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GEOMORPHOLOGY, CLASSIFICATION AND LAND EVALUATION OF EL-FAYOUM SOILS IN EGYPT USING REMOTE SENSING AND GIS.

A. D. A. Salem

Soils, water and Environment Res. Institute, Agric, Res, Center، Egypt.

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ABSTRACT: *Remote Sensing (RS) and GIS techniques are used in this study to identify the geomorphic units and produce the geomorphic map in addition to soil map of EL-Fayoum governorate, Egypt. Soil classification and land evaluation for this area are also performed. According to the RS and GIS works six geomorphic units are recognized. These units are alluvial fan (41.5 %), alluvial plain (27.4%), Flood plain (1.4%), lacustrine plain (4.2%), fluvio lacustrine plain (10.5 %), and terraces (12.6%). The soils of the different geomorphic units were represented by 12 soil profiles. The morphological description was carried out and 34 disturbed soil samples were collected for physical and chemical analyses. The correlation between landforms and soils was carried out and then the soil map was created using the Arc- GIS 9.3 software. Based on the land characteristics, the studied soils were classified up to the family level according to Soil Survey Staff (2014). These soils could be affiliated to Aridisols, Vertisols, and Entisols orders.*

The soils are evaluated according to their suitability for agriculture in the current situation, the result revealed that the studied soils could be categorized into four classes namely, highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N). The limitations affected these soils are texture, salinity & alkalinity and wetness. Also, the potential suitability of these soils are predicted which could be improved to S1, S2 and S3 when their limitations are remedied.

Key words: *Remote Sensing (RS); GIS, Soil classification, Land evaluation.*

INTRODUCTION

The Fayoum governorate, (about 90 km. south- west of Cairo), is one of the depressions in the limestone plateau of the Egyptian Western Desert. It is connected to the Nile valley by Bahr Yusuf Channel. The topographic and hydrological boundaries are clear. Qarun Lake is located at the north-west in the bottom of the Depression. The Land of the area slopes from 25 m above MSL at EL- Lahun to 43 m below MSL at the lack Qarun. The studied area is located between latitudes 29° 02` and 29°35` N and longitudes 30° 23` and 31 °05` E (Fig1).

The climatic data of EL-Fayoum district indicate that the total rainfall doesn't exceed 7.2 mm/year. the mean minimum and maximum annual temperatures are 14.5^{o} and 31.0^{o} respectively. The lowest evaporation rate (l.9 mm/day) was recorded in January, while the highest value (7.3 mm/day) was recorded in June (CLAC, 2010). According to the aridity index classes of Hulme & March (199٠) the Fayoum depression is located under arid climatic condition.

Said (200٠) reported that the area of EL-Fayoum depression was formed in the latter of Miocene and beginning of Pliocene periods. It occupies a portion of the Eocene limestone plateau at the northern part of the Western Desert and the subsurface lithology consists of marine sedimentary strata, which has undergone alternating periods of erosion and deposition. The present depression has been formed when the basin was subsided relative to the Nile River, allowing it to break through and to flood the area. This led to the formation of a thick fertile alluvium (Euroconsult, 1992).

The irrigation water for the soils of El-Fayoum is diverted from the Nile into the Ibrahimiya Canal at Assiut. At Dairut, 284 km upstream of EL-Lahun flow is diverted from the Ibrahimiya Canal to Bahr Yusuf. The depression is drained by gravity through two main drains namely, EL-Batts and EL Wadi Drains.

The land capability evaluation and mapping for EL-Fayoum area is an essential action in order to maintain the sustainable development of effort and investment as well as the sustainable usage of the soils (Bandyopadhyay *et.al,* 2009).

Satellite remote sensing (RS) in conjunction with geographic information system (GIS), have been widely applied and recognized as a powerful and effective tools in analyzing land use categories (Ehlers *et.al,* 1990; Harris & Veturea 1995 and Weng, 2001). GIS provide indispensable tools for decision – makers. Both R.S and GIS techniques are considered very important geometric tools, which are fully utilized in the developed countries (Arafat, 2003). The integration of remotely sensed data, GIS and spatial statistics provides useful tools for modeling variability to predict the distribution, presence, and pattern of soil characteristics (Kalkhan *et al.,* 2000). The potential of the integrated approach in using GIS and RS data for quantitative land evaluation has been demonstrated by Martin & Saha (2009).

The aim of this study was to demonstrate the usefulness of (RS) and (GIS) technologies to producing the geomorphic map of the EL-Fayoum governorate. These techniques are also used to produce the soil characteristics, classification and land evaluation maps of the studied area.

MATERIALS AND METHODS

Remote Sensing:

Landsat ETM^+ data, that cover EL-Fayoum Governorate, were acquired in 2015. The satellite image was geometrically corrected to UTM grid system (Zone 35 N, datum: WGS84). The image was radiometrically corrected to remove any noise and additives from the atmosphere by using ENVI 4.7 Software. Topographic maps covering EL-Fayoum governorate (Fig., 2) was used to generate Digital Elevation Model (DEM) (Fig., 3) through grouping and processing in Arc GIS 9.3 software to define the different landforms of the studied area (Fig., 4). The extracted data are utilized to generate a preliminary geomorphologic map which was checked and completed through field observation. Resolution merge is used for imagery integration of different spatial resolutions. (Dobos *et.al,* 2002).

Field work and laboratory analyses

Twelve soil profiles were chosen to represent different mapping units (Fig., 4). The morphological description of these soil profiles was carried out according to FAO (2006), Table (1). Representative 34 disturbed soil samples have been collected from the studied soil profiles according the morphological variations and were used for laboratory analyses. The laboratory analyses were carried out according to the methods outlined by Soil Survey Staff (2004), Table (2) . The soils were classified to the family levels on the basis of Soil Survey Staff (2014).

Land evaluation:

Data input process is the operation of entering the spatial and non – spatial data into GIS database. The digital physiographical map was used as base map in the database. The spatial analyses function in Arc GIS 9.3 was used to create the thematic layers of $CaCO_3$ and Gypsum, contents, soil depth, ECe, texture class, CEC, sodicity (ESP %) and soil classification. The thematic layers were matched to produce the soil capability map. The land capability classes were defined using the ratings and methods of Sys and Verheye (1978) and Sys *et al.* (1991).

