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CHARACTERISTICES, CLASSIFICATION AND EVALUATION OF SOILS IN THE AREA SOUTHEAST EL-SADAT CITY, MENOUFIA GOVERNORATE, EGYPT

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ABSTRACT: **The current work was performed in 2019 aiming to study the geomorphological and pedological characteristics as well as classification and capability evaluation for soils in the area southeastern El-Sadat City, Menoufia governorate, Egypt. The study area is located at the western side of the Nile-Delta in the east of Cairo-Alexandria desert highway adjacent to the Rashid branch of the River Nile, Menoufia governorate, Egypt. The integration of Remote Sensing (RS) and Geographic Information System (GIS) techniques was used to achieve this work.**

The geomorphic map produced by processing and identifying the Landsat image using RS and GIS technology indicated that, the studied area has three main geomorphic units with different landforms. These three main units are 1) Alluvial Plain includes three landforms namely: High Terraces (17.33% of the studied area), Moderate Terraces (5.87%) and Low Terraces (11.48%); 2) Pediplain with two landforms namely: High Terraces (16.22 %) and Low Terraces (12.47%); 3) as well as Aeolian Plain with three landforms namely: High Terraces (7.08%), Moderate Terraces (4.97%) and Low Terraces (24.58%).

Nineteen soil profiles were chosen to represent the different geomorphic and landform units. The land and site features are observed and registered. The soil profiles were dug, morphologically described, and then samples were collected representing the subsequent layers in each profile for integrated physical and chemical analyses. Also, irrigation water samples were collected and analyzed especially for land capability evaluation.

The studied area has almost flat to slightly undulated topography. Soils were deep to very deep where they were well drained. Most of the soils have gravely sand to gravely loamy sand texture except the soils of low Alluvial plain terraces that have clay loam texture.

The analytical data revealed that, the studied soils are slightly to moderately alkaline, mostly non-saline and haven't sodicity effect. Few parts showed a sodic horizon feature. The soils are slightly to moderately calcareous having Low gypsum and Organic matter contents.

Most of the soils haven't any diagnostic horizons, therefore they were classified under Entisols. The few soils having sodic horizon were classified under Aridisols.

The land capability evaluation indicated that, most of the studied soils (92.18%) are affiliated to the Fair, C3 class. Rest of the soils are classified either as a Good capability class, C2, (4.52%), or as a Poor capability class, C4 (3.30%).

Key words: **RS, GIS, geomorphic units, landforms, pedological features, soil classification, land capability evaluation.**

INTRODUCTION

The balance between the land and human resources is the most critical problem in Egypt. Accordingly, the major challenge of Egyptian government today is facing the need for better development and management of natural resources, to meet requirements of the fast-growing population. Therefore, agriculture expansion in the Western Desert is one of the most vital objectives in Egyptian policy to satisfy the food security needs of the ever- increasing population (Ismail et al., 2010). One of the susceptible lands occurs mainly in the fringes of the Nile valley and Delta. Fringes of the Nile Delta are considered to be the most important location of the ambitious projects. These fringes have the most of best potentially suitable agricultural land resources for future expansion and development in Egypt.

El-Sadat City area is located at the northeastern side of the Western Desert of Egypt to the west of Nile Delta and the east of Cairo-Alexandria desert road adjacent to the Rosetta branch of the River Nile. It is generally formed from some low-lying hills that received special attention due to its reasonably good groundwater resources.

Geomorphologically, this area in the western side of Nile Delta is divided into four units; young alluvial plains, old alluvial plains, conglomerates and sand dunes (Dawoud et al., 2005).

El–Maaz (1997) stated that, all the studied soils in western side of the Nile Delta have Torric soil moisture regime with Thermic soil temperature regime. She classified these soils according Soil Survey staff (1994) as: a) *Typic Torripsamments* and *Typic Torriorthents*.

The western Nile Delta contains four aquifer systems: Delta aquifer (Quaternary), Wadi El Natrun aquifer (Pliocene), El Moghra aquifer (Miocene), and the Oligocene aquifer (RIGW and IWACO, 1991).

Remote sensing (RS) is now recognized as an important tool in monitoring and managing natural resources (Lillesand and Kiefer, 2007). They added that RS technique is one of the important methods that used for soil survey, mapping and environmental investigation.

ESRI (2003) stated that, geographic information system (GIS) is a system for the management, analysis, and displaying geographic information, which is represented by a series of geographic datasets that model geography using simple, generic data structures.

Integration of RS and GIS play a major role in both soil survey and soil mapping applications. The development of methods to map soil properties using optical RS data in combination with field measurements has been the objective of several studies during the last decade (Dehaan and Taylor, 2003).

The aim of the present work is to furnish a comprehensive study on geomorphological and pedological features of the soils in the area southeast of El-Sadat City using the integration of Remote Sensing (RS) and Geographic Information System (GIS) techniques. Also, soil classification and land capability evaluation are achieved.

MATERIALS AND METHODS

Study area

The study area is located at the southeastern part of El-Sadat City, in the east of Cairo-Alexandria desert highway. It lies between longitudes 30°34'00"–30°52'00" E and latitudes 30°16'00"–30°28'00" N covering an area of 353.29 km^2 (84117.92 Feddan), Fig (1). The studied area is characterized by a hot dry summer and warm winter with few rainfalls.

Geomorphology of the study area

The digital elevation model (DEM) of the study area was extracted from the Shuttle Radar Topography Mission (SRTM) and a topographic map with a scale of 1:25,000 covering the study area using Arc-GIS 10.4.1 software (ESRI, 2003). The Landsat 8 (path 178 / row 39) image acquired in 2019 and SRTM data were processed in ENVI 5.1 software (ITT, 2012) to identify the geomorphology and landforms of the studied area according to the approach developed by Dobos et al. (2002). The map legend was designed according to Zinck and Valenzuela (1990). ArcMap 10.4.1 software was used to display and produce geomorphic map of the study area with help of its DEM features and field observations (ESRI, 2014).

Field work.

Reconnaissance soil survey was conducted throughout the investigated area in order to acquire an appreciation of its broad soil patterns and characteristic landscape. The primary mapping units resulting from analysis of the DEM and interpretation information gained during unsupervised classification Landsat images were verified.

Longitudes, latitudes, elevations and soil profiles locations were defined in the field by using GPS system "Corporation MAGELLAN"- NAV DLX-10 TM.

