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THE USE OF GIS FOR DETECTION AND IDENTIFICATION OF OCCURRENCE OF PETROCALCIC AND PETROGYPSIC HORIZONS IN THE CULTIVATED LANDS OF MARYOUT REGION, EGYPT

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ABSTRACT

The present work aims at using GIS, remote sensing and soil data, as a mean for detection and identification of Petrocalcic and Petrogypsic horizons in the cultivated areas of Maryout region, North-Western Coast of Egypt. The area under investigation bounded by longitudes 29° 35' 13.60" and 29° 57' 03.25" East and latitudes 30° 45' 00.15" and 30° 56' 35.47" North with a total area of about 757.80 km^2 (180428.57 feddans).

Remote Sensing (RS) and GIS are incorporated to execute the soil base map. Results of thirty nine soil profiles located in the studied area were used as a database for the present study. Twenty soil profiles were dug and described to represent the SMUs. Soil samples were collected for the Laboratory analyses according to the differences in the morphological properties and stored as attributes in a geographical soil database linked with the soil map units. Based on the morphological description and analytical data the soils are classified as Typic Haplocalcids; Typic Petrocalcids; Typic Calcigypsids; Typic Haplogypsids; Petrocalcic Petrogypsids; and Typic Petrogypsids. Four dominant diagnostic horizons were observed in the studied soils; Calcic, Gypsic, Petrocalcic and Petrogypsic horizon. Based on the field observations and using RS and GIS we could define the different diagnostic horizons in the studied area.

Spatial interpolation, using exact interpolator [nearest neighborhood (Thiessen polygon)] between the field observations was used to drive the distribution of current diagnostic horizon. Results showed that, Calcic horizon occupies 349.51 km^2, Petrogypsic horizon occupies 168.36 km^2, Petrocalcic horizon occupies 63.08 km^2, and Gypsic horizon occupies 16.77 km^2. Results also showed that, there is some factors affect the formation of Petrocalcic and Petrogypsic horizons namely: land use, parent material, land form, slope gradient. From the previous finding it can be concluded that, soils having these horizons need a special management in order to avoied the effect of these horizons. Also we can concluded that GIS with other source of data are a suitable tool for detection, prediction and planning studies and consequently for decision making in the studied area.

Keywords: GIS, Remote Sensing, Detection, Petrocalcic, Petrogypsic, Maryout , Egypt

INTRODUCTION

Agricultural activities play a key role in the Egyptian economy, it's considered as a major source of national income and the way of life for sizable part of the population. The agricultural sector in Egypt absorbs 38.2 % of the labor force and able to absorb more.

Increasing demand for food as a result of population growth has created more pressure on land recourses. The continuous increase of human pressure on limited natural resources of Egypt (including water and cultivated area) requires proper management of such resources. Nowadays, a great attention is directed to the Northern coast of Egypt, due its comparative characteristics. Therefore, management of natural resources in such region is considered of vital importance.

Geographic Information System (GIS) and Remote Sensing (RS) techniques proved to be effective in management and planning studies. GIS is a powerful set of tools for collecting, storing, retrieving, transforming, and displaying spatial data from the real world for a particular set of purposes (Burrough and McDonnall, 1998). So that, Geographic information systems (GIS) can be used for scientific investigations, resource management, and development planning. The essence of agricultural remote sensing- which encompasses both photographic and non-photographic sensors- is the collection and measurement of electromagnetic radiation reflected by vegetation, soil, water and other features of the earth's surface (El Kady, 1994).