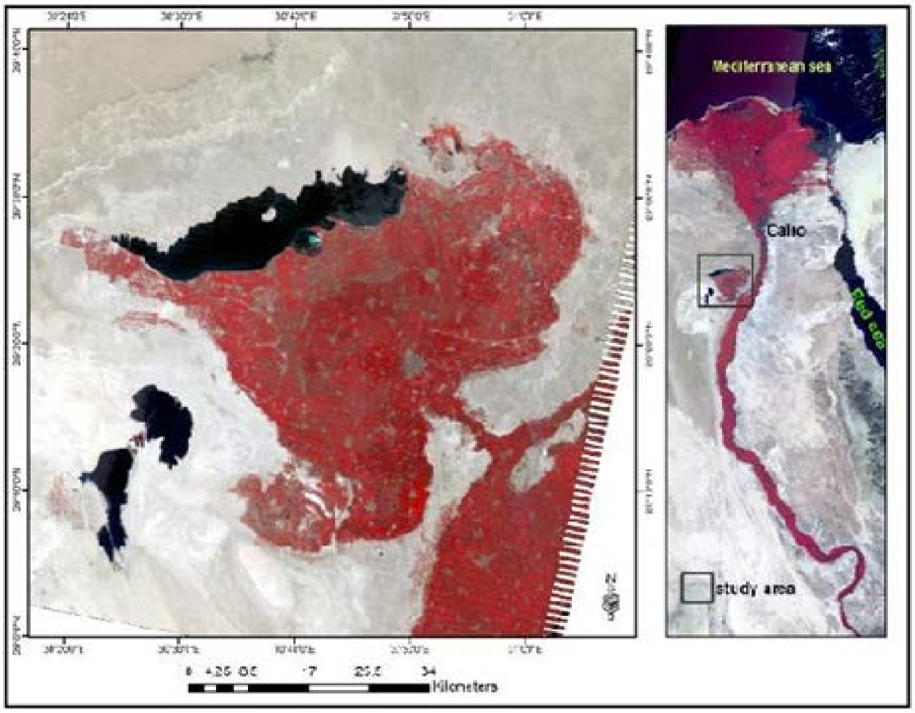

Fig (1): Location map of the studied area

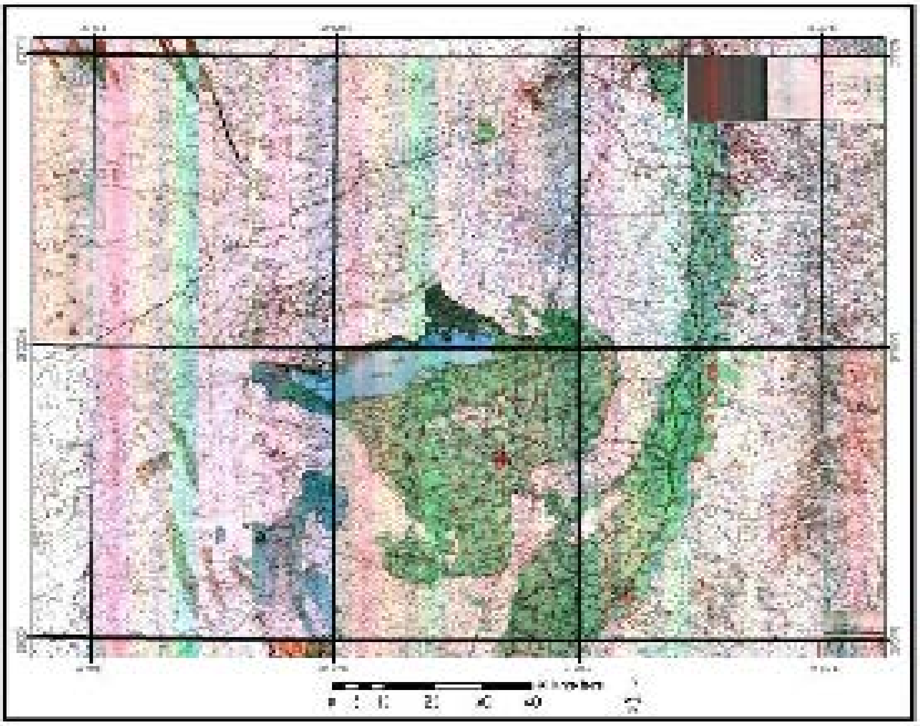

Fig (2): Topographic map of the studied area

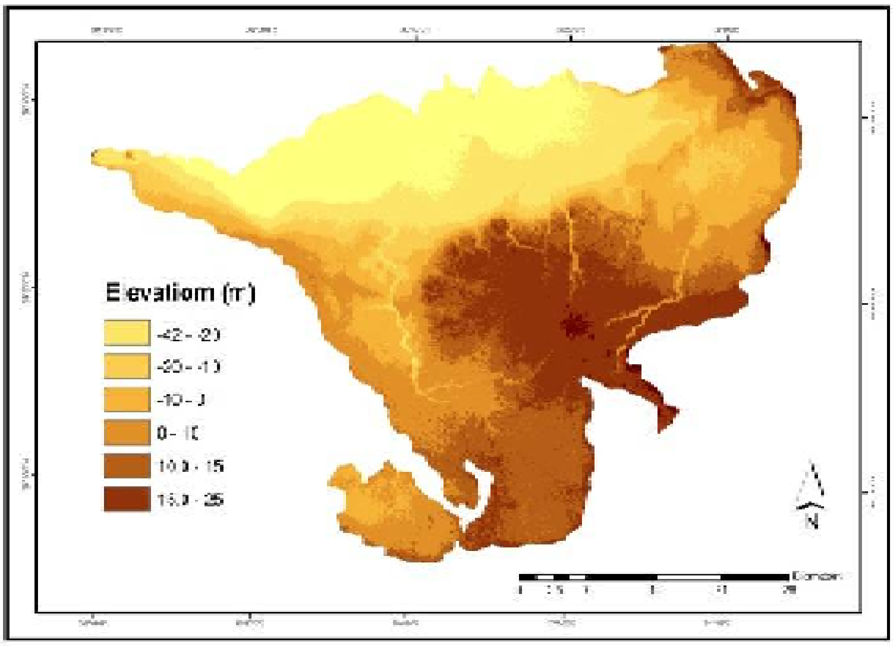

Fig (3): Digital elevation model (DEM) of the studied area

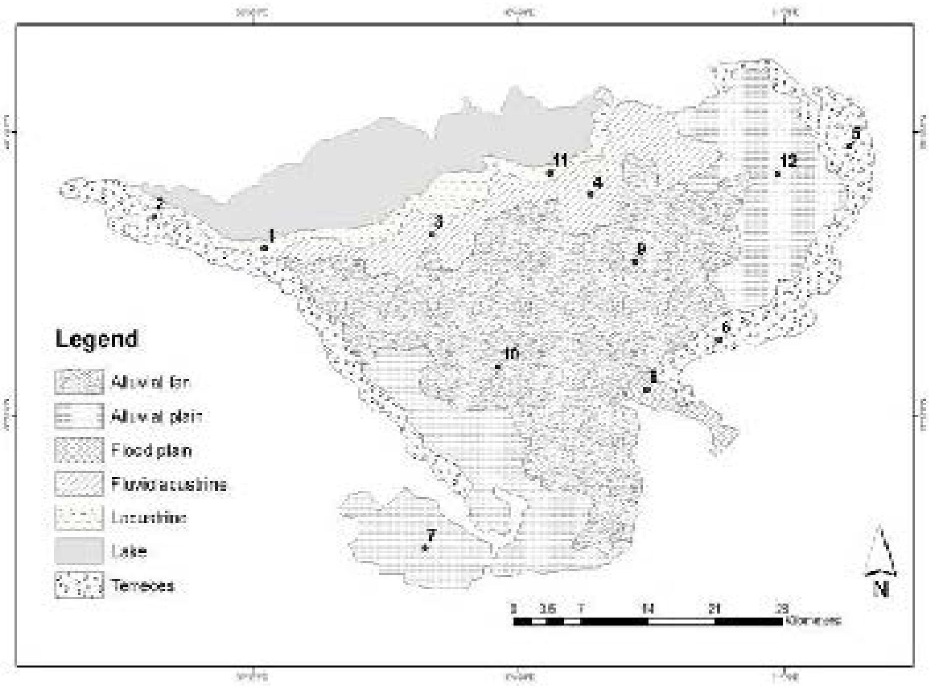

Fig (4): Geomorphic units and profiles locations of the studied area

Table 1

Table 1

Table 2

Table 2

RESULTS AND DISCUSSION

Geomorphology and Soils of EL-Fayoum depression

Field survey data, Landsat ETM images and digital elevation model (DEM) were used to define the main geomorphic units in EL-Fayoum depression as shown in Fig. (3). The correlation between the geomorphology and soils were carried out. Produced data revealed that the main geomorphic units of El-Fayoum depression are alluvial fan, alluvial plain , flood plain, flavio lacustrine plain, lacustrine plain and terraces. The geomorphic mapping units are presented in Table (4).

Description (Table, 1) and soil characteristics (Table 2 and 3 and Figs 5 to 9) of the identified geomorphic units at EL-Fayoum depression could be summarized as follows:

1- Lacustrine plain (LP 111)

This unit includes lacustrine terraces with different elevations. It is adjacent closely to the Qaroun lake. It covers an area of 18625.7 feddans (about 4.8% of the total area). This unit is represented by profiles No 1 and 11. The analytical data of soil profiles are given in Tables (2) and (3). The data showed that the soil texture class is clayey throughout the entire profile depth except for the surface layer of profile (1), where it is sandy clay. $CaCO_3$ content varied from 5.4 to 47.27% that increased with depth. Soil PH values (8.1 to 8.45) are indicoted moderately alkaline. The soils are slightly to moderately saline, where the ECe values ranged from 6.68 and 14.50 dsm^{-1}. Soluble cations were dominated by Ca^{+2} followed by Na^{+}, Mg^{+2} and K^{+}. While soluble anions were dominated by SO_4^{-2} followed by Cl^{-1}, and HCO^{-3}. CEC values ranged from 37.41 to 51.26 C mole Kg^{-1} that it coincides with the fine fraction content and type. ESP varied from 20.28 and 54.2% indicating that these soils are sodic. Organic matter content is very low, not exceeding 2.16%. The gypsum content ranged from 0.5 to 2.70% with trends to decrees with soil profile depths.

2- Fluvio– lacustrine plain (FL 111)

This unit extends at the north of EL-Fayoum governorate from east to west between alluvial fan and lacustrine plain. The total area of this geomorphic unit is 40263.6 feddans (10.4 %). It is represented by profiles (3) and (4). According to the analyses (Tables 2 and 3). The soil texture class is clay in surface layer and clay loam in the deepest layers of profile (3). The uppermost surface layers of profile (4) have sandy clay texture and clay in the deepest one. $CaCO_3$ content is very low and varied between 5.6 and 8.5% with an irregular distribution pattern with depth. Soil reaction is generally moderately to strongly alkaline as indicated by pH values, which ranged from 8.05 and 8.6. Soil salinity varied between 4.6 and 7.6 dsm^{-1} indicating slightly saline. Soluble cations followed the order of Na^{+}> Ca^{+2}> Mg^{+2}> K. The soluble anions followed the descending order $SO^{=}_4$> CL^{-}> HCO_3. CEC values ranged from 28.5 to 38.6 C mole Kg^{-1} depending on the clay content. ESP is more than 15% indicating that these soils are sodic. Organic matter content is very low, that ranges from 0.58% to 1.87% owing to the prevailing arid conditions. Gypsum content is relatively low and varied from 2.4 to 3.2%.