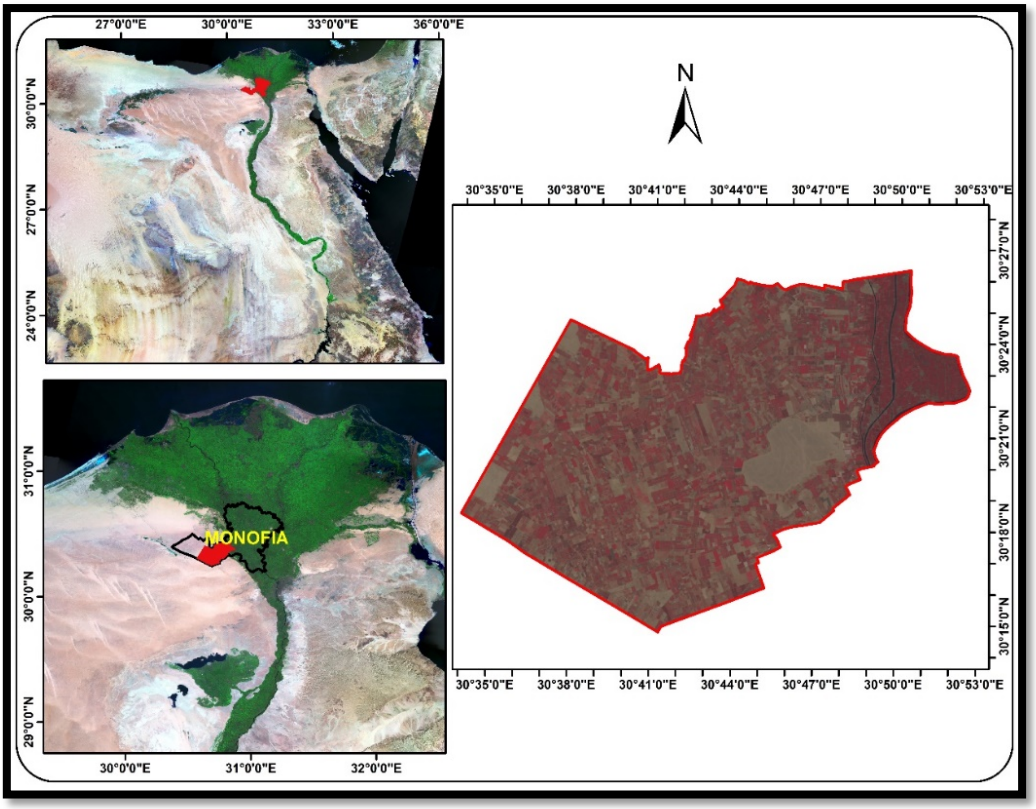

Fig (1): Location map of study area.

Nineteen soil profiles were chosen to represent the landform units in the studied area (Fig, 2). Detailed morphological description of these soil profiles were recorded on the basis outlined by FAO (2006). Soil samples were collected based on the vertical variations of each soil profile for the laboratory analyses of soil physical and chemical properties. Also, water samples were collected from the available irrigation water sources for laboratory analyses of their chemical properties that used in the model of land capability evaluation.

Laboratory analyses

Particle size distribution, electrical conductivity (EC), pH, organic matter (OM), calcium carbonate ($CaCO_3$), gypsum contents, cation exchange capacity (CEC), hydraulic conductivity (HC), exchangeable Na^+ percentage (ESP) and available N, P and K in the soil surface samples were determined according to Burt and Soil Survey Staff (2014). The weighted profile mean (w.p.m.) of each soil property was calculated for the studied profiles. Also, EC, pH, soluble cations and anions as well as sodium adsorption ratio (SAR) and soluble boron were determined in the irrigation water samples according to Burt and Soil Survey Staff (2014).

Soil classification

The soils of the studied area were classified up to sub great group level based on Soil Survey Staff (2014).

Land Evaluation

Land capability classification was carried out using the Agriculture Land Evaluation System for arid and semi-arid regions (ALES-Arid) developed by Ismail et al. (1994 and 2005). ALES-Arid software is inserting of soil database and calculates possible indices combinations between the major land properties. These properties are, soil physical properties (clay content, available water, profile depth, landform, slope and level of surface), chemical properties (pH, soil salinity, gypsum and carbonate contents), soil fertility (OM, available N, P, and K) and Irrigation water characteristics (pH, EC, SAR and soluble boron).

RESULTUS AND DISCUSSION

Geomorphology

Based on the satellite image treating, processing and interpretation with the help of topographic maps and field survey, the integration of RS and GIS was used to identify the geomorphic and landform units of the study area. The main interpreted and identified geomorphic units in the investigated area are Alluvial Plain, Pediplain and Aeolian Plain with detailed gradated landforms as shown with their representative soil profiles in Fig (2) and Table (1).

Soil morphology

The morphological features of the studied soils presented in Table (2) revealed that, the elevation of the studied soils is between 10 m to 90 m above sea level. The soils have almost flat to slightly undulating topography. Most of studied soils are very deep and well drained. The main hue notation of studied soil color is around brown to red degrees (10YR to 7,5YR). The soils have mostly weak to moderate medium to fine subangular blocky and granular structure. The sandy soils have single grains. The studied soils are slightly to moderately calcareous having mostly slightly hard (dry) and firm (moist) consistency. The most studied soils are cultivated with field or horticultural (vegetable and/or fruit) crops.

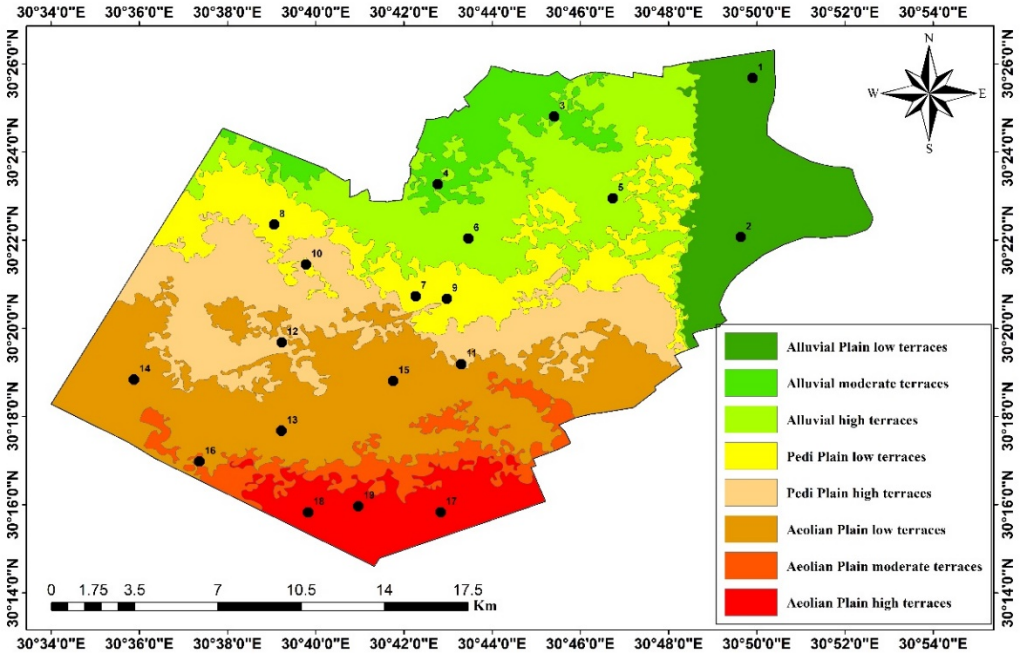

Fig (2): Detailed geomorphic map and locations of soil profiles in the study area.

Table (1): Geomorphic and landform units of the study area and their profiles and areas.