Soils with Petrocalcic and Petrogypsic horizons are widely distributed in arid and semi-arid lands of the world. Petrocalcic horizon is an illuvial horizon, 10 cm or more thick, in which secondary calcium carbonate or other carbonates have accumulated to the extent that the horizon is cemented or indurated (Soil Survey Staff, 1998 and 2006). The Petrogypsic horizon is an illuvial horizon, 10 cm or more thick, in which secondary gypsum has accumulated to the extent that the horizon is cemented or indurated (Soil Survey Staff, 1998 and 2006). Mekhail, (1998) stated that, the King Maryut-Burg El-Arab depression, which lies between the last tow ridges, is famous by the presence of thick gypsum evaporates at some sites that may confirm its formation under lagoonal conditions. Its surface is occupied by scattered disconnected Oolitic limestone recrysalized to brownish layer on top. Previous word is great but we have a serious problem that must be recognize and solve. This problem is the presence of petro-horizons (Petrocalcic and Petrogypsic horizons). If we didn't recognize and solve this problem, it will spoil reclamation of lands and our efforts and money will go with wind. So we must catch the problem at anywhere to solve it and plane a strategy to save our cultivated and new lands.

The study area (Maryut region) is located in the northwestern coast of Egypt. It lies approximately between longitudes 29° 35` 13.60" and 29° 57` 03.25" East and latitudes 30° 45` 00.15" and 30° 56` 35.47" North with a total area of about 180428.57 feddans (757.80 km^2) as shown in Map 1. As a part of the Mediterranean coast of Egypt, the long dry summer and the short rainy winter characterize the study area. The meteorological data of El-Dekhila station (average of 30 years) show that the mean annual temperature is 20.28C°. The average annual rainfall is 178.90 $mm.year^{-1}$. Evaporation values ranged between 5.5 and 9.6 $mm.day^{-1}$. Relative humidity values ranged between 63.00 and 72.00 %. The wind velocity ranges between 7.3 and 9.7 $m.sec^{-1}$. Based on Soil Taxonomy (2006) the soil temperature regime could be defined as Thermic and soil moisture regime is Aridic.

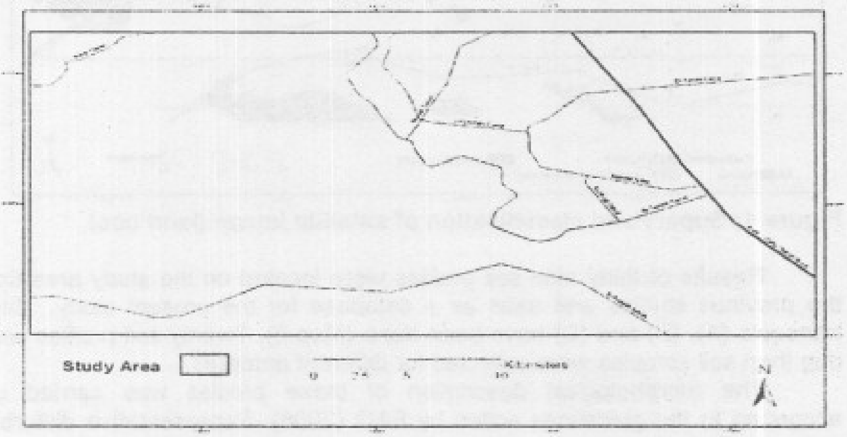
The main geological deposits occurred in the studied area are Marine deposits, exemplified by the Oolitic limestone's distributed along the cost of the Mediterranean west of Alexandria. These formations occur in chains extending parallel to the cost (Said, 1962).

The geomorphology of the studied area is distinguished by a succession of ridges which are separated from the other by a depression and a southern tableland (Balba, 1987). These ridges are composed of Oolitic limestone that considered as a product of the consolidation of ancient littoral dunes formed along the shoreline. The areas between the depressions are formed from materials washed from the neighboring ridges and hills and considered the main potentially agricultural land (Balba, 1990).

Regarding to the hydrology of the studied area, the aquifer system comprises an impermeable basement of marine clays over which lie two distinct zones (ULG, 1978). The lower zone has a high permeability while the upper zone is of lagoonal and littoral facies has a low permeability. Although semi-confining, the upper zones are not impervious and do not produce a permanent water table. The area is surrounded by impervious or low permeability restrictions which generally prevents the discharge of groundwater out of the area. Therefore, the aquifer can be considered as a groundwater basin retaining any water which flows into it.

