvial terraces are widely distributed in the study area, flanking of wadi Hagol, different sites along of wadi Bedaa and wadi Ghwaiba, and area between wadies Hagol and Al-Naqah. The total area of this unit about 21000 ha. (50016 fed.), with 23.6% of the lowland areaand represented by soil profiles 2 and 6.

2.2. 3-Alluvial fans:

These sediments were transported and deposited by water flush flooding, that intersect the mountain fronts, crossing the piedmont, forming a cone shape. A fan covers about 8190 ha (19500 fed.) with 9.2% of the lowland area and are identified in the southwest, southern and middle parts of the study area in the approximate of the faulted escarpment of the sedimentary rock structure. They have stony and gravelly surface, sloping to the west and south west and are mostly dissected by narrow channels and gullies. This unit is represented by soil profiles 15 and 16.

2.2. 4-Bajadas:

It covers about 9622 ha. (22910 fed.) with 10.8% of the lowland area and identified distributed in the southwest and southern parts of the study area. The parent material of bajada is alluvium, derived from calcareous rocks. It is a pattern of coalescing fans as a belt along the piedmont zone, in the eastern part of the study area. The surface is nearly level, gently sloping and detritus. This unit is represented by soil profiles 9 and 14.

2.2. 5-Wadies:

Wadies and their tributaries are found at the lowest level of the study area compared with the other landforms. The highlands which are sedimentry limestone rocks comprise the main catchments area for water harvesting. Wadies extend from the highland eastwards to the Gulf of Suez. They are filled with alluvial material developed through weathering the parent rock structure and transported by flood water to the lowlands. The wadies end with interacting coalesence of fans

which composes a delta-like unit adjacent to the Gulf of Suez. Its surface is almost flat to nearly level, covers about 23559 ha. (56095 fed.), with 26.5% of the lowland area. It is represented by soil profiles No. 3, 5, 8 and 10.

The study area involves four main wadies listed from south to north as follows:

a) Wadi Ghwaiba: This is the largest wadi, has an area about 13012 ha. (30982 fed.). It is borderd from north by Wadi Bedaa and jabal Akhaydir, from west by jabal qattamiyyah and from south by jabal Minaydrah, jabal al-jalalah al-Bahariyyah and jabal Umm Risays. It includs al-sokhna harbor and the newly developed industrial area.

(b) Wadi Bedaa: It has an area 5051.7 ha. (12028 fed.), located north of wadi Ghwaiba and jabal Ar-Ramliyyah, borderd from west by jabal qattamiyyah, from north by wadi Hagol and jabal al-kihayliyyah. It includes the Suez cement factories and other industrial activities.

(c) Wadi Hagol: It has an area 2940.3 ha. (7001 fed.), extends from the highlands (jabal Ataqah) in northwest to Gulf of Suez south east. It is bordered from southwest by both wadi Bedaa and jabal al-kihayliyyah and northeast by Al-Naqah and jabal Ataqah.

(d) Wadi Al-Naqah: Wadi Al-Naqah, has an area of 1749.3 ha. (4165 fed.), extends alike wadi Hagol northwest – southeast. It is bordered from; southwest by wadi Hagol and from northeast by jabal Ataqah.

2.2.6- Coastal braided deltas:

The deltas was formed from alluvial parent material that were transported by a long stream which deposited its load in and near the sea after the water velocity become less and carrying relatively finer fractions. The surface is partly channeled by seasonally active streams and has gully and sheet erosion. It is covers about 5152.5 ha. (12268 fed.) which represent 5.8% of the lowland area and characterized by almost flat surface which is covered by coarse gravel, stones locally. This unit is represented by soil profiles 4 and 13.

2.2.7- Marine sediments:

The marine sediments cover about 1823 ha. (4341 fed.), which represent 2% of the lowland area. These sediments were mainly deposited by seawater actions, due to currents, waves and winds. They

occupy a narrow strip of a complex pattern along the shoreline of Suez Gulf. The surface is locally covered with overblown sand and scattered natural vegetation of halophytic communities and almost flat or nearly level. This unit is represented by soil profiles 11 and 12.

3. Physic-chemical properties:

It could be concluded from the obtained data in tables (1 and 2), that soil texture restricted between three extremes of texture closes namely loamy sand, sand, and sandy loam. The lowest values of clay are recorded the alluvial terraces and alluvial fan soils, while the highest content is recorded in the wadies, alluvial terraces and coastal braided delta soils. The lowest values of silt are recorded in the soils of the alluvial terraces, alluvial fan, and bajada soils while the highest content is recorded in the wadies, alluvial terraces coastal braided delta and marine sediments soils. Sand is recorded highest content in the soils of the all physiographic units

Considering the analytical data, calcium carbonate content varies widely from 12.4 to 68.5 g/kg, the lowest values are recorded in the soils of wadies, while the highest content is detected in the alluvial fan and coastal braided delta soils.

Gypsum content is considerably high ranges from 0.04 to 18.92 g/kg. The lowest values are recorded in the soils of the alluvial fan and wadies, while the highest content is detected in the alluvial fan and marine sediments soils.