Geomorphic units	landform	Profiles No.	Area in	
			Feddan	%
Alluvial Plain	Low Terraces	P1, P2	9654.55	11.48
	Moderate Terraces	P3, P4	4938.99	5.87
	High Terraces	P5, P6	14581.78	17.33
	Total		29175.32	34.68
Pediplain	Low Terraces	P7, P8, P9	10486.53	12.47
	High Terraces	P10, P11, P12	13641.04	16.22
	Total		24127.57	28.69
Aeolian Plain	Low Terraces	P13, P14, P15	20679.88	24.58
	Moderate Terraces	P16	4183.02	4.97
	High Terraces	P17, P18, P19	5952.13	7.08
	Total		30815.03	36.63
Total of Study area			84117.92	100

Table (2): Morphological features of the studied soil profiles.

Geomorphic units	Land forms	Profile No.	Elevation m asl	Depth cm	Color		Structure[1]	Consistence[2]		Boundary[3]
					Dry	Moist		Dry	Moist	
Alluvial Plain	low Terraces	1	+ 10	0-30	10YR 5/2	3/2	2 c to m sbk	ex hard	v firm	diffuse
				30-60	10YR 5/2	4/2	2 c to f sbk	ex hard	ex firm	diffuse
				60-90	10YR 5/2	3/2	2 c to f sbk	ex hard	v firm	gradual s
				90-110	10YR 5/2	4/2	2 c to f sbk	ex hard	firm	diffuse
				110-130	10YR 5/3	4/3	1 m to f sbk	ex hard	friable	-
		2	+ 17	0-30	10YR 4/2	3/2	2 c, m to f sbk	V hard	firm	gradual s
				30-60	10YR 5/2	4/2	2 c to f sbk	ex hard	ex firm	diffuse
				60-90	10YR 5/2	3/2	2 c to f sbk	ex hard	v firm	gradual s
				90-110	10YR 5/2	4/2	2 c to f sbk	ex hard	firm	diffuse
				110-130	10YR 5/3	4/3	1 m to f sbk	ex hard	friable	-
	Moderate Terraces	3	+33	0-30	10YR 6/4	5/4	1 m to f sbk	s hard	Friable	gradual s
				30-60	10YR 6/5	5/5	1 gr + sg	loose	loose	gradual s
				60-90	10YR 7/4	3/2	sg	loose	loose	diffuse
				90-140	10YR 7/4	6/4	sg	loose	loose	-
		4	+33	0-30	10YR 5/6	4/6	2 m to f sbk	s hard	friable	gradual s
				30-60	7.5YR 5/6	4/6	2 m to f sbk	s hard	friable	clear
				60-90	10YR 6/6	5/6	1 m to f sbk	soft	loose	diffuse
				90-120	10YR 6/6	5/6	1 m to f sbk	soft	loose	diffuse
				120-150	10YR 6/6	5/6	1 f sbk	soft	loose	-
	High Terraces	5	+ 41	0-30	10YR 5/6	4/6	2 m to f sbk	S hard	loose	diffuse
				30-60	7.5YR 5/6	4/6	2 m to f sbk	s hard	loose	diffuse
				60-90	10YR 6/6	5/6	1 m to f sbk	soft	loose	diffuse
				90-120	10YR 6/6	5/6	1 m to f sbk	soft	loose	diffuse
				120-150	10YR 6/6	5/6	1 f sbk	soft	loose	-
		6	+ 39	0-30	10YR 6/6	5/6	2 m to f sbk	s hard	friable	diffuse
				30-60	10YR 6/6	5/6	2 m to f sbk	s hard	friable	gradual s
				60-90	10YR 6/5	5/5	2 m to f sbk	s hard	friable	diffuse
				90-120	10YR 6/5	5/5	2 m to f sbk	s hard	friable	diffuse
				120-150	10YR 6/5	5/5	1 f sbk	s hard	friable	-
Pediplain	Low Terraces	7	+50	0-30	10YR 6/6	5/6	2 c to f sbk	s hard	Friable	clear
				30-60	7.5YR 6/5	5/5	2 m to f sbk	s hard	Friable	diffuse
				60-90	7.5YR 6/5	5/5	2 m to f sbk	s hard	friable	diffuse
				90-120	7.5YR 6/5	5/5	2 m to f sbk	s hard	friable	diffuse
				120150	7.5YR 6/4	5/4	2 m to f sbk	loose	loose	-
		8	+49	0-25	7.5YR 7/6	6/6	2 m to f sbk	s hard	friable	abrupt
				25-45	10YR 5/2	3/2	2 m to f sbk	s hard	friable	abrupt
				45-77	10YR 6/6	5/6	2 m to f sbk	s hard	friable	diffuse
				77-105	10YR 6/6	5/6	2 m to f sbk	s hard	friable	diffuse
				105-150	7.5YR 6/6	5/6	2 m to f sbk	s hard	friable	-
		9	+49	0-30	10YR 6/6	5/6	2 m to f sbk	s hard	friable	gradual s
				30-60	7.5YR 6/4	5/4	2 m to f sbk	s hard	friable	gradual s
				60-90	10YR 6/5	5/5	1 f sbk	s hard	friable	diffuse
				90-120	10YR 6/4	5/4	sg	loose	loose	diffuse
				120-150	10YR 6/4	5/4	1 f sbk + sg	soft	v friable	-
	High Terraces	10	+52	0-50	10YR 6/5	5/5	Sg	loose	loose	gradual s
				50-70	7.5YR 7/5	6/5	1 m to f sbk	s hard	friable	clear
				70-110	10YR 6/5	5/5	2 c, m to f sbk	ex hard	friable	abrupt
				110-150	7.5YR 5/6	4/6	sg	loose	loose	-
		11	+56	0-30	7.5YR 6/5	5/5	1 m to f sbk	s hard	Friable	abrupt
				30-50	10YR 5/3	4/3	2 m to f sbk	s hard	Friable	abrupt
				50-90	10YR 6/6	5/6	2 c to m bk	hard	friable	gradual s
				90-150	7.5YR 6/5	5/5	2 m to f sbk	s hard	friable	-
		12	+59	0-20	7.5YR 6/6	5/6	1 m to f gr	s hard	Friable	gradual s
				20-70	7.5YR 7/6	5/6	2 m to f sbk	v hard	friable	abrupt
				70-100	10YR 6/3	4/3	2 m to f sbk	ex hard	friable	abrupt
				100-140	7.5YR 6/6	5/6	sg	loose	loose	-

Abbreviations: Texture[*]: L=loamy, S= sandy, s g=slightly gravely, g=gravely; Structure[1]: 1=weak, 2 =moderate, v = very, f = fine, m = medium, c=coarse, gr = granular, sbk = subangular blocky, bk= blocky, sg= single grains; Consistence[2]: v = very, x =extremely; Boundary[3]: s= smooth

Table (2): Content.