3- Terraces (AP114)

This geomorphic unit dominates the eastern and western sides of EL-Fayoum governorate with an area of about 55511.2 feddans and extends from south to north. The soils of this unit are represented by profiles (2), (5) and (6). Data in Tables (2) and (3) reveal that the soil texture is sandy clay loam in the soils of profiles 2 and 6. The texture of profile (5), is loamy in the surface layer changes into silty clay in the deepest layer. $CaCo_3$ content varied from 9.5 to

Table (3): Particle size distribution, texture classes and $CaCO_3$ % of the studied soil profiles.

Geomorphic unit	Prof. No.	Depth (Cm)	Particle size distribution %				Texture class	CaCO3 %
			C.Sand	F.Sand	Silt	Clay		
Lacustrine (LP111)	1	0-25	36.90	9.28	8.75	45.07	SC	13.43
		25-50	19.51	10.69	22.5	47.30	C	31.75
		50-150	5.78	6.31	15.16	72.75	C	47.27
	11	0-30	2.5	12.1	25.5	59.6	C	5.6
		30-60	1.5	5.8	24.5	65.4	C	5.4
		60-90	1.9	5.9	32.1	60.7	C	11.5
		90-120	6.2	25.8	11.5	57.3	C	12.3
Terraces (AP114)	2	0-25	46.78	15.52	14.70	23.00	SCL	31.75
		25-50	44.20	9.99	18.06	27.75	SCL	36.63
	5	0-25	2.8	29.5	40.3	27.7	L	35
		25-85	0.8	11.7	41.5	46.7	Si.C	45
	6	0-25	23.1	37.5	14.7	24.5	SCL	10.5
		25-75	15.9	43.2	12.7	28.2	SCL	9.5
Flood plain (AP113)	8	0-30	4.7	23.9	27.8	43.5	C	9.6
		30-90	3.1	20.1	27.6	49.1	C	7.4
Fluvio Lacustrine (FL111)	3	0-30	2.6	36.9	12.5	48.1	C	8.5
		30-65	2.8	39.4	25.2	32.6	CL	6.5
		60-95	2.6	37.6	22.5	37.4	CL	6.7
	4	0-25	15.6	33.9	5.1	45.5	SC	7.5
		25-75	17.8	34.1	5.2	43.1	SC	5.6
		75-150	11.7	21.3	7.8	59.3	C	5.8
Alluvial plain (AP112)	7	0-35	75.4	10.7	6.75	7.5	LS	9.5
		35-90	39.8	40.1	6.5	13.5	SL	8.5
	12	0-25	21.5	45.2	8.3	25.1	Si.L	11.5
		25-75	12.4	63.1	5.1	19.2	SL	10.5
		75-130	3.7	65.8	10.5	18.8	SL	16.8
Alluvial Fan (AP111)	9	0-25	2.5	32.8	15.5	49.2	C	8.4
		25-70	2.9	34.7	10.1	54.2	C	7.5
		70-100	2.5	31.3	17.4	48.7	C	8.6
		100-140	3.7	33.5	11.5	51.6	C	7.8
	10	0-30	5.3	16.8	23.0	54.6	C	7.9
		30-70	5.1	13.5	22.4	59.2	C	8.5
		70-110	4.5	10.5	25.5	59.8	C	6.8
		110-150	5.5	10.7	27.7	58.1	C	7.5

C:	clayey	L:	loam
CL:	Clay loam	Si.C:	Silty loam
SC:	Sandy clay	LS:	Loamy sand
SCL:	Dandy clay loam	SL:	Sandy loam

Table (4): Areas of the geomorphic mapping units of EL-Fayoum depression.

Landscape	Lithology (origin)	Relief	Land form	Code	Area feddans	Area %
Lacustrine plain (Lp)	Lacustrine deposits(1)	Flat to almost flat (1)	Lacustrine terraces (1)	Lp 111	18625.7	4.8
Fluvio Lacustrine (FL)	Alluvial deposits mixed with lacustrine deposits	Flat	Fluvio Lacustrine terraces	FL 111	40263.6	10.5
Alluvial plains (AP)	Alluvial deposits	Almost flat to gently undulating	Alluvial fan(111)	AP 111	159409.8	41.5
			Alluvial plain(112)	AP 112	105195.1	27.4
			Flood plain(113)	AP 113	5432.9	1.4
			Terraces (114)	AP 114	55511.2	14.4

45.0% with an increase with soil profile depths. These soils are generally moderately alkaline, where pH values varied between 7.5 and 8.4. These soils are very slightly saline to moderately saline, (ECe values ranged from 2.1 to 14.4 dsm^{-1}).The distribution pattern of soluble cations followed the descending order, Na^+ and / or Ca^{+1} followed by Mg^{+2} and K^+. The soluble anions have the order of $SO4^=$>Cl^-> HCO^{-3}. CEC ranged from 13.3 to 17.8 C mole Kg^{-1}. The low values of CEC in these soils could be due to its relatively low content of clay fraction. The ESP data of profiles 2 and 6 are more than 15% indicating sodocity effect in these soils. Organic matter and gypsum content varied from 0.93 to 2.8% and 0.6 to 8.34%, respectively.

4- Flood plain (AP 113)

This unit covers an area of about 5432.9 feddans (1.4%). it located at the south eastern part of EL-Fayoum governorate. These soils are represented by profile (8). Data in Tables (2 and 3) show that, the soil texture is clay throughout the entire profile depths (clay content is varied from 43.5% to 49.1%). $CaCO_3$ is low ranges from 7.4 to 9.6% and trends to decrease with soil profile depth. These soils are moderately alkaline (pH 7.9 – 8.1). The soils are non-saline, (ECe values not exceed 2dsm^{-1}. Soluble cations are dominated by Na^+ followed by Ca^{+2}, Mg^+ and K^+. Soluble anions follows the order $SO^=_4$>Cl^-> HCO^{-3}. CEC values ranged from 36.2 to 38.1 C mole Kg^{-1}. ESP is not exceeding 15%. Organic matter and gypsum contents were very low and varied from 0.85 to 1.4% and 1.5 to 2.5%, respectively.

5- Alluvial plain (AP 112)

The alluvial plain unit is widespread at the north eastern part and south western sides of EL-Fayoum governorate with an area of about 105195.1 feddan (27.4%). Their representative profiles are (7) and (12). Data in tables (2 and 3) indicate that, soil texture in profile 7 is loamy sand in the surface layer and sandy loam in the deepest layer. The texture of profile 12 is silty loam in the surface layer and sandy loam in the deepest layers. $CaCO_3$ content ranged from 8.5 to 16.8%. The relatively high content of $CaCO_3$ may be attributed to the effect of the adjacent calcareous sediments. Soil pH varied between 7.8 and 8.2 indicating moderately alkaline reaction. The soils are non- to slightly saline (ECe values varied between 1.1 and 4.3 dsm^{-1}). The sequence of cations and anions in the studied soils follows the order Na^{+}>Ca^{++}> Mg^{++}> K^{+} and $SO^{=}_{4}$>Cl^{-}> HCO^{-}_{3}. CEC values ranged between 8.3 and 16.8 Cmole Kg^{-1}. ESP percent varied from 4.9 to 13.8%. Organic matter and gypsum contents are very low and varied from 0.36 to 1.2% and 1.6 to 2.9%, respectively.

6- Alluvial fan (AP 111)

This geomorphic unit dominates the middle part of EL-Fayoum depression and extends from south to north and from east to west with an area of about 159409.8 feddans (41.5%). The soils of this unit is represented by two profiles (9 and 10). Data in Tables (2 and 3) indicated that these soils have clay texture in their successive layers (48.7 to 59.8% clay content). CaCO3 content ranged from 6.8 to 8.6% without specific distribution pattern with profiles depth. Soil pH varied from 7.5 to 8.2 (slightly to moderately alkaline). ECe values ranged from 0.85 to 2.4 dsm^{-1} indicating non to very slightly saline. Soluble cations are dominated by Na^{+} followed by Ca^{++}, Mg^{++} and K^{+}. Soluble anions are dominated by $SO_4^{=}$ followed by Cl^{-} and HCO^{-}_{3}. CEC values are generally high and varied from 39.8 and 51.4 Cmole Kg^{-1} depending on the clay content. ESP values of the studied soils not exceed 15% indicating that the soils of alluvial fan are non-sodic. Organic matter and gypsum contents are very low and varied from 0.04 to 1.3% and 1.7 to 2.7%, respectively.

Spatial distribution of soil properties

The spatial distribution of the studied soil properties are showed in Figs., (5 to 9).

Soil classification:

Based on the different soil characteristics of the studied area the soils are classified according to Soil Survey Staff (1975 and 2014). Accordingly, the studied soils could be classified into three orders namely, Vertisols, Aridisols and Entisols (Fig.10). The soils represented by different profiles could be classified up to family levels as presented in Table (5) and showed in Fig. (10) as follows:

The flood plain soils (profile, 8), alluvial fan (profiles 9 and 10) and lacustrine plain (profile 11) have more than 35% fine clay content. These soils are characterized by deep cracks, galgai microrelief and slickenside structure units. These are mostly the features of soils rich in smectite clay mineral. These soils are classified into order Vertisols up to family level according to their texture as follow:

1- Typic Calcitorrerts, very fine clayey, smectitic, thermic (profile, 1)
2- Typic Haplotorrerts, clayey, smectitic, thermic (profiles, 9 and 10)
3- Sodic Haplotorrerts very clayey, smectitic, thermic (profile, 11)
4- Typic Gypsitorrerts clayey, smectitic, thermic (profile, 8).