Organic matter content is very low not exceed from 0.02 to 0.90 gkg^{-1} and such low content of soil organic matter is expected due to the prevailing aridity of the region and its very scanty vegetation.

Table (2) indication that soil reaction is natural to strongly alkaline as the pH ranges between 7.3 and 8.7. The electric conductivity of soil paste extract show that the soils are non saline to strongly saline with Ec value ranges 0.8 - 127.4 $dsm-^{1}$. The general cationic composition is dominated by Na^{+}, Ca^{++}, Mg^{++} and K^{+} accompanied by anionic composition Cl^{-} and/or $SO_4^{=}$ followed by HCO_3^{-}.

4. Soil Taxonomy:

According to Soil Taxonomy System undertaken by U.S.D.A (2001 and 2003), soils of the studied area could be classified into two orders (Aridisols and Entisols), five suborders (Salids, Gypsids, Calcids, Fluvents and Orthents), five great groups (Aquisalids,

Calcigypsids, Haplocalcids, Torrifluvents and Torriorthents), seven subgroups (Sodic Aquisalids, Typic Calcigypsids, Typic Haplocalcids, Sodic Haplocalcids, Typic Torrifluvents, Typic Torriorthents and Lithic Torriorthents) and ten soil families. Six soil families belong to Aridisols, as follows:

Table (1): Physical properties of the studied physiographic units.

Profile No.	Physiographic unit	Horizon	Depth (cm)	Gravel %	Mechanical composition %				Modified texture class	$CaCO_3$ %	O.M%	Gypsum %
					Coarse Sand	Fine Sand	Silt	Clay				
1	Piedmont	C1	0-10	30	24.6	47.5	14.4	13.5	SL	29.7	0.13	0.50
		C2	10-45	40	31.4	39.2	16.6	12.8	SL	30.5	0.10	1.40
		2R	45+	Hardpan								
7		ABk	0-30	30	40.7	33.5	15.1	10.7	SL	37.1	0.10	4.14
		Bk1	30-85	60	36.5	35.9	17.1	10.5	SL	27.2	0.20	1.63
		Bk2	85-150	70	35.9	37.8	18.3	8.0	SL	34.7	0.20	3.80
2	Alluvial terraces	ABk	0-25	10	49.5	35.7	5.7	9.1	LS	19.8	0.07	0.60
		Bk1	25-75	35	62.8	31.4	3.7	2.1	S	21.5	0.08	2.55
		Bk2	75-150	60	63.7	30.4	3.4	2.5	S	25.6	0.07	1.72
6		ABk	0-20	12	27.3	38.4	19.5	14.8	SL	42.9	0.05	2.56
		Bk1	20-45	50	30.5	39.5	13.8	16.2	SL	33.0	0.12	0.27
		Bk2	45-95	60	34.1	37.3	14.9	13.7	SL	23.1	0.05	0.30
		Bk3	95-150	10	33.8	36.8	16.2	13.2	SL	14.0	0.08	1.69
15	Alluvial fan	ABk	0-15	8	55.0	34.8	5.9	4.3	S	37.2	0.21	5.25
		Bky	15-30	5	50.0	32.1	8.3	9.4	LS	65.0	0.13	10.44
		Bk1	30-65	40	60.1	27.8	6.5	5.7	S	20.6	0.05	0.04
		Bk2	65-90	0	59.3	20.9	11.3	8.5	LS	30.5	0.08	3.56
		Bk3	90-150	8	56.4	24.8	11.2	7.6	LS	34.6	0.08	0.20
16		ABk1	0-15	10	38.4	37.9	13.1	10.6	SL	47.8	0.08	2.38
		ABk2	15-30	6	37.3	36.8	17.1	8.8	SL	63.5	0.11	0.40
		Bk1	30-75	0	36.5	39.3	13.5	10.7	SL	68.5	0.03	1.55
		Bky	75-100	15	41.0	38.2	12.5	8.3	SL	54.5	0.05	18.92
			100+	Hardpan								
9	Bajada	ABk	0-30	35	41.3	37.9	15.4	5.4	LS	33.8	0.08	2.97
		Bk1	30-85	40	39.7	38.9	13.8	7.6	LS	17.3	0.10	2.57
		Bk2	85-100	50	36.5	38.5	17.6	7.4	SL	31.4	0.13	0.34
		Bk3	100-150	45	35.4	39.6	16.7	8.3	SL	47.0	0.10	2.12
14		ABk	0-15	10	68.4	22.2	5.1	4.3	S	23.1	0.27	2.18
		Bk	15-50	50	56.5	27.2	9.2	7.1	LS	27.2	0.10	2.54
		2R	50-75	35	56.4	28.1	8.5	7.0	LS	30.5	0.08	4.06
			75+	Hardpan								

S : Sand , LS : Loamy sand, SL : Sandy loam, O. M : Organic matter

Table (1): Cont.