Geomorphic units	Land forms	Profile No.	Elevation m asl	Depth cm	Color		Structure[1]	Consistence[2]		Boundary[3]
					Dry	Moist		Dry	Moist	
Aeolian Plain	Low Terraces	13	+ 59	0-20	10YR 6/4	5/4	1 f gr	s hard	friable	gradual s
				20-40	10YR 6/6	5/6	1 m to f sbk	s hard	friable	abrupt
				40-100	7.5YR 6/6	5/6	1 m to f sbk	s hard	friable	abrupt
				100-110	7.5YR 6/6	5/6	1 m to f sbk	s hard	friable	abrupt
				110-150	7.5YR 6/6	5/6	1 f sbk to gr	s hard	friable	-
		14	+55	0-30	10YR 6/6	5/6	2 m to f sbk	s hard	Friable	gradual s
				30-60	7.5YR6/6	5/6	2 m to f sbk	s hard	friable	diffuse
				60-90	7.5YR6/6	5/6	2 m to f sbk	s hard	friable	gradual s
				90-120	10YR 7/7	6/7	2 m to f sbk	s hard	friable	gradual s
				120-150	7.5YR7/6	6/6	2 m to f sbk	s hard	friable	-
		15	+55	0-30	10YR 6/4	5/4	2 c to m sbk	ex hard	friable	Abrupt
				30-80	7.5YR 5/6	4/6	1 m to f sbk	s hard	friable	gradual s
				80-120	7.5YR 6/6	5/6	1 m to f sbk	s hard	friable	-
	High Terraces	16	+67	0-40	10YR 6/4	5/4	1 m to f sbk	soft	friable	abrupt
				40-75	10YR 7/4	6/4	sg	loose	loose	gradual s
				75-90	10YR 6/6	5/6	1 m to f sbk	soft	friable	abrupt
				90-135	10YR 6/6	5/6	sg	loose	loose	-
	plateau	17	+ 72	0-60	10YR 6/6	5/6	1 f g + sg	loose	Loose	diffuse
				60-90	10YR 6/6	5/6	sg	loose	loose	diffuse
				90-120	10YR 6/6	5/6	sg	loose	loose	diffuse
				120-150	10YR 7/6	6/6	sg	loose	loose	-
		18	+ 80	0-38	10YR 6/6	5/6	1 f sbk to gr	s hard	friable	clear
				38-77	10YR 6/6	4/6	1 f sbk	s hard	friable	-
		19	+84	0-25	7.5YR 6/6	5/6	sg	loose	Loose	clear
				25-50	10Y R 6/6	5/6	sg	loose	loose	gradual s
				50-70	10YR 7/5	6/5	sg	loose	loose	clear
				70-90	7.5YR 6/6	5/6	sg	loose	loose	diffuse
				90-110	7.5YR 6/6	5/6	sg	loose	loose	diffuse
				110-140	7.5YR 6/6	5/6	sg	loose	loose	-

Abbreviations: Texture[*]: L=loamy, S= sandy, s g=slightly gravely, g=gravely; Structure[1]: 1=weak, 2 = moderate, v = very, f = fine, m = medium, c=coarse, gr = granular, sbk = subangular blocky, bk= blocky, sg= single grains; Consistence[2]: v = very, x =extremely; Boundary[3]: s= smooth

Physiochemical properties

The physiochemical properties of the studied soils are registered in Table (3). Data in Table (3) show that, most of the studied soils have slightly to highly gravely sandy, loamy sand to sandy loam texture. Only the soils of low alluvial plain terraces have clay loam texture (as w.p.m.). Most of the studied soils are non-saline (EC < 2 dSm^{-1}, as w.p.m.), haven't sodicity effect and having slightly to moderately alkaline reaction (pH > 7 to < 8.5 as w.p.m.). Only soils of profile 19 in the High Aeoline Terraces had shown a clear salinity (EC > 4dSm^{-1}) and sodicity (> 15% ESP) effects.

These soils are slightly to moderately calcareous having < 7% $CaCO_3$ content (as w.p.m.). Gypsum content is low (< 3%). Organic matter (OM) is low (< 2%, as w.p.m.). The cation exchange capacity (CEC) is depending on the fine fractions and organic matter contents.

Table (3): Some physical and chemical properties of studied soil profiles.