The study area is irrigated by Nile water pumped through El-Nasr Canal, El-Tahrir Canal and El-Nobaria Canal. The flooding system of irrigation is widely used in the area.

Regarding to the land use of the study area, the cropping pattern in the studied area involves the cultivation of field crops, vegetables, fodders and fruit trees. The aim of this study is to build up a soil map for Maryout region using Remote Sensing Data and detect the occurrence of Petrocalcic and Petrogypsic horizons in the study area.



Map 1: Location map of the study area.

MATERIAL AND METHODS

LANDSAT ETM+7 image (2004) was used for the present study. Scanned topographic maps scale 1:50000 were used first for the image geo-referencing using image-to-image geometric module in ERDAS IMAGINE 9.1. Stretching radiometric enhancement and convolution and adaptive filtering were applied. The resulted enhanced false color composite (band 4, 3, 2) and the enhanced natural like composite (band 7, 4, 2) were used for the interpretation of land use units (Figure 1), whereas, the normalized difference vegetation index (NDVI) is used to distinguish the different land covers in the study area

All contour lines and spot heights are digitized from the topographic map scale 1:50000, then, interpolation is made using ARC GIS 9.2 in order to create the digital elevation model (DEM) with pixel size of 5m. This DEM is used for soil map generation. And enhanced false color composite of LANDSAT ETM+7 image is overlayed on the 3D model (Figure 2) created using ARC GIS 9.2. The same was done with the enhanced natural like composite LANDSAT image.

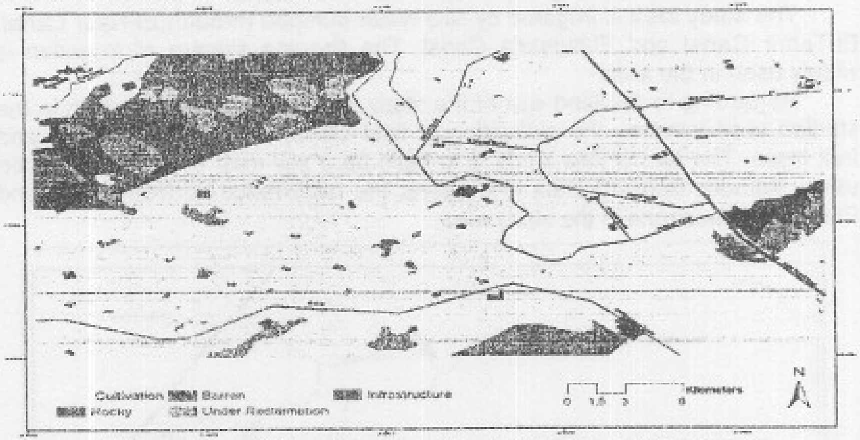


Figure 1: Supervised classification of satellite image (land use).

Results of thirty nine soil profiles were located on the study area from the previous studies and used as a database for the present study. Three transects (A), (B) and (C) have been done (Map 2). Twenty soil profiles were dug then soil samples were collected for different analyses.

The morphological description of these profiles was carried out according to the guidelines edited by FAO (2006). Representative disturbed soil samples have been collected and analyzed using the soil survey laboratory methods manual (USDA, 2004). The soil survey staff (2006) was used to classify the different soils of the investigated area to the sub great group level.