Profile No.	Physiographic unit	Horizon	Depth (cm)	Gravel %	Mechanical composition %				Modified texture class	$CaCO_3$ %	O.M%	Gypsum %
					Coarse Sand	Fine Sand	Silt	Clay				
3	Wadies	C1	0-20	10	36.5	42.6	10.2	10.7	LS	14.9	0.07	2.64
		C2	20-70	40	39.3	36.3	13.9	10.5	SL	12.4	0.03	0.85
		C3	70-150	25	37.8	38.5	16.5	7.2	LS	20.6	0.08	0.42
5		A	0-20	10	29.6	33.7	22.6	14.1	SL	25.6	0.13	1.74
		C1	20-65	40	28.1	30.3	23.7	17.9	SL	26.4	0.11	1.56
		C2	65-100	60	36.4	38.1	15.3	10.2	SL	19.8	0.10	3.36
		C3	100-150	25	38.6	36.9	17.6	6.9	LS	34.7	0.12	1.57
8		C1	0-30	35	40.1	34.5	19.4	6.0	LS	18.9	0.08	2.14
		C2	30-40	5	38.3	39.7	13.9	8.1	LS	30.5	0.05	0.25
		C3	40-85	65	38.7	35.8	17.1	8.4	SL	28.1	0.02	1.12
		C4	85-150	50	40.5	36.1	16.5	6.9	LS	23.9	0.02	0.95
10		C1	0-30	15	37.4	35.3	15.9	11.4	SL	18.9	0.05	0.32
		C2	30-45	10	36.5	39.5	13.8	10.2	SL	22.3	0.08	0.70
		C3	45-90	3	36.8	37.4	16.1	9.7	SL	44.6	0.08	1.30
		C4	90-100	25	39.3	38.5	14.5	7.7	LS	26.4	0.10	1.09
		C5	100-150	3	36.5	37.5	18.7	7.3	SL	39.6	0.07	0.26
4	Coastal braided delta	A	0-30	3	33.2	34.2	20.1	12.5	SL	43.7	0.44	3.24
		C1	30-65	1	25.5	38.1	19.6	16.8	SL	28.8	0.15	1.73
		C2	65-100	1	34.5	36.1	18.9	10.5	SL	29.7	0.13	1.20
		C3	100-150	1	33.1	34.5	22.5	9.9	SL	29.7	0.15	0.75
13		A	0-15	2	38.7	37.9	17.1	6.3	LS	28.9	0.13	0.39
		C1	15-60	1	36.4	38.6	18.7	6.3	SL	47.0	0.27	3.34
		C2	60-150	1	39.5	37.6	14.9	8.0	SL	66.8	0.10	1.15
11	Marine sediments	A1Z	0-20	1	39.3	36.9	17.1	6.7	LS	33.8	0.90	5.25
		A2	20-30	1	38.1	38.7	16.8	6.4	LS	28.9	0.19	2.60
		Cg	30-70	1	36.5	39.5	14.3	9.7	SL	32.2	0.10	2.29
			70+	Water table								
12		AZ	0-15	1	37.9	35.9	15.3	10.9	SL	43.7	0.58	1.65
		Cg	15-35	1	39.5	34.5	13.5	12.5	SL	47.0	0.10	0.54
			35+	Water table								