Geomorphic units	Landforms	Profile N°	Depth Cm	Gravels %	Particle size distribution %			Texture Class	pH 1:2.5	EC dSm^{-1}	CEC meq/100 g soil	ESP	$CaCO_3$ %	Gypsum %	OM %
					Sand	Silt	Clay								
Alluvial Plain	Low Terraces	1	0-30	-	38.1	32.6	29.3	Clay L.	7.5	0.39	40.6	3.22	1.59	1.1	0.84
			30-60	-	36.1	33.3	30.6	Clay L.	7.5	0.27	28.6	4.08	1.81	0.9	0.69
			60-90	-	34.3	33.5	32.2	Clay L.	7.6	0.26	26.5	4.22	2.27	0.8	0.34
			90-110	-	34.2	33.6	32.2	Clay L.	7.9	0.24	26.5	5.25	1.31	1.1	0.22
			110-130	-	34.6	34.0	31.4	Clay L.	8.1	0.22	24.4	3.87	0.23	1.3	0.08
			W.P.M	-	35.6	33.3	30.1	Clay L.	7.7	0.28	29.9	4.06	1.55	1.02	0.48
		2	0-30	-	41.2	30.6	28.2	Clay L.	7.7	0.25	35.5	2.59	0.54	1.5	0.55
			30-55	-	37.8	31.8	30.4	Clay L.	7.7	0.24	32.2	1.92	1.18	1.1	0.18
			55-70	-	36.9	32.4	30.7	Clay L.	7.7	0.23	35.0	2.77	0.91	0.9	0.15
			70-100	-	36.1	32.8	31.6	Clay L.	7.8	0.21	28.7	2.83	1.54	0.8	0.25
			100-130	-	33.5	34.2	32.3	Clay L.	7.8	0.21	22.4	3.38	1.90	0.7	0.25
			130-150	-	32.0	35.0	33.0	Clay L.	7.8	0.21	21.0	3.48	1.54	0.6	0.50
			W.P.M	-	36.3	32.7	31.0	Clay L.	7.8	0.23	29.0	2.82	1.29	0.95	0.32
	mod Terraces	3	0-30	40.0	85.9	10.2	3.9	Loamy S.	7.1	1.53	10.5	10.19	1.77	1.5	0.29
			30-60	18.0	86.8	10.0	3.2	Sand	7.3	0.61	9.1	8.33	0.59	1.9	0.20
			60-90	38.0	87.8	9.5	2.7	Sand	7.1	0.20	8.4	9.67	1.09	2.0	0.17
			90-140	63.6	88.5	9.2	2.3	Sand	7.7	0.19	8.4	8.70	0.95	1.7	0.17
			W.P.M	43.3	87.4	9,7	2.9	Sand	7.3	0.57	9.0	9.15	1.08	1.76	0.20
		4	0-30	25.0	83.5	11.6	4.9	Loamy S.	7.9	0.23	12.6	5.58	1.31	1.1	0.39
			30-60	33.6	84.5	11.0	4.5	Loamy S.	7.8	0.25	11.9	5.44	2.58	1.5	0.20
			60-90	14.9	85.3	10.9	3.8	Loamy S.	7.9	0.18	10.5	5.34	1.59	1.8	0.20
			90-120	8.6	86.0	10.4	3.6	Loamy S.	8.1	0.18	10.5	3.65	0.63	1.9	0.17
			120-150	6.3	86.5	10.3	3.2	Loamy S.	8.1	0.17	10.5	3.94	0.41	1.2	0.10
			W.P.M	17.7	85.2	10.8	4.0	Loamy S.	8.0	0.20	11.2	4.76	1.30	1.5	0.21
	High Terraces	5	0-30	16.7	85.1	10.6	4.3	Sand	7.2	0.13	15.5	5.58	0.50	1.7	0.10
			30-60	17.1	85.7	10.1	4.2	Sand	7.3	0.38	14.5	5.23	0.45	1.5	0.12
			60-90	17.3	86.4	9.9	3.7	Sand	7.5	0.39	14.2	4.97	0.72	2.1	0.02
			90-120	18.4	87.0	9.5	3.5	Sand	7.5	0.51	13.1	5.14	0.86	2.3	0.12
			120-150	16.3	87.7	9.1	3.1	Sand	7.5	0.58	8.8	5.07	0.77	2.6	0.12
			W.P.M	17.2	86.4	9.8	3.8	Sand	7.4	0.43	13.2	5.20	0.66	2.0	0.09
		6	0-30	23.8	84.7	12.0	3.3	Loamy S.	7.5	0.36	9.2	7.02	1.90	2.5	0.34
			30-60	22.8	82.8	12.5	4.7	Loamy S.	7.6	0.19	8.5	6.61	3.17	1.3	0.24
			60-90	22.2	83.3	12.5	4.2	Loamy S.	8.0	0.16	6.7	7.51	2.49	1.8	0.18
			90-120	19.6	82.0	12.7	5.3	Loamy S.	8.6	0.15	6.7	6.18	2.22	1.1	0.15
			120-150	18.5	80.3	13.2	6.5	Loamy S.	8.9	0.21	5.8	6.59	1.77	1.9	0.13
			W.P.M	21.4	82.6	12.6	4.8	Loamy S.	8.1	0.21	7.4	6.78	2.31	1.7	0.21
Pediplain	Low Terraces	7	0-30	34.3	83.1	12.3	4.6	Loamy S.	7.6	1.52	16.2	4.00	3.99	1.7	0.30
			30-60	37.4	80.9	13.6	5.5	Loamy S.	7.8	0.59	14.7	5.16	6.66	1.5	0.25
			60-90	30.6	81.6	13.2	5.2	Loamy S.	7.8	0.41	14.0	6.18	5.17	1.3	0.25
			90-120	28.8	79.3	14.0	6.7	Loamy S.	7.9	0.23	10.5	4.79	4.53	0.9	0.17
			120-150	26.7	75.1	17.6	7.3	Sandy L.	8.2	0.19	9.7	5.16	4.94	1.7	0.17
			W.P.M	31.6	78.0	14.1	5.9	Loamy S.	7.9	0.59	13.0	5.06	5.06	1.4	0.23
		8	0-30	30.0	76.3	19.6	4.1	sandy L	7.9	0.19	23.8	2.84	7.11	1.5	0.37
			30-60	16.4	75.7	19.8	4.5	Sandy L.	7.5	0.43	39.2	3.15	2.95	1.2	1.38
			60-90	24.6	83.4	11.7	4.9	Loamy S.	7.5	0.33	14.7	6.60	6.57	2.3	0.76
			90-120	20.2	78.8	14.7	6.5	Loamy S.	7.2	0.30	16.8	5.15	4.71	2.5	0.17
			120-150	14.7	78.2	12.5	9.3	Loamy S.	7.3	0.22	21.0	1.68	3.22	1.6	0.17
			W.P.M	20.6	78.8	14.9	6.3	Loamy S.	7.5	0.28	21.8	3.77	4.83	1.8	0.49
		9	0-30	24.2	83.5	12.3	4.2	Loamy S.	7.1	0.53	23.1	4.63	2.76	1.5	0.49
			30-60	27.2	81.8	13.4	4.8	Loamy S.	7.3	0.37	21.7	4.23	2.72	2.1	0.25
			60-90	28.4	79.1	15.0	5.9	Loamy S.	7.5	0.19	14.0	4.82	1.54	2.3	0.18
			90-120	50.4	79.3	14.5	6.2	Loamy S.	7.8	0.17	13.7	4.51	1.81	2.4	0.17
			120-150	38.1	76.5	16.3	7.2	Sandy L.	7.8	0.16	10.2	6.34	1.77	2.8	0.13
			W.P.M	33.7	80.0	14.3	5.7	Loamy S.	7.5	0.28	16.6	4.91	2.12	2.2	0.25

W.P.M = weighted profile means, L.= loam, S.= Sand

Table (3): Cont.