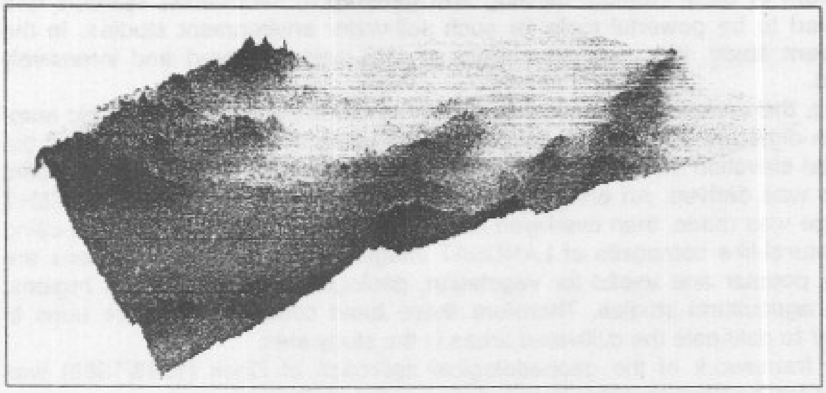
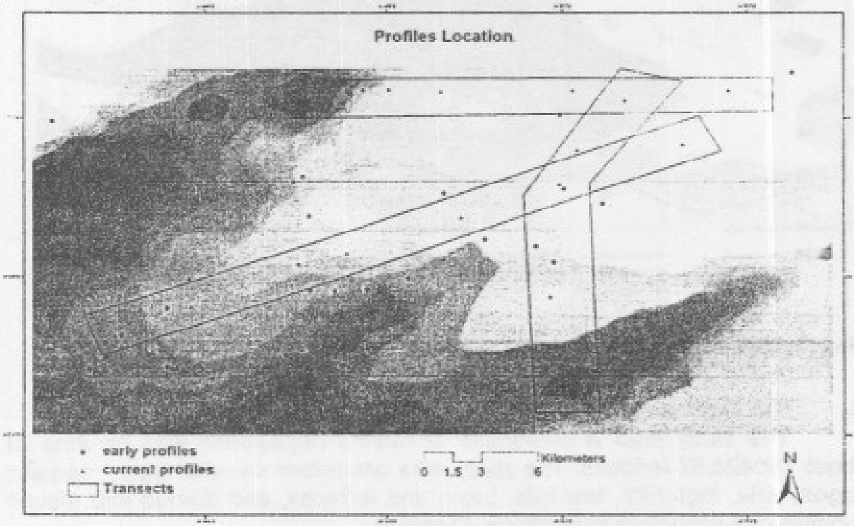


Figure 2: 3D model of the study area.

The geopedological approach (Zinck, 1989) of the physiographic aerial photo interpretation is adapted to be applied on the LANDSAT image interpretation. The enhanced colour composite LANDSAT image is overlaid on 3D model, created using ARC GIS 9.2, the visual interpretation is made to produce the soil map.



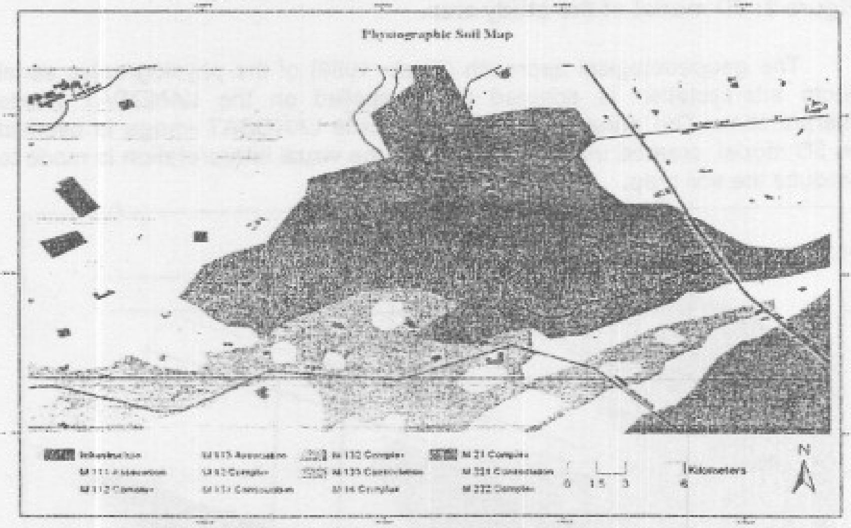
Map 2: Location map of the studied soil profiles.

RESULTS AND DISCUSSION

Handling data in digital format has become essential for many disciplines, especially those dealing with large extent regions and large amount of data. Remote sensing and geographic information systems GIS proved to be powerful tools for such soil-water environment studies. In the present study, the great capabilities of GIS were explored and intensively used.