S : Sand , LS : Loamy sand, SL : Sandy loam, O. M : Organic matter

Table (2): Chemical analysis of the studied Physiographic units

Profile No.	Physiographic unit	Horizon	Depth (cm)	Soil past	pH of soil past	EC (dS/m) soil past	EC (dS/m) extract 1:1	Soluble ions in saturated extract ($mmol_c$/ L)							
								Cations ($mmol_c$/L)				Anions ($mmol_c$/ L)			
								Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
1	Piedmont	C1	0-10	25	7.5	33.8	11.6	111.3	56.6	285.9	2.5	-	0.78	314.0	141.5
		C2	10-45	30	7.3	33.8	15.4	117.7	38.9	299.2	2.2	-	1.0	300.0	156.9
		2R	45+	Hardpan											
7		ABk	0-30	25	7.6	46.8	17.6	111.3	44.3	496.8	2.9	-	0.8	414.0	240.4
		Bk1	30-85	25	7.5	20.8	13.8	64.2	17.2	180.6	2.2	-	1.0	158.0	105.1
		Bk2	85-150	29	7.6	40.3	14.3	112.4	35.9	407.2	2.6	-	1.0	364.0	193.1
2	Alluvial terraces	ABk	0-25	25	7.8	13.0	1.6	39.6	15.0	106.2	0.9	-	1.0	80.0	80.6
		Bk1	25-75	25	7.8	13.0	4.6	35.3	18.3	106.6	1.4	-	1.0	82.0	78.6
		Bk2	75-150	30	7.6	3.6	5.3	24.6	6.3	4.6	1.0	-	1.6	8.0	26.9
6		ABk	0-20	25	7.8	20.8	6.6	39.6	11.9	192.6	2.1	-	1.0	136.0	109.2
		Bk1	20-45	18	7.7	40.3	8.5	86.7	15.3	455.4	2.7	-	1.0	326.0	233.1
		Bk2	45-95	25	7.6	14.3	7.2	41.7	20.1	115.0	1.2	-	0.8	90.0	87.2
		Bk3	95-150	25	7.5	8.5	6.1	39.6	15.0	46.2	0.7	-	0.8	56.0	44.6
15	Alluvial fan	ABk	0-15	25	8.0	6.5	18.7	33.2	7.0	28.5	6.4	-	2.4	32.0	40.8
		Bky	15-30	29	7.9	106.6	19.8	35.7	14.0	22.8	2.5	-	1.8	19.0	64.2
		Bk1	30-65	25	8.7	16.9	7.7	123.1	59.3	24.9	2.3	-	1.6	58.0	150.0
		Bk2	65-90	30	7.8	18.2	5.5	127.3	27.2	73.4	2.4	-	1.6	68.0	160.7
		Bk3	90-150	33	7.7	20.8	8.5	187.3	23.9	53.2	1.9	-	1.6	64.0	200.7
16		ABk1	0-15	25	7.6	44.2	11.6	101.7	31.2	484.5	1.4	-	1.6	348.0	269.2
		ABk2	15-30	25	7.8	70.2	19.8	157.3	56.9	794.1	2.5	-	1.6	654.0	355.3
		Bk1	30-75	22	7.7	79.0	18.2	349. 9	242.4	429.4	1.3	-	1.3	588.0	433.7
		Bky	75-100	30	7.8	31.2	8.8	201.2	40.9	273.6	2.4	-	1.3	222.0	294.8
			100+	Hardpan											
9	Bajada	ABk	0-30	25	7.6	15.6	5.5	43.9	16.9	133.7	0.6	-	1.0	112.0	81.9
		Bk1	30-85	30	7.6	8.6	6.0	23.5	15.6	63.5	0.3	-	1.0	68.0	33.9
		Bk2	85-100	25	7.6	9.8	6.0	23.5	18.7	75.4	0.4	-	1.0	76.0	40.9
		Bk3	100-150	22	7.7	75.4	5.5	72.8	214.6	825.7	26.9	-	2.6	750.0	387.4
14		ABk	0-15	25	7.7	4.8	14.9	10.7	14.0	22.8	0.5	-	1.8	19.0	27.2
		Bk	15-50	25	7.4	15.6	18.7	47. 7	10.3	136.1	2.0	-	1.8	138.0	56.2
		2R	50-75	42	7.4	15.6	19.2	39.6	8.8	145.8	1.8	-	2.6	128.0	65.4
			75+	Hardpan											

Table (2): Cont.

Profile No.	Physiographic unit	Horizon	Depth (cm)	Soil past	pH of soil past	EC (dS/m) soil past	EC (dS/m) extract 1:1	Soluble ions in saturated extract ($mmol_c$/ L)							
								Cations ($mmol_c$/L)				Anions ($mmol_c$/ L)			
								Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}
3	Wadies	C1	0-20	25	7.9	1.9	0.8	11.8	2.7	4.6	0.5	-	1.3	4.0	14.2
		C2	20-70	30	8.1	0.9	0.3	3.2	1.0	4.7	0.2	-	1.6	2.5	5.0
		C3	70-150	25	8.0	0.8	0.2	2.1	1.5	4.0	0.2	-	1.3	3.0	3.5
5		A	0-20	25	7.8	4.3	1.4	23.5	6.3	13.7	1.4	-	1.3	12.0	31.7
		C1	20-65	26	7.8	15.6	4.2	55.6	16.5	121.1	1.8	-	1.0	108.0	85.9
		C2	65-100	25	7.7	15.6	4.6	51.4	26.9	115.6	1.1	-	1.0	118.0	75.9
		C3	100-150	25	7.6	22.1	6.3	75.9	34.2	171.6	1.1	-	0.8	176.0	106.1
8		C1	0-30	30	8.3	6.6	1.8	33.2	5.9	33.6	2.2	-	1.0	36.0	37.9
		C2	30-40	29	8.1	19.5	0.8	41.7	29.4	177.1	1.5	-	1.0	132.0	116.6
		C3	40-85	30	8.0	13.0	0.5	49.2	16.7	93.9	1.7	-	1.6	68.0	92.0
		C4	85-150	25	8.3	26.0	0.7	114.5	44.3	187.3	1.0	-	1.0	224.0	122.1
10		C1	0-30	20	7.8	15.6	3.4	22.5	40.9	129.4	2.3	-	1.6	124.0	69.4
		C2	30-45	25	7.4	15.6	7.5	54.6	16.5	113.7	2.4	-	1.3	100.0	85.9
		C3	45-90	26	7.6	78.0	4.6	63.1	164.4	951.9	6.2	-	1.3	780.0	404.3
		C4	90-100	25	7.7	28.6	4.0	38.5	53.2	288.6	3.0	-	1.3	250.0	131.9
		C5	100-150	26	7.6	68.9	4.5	55.6	22.6	911.7	2.2	-	1.6	642.0	348.6
4	Coastal braided delta	A	0-30	25	7.5	127.4	38.0	157.6	179.2	1554.8	20.9	-	1.6	1484.0	426.9
		C1	30-65	24	7.6	5.7	4.7	25.7	10.4	30.0	0.9	-	1.3	30.0	35.6
		C2	65-100	25	7.8	7.5	3.5	29.9	14.3	42.1	1.9	-	1.6	38.0	48.7
		C3	100-150	25	7.6	7.2	2.8	28.9	24.7	28.4	0.9	-	1.3	40.0	41.6
13		A	0-15	26	8.0	2.7	27.0	17.1	2.5	7.3	0.4	-	1.6	6.0	19.7
		C1	15-60	30	8.2	79.3	13.8	192.6	47.4	967.9	1.4	-	1.3	774.0	434.0
		C2	60-150	30	7.6	80.6	9.0	194.7	59.7	960.1	2.5	-	1.3	770.0	445.8
11	Marine sediments	A1Z	0-20	25	7.4	42.9	45.7	28.9	10.3	560.2	1.3	-	1.8	470.0	128.8
		A2	20-30	25	7.6	26.0	2.4	22.5	7.4	315.1	0.9	-	1.6	148.0	196.2
		Cg	30-70	31	7.6	36.4	4.4	133.8	9.5	353.9	1.6	-	1.6	274.0	223.1
			70+	Water table											
12		AZ	0-15	26	7.4	63.7	79.0	374.5	79.7	447.9	1.4	-	1.0	480.0	422.4
		Cg	15-35	35	7.8	46.8	12.0	197.9	51.4	404.8	1.1	-	2.6	400.0	252.6
			35+	Water table											