The soils of terraces (profiles, 2 and 5) and alluvial plain (profile, 12) have one or more diagnostic horizons and could be belong to order Aridisols.

These soils are classified up to family level as follows.

1- Typic Haplocalcids, clayey, mixed, thermic, (profile, 5).
2- Typic Haplocalcids loamy, mixed, thermic (profile, 12)
3- Typic Calcigypsids, loamy, mixed, thermic (profile, 2)

The soils of fluvio lacustrine (profiles 3 and 4), terraces (profile, 6) and alluvial fan (profile, 7) could be classified into the order Entisolsand up to family level as follows.

Table 5

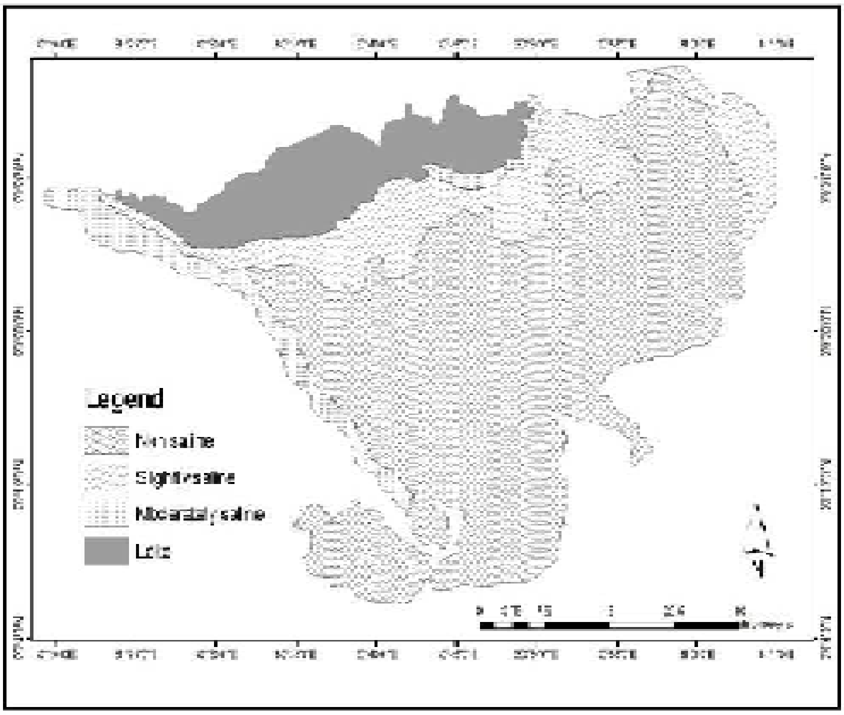

Fig (5): Spatial distribution of salinity status in the studied area

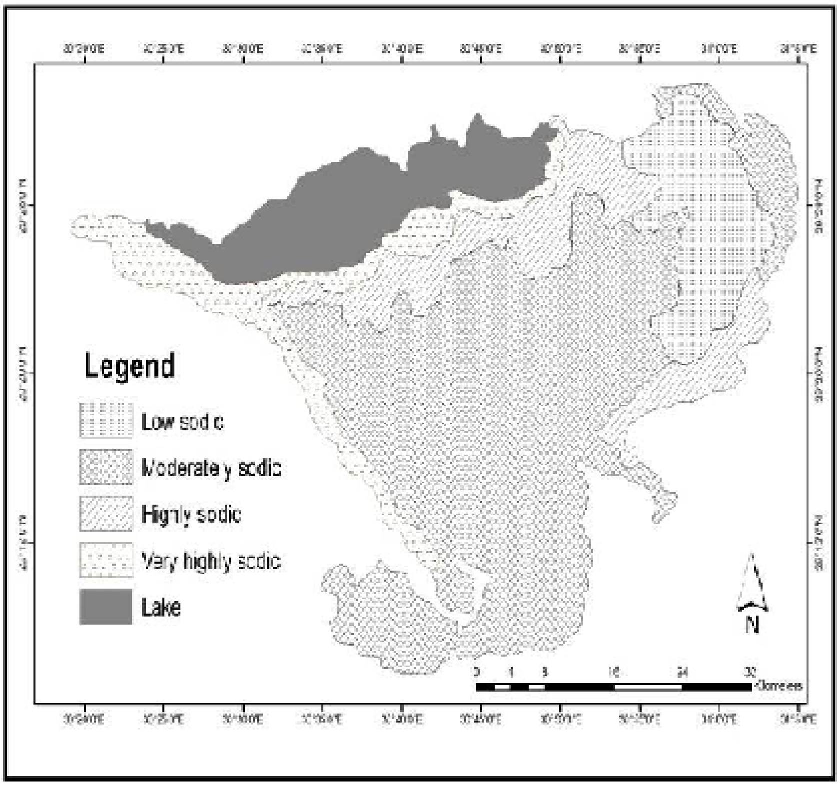

Fig (6): Spatial distribution of soil sodocity in the studied area

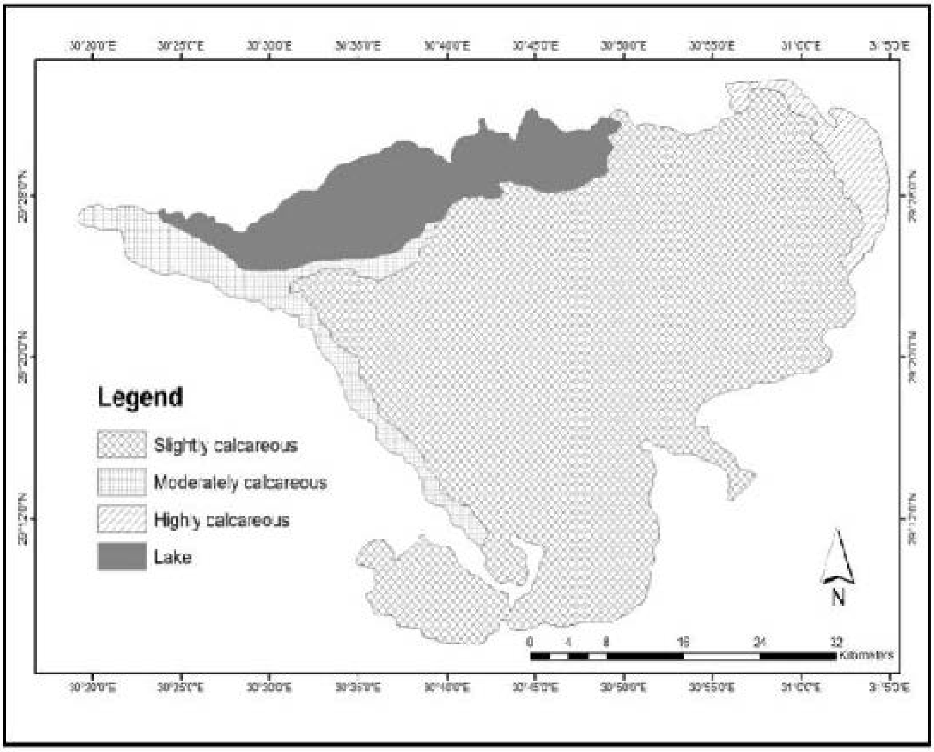

Fig. (7): Spatial distribution of calcareous features in the studied area

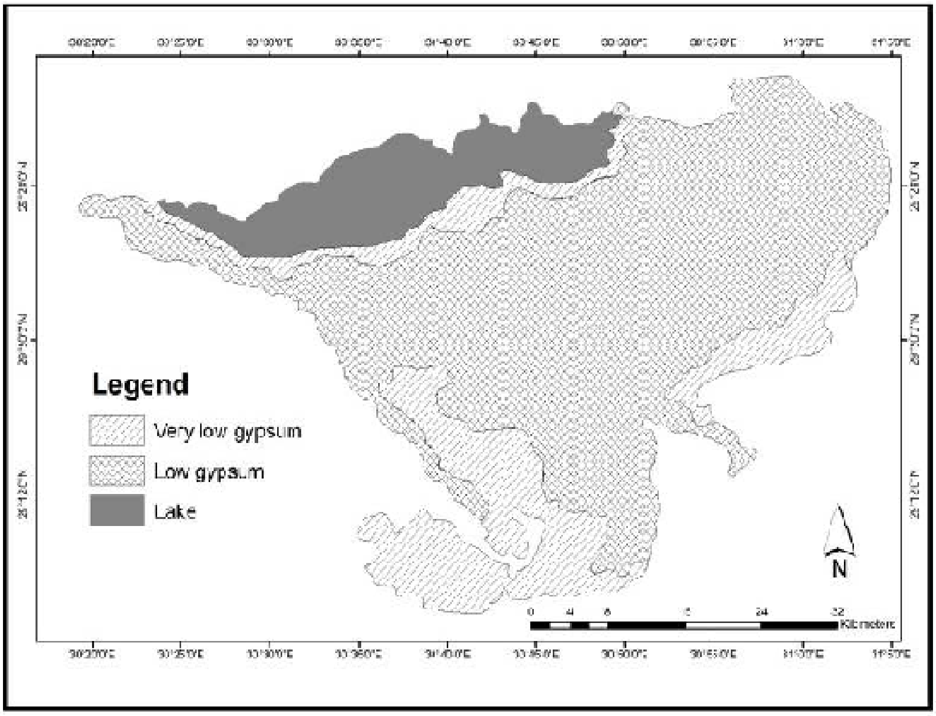

Fig (8): Spatial distribution of gypsum content in the studied area

1- Typic Torriorthrnts, loamy, mixed, thermic (profiles, 6 and 3)