Geomorphic	Landforms	Profile Nº	Depth cm	Gravels %	Particle size distribution %			Texture class	pH 1:2.5	EC dSm^{-1}	CEC meq/100 g soil	ESP %	$CaCO_3$ %	Gypsum %	OM %
					Sand	Silt	Clay								
Pedi Plain	High Terraces	10	0-50	43.0	80.4	14.2	5.4	Loamy S.	6.9	0.57	14.0	8.16	5.75	2.5	0.40
			50-70	44.1	76.2	17.3	6.5	Sandy L.	8.1	0.26	15.4	4.56	7.48	1.9	0.47
			70-110	34.4	74.1	18.9	7.0	Sandy L.	8.0	0.28	12.0	9.31	7.20	2.3	0.44
			110-150	85.0	73.7	18.8	7.5	Sandy L.	8.1	0.24	10.8	7.02	3.22	2.0	0.22
			W.P.M	52.1	76.4	17.1	6.5	Sandy L.	7.8	0.37	12.8	7.68	5.69	2.2	0.37
		11	0 - 30	29.2	74.1	17.6	8.3	Sandy L.	7.9	0.46	20.3	3.73	4.21	1.3	1.32
			30 - 60	31.5	75.5	17.3	7.2	Sandy L.	7.9	0.39	18.9	6.78	2.76	1.2	0.65
			60 - 90	28.5	75.1	18.9	6.0	Sandy L.	8.2	0.27	17.5	4.95	3.94	1.1	0.40
			90-120	24.0	74.7	19.1	6.2	Sandy L.	7.6	0.18	17.5	2.02	2.72	1.2	0.30
			120-123	33.0	75.5	19.3	5.2	Sandy L.	7.9	0.17	17.5	3.37	1.84	1.4	0.10
			W.P.M	28.4	74.9	18.2	6.9	Sandy L.	7.9	0.32	18.5	4.35	3.77	1.2	0.66
		12	0 - 20	46.7	78.6	15.2	6.2	Loamy S.	8.2	0.25	10.5	5.07	4.58	1.1	0.76
			20 - 70	58.0	74.8	18.4	6.8	Sandy L.	8.1	0.18	11.2	3.96	10.06	1.3	0.42
			70 - 100	49.6	72.2	20.3	7.5	Sandy L.	7.7	0.15	14.0	4.62	8.61	1.3	0.26
			100-140	32.0	70.5	21.2	8.3	Sandy L.	7.4	0.15	14.7	3.02	1.90	1.4	0.17
			W.P.M	47.2	73.5	19.2	7.3	Sandy L.	7.8	0.18	12.7	3.99	6.64	1.3	0.36
Aeolian Plain	Low Terraces	13	0-20	17.4	81.0	14.2	4.8	Loamy S.	7.5	0.68	14.0	9.48	1.59	1.4	0.24
			20-40	14.4	83.2	12.5	4.3	Loamy S.	8.1	0.21	14.0	4.82	3.35	1.3	0.17
			40-100	65.9	84.9	10.5	4.6	Loamy S.	8.2	0.21	14.7	4.78	8.65	0.9	0.15
			100-110	72.5	85.4	10.4	4.2	Loamy S.	8.2	0.20	13.4	5.25	5.44	1.4	0.12
			110-150	53.3	84.9	10.6	4.5	Loamy S.	8.5	0.20	13.4	5.66	2.95	1.0	0.08
			W.P.M	49.7	84.2	11.3	4.5	Loamy S.	8.1	0.29	14.1	5.68	5.27	1.1	0.14
		14	0-30	20.3	84.0	12.3	3.7	Loamy S.	8.2	0.44	9.1	7.11	3.67	0.8	0.15
			30-60	17.5	82.9	12.2	4.9	Loamy S.	8.2	0.39	12.6	5.80	4.44	0.8	0.12
			60-90	21.8	81.8	12.9	5.3	Loamy S.	8.4	0.36	12.3	3.34	4.89	0.6	0.02
			90-120	29.0	80.1	13.4	6.5	Loamy S.	8.5	0.32	12.5	7.76	6.52	1.0	0.08
			120-150	17.8	79.7	13.9	6.4	Loamy S.	8.6	0.24	12.0	5.86	4.62	1.0	0.03
			W.P.M	21.3	81.7	12.9	5.4	Loamy S.	8.4	0.35	11.9	5.97	4.83	0.9	0.08
		15	0-30	28.6	82.8	12.9	4.3	Loamy S.	7.2	1.39	14.0	13.56	5.35	1.1	1.01
			30-80	64.3	81.8	13.3	4.9	Loamy S.	7.4	0.65	10.5	12.64	9.83	0.8	0.52
			80-120	27.0	74.9	17.3	7.8	Sandy L.	7.4	0.53	8.4	14.45	3.85	1.1	0.45
			W.P.M	42.9	79.8	14.5	5.7	Loamy S.	7.4	0.80	10.7	13.47	6.72	1.0	0.62
	Mod. Terraces	16	0-40	17.0	72.7	19.0	8.3	Sandy L.	7.0	1.49	21.0	5.55	2.95	1.0	0.84
			40-75	2.7	74.6	18.2	7.2	Sandy L.	7.8	0.29	10.5	3.94	0.23	1.0	0.76
			75-90	11.6	79.7	15.3	5.0	Loamy S.	7.8	0.27	14.7	5.71	1.99	1.1	0.39
			90-135	86.7	81.9	11.2	6.9	Loamy S.	7.8	0.25	14.0	6.37	4.94	1.2	0.45
			W.P.M	35.9	77.0	15.8	7.2	Sandy L.	7.6	0.63	15.2	5.42	2.80	1.1	0.64
	High Terraces	17	0-60	7.5	81.1	14.6	4.3	Loamy S.	7.5	0.36	10.5	10.88	0.63	1.1	0.18
			60-90	12.9	79.0	15.7	5.3	Loamy S.	7.5	0.44	9.8	8.56	0.23	1.2	0.45
			90-120	2.2	77.7	16.7	5.6	Loamy S.	8.5	0.26	9.1	6.48	0.02	1.0	0.44
			120-150	6.1	77.3	17.2	5.5	Loamy S.	8.5	0.12	8.5	5.22	0.09	0.8	3.36
			W.P.M	7.2	79.2	15.8	5.0	Loamy S.	8.0	0.41	9.7	8.41	0.32	1.1	0.92
		18	0-38	14.7	77.0	15.6	7.4	Sandy L.	7.5	1.45	28.0	5.27	6.16	1.3	1.21
			38-77	25.7	83.1	12.3	4.6	Loamy S.	8.2	0.45	25.2	4.43	5.21	1.3	0.59
			W.P.M	20.2	80.1	13.9	6.0	Loamy S.	7.9	0.94	26.6	4.85	5.68	1.3	0.89
		19	0-25	34.3	82.0	13.5	4.5	Loamy S.	7.5	10.89	10.8	57.23	3.85	1.3	0.27
			25-50	40.0	82.9	13.5	3.6	Loamy S.	7.8	6,15	11.2	26.05	7.93	1.3	0.44
			50-70	6.0	80.7	13.6	5.7	Loamy S.	7.9	1.24	11.5	7.98	1.72	1.1	0.35
			70-90	37.6	80.4	14.2	5.4	Loamy S.	8.1	5.08	12.7	13.15	3.26	1.4	0.34
			90-110	19.5	78.4	15.0	6.6	Loamy S.	8.2	3.59	13.1	10.63	2.49	1.3	0.02
			110-140	41.5	77.8	15.3	6.9	Loamy S.	8.4	1.59	14.0	5.80	0.68	1.3	0.15
			W.P.M	31.1	80.3	14.2	5.5	Loamy S.	8.0	4.80	12.3	20.65	3.32	1.3	0.26

Soil classification

Based on climatic condition, soil morphological, physiochemical characteristics the studied soils are classified up to sub great group level according to Soil Survey Staff (2014). According to FAO (1977) and USDA-NRCS (1997), the dominant soil moisture regime of this area is "Torric" with "Thermic" soil temperature regime. Most of studied soils haven't any diagnostic sub-surface horizons. Therefore, these soils were classified under Entisols Order as Typic Torripsamments or Typic Torriorthents according to their predominant texture grade as presented and showed in Table (4) and Fig (3). Only soils of profile (19) showed the features for occurrence of sodic horizon with ESP > 15% within 100 cm of the soil surface. Accordingly, they affiliated to Aridisols as Sodic Haplocambids (Table, 4 and Fig, 3).

Table (4): Soil classification in the study area.