1- Sodic Aquisalids, coarse loamy, mixed, hyperthermic.

These soils were identified in the Marine Sediments. They are represented by profiles 11 and 12.

2- Typic Haplocalcids, sandy skeletal, mixed, hyperthermic.

These soils were identified in the alluvial terraces which are represented by soil profile 2 and Bajadas which are represented by soil profile 9.

3- Sodic Haplocalcids, loamy skeletal, mixed, hyperthermic.

These soils were identified in the alluvial terraces which are represented by soil profile 6 and piedmont which are represented by soil profile 7 .

4- *Sodic Haplocalcids, sandy skeletal, mixed, hyperthermic*.

These soils were identified in the bajada. This is represented by profile 14.

5- Typic Clacigypsids, sandy, carbonitic. hyperthermic.

These soils were identified in alluvial fan. This is represented by profile 15.

6- Typic Clacigypsids, coarse loamy, carbonitic. hyperthermic.

These soils were identified in alluvial fan. This is represented by profile 16.

There are four Entisol families were identified. They are as follows:

1- Typic Torrifluvents, loamy skeletal, mixed, hyperthermic.

These soils were identified in the Wadis of the study area. They are represented by profiles 3, 5 and 8.

***2*- Typic Torrifluvents, coarse loamy, mixed, hyperthermic.**

These soils were idendified in the Wadi of the study area. This is represented by profile 10.

3- Typic Torriorthents, coarse loamy, mixed, hyperthermic.

These soils were identified in the coastal braided deltas. They are represented by profiles 4 and 13.

4- Lithic Torriorthents, loamy skeletal, mixed, hyperthermic.

These soils were identified in the piedmont area. This is represented by profile 1.

5- Land evaluation:

5.1. Current land suitability:

Current land suitability refers to the suitability for a defined use of land in its present condition, without major improvements. The current suitability of the studied area was estimated by the present land characteristics and their ratings outlined by Sys et al. (1991).

Table (3), and fig. (4) are shown currently land suitability include two orders {suitable (S) and not suitable (N)}, two classes {marginally suitable (S3) and currently not suitable (N1)}, two subclasses (N1sn and N1wsn) and five units (S3sn-1, S3sn-2, N1tsn-1, N1tsn-2 and N1tsn-3) as follows:

- **N1sn:** not suitable with a severe intensity of texture, moderate intensity of salinity and alkalinity, and slight intensity of topography, calcium carbonate and gypsum limitations. This subclass represents soils of the alluvial terraces physiographic unit and occupies an area of about 50016 feddans.

- **N1wsn:** not suitable with a very severe intensity of wetness, severe intensity of texture, depth and salinity and alkalinity, and slight intensity of topography, calcium carbonate and gypsum limitations. This subclass represents soils of the marine sediments physiographic unit and occupies an area of about 4341 feddans.
- **S3sn-1:** Marginally suitable with a severe intensity of salinity and alkalinity, moderate intensity of texture and calcium carbonate, and slight intensity of topography and gypsum limitations. This unit represents soils of the coastal braided deltas physiographic unit and occupies an area of about 12268 feddans.
- **S3sn-2:** marginally suitable with a moderate intensity of texture and salinity and alkalinity, and slight intensity of topography, calcium carbonate and gypsum limitations. This unit represents soils of the wadies physiographic unit and occupies an area of about 56095 feddans.
- **N1tsn-1:** not suitable with a sever intensity of texture and salinity and alkalinity, moderate intensity of topography, calcium carbonate and slight intensity of gypsum limitations. This unit represents soils of the alluvial fans physiographic unit and occupies an area of about 19500 feddans.
- **N1tsn-2:** not suitable with a sever intensity of texture, moderate intensity of topography, depth, calcium carbonate and salinity and alkalinity, and slight intensity of gypsum limitations. This unit represents soils of the bajadas physiographic unit and occupies an area of about 22910 feddans.
- **N1tsn-3:** not suitable with a very sever intensity of salinity and alkalinity, sever intensity of depth, moderate intensity of topography and texture and slight intensity of calcium carbonate and gypsum limitations. This unit represents soils of the piedmont physiographic unit and occupies an area of about 46623 feddans.