2- Typic Torriorthrnts, clayey mixed, thermic (profile, 4)

3- Typic Torriorthrnts, loamy, mixed, thermic (profile, 7)

Land evaluation:

The studied soils are evaluated by matching between their characteristics and their ratings outlined by Sys and Verheye (1978), to get their suitability for agriculture in the current and potential state. The current study deals with spatial analysis techniques to evaluate the agricultural land capability in the studied area. The landforms of the studied area were delineated by using the digital elevation model, Landsat ETM and ground truth data of the studied area. The produced map, represents the land forms of the studied area, is imported in a geodatabase and considered as a base map.

Thematic layers

The attribute data of topography, wetness, soil texture, soil depth, $CaCO_3$, gypsum, salinity alkalinity, CEC and Esp (Table 6) were compiled into the units of the digitized geomorphologic map in a geographic information system. The incorporated attributes were used to obtain the thematic layers of spatial distribution of the above mentioned characteristics as shown in figures from 5 to 9. The produced layers include information on the rating value capability sub class, and distribution for each soil characteristics.

A- Current Land suitability:

The current suitability indexes and classification of the studied soils in the different geomorphic units are presented in Table (6) and shown in Fig. (11), revealed that there are four suitability classes in the studied area namely , highly suitable (S1), moderately suitable (S2), marginally suitable (S3) and not suitable (N1). These classes could be divided into seven subclasses i.e. $S2_{s1,n}$, $S2_{w}$, $S2_{w,s1,n}$, $S2_{w,n}$, $S3_{w}$, $S3_{w,s1}$ and $N_{w,s1,n}$. The obtained data revealed that the most limiting factors in the soils of lacustrine, alluvial fan and flood plain are soil texture and salinity and alkalinity. The most limiting factor affecting the soils of terraces is soil wetness. The soils of fluvio lacustrine plain were affected by wetness, soil texture, salinity and alkalinity with different intensity degrees (slight, moderate, and severe).

B- Potential land suitability:

Further land improvements are required to correct or reduce the severity of limitations exiting in the studied area. These are such as 1) Leveling of undulating surfaces, 2) leaching of soil salinity and reclamation of alkalinity existing in the soils, 3) construction of efficient open drainage ditches to lower the saline ground water table level 4), Using gypsum as a soil amendment, 5) continuous application of organic manure to improve soil- physio-chemical properties and fertility status.

By applying the previous improvement practices, potential suitability of the studied soils could be ameliorated to three suitability classes, namely highly suitable (S1), moderately suitable (S2) and marginally suitable (S3).These could be divided into four subclasses namely ($S1_{s1,s2}$), ($S1_{s1}$), ($S2_{s1}$) and ($S3_{S1,S2}$). (Fig.12).

REFERENCES

Arafat, S.M. (2003). The utilization of geoiformation techndegy for agricultural development and management in Egypt Diffuse pollution Conference. Dublin.

Bandyopadhyay, S., R.K. Jaiswal, V.S. Hegde and V. Jayaraman (2009). Assessment of land suitability potentials

Table 6

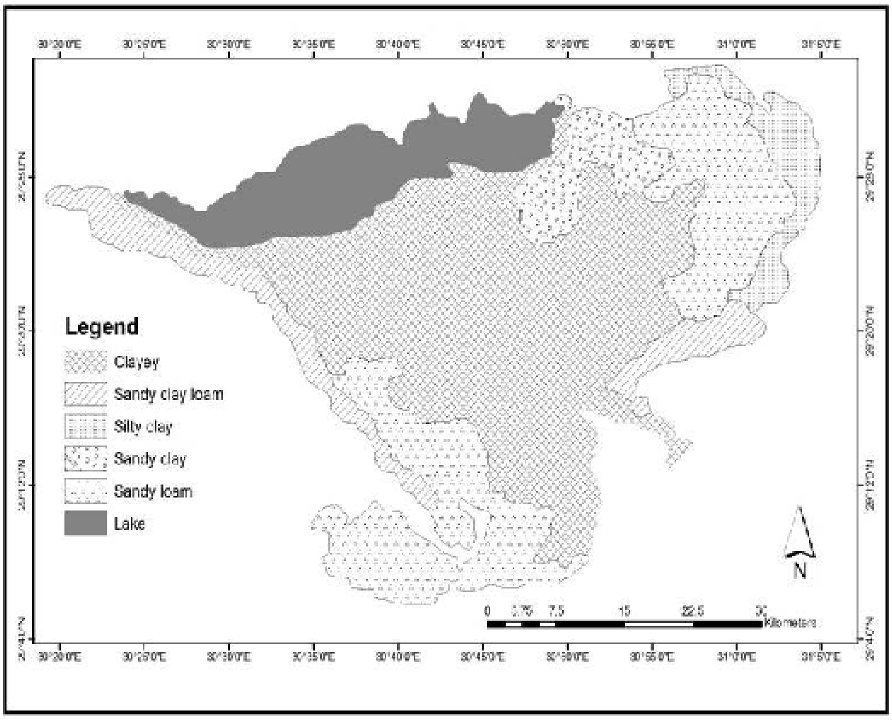

Fig (9): Spatial distribution of soil texture in the studied area.

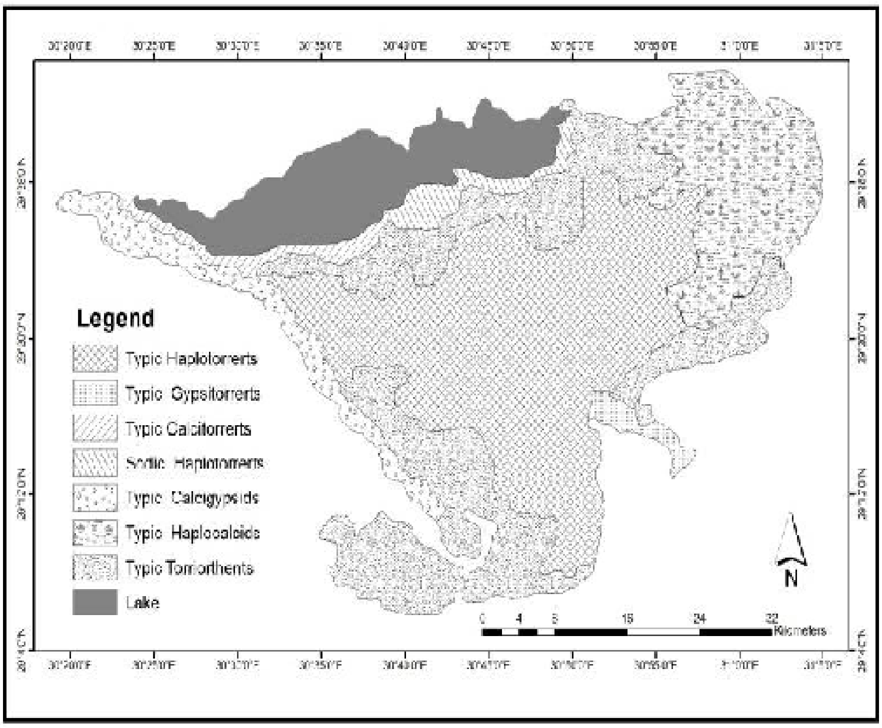

Fig (10): Spatial distribution of soil classification in the studied area.