First, the contour lines and all spot heights -from 1:50,000 topographic map- were digitized. Then, interpolation is made using ARC GIS 9.2 to create the digital elevation model (DEM). From the digital elevation model slope gradient map was derived. An enhanced false color composite of LANDSAT ETM+7 image was made, then overlayed on a 3D model. The same was made using a natural-like composite of LANDSAT image. These band combinations are very popular and useful for vegetation, geological, wetland, desert regions, and agricultural studies. Therefore these band combinations were used in order to delineate the cultivated areas in the study area.

The framework of the geopedological approach of Zinck (1988/1989) was used for the physiographic interpretation of the study area.



Map 3: Soil Map of the Study Area

a. The Main Description of the Physiographic Units:

The study area is composed of marine depositions with an area of about 180428.57 feddans. The study area comprises six relief types, namely; ridges, vale, high hills, low hills, basin and terraces, and divided into eleven subdivisions according to landform, (Table 1).

b. Soil Map:

A soil map is one of the key data layers for developing a robust global model and evaluating land quality and use (Ahn, 1999). The study area is characterized by Marine deposits, Hillands and Valley landscape, subdivided into six relief types.

Table 1: Legend of physiographic soil map.

Environment Deposits	Landscape	Relief	Land Form	Mapping Unit Symbol	Area Km².	Area fed	Percentage of the total area	Main Soils	% of the Mapping Unit Area	Kind of Mapping Unit
Marine Deposits M	Hillands M 1	Ridges M 11	Summit	M 111	43.32	10315.01	5.72	Typic Haplocambids Typic Petrocalcids Typic Haplocalcids	50 25 25	Association
			Back slope	M 112	66.36	15799.43	8.76	Sodic Haplocalcids Typic Haplocalcids Calcic Petrocalcids Petrocalcic Petrogypsids	20 20 40 20	Complex
			Foot slope	M 113	40.26	9586.80	5.31	Typic Haplocalcids Sodic Haplocalcids	75 25	Consociation
		Vale M 12	flat	M 12	16.25	3868.32	2.14	Typic Haplocalcids Typic Petrocalcids Typic Calcigypsids Typic Haplocambids	33.33 11.11 44.44 11.11	Complex
		High hills M 13	Summit	M 131	36.38	8663.08	4.80	Calcic Petrogypsids Typic Petrogypsids	75 25	Consociation
			Back slope	M 132	89.72	21360.73	11.84	Typic Haplocalcids Calcic Petrogypsids Typic Haplogypsids Typic Petrogypsids	40 20 20 20	Complex
			Foot slope	M 133	20.34	4843.17	2.68	Calcic Petrogypsid	100	consociation
		Low hills M 14	Low hills	M 14	70.39	16760.24	9.29	Typic Petrocalcids Calcic Petrogypsids Typic Calcigypsids Typic Haplocalcids	20 20 20 40	Complex
	Mena Valley M 2	Basin M 21	Basin	M 21	256.61	61098.33	33.86	Calcic Petrogypsids Typic Petrogypsids Typic Haplocalcids Typic Petrocalcids Typic Haplogypsids	21.05 15.79 47.37 10.53 5.26	Complex
		Terraces M 22	Riser	M 221	82.73	19697.38	10.92	Typic Haplocalcids	100	consociation
			Tread	M 222	35.43	8435.54	4.68	Typic Petrogypsids Typic Haplocambids Typic Haplocalcids	46.37 44.35 9.28	Complex

Each relief type is characterized by one or more landform. The soil map and the legend of the studied area are shown in Map 3 and Table 1. Table 2 shows the soil taxonomy of the studies soil profiles in addition to the depth where the diagnostic horizons occur. Salinity is varied in moderate to relatively high ranges from 0.84 dS/m to 6.33 $dS.m^{-1}$. Calcium carbonate content is varied from high to extremely high (from 26 % to 75%), which permit the formation of Calcic and Petrocalcic horizons in some profiles. The gypsum content is very low to rather high and varied from 0.12 % to 40 %, mainly concentrated at subsurface layers which permit the formation of Gypsic and Petrogypsic horizon in some profiles. Organic matter content ranged from 0.12 % to 1.26 %. Table 3 shows the chemical analyses results of studied soils.