Table (3): A detailed description of the current land suitability units and subclasses in the study area.

Land suitability				Intensity of limitations
Order	Class	Subclass	Unit	
S Suitable	S3 Marginal suitable	S3sn	S3sn-1	Severe for salinity and alkalinity, moderate for texture and calcium carbonate, and slight for topography and gypsum.
			S3sn-2	Moderate for both texture and salinity and alkalinity, and slight for topography, calcium carbonate and gypsum.
N Not suitable	N1 Not suitable	N1tsn	N1tsn-1	Sever for both texture and salinity and alkalinity, moderate for both topography and calcium carbonate and slight for gypsum.
			N1tsn-2	Sever for texture, moderate for topography, depth, calcium carbonate and salinity and alkalinity, and slight for gypsum.
			N1tsn-3	Very sever for salinity and alkalinity, sever for depth, moderate for both topography and texture and slight for calcium carbonate and gypsum.
		N1sn		Severe for texture, moderate for salinity and alkalinity, and slight for topography, calcium carbonate and gypsum.
		N1wsn		Very severe for wetness, severe for texture, depth and salinity and alkalinity, and slight for topography, calcium carbonate and gypsum.

Soil limitations {t: topography, w: wetness, s: (s_1: texture, s_2: soil depth, s_3: calcium carbonate, s_4: gypsum), n: salinity and alkalinity} S2: Moderately suitable (50-75), S3: marginally suitable (25-50), N1: Currently not suitable (<25).

5.2. Potential land suitability:

Potential suitability term refers to the suitability of units, for a defined use, in their conditions at some future data, after specified major improvements have been completed where necessary (FAO, 1976). Land improvements are activities which cause beneficial changes in the qualities of the land itself.

The future land improvements are required to correct or reduce the severity of limitations exiting in the area under consideration. Such as a) leveling of undulating surface soils, construction of good drainage systems to lower the saline ground water table in the soils of marine sediments, leaching of salinity and reclamation of alkalinity existing in the soils of coastal braided delta, alluvial fans, piedmont and

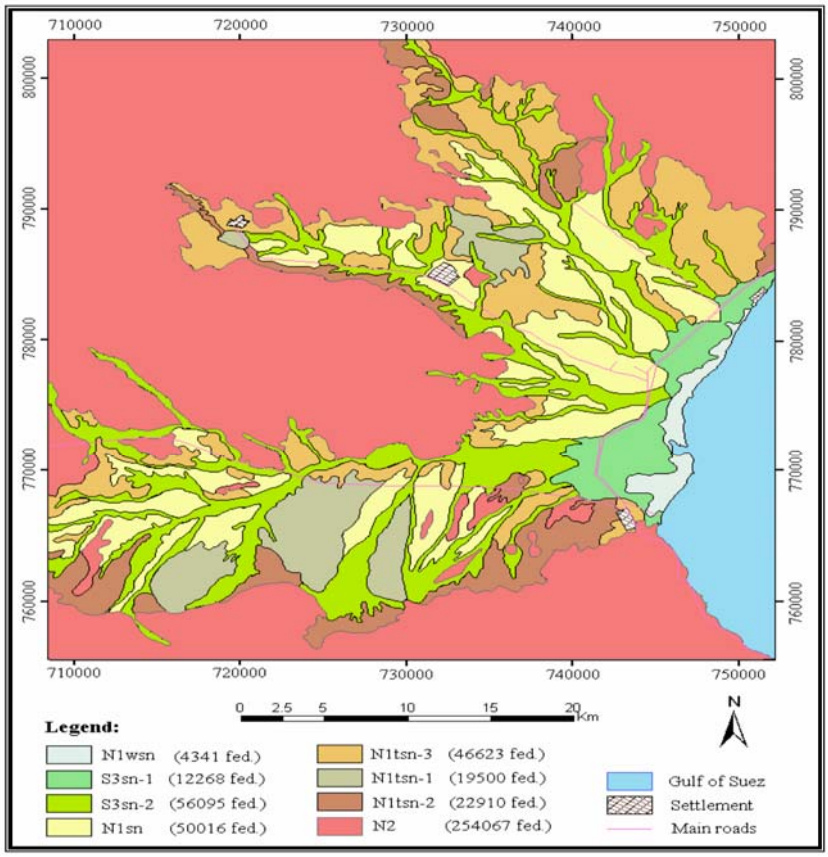

Fig. (4): Current land capability map of the study area.

marine sediments, application of chemical and organic fertilizers, green manure and soil conditioners to increase soil fertility to improve the physical and chemical soil characteristics and application of modern irrigation systems, such as drip and sprinkler to save irrigation water.