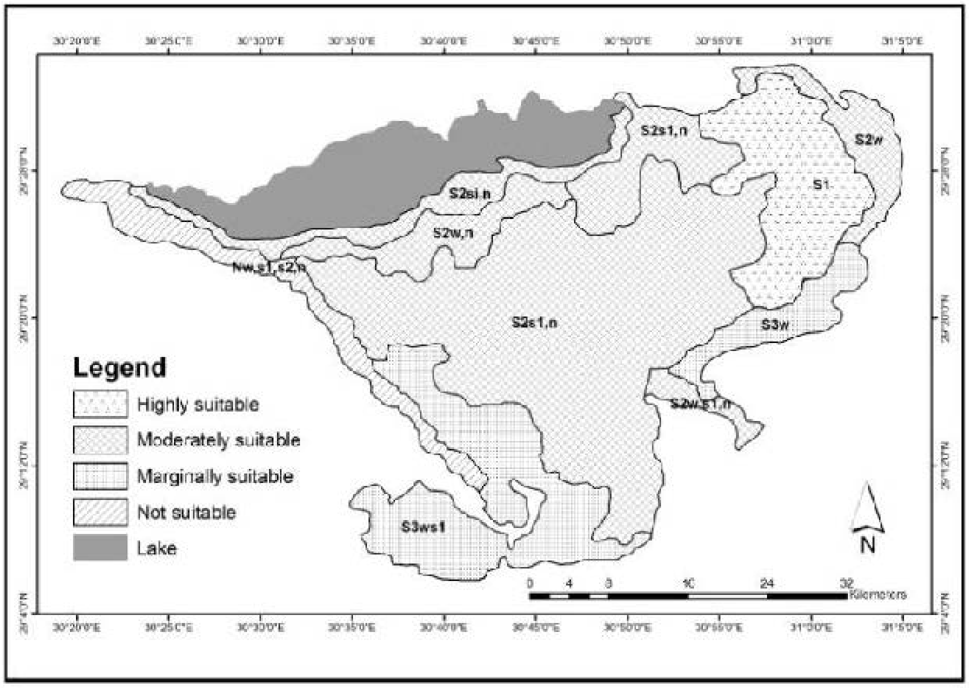

Fig (11): Spatial distribution of the current soil suitability classes in the studied area.

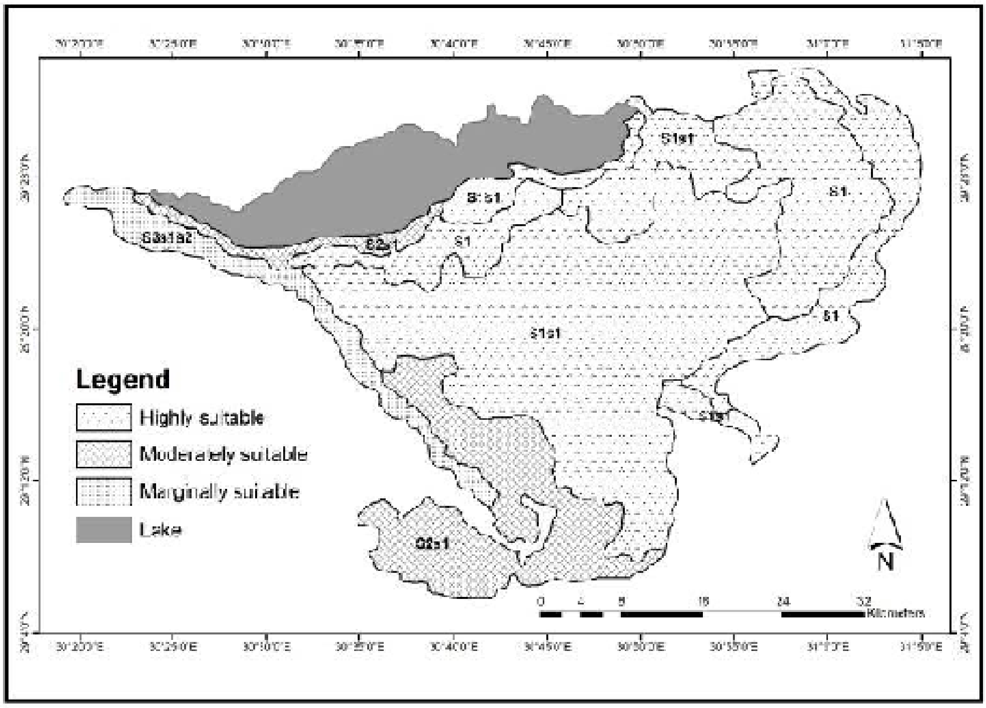

Fig (12): Spatial distribution of potential soil suitability classes in the studied area.

for agriculture using a remote sensing and GIS based approach. International journal of remote sensing 30 (4): 879-895.

CLAC (2010). Central Laboratory for Agricultural Climate (CLAC) website. http: // w.w.w.calc. edu, eg.l

Dobos, E., B. Norman, W. Bruse, M. Lnca, J. Chris and M. Erika (2002). The Use of DEM and Satellite Images for Regional Scale. Soil Database, 17th,World Congress of Soil Sciorces (WCSS), 14-21 August 2002, Bangkak, Thailand.

Ehlers, M., M.A. Jadkowski, R.R. Howard and D.E. Brousten (1990). Application of spot data for regional growth analysis and local planning. Photogrametric Engineering and Remote Sensing 56: 175.

Euroconsult, (1992). “Environmental profile, Fayoum Governorate, Egypt”, Al-Shorouk press, cairo Egypt.

FAO (2006). Guidelines for soil description, Food and Agricultural Organization of the United Nations, Rome.

Hulme, M. and R. March (1990). Global Mean Monthly, Humidity Surfaces for 1930-59, 1960-89 and projected for 2020, (UNEP/GEMS/GRID, Climatic, Res. Unit Univ. of East Anglia, Norwich, England.

Harris, P.M. and S.J. Ventura (1995). The integration of geographic data with remotely sensed imagery to improve classification in an urban area .Phtogromtric Engineering and Remote Sensing 61: 993.

Kalkhan, M.A., T.J. Stohlgren, G.W. Chong, D. lisa and R.M. Reich (2000). Apredictive spatial model of plant diversity integration of remote sensed data, GIS and spatial statisties. 8th Biennial Remote Sensing Application Conference, Albuquerque, NM.

Martin, D. and S.K. Saha (2009). Land evaluation by integrating remote sensing and GIS for cropping system analysis in a watershed . Current Science. 96 (4): 569-575.

Said, R. (2000). The Geology of Egypt. Elsevier publishing Company, New York, U.S.A.

Sys, C. and W. Verheye (1978). An attempt to the evaluation of physical land characteristics for irrigation according to the FAO Framework for land Evaluation. Int. Train. Cent.For Post Graduate of Soil Scientists, Ghent, Belgium.

Sys, C., E. Van Ranst and J. Debaveye (1991). land Evaluation. part II International Traning Center Ghent Belguma.

Soil Survey Staff (2004). “Soil Survey Laboratory Manual” Soil Survey Investigation.Report, No. 42.

Soil Survey Staff (2014). Keys to Soil Taxonomy. 12th.Edition, USDA.

Weng, Q. (2001). A remote Sensing-GIS evaluation of Urban expansion and its impact on surface temperature in the Zhujian .Delta, South China. International journal of Urban and Regional Studies 22: 425.

استخدام تقنية الاستشعار من البعد ونظم المعلومات الجغرافية فى وصف الخصائص الجيومورفولوجية وتقسيم وتقييم أراضى محافظة الفيوم – مصر

عبداللطيف دياب عبد اللطيف سالم
معهد بحوث الاراضى والمياه والبيئة – مركز البحوث الزراعية – مصر

الملخص العربى

استخدمت تقنية الاستشعار من البعد ونظم المعلومات الجغرافية فى هذه الدراسة بغرض انتاج خريطة جيومورفولوجية لمحافظة الفيوم حيث تم استخدام صور القمر الصناعى لاندسات والنظام الرقمى ثلاثى الابعاد لتحديد هذه الوحدات الجيومورفولوجية مع الاستعانة ببرنامج ENVI 4.7،Arc GIS 9.3.

وقد اوضحت نتائج الدراسة ان منخفض الفيوم يتكون من ست وحدات جيومورفولوجية رئيسية هي: المراوح الفيضية بنسبة ٤١.٥ % من المساحة الكلية السهل الفيضى (٢٧.٤ %) السهل الرسوبى (١.٤%) ، المصاطب (١٤.٤%) ، السهل البحيرى (٤.٨%) ، السهل النهرى البحيرى (١٠.٤%).

حيث تشغل أراضى السهول الرسوبية (مراوح فيضية) ، السهل الفيضى ، المصاطب، السهل الرسوبى نسبة ٨٤.٧ % من مساحة منطقة الدراسة بينما تشغل رواسب السهل البحيرى والسهل النهرى البحيرى باقى المساحة.

وقد تم تمثيل هذه الوحدات الجيومورفولوجية بعدد ١٢ قطاع ارضيا والتى تم وصفها فى الموقع مورفولوجيا وجمعت منها ٣٤ عينة تربة ممثلة لطبقات القطاعات ، بغرض تحليلها طبيعيا وكيميائيا لتقييم خواص هذه الاراضى، وقد تم عمل ربط بين الوحدات الجيومورفولوجية وخصائص الاراضى لانتاج مختلف الخرائط الارضية.

وقد اجري تقسيم الاراضى حتى مستوى العائلة تحت ثلاث رتب هى Aridisols, Vertisols and Entisols وذلك حسب احدث دليل لتقسيم الاراضى الامريكى 2014 .