Order	Sub Great Group	Soils of profiles No.	Area	
			Feddan	%
Entisols	Typic Torripsamments	3, 4, 5, 6, 7, 8, 9, 13,14, 15, 17, 18	5235.44	62.25
	Typic Torriorthents	1, 2, 10, 11, 12, 16	30369.38	36.10
Aridisols	Sodic Haplocambids	19	1391.10	1.65
Total			84117.92	100

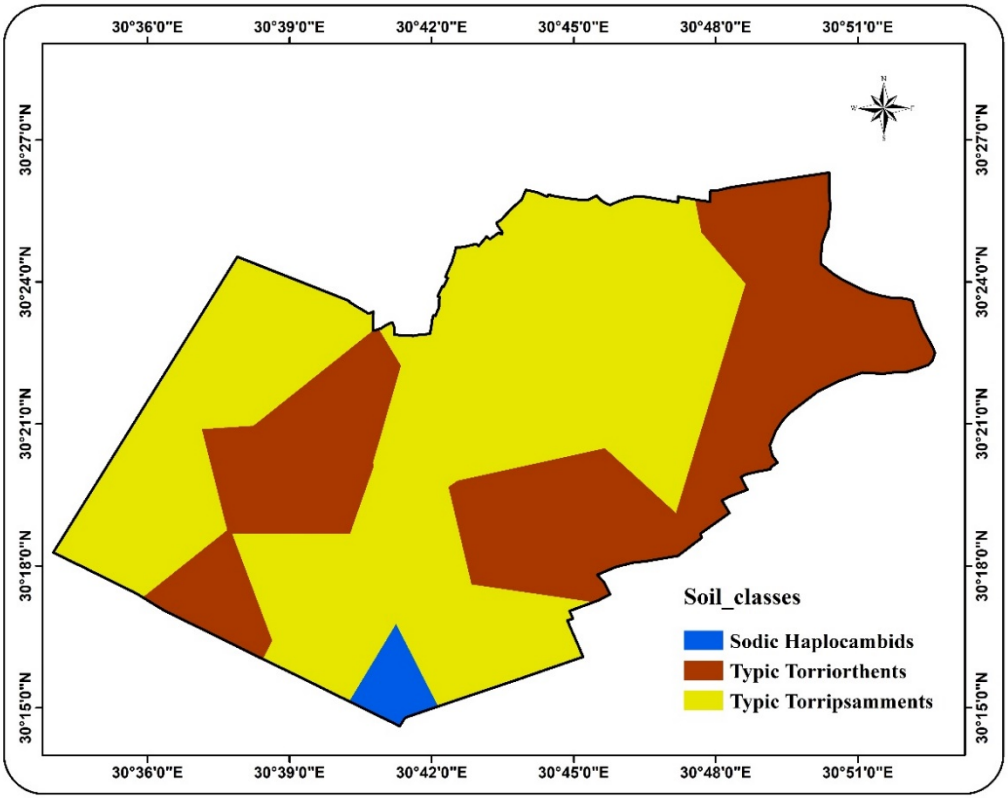

Fig (3): Spatial distribution of soil mapping units in the study area.

Land capability evaluation

The Agriculture Land Evaluation System for arid and semi-arid regions (ALES-Arid) model developed by Ismail et al. (1994 and 2005) was used to assess the land capability for the studied soils. The land capability indices for these soils were obtained from the integration between this model and ArcGIS software based on the land, soil, fertility (Table, 5) and irrigation water characteristics (Table, 6). The final land capability indices and classes for the soils of the studied area are presented in Table (7). Also, the spatial land capability classes map for this area are illustrated in Fig (4). The areas of these classes are shown in Table (8) which indicated that, about 4.52% of the studied soils have a Good (C2) capability class, 92.18% have a Fair (C3) capability class and the rest (3.3%) are considered as a poor (C4) one.

Table (5): Available macronutrients as an indicator for the studied soils fertility.

Geomorphic units	Landform	Profiles No.	Depth (cm)	Macronutrients		
				N	P	K
Alluvial Plain	Low Terraces	1	0 - 30	35.14	12.01	563.47
		2	0 - 30	42.5	10.1	231.17
	Moderate Terraces	3	0 - 30	13.37	9.02	93.91
		4	0 - 30	13.5	8.01	151.70
	High Terraces	5	0 - 30	15.65	9.02	36.12
		6	0 - 30	13.25	8.01	93.91
Pediplain	Low Terraces	7	0 - 30	19.5	10	137.25
		8	0 - 25	20.22	10.1	173.37
		9	0 - 30	22.5	11.05	296.18
	High Terraces	10	0 - 50	15.15	8.21	166.15
		11	0 - 30	13.5	8.01	72.24
		12	0 - 20	13.6	9.02	216.73
Aeolian Plain	Low Terraces	13	0 - 20	11.12	8.01	130.03
		14	0 - 30	9.82	7.21	144.48
		15	0 - 30	13.72	9.02	202.27
	Moderate Terraces	16	0 - 40	17.6	10.01	158.93
	High Terraces	17	0 - 60	21.2	11.05	180.60
		18	0 – 38	23.23	11.21	368.42
		19	0 - 25	17.64	9.02	288.96

Table (6): The main irrigation water properties.

Geomorphic units	Landform	Irrigation water sample No.	pH	EC ds/m	Cations (meq / L)				Anions (meq/L)			SAR %	Soluble boron mg/L
					Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2} & HCO_3	CL^{-}	SO_4^{-2}		
Alluvial Plain	Low Terraces	1	7.9	0.37	1.25	0.68	1.60	0.17	0.35	2.80	0.55	1.63	0.10
		2	7.8	0.50	1.30	0.85	2.45	0.40	0.4	3.11	1.49	2.36	0.08
	Moderate Terraces	3	8.1	1.89	5.80	5.50	6.25	1.35	0.52	11.75	6.63	2.63	0.09
		4	8.0	1.36	4.03	3.22	5.37	0.98	0.48	7.95	5.17	2.82	0.09
	High Terraces	5	7.8	2.00	7.65	4.65	7.13	0.57	0.61	12.12	7.27	2.88	0.09
		6	8.0	0.90	2.90	2.25	3.50	0.35	0.37	5.75	2.88	2.18	0.08
Pediplain	Low Terraces	7	7.8	1.65	5.61	4.15	5.73	1.01	0.60	10.88	5.02	2.59	0.08
		8	7.8	1.65	5.61	4.15	5.73	1.01	0.60	10.88	5.02	2.59	0.07
		9	7.8	1.92	7.37	3.67	7.75	0.41	0.85	12.12	6.23	3.30	0.08
	High Terraces	10	7.8	2.63	8.95	4.18	12.44	0.73	1.28	16.33	8.69	4.86	0.07
		11	8.2	0.79	1.85	0.78	3.80	1.47	0.42	4.28	3.20	3.31	0.08
		12	8.2	0.79	1.85	0.78	3.80	1.47	0.42	4.28	3.20	3.31	0.08
Aeolian Plain	Low Terraces	14	7.9	0.99	1.48	0.46	2.28	5.68	0.27	3.95	5.68	2.31	0.09
	Moderate Terraces	16	7.8	4.60	14.05	8.81	20.2	2.94	1.78	30.40	13.82	5.97	0.09
	High Terraces	17	7. 8	1.42	4.20	3.25	6.20	0.55	0.37	13.40	0.43	3.21	0.09
		18	8.0	3.10	9.33	5.15	13.78	2.74	1.23	19.92	9.85	5.12	0.08
		19	8.1	0.58	1.67	1.05	2.48	0.60	0.25	3.35	2.20	2.13	0.09

Table (7): Land capability indices and classes for the study area.