Table (4), and fig. (5) are shown Potential land suitability of the studied soils indicated the existing of two orders (S and N), three classes (S2, S3 and N1), three subclasses (S2s, S3s and N1ws) and three units (S3s-1, S3s-2 and S3s-3) as follows:

- **S3s-1:** This unit represents soils of the coastal braided deltas physiographic unit occupies an area of about 12268 feddans. It is marginally suitable with a moderate intensity of texture and calcium carbonate, and slight intensity of gypsum limitations.

- **S3s-2:** This unit represents the soils of alluvial terraces, alluvial fans and Bajadas physiographic units occupy an area of about 92426 feddans. It is marginally suitable with a sever intensity of texture, moderate intensity of calcium carbonate, and slight intensity of gypsum limitations.
- **S3s-3:** This unit represents soils of the piedmont physiographic unit and occupies an area of about 46623 feddans. It is marginally suitable with a sever intensity of depth, moderate intensity of texture and slight intensity of calcium carbonate gypsum limitations.
- **S2s:** This subclass represents the soils of wadies physiographic unit and occupies an area of about 56095 feddans. It is moderately suitable with a moderately intensity of texture and slight intensity of calcium carbonate and gypsum limitations.
- **N1ws:** This subclass represents the soils of marin sediments physiographic unit and occupies an area of about 4341 feddans. It is not suitable with a sever intensity of wetness, moderate intensity of texture and depth and slight intensity of calcium carbonate and gypsum limitations.

Table (4): A detailed description of the Potential land suitability units and subclasses in the study area.

Land suitability				Intensity of limitations after leveling of undulating surface soils to correct the limitation of topography, construction of good drainage systems and Leaching of salinity and reclamation of alkalinity existing in the soils.
Order	Class	Subclass	Unit	
S Suitable	S2 Marginal suitable	S2s		Moderately for texture and slight intensity of calcium carbonate and gypsum limitations.
	S3 Marginal suitable	S3s	S3s-1	Moderate for texture and calcium carbonate, and slight intensity of gypsum limitations
			S3s-2	Sever for texture, moderate intensity of calcium carbonate, and slight intensity of gypsum limitations.
			S3s-3	Sever intensity of depth, moderate intensity of texture and slight intensity of calcium carbonate gypsum limitations.
N Not suitable	N1 Not suitable	N1ws		Sever intensity of wetness, moderate intensity of texture and depth and slight intensity of calcium carbonate and gypsum limitations.

Soil limitations {t: topography, w: wetness, s: (s_1: texture, s_2: soil depth, s_3: calcium carbonate, s_4: gypsum), n: salinity and alkalinity}
S2: Moderately suitable (50-75), S3: marginally suitable (25-50), N1: Currently not suitable (<25).

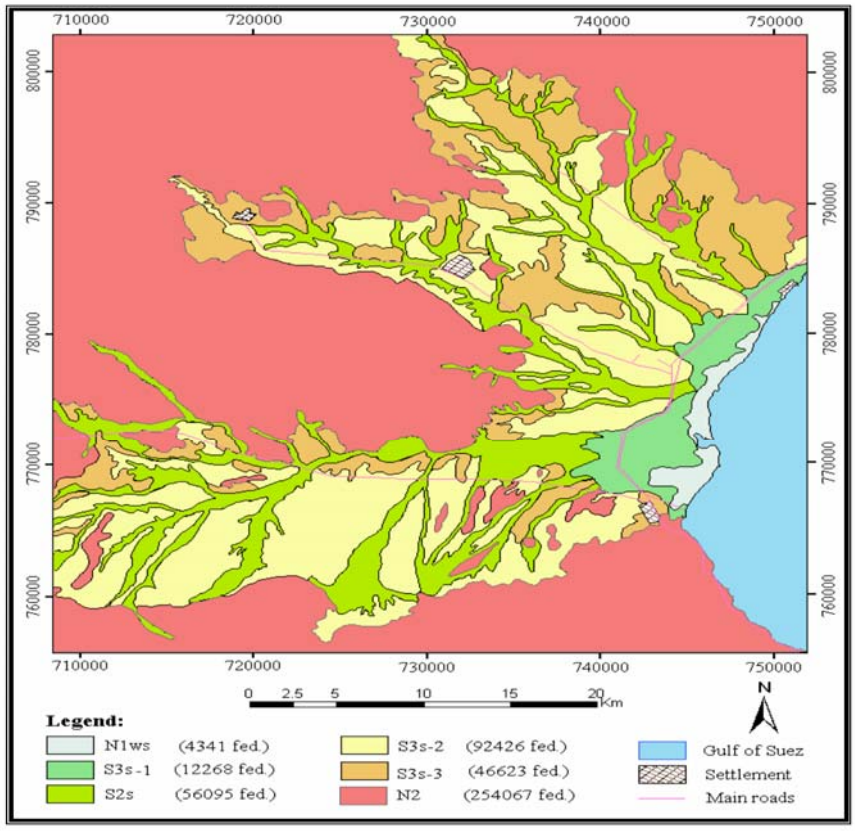

Fig. (5): Potential land capability map of the study area.