وقد تم تقييم القدرة الانتاجية للاراضى باستخدام دليل الإنتاجية، حيث اعتبرت العوامل المحددة لصلاحية الاراضى هى قوام التربة ، عمق القطاع الارضى ، حالة الملوحة ، القلوية ، المحتوى من كربونات الكالسيوم والجبس ، حالة الصرف ، انحدار؛ السطح وذلك بتطبيق نظام (Syes and Verheye–1978) لتقييم الاراضى حيث اوضحت نتائج ادلة ملائمة التربة حسب خصائصها الحالية الى انتمائها الى اربعة رتب هى عالية الصلاحية ، متوسطة الصلاحية، هامشية الصلاحية ، غير صالحة ، حيث كانت أهم محددات تقييم هذه الأراضى هى قوام التربة الخشن والملوحة والقلوية وحالة الرطوبة والصرف وبدرجات شدة مختلفة (خفيفة – متوسطة – شديدة) ، وباجراء عمليات تحسين لهذه المحددات فى الاراضى فان درجات الصلاحية الكامنة لها يمكن ان ترتفع الى عالية الصلاحية ، متوسطة الصلاحية ، هامشية الصلاحية .

Table (1): Some morphological features of the studied soil profiles

Physiographic unit	Profile (No)	Depth (cm)	Colour		Texture	Structure	Consistence			$CaCO_3$	Gypsum	Lower boundary
			Dry	Moist			Dry	Moist	Wet			
Lacustrine plain (LP 111)	1	0-25	10YR6/8	10YR6/6	SC	m	SO	V.Fr.	S.s,S.p	St.calc.	Sligypsic	CS
		25-50	10YR6/3	10YR5/3	C	w.c.subangular	SO	Fr		Ex.calc	Sligypsic	CS
		50-150	10YR4/3	10YR3/3	C	Mo.mang.blo.	SO	Fir		Ex.calc	Sligypsic	-
	11	0-30	10YR3/3	10YR3/2	C	w.c.ang.blocky	SO	Fir n	Vs.,Vp	Mod.calc	Sli gyp.	CS
		30-60	10YR3/2	10YR2/2	C	Mo.mang. blocky	SO	Fir	Vs.,Vp	St.calc.	Sli gyp.	DS
		60-90	10YR3/3	10YR3/2	C	St.F.ang. blocky	SH	Fir	Vs.,Vp	St.calc.	Sli gyp.	DS
		90-120	10YR3/3	10YR3/2	C	St.F.ang. blocky	SH	Fir	Vs.,Vp	St.calc.	Sli gyp.	-
Terraces (AP 114)	2	0-25	10YR7/4	10YR7/3	SCL	m	SO	Fir	Ss,Sp	Ex.calc	Mod. gypsic	CS
		25-50	10YR7/4	10YR6/3	SCL	m	SO	Fir	Ss,Sp	Ex.calc	Sli gyp.	-
	5	0-25	10YR6/1	10YR5/1	L	m	SO	Fir	Ss,Sp	Ex.calc	Sli gyp.	CS
		25-85	10YR6/2	10YR5/2	SiC	m	SO	Fir	Ss,Sp	Ex.calc	Sli gyp.	-
	6	0-25	10YR8/3	10YR7/3	SCL	m	SO	Fir	Ss,Sp	St.calc.	Sl. gyp.	CS
		25-75	10YR8/3	10YR7/3	SCL	m	SO	Fir	Ss,Sp	Mod.calc	Sl. gyp.	-
Flood plain (AP 113)	8	0-30	10YR5/3	10YR4/3	C	w.c.ang. blocky	SO	Fir	Vs.,Vp	Mod.calc	Sli gyp.	CS
		30-90	10YR4/3	10YR3/3	C	m.o.f.ang. blocky	SO	Fir	Vs.,Vp	Mod.calc	Sli gyp.	CS

Texture
C:clay
CL: clay loam
SiL:silty loam
SL: sandy loam
SC: sandy clay loam

Structure
w.c.: weak coarse
w. f: weak fine
mo: moderate
s:strongang.Blo. Angular blocky
m: massive

Consistence

Dry
SO: soft
SH: slightly

moist
Fir: firm /fir: friable

wet
V.s: very sticky
V.p: very plastic
S.s slightlyplastic
N.s: non sticky N.p: non plastic

$CaCO_3$
Mod: Moderate
St: strong
Sli: slight
Ex; extra

Lower boundary
CS: clear smooth
DS: diffuse
CW: clear wavy

Table (1): cont.

Physiographic unit	Profile (No)	Depth (cm)	Colour		Texture	Structure	Consistence			$CaCO_3$	Gypsum	Lower boundary
			Dry	Moist			Dry	Moist	Wet			
Fluvio Lacustrine (FL 111)	3	0-30	10YR4/2	10YR3/2	C	w.c.ang. blocky	SO	Fir	Vs.,vp	Mod.cale .	Sli gyp.	CS
		30-65	10YR4/2	10YR3/3	CL	w.c.ang. blo.	SO	Fir	S,p	Mod.calc.	Sli gyp.	DS
		65-95	10YR3/3	10YR3/2	CL	w.c.ang. blo.	SO	Fir	S,P	Mod.calc.	Sli gyp.	-
	4	0-25	10YR4/3	10YR3/3	SC	m	SO	Fir	Ss,Sp	Mod.calc.	Sli gyp.	DS
		25-75	10YR4/2	10YR3/3	SC	w.c.ang. blo.	SO	Fir	Ss,sp	Mod.calc.	Sli gyp.	CS
		75-150	10YR3/3	10YR3/2	C	w.c.ang. blo.	SO	Fir	S,P	Mod.calc.	Sli gyp.	-
Alluvial Plain (AP 112)	7	0-35	10YR7/1	10YR6/1	LS	m	SO		Ns,np	Mod.calc.	Sli gyp.	CS
		35-90	10YR7/2	10YR6/1	SL	m	SH		Ns,np	Mod.calc.	Sli gyp.	-
	12	0-25	10YR7/3	10YR6/3	Sil	m	SO		Ss,sp	St.calc.	Sli gyp.	CS
		25-75	10YR7/3	10YR6/2	Sl	m	SH		Ns,np	St.calc	Sli gyp.	DS
		75-130	10YR7/2	10YR6/3	Sl	m	SH		Ns,np	St.calc	Sli gyp.	-
Alluvial Fan (AP 111)	9	0-25	10YR4/3	10YR3/3	C	w.c.subang.	SO	Fir	Vs.,vp	Mod.calc.	Sli gyp.	DS
		25-70	10YR4/2	10YR3/3	C	m.f.ang.bloc	SO	Fir	Vs.,vp	Mod.calc.	Sli gyp.	DS
		70-100	10YR3/3	10YR3/2	C	m.f.ang.bloc	SO	Fir	Vs.,vp	Mod.calc.	Sli gyp.	DS
		100-140	10YR3/3	10YR3/2	C	m.f.ang.bloc	SH	Fir	Vs.,vp	Mod.calc.	Sli gyp.	-
	10	0-30	10YR5/3	10YR4/3	C	w.c.ang. bloc	SO	Fir	Vs.,vp	Mod.calc.	Sli gyp.	CW
		30-70	10YR4/3	10YR3/3	C	m.f.ang.bloc	SO	Fir	Vs.,vp	Mod.calc.	Sli gyp.	CS
		70-110	10YR3/3	10YR3/2	C	m.f.ang.bloc	SO	Fir	Vs.,vp	Mod.calc.	Sli gyp.	CS
		110-150	10YR3/3	10YR3/2	C	S.f.ang.bloc	SO	Fir	Vs.,vp	Mod.calc.	Sli gyp.	-

Texture
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V.s: very sticky
V.p: very plastic
S.s slightlyplastic
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$CaCO_3$
Mod: Moderate
St: strong
Sli: slight
Ex; extra