Geomorphic units	Landform	Soils of profile	Land Capability	
			indices	classes
Alluvial Plain	Low Terraces	1	69.36	C2 (Good)
		2	63.14	C2 (Good)
	Moderate Terraces	3	41.01	C3 (fair)
		4	45.55	C3 (fair)
	High Terraces	5	36.74	C4 (poor)
		6	44.56	C3 (fair)
Pediplain	Low Terraces	7	47.3	C3 (fair)
		8	54.19	C3 (fair)
		9	51.79	C3 (fair)
	High Terraces	10	43.02	C3 (fair)
		11	50.77	C3 (fair)
		12	53.4	C3 (fair)
Aeolian Plain	Low Terraces	13	45.04	C3 (fair)
		14	43.37	C3 (fair)
		15	53.09	C3 (fair)
	Moderate Terraces	16	28.9	C4 (poor)
	High Terraces	17	47.01	C3 (fair)
		18	41.04	C3 (fair)
		19	51.97	C3 (fair)

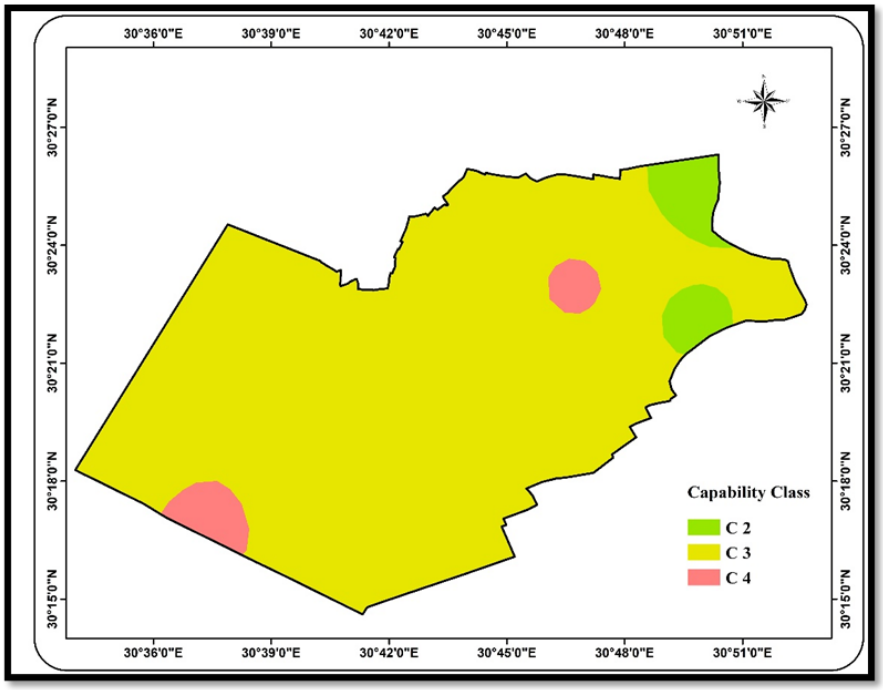

Fig (4): Land capability classes map of the studied area.

Table (8): Areas of land capability classes for the studied soils.

Capability classes	Area (km2)	Area (Fed)	%
C2 (Good)	15.94	3795.83	4.52
C3 (Fair)	325.67	77540.51	92.18
C4 (poor)	11.68	2781.58	3.30
Total	353.29	84117.92	100

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خصائص وتقسيم وتقييم أراضي المنطقة الواقعة جنوب شرق مدينة السادات، محافظة المنوفية، مصر

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الملخص العربى

أجري هذا البحث خلال ٢٠١٩ بهدف دراسة الخصائص الجيومرفولوجية والبيدولوجية وكذلك تقسيم وتقييم أراضي المنطقة الواقعة جنوب شرق مدينة السادات بمحافظة المنوفية، مصر، ولقد استخدم تكامل التقنيات الحديثة للاستشعار من البعد (RS) مع نظم المعلومات الجغرافية (GIS) في اجراء هذا العمل.

ولقد أوضحت الخريطة الجيومرفولوجية الناتجة من معالجة وتفسير الصور الجوية أن منطقة الدراسة تتميز بوجود ثلاث وحدات جيومرفولوجية رئيسية هي السهل الفيضي Alluvial Plain لرواسب دلتا نهر النيل التي تتضمن ثلاث أشكال أرضية هي: الشرفات العليا (تمثل ١٧.٣٪ من مساحة منطقة الدراسة)، الشرفات الوسطى (٥.٩٪)، الشرفات السفلى (١١.٥٪)، السهل الصحراوي المنحوت Pedi Plain ويشمل الشرفات العليا (١٦.٢٪)، الشرفات السفلى (١٢.٥٪)، بالإضافة إلى سهل الرواسب الهوائية ويتضمن الشرفات العليا (تمثل ٧.١٪)، الشرفات الوسطى (٥.٠٪)، الشرفات السفلى (٢٤.٥٪).

ولقد تم تحديد مواقع وحفر تسعة عشر قطاعاً أرضياً لتمثل أراضي تلك الأشكال الأرضية، ودرست وسجلت الملامح الطبوغرافية المميزة لهذه الأراضي ، كما وصفت القطاعات مورفولوجياً وجمعت منها عينات ممثلة للأفاق المختلفة، وكذلك جمعت عينات من مياه الري المتاحة في مناطق الدراسة لإجراء التحليلات المعملية لتقدير الخواص الطبيعية والكيماوية.

وأوضحت الدراسات الحقلية أن طبوغرافية المنطقة شبه مستوية إلى بسيطة التموج، والأراضي عميقة، وحالة الصرف جيدة، وقوام هذه الأراضي يغلب عليه الحصوي رملي إلى الحصوي طميي رملي، إلا أراضي الشرفات السفلى للسهل الفيضي فهي ذات قوام رملي طميي، وبناءها متوسط من النوع الكتلي.

يميل تأثير هذه الأراضي إلى القلوية، معظمها غير ملحية، وغير صودية، إلا منطقة محدودة يظهر فيها ملامح للأفق الصودي، والأراضي قليلة إلى متوسطة المحتوى من الكربونات الكلية، ونسبة الجبس والمادة العضوية ضئيلة، وبالتالي السعة التبادلية الكاتيونية منخفضة.

ونظراً لأنه لم يتضح في معظم الأراضي أي آفاق تشخيصية فلقد تم تقسيمها تبعا للتقسيم الأمريكي الحديث (٢٠١٤) تحت رتبة الأراضي غير المتطورة Entisols، وصنفت أراضي المنطقة المحدودة ذات الأفق الصودي تحت رتبة الأراضي الجافة Aridisols حتى مستوى تحت المجموعات..

ولقد دل تقييم الكفاءة الإنتاجية للأراضي المدروسة على أغلبها (حوالي ٩٢,٢٪) يصنف كأراضي مقبولة (C3)، وباقي الأراضي صنف إما كأراضي جيدة (C2) بنسبة ٤,٥٪ أو أراضي فقيرة (C4) بنسبة ٣,٣٪.

الكلمات الدالة:

الاستشعار من البعد، نظم المعلومات الجغرافية، الوحدات الجيومورفولوجية، تقسيم الأراضي، تقييم الأراضي.

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