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تقييم الأراضي فى الوحدات الفزيوجرافيه لبعض الوديان بالصحراء الشرقية المصرية باستخدام الاستشعار عن بعد ونظم المعلومات الجغرافية

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تهدف هذه الدراسة إلى تقييم صلاحية الأراضى فى الوحدات الفزيوجرافيه لبعض الأودية بالصحراء الشرقية المصرية (وادى غوبية – وادى بدع – وادى حجول – وادى الناقة) كمناطق واعدة يمكن إضافتها إلى جملة الاراضى الزراعية. وتقع منطقة الدراسة فى المنطقة المحصورة بين غرب خليج السويس وشرق القاهرة بين خطى طول 55″ 57′ 31° ، 25″ 25′ 32° شرقا ودائرتى عرض 19″ 30′ 29° ، 07″ 56′ 29° شمالا. وتبلغ مساحتها حوالى 2160 كم^2 (514285.7 فدان).

وقد إعتمدت الدراسه على تحليل وتفسير صوره القمر الصناعى الامريكى لاندسات-7 (TM-7) لتحديد الوحدات الفزيوجرافيه لمنطقة الدراسة وتم تحسين حدود هذه الوحدات بمطابقة بيانات المرئية الفضائية المفسرة والبيانات الحقلية للوصول للخريطة الفزيوجرافية للمنطقة وذلك باستخدام نظم المعلومات الجغرافية.

شملت الدراسة 16 قطاعا أرضيا لتأكيد مصداقية التحليل الفزيوجرافى حيث جمعت منها 56 عينة تربة تمثل الطبقات أو الآفاق المختلفة تبعا للاختلافات المورفولوجية لتحديد خواص وصفات التربة الطبيعية والكيماوية، وتم استخدام النتائج فى تصنيف وتقييم التربة، وأظهرت نتائج هذه الدراسة تحديد الوحدات الفزيوجرافية آلاتية:-

أ- الاراضى الجبلية: مادة اصلها ذات تراكيب بنائية صخرية تمثل مساحة 254067 فدانا،

ب- الاراضى المنخفضة الرسوبية: تمثل مساحة 211753 فدانا، وهى الاراضى الواعدة والتى يمكن إضافتها إلى الرقعة الزراعية وتم تقسيم منطقة الدراسة فزيوجرافيا إلى الوحدات الآتية: مناطق سفح الجبل: تمثل مساحة 46623 فدانا ، الرسوبيات المروحية: تمثل مساحة 19500

فدانا ، المراوح المتجمعة: تمثل مساحة 22910 فدانا ، المصاطب الرسوبية: تمثل مساحة 50016 فدانا ، الأودية: تمثل مساحة 56095 تمثل (وادى غويبة - وادى بدع -وادى حجول - وادى الناقة) ، الدلتا: تمثل مساحة 12268 فدانا ، الرسوبيات البحرية: تمثل مساحة 4341 فدانا.

تم تصنيف التربة طبقا لنظام التقسيم الأمريكى ووجد ان اراضى منطقة الدراسة تنتمى الى رتبتين (الأراضى الجافة - والاراضى حديثة التكوين) ، خمس تحت رتب وخمس مجموعات وسبع تحت مجموعات وعشر عائلات تربة ، منها ست عائلات ضمن رتبة (الأراضى الجافة) ، اربع عائلات ضمن رتبة (الاراضى حديثة التكوين).

تم تقييم درجة الصلاحية الحالية والمستقبلية للاراضى تحت الدراسة وقد أمكن تمييز رتبتين لدرجات الصلاحية الحالية هما صالحة (S) وغير صالحة (N) ، كذا قسمين هما حدية الصلاحية (S_3) وغير صالحة (N_1) وأربعة تحت أقسام.

وتم تقييم درجة الصلاحية المستقبلية فى حالة إتمام عمليات التحسين المطلوبة كتسوية سطح الأرض وغسيل الأملاح وعلاج القلوية بإضافة محسنات التربة المناسبة وتوفير نظام صرف جيد خاصة فى المناطق الساحلية لتخفيض مستوى الماء الارضى واستخدام الأسمدة العضوية والمعدنية لزيادة خصوبة التربة وتحسين خواصها الطبيعية والكيميائية واستخدام أساليب الرى المتطور لتوفير المياه وزيادة كفاءة استخدام مياه الرى ومنع تكوين مستوى أرضى مرتفع.

وقد أمكن تمييز رتبتين لدرجات الصلاحية المستقبلية للاراضى تحت الدراسة هما صالحة (S) وغير صالحة (N) ، كذا ثلاثة أقسام هى متوسطة الصلاحية (S2) و حدية الصلاحية (S_3) وغير صالحة (N_1) و ثلاثة تحت أقسام.