Lower boundary
CS: clear smooth
DS: diffuse
CW: clear wavy

Table (2): Chemical properties of the Studied Soil Profiles

Geomorphic unit	Prof. No.	Depth Cm	pH	ECe (ds/m)	Anions (meq/L)				Cations (Cmole.kg^{-1})				CEC (Cmole. kg-1)	ESP %	SAR	OM %	Gypsum %
					$CO_3^{=}$	HCO_3^{-}	Cl^{-}	SO_4^{--}	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}					
Lacustrine (LP 111)	١	0-25	8.17	14.50	trace	5.58	224.0	100.3	41.35	22.67	313.0	2.88	37.41	44.54	55.31	1.07	2.70
		25-50	8.23	8.26	0.00	2.75	50.0	72.86	19.13	1.60	103.9	0.98	39.63	31.67	32.27	0.74	1.54
		50-150	8.23	6.68	0.00	1.72	14.0	86.19	29.63	0.85	70.6	0.83	51.26	20.28	18.10	0.58	1.54
	11	0-30	٨.٤٥	٩.١	0.00	0.00	٣.٩	٣١.٥	٨٦.٩	١٩.٥	٢٠.٦	٨٢.٣	5١.٢	٤٩.٥	٢٠.٥	١.٨٥	٠.٩٢
		30-60	٨.١	١٠.٨	0.00	0.00	٣.٨	٤٣.٥	١٠٨.٥	٢١.٤	٢٥.٣	١٠٦.٨	4٢.١	٥٤.٢	٢٥.١	٢.١٦	٠.٥
		60-90	٨.١٥	٩.٦	0.00	0.00	٣.٧	٣٥.٧	٩٠.٦	١٦.٨	٢.٥	٨٩.٥	4١.٩	٤٨.٥	٢١.٥	١.٩٨	٠.٥
		90-120	٨.٢	٩.٧	0.00	0.00	٣.٨	٣٢.١	٣٣.٤	١٩.٤	٢٣.١	٨٥.٥	4١.٩	٤٧.٢	٢٢.١	١.٨٥	٠.٦
Terraces (AP 114)	٢	0-25	7.76	9.66	0.00	2.58	92.0	274.1	37.4	23.93	306.2	1.56	15.95	44.62	55.47	0.93	8.34
		25-50	7.73	14.40	0.00	2.41	294.0	113.4	43.21	59.13	306.2	1.27	15.68	38.24	42.83	0.95	1.14
	5	0-25	8.4	4.3	0.00	2.1	19,4	24.5	17.2	7.6	21.6	0.65	14.6	9.8	6.5	1.3	3.2
		25-85	8.3	4.2	0.00	1.8	13.5	30.4	26.8	9.4	10.4	0.78	17.8	8.6	2.6	1.2	2.9
	6	0-25	٧.٦	2.1	0.00	0.00	1.8	2.1	6.5	1.2	4.6	3.6	13.4	18.6	4.7	2.6	1.1
		25-75	٧.٥	2.4	0.00	0.00	1.3	3.2	8.4	1.3	3.5	5.4	13.3	23.7	5.7	2.8	0.6
Flood plain (AP 113)	8	0-30	7.9	1.4	0.00	2.1	2.95	8.3	4.85	1.4	6.6	0.15	36.2	10.5	3.8	1.4	1.5
		30-90	8.1	1.9	0.00	1.7	5.1	9.2	5.95	0.9	8.9	0.1	38.1	12.4	4.7	0.85	2.5

Table (2):Cont.

Geomorphic unit	Prof. No.	Depth Cm	pH	ECe (ds/m)	Anions (meq/L)				Cations (meq/L)				CEC (Cmole.kg-1)	ESP %	SAR	OM %	Gypsum %
					$CO_3^{=}$	HCO_3^-	Cl^-	SO_4^{--}	Ca^{2+}	Mg^{2+}	Na^+	K^+					
Fluvio Lacustrine (FL 111)	3	0-30	8.05	5.3	0.00	4.1	27.7	32.1	9.6	10.1	44	0.13	35.6	17.2	13.8	0.85	2.6
		30-65	8.4	6.6	0.00	4.1	39.6	38.25	6.7	11.0	64	٠.١٢	28.5	22.4	20.6	0.76	3.2
		60-95	8.5	7.4	0.00	4.9	40.6	40.1	6.8	10.2	68	٠.٢٥	32.7	28.6	22.8	0. 58	2.7
	4	0-25	8.6	4.6	0.00	4.2	17.3	29.3	4.5	4.3	41.7	o.35	38.6	26.1	20.3	1.87	2.4
		25-75	8.3	5.2	0.00	3.4	23.2	66.1	17.4	10.6	65.5	o.75	35.4	22.4	17.8	0.95	2.7
		75-150	8.5	7.6	0.00	4.1	15.4	74.3	21.6	11.2	61.3	o.86	35.7	21.3	15.2	0.76	3.2
Alluvial plain (AP 112)	7	0-35	8.2	2.4	0.00	2.7	2.9	18	9.6	1.3	12.7	0.17	8.3	11.6	5.6	0.56	1.6
		35-90	8.1	1.1	0.00	2.2	2.1	1.5	1.4	0.96	2.9	0.25	9.4	13.8	2.7	0.36	1.7
	12	0-25	٧.٨	١.٨	0.00	٢.٣	٤.١	١١.١	٧.٨	٢.٣	٧.١	٠.١	1٤.٥	٨.٣	٣.٢	١.٢	٢.٨
		٧٥-٢٥	٨.١	٤.٣	0.00	٠.٨	١٧.٧	٣٠.٥	١٢.٢	٦.٣	٢٩.٨	٠.٢	1٦.٨	٥.١	١٠.٢	٠.٦	٢.٨
		١٣٠-٧٥	٨.٢	٣.٨	0.00	٠.٧٥	١٥.١	٢٦.١	١٥.٦	٥.٤	٢٠.٢	٠.٣	1٠.٤	٤.٩	٦.٤	٠.٧	٢.٩
Alluvial Fan (AP 111)	9	0-25	7.8	1.6	0.00	2.5	4.1	10.8	5.5	2.9	8.9	0.24	42.7	9,5	4.3	1.3	1.7
		25-70	7.9	1.9	0.00	1.95	5.9	11.9	8.1	2.4	9.5	0.17	45.6	10.4	4.2	1.1	2.4
		70-100	7.8	2.4	0.00	1.8	8.8	16.3	9.8	4.1	11.6	0.1	47.4	12.5	4.8	0.66	2.6
		100-140	8.2	2.3	0.00	1.5	9.8	15.1	8.3	3.2	13.7	0.1	39.8	13.8	5.3	0.68	2.1
	10	0-30	7.5	2.1	0.00	2.1	7.0	11.4	7.5	3.2	9.5	0.24	47.5	7.5	4.2	0.09	2.3
		30-70	7.7	1.3	0.00	1.9	1.9	7.5	3.8	0.76	7.1	0.1	49.7	9.6	4.8	0.05	2.1
		70-110	7.9	1.2	0.00	3.2	2.0	7.2	4.9	1.8	5.6	0.07	51.4	11.8	3.1	0.08	2.4
		110-150	7.8	0.85	0.00	2.7	2.1	4.o	3.5	0.79	4.4	0.06	48.6	12.7	2.9	0.04	2.7

Table (5): Classification of the studied soil profiles

Order	Sub order	Great group	Sub great group	Family	Profile No
Vertisols	Torrerts	Calcitorrerts	TypicCalcitorrerts	Very fine clay , smectitic, hyperthermic	1
		Haplotorrerts	TypicHaplotorrerts	clay, smectitic, hyperthermic	9 and 10
		Gypsitorrerts	SodicHaplotorrerts	very fine clay, smectitic, hyperthermic	11
			TypicGypsitorrerts	Clayey, smectitic, hyperthermic	8
Aridisols	Clacids	Haplocalcids	TypicHaplocalcids	Clayey, mixed, hyperthermic, moderately deep	5
	Gypsids		TypicHaplocalcids	Coarse loamy, mixed, hyperthermic, deep	12
		Calcigypsids	TypicCalcigypsids	Fine loamy mixed, hyperthermic, deep	2
Entisols	Orthents	Torriorthents	TypicTorriorthents	Fine loamy, mixed, hyperthermtc, moderately	6 and 3
				Clayey, mixed, hyperthermtc, v. deep	4
				Coarse loamy, mixed, hyperthermtc, moderately deep.	7

Table (6): Land suitability rating and classes for the studied soil profiles in the current (c) and potential (p) state.

Prof. No.	Topography (t)		Wetness (w)		Soil		CaCo3 Content (s3)	Gypsum Content (s3)	Salinity / alkalinity (n)		Rating index		Suitability classes	
	C	P	C	P	Texture (s1)	Depth (s2)			C	P	C	P	C	P
Lacustrine (LP111)														
1	100	100	100	100	85	100	90	90	75	100	51.5	68.5	$S2_{s1,n}$	$S2_{s1}$
11	100	100	95	100	85	100	95	100	70	100	53.8	80.8	$S2_{s1,n}$	S1,S1
Terraces (AP 114)														
2	100	100	70	100	65	60	90	100	75	100	18.5	36	$N_{N,s1,n}$	$S3_{s1,s2}$
5	100	100	70	100	90	100	90	100	96	100	54.5	80.7	$S2_{w}$	S1
6	100	100	55	100	95	100	95	100	100	100	49.6	90.5	$S3_{w}$	S1
Flood plain (AP 113)														
8	100	100	70	100	85	100	95	100	90	100	50.8	80.7	$S2_{w,s1,n}$	$S1_{s1}$
Fluvio Lacustrine (FL 111)														
3	100	100	70	100	95	100	95	100	85	100	53.7	90.4	$S2_{w,n}$	S1
4	100	100	100	100	85	100	95	100	70	100	56.5	80.7	$S2_{s1,n}$	$S1_{s1}$
Alluvial plain (AP 112)														
7	100	100	55	100	70	100	95	100	96	100	35.6	66.5	$S3_{w,s1}$	$S2_{s1}$
12	100	100	100	100	95	100	100	100	96	100	92	95	S1	S1
Alluvial Fan (AP 111)														
9	100	100	100	100	85	100	95	100	90	100	72.6	81.1	$S2_{S1,n}$	$S1_{S1}$
10	100	100	100	100	85	100	95	100	90	100	72.6	80.9	$S2_{S1,n}$	$S1_{S1}$

s1=Soil depth (cm), s2=Texture, s3= Calcium carbonate status and s4= Gypsum status
N= notsuitable, S1= High suitability, S2=Moderate suitability and S3= Limitation suitability