Table 2: Soil classification of the studied soil profiles.

Prof. No.	Horizon	Depth cm	Classification	Elevation m A.S.L.	Slope %
1	Calcic	20-40	Typic Haplocalcids	67	3
2	-	-	Typic Haplocambids	59	1.37
3	-	-	Typic Haplocambids	52	1.19
4	Calcic	50-80	Typic Haplocalcids	40	2
5	Calcic	20-40	Typic Haplocalcids	31	1.41
6	Petrocalcic	20-40	Typic Haplocalcids	17	0.58
7	Calcic	20-40	Typic Haplocalcids	14	1.26
8	-	-	Typic Haplocambids	6	0.87
9	Calcic	30-60	Typic Haplocalcids	15	0.83
10	Calcic	20-40	Typic Haplocalcids	23	0.62
11	Calcic	30-60	Typic Haplocalcids	30	0.78
12	Gypsic	60-80	Typic Haplogypsids	30	0.89
13	Petrogypsic	40-80	Typic Petrogypsids	35	0.45
14	Calcic	60-90	Typic Haplocalcids	40	0.98
15	-	-	Typic Haplocambids	45	1.24
16	Calcic	20-40	Typic Haplocalcids	10	0.83
17	Petrogypsic	60-90	Typic Petrogypsids	20	0.56
18	Calcic Petrogypsic	20-40 40-60	Calcic Petrogypsids	30	0.44
19	Calcic	20-40	Typic Haplocalcids	45	0.39
20	Petrogypsic	20-40	Typic Petrogypsids	50	2.46

C. Distribution of current horizons:

Spatial interpolation, using exact interpolator [nearest neighborhood (Thiessen polygon)] between the field observations (Burrough and McDonnell, 1998) was used to drive the distribution of current diagnostic horizon as shown in Map 4. Four diagnostic horizons were observed in the studied area Calcic, Gypsic, Petrocalcic and Petrogypsic horizon.

Cultivated lands represent 81.63 % of the total area. Table 4 shows that, the cultivated areas are located in the basin (247.35 km^2), back slope (115.83 km^2), riser (81.70 km^2), tread (35.40 km^2), and foot slope (43.29 km^2). This is because these areas have a deep effective soil depth, well drained, and the slope is flat to almost flat. Soils in the basin are considered the most arable productable lands in the study area.

Table 3: Texture classes and some chemical characteristics of the studied soils.

P. NO.	Depth Cm	EC dS.m^{-1}	pH	O.M %	Total $CaCO_3$ %	Active $CaCO_3$ %	Gypsum %	C.E.C. Meq.100 g soil^{-1}	Texture*
1	0-20	1.49	7.95	0.35	47.43	14.21	1.35	12.08	SL
	20-40	3.43	8.46	0.24	73.97	16.26	1.42	14.09	SCL
	>40	3.86	8.46	0.00	66.26	16.47	1.59	13.29	SCL
2	0-20	6.10	8.07	0.29	60.30	17.90	2.65	15.70	SCL
	20-40	5.41	8.31	0.19	58.80	16.86	2.75	18.12	CL
	>40	4.90	8.31	0.00	62.12	17.45	2.10	17.71	SCL
3	0-20	0.91	8.04	0.63	38.22	5.80	3.77	10.07	SL
	20-40	0.85	8.00	0.41	24.22	4.74	3.93	9.26	SL
	40-80	0.85	8.03	0.25	25.48	6.28	3.21	8.05	SL
	>80	0.83	8.06	0.00	43.80	12.55	1.03	9.66	SL
4	0-50	1.00	8.18	0.67	38.10	15.60	3.83	16.10	SL
	50-80	0.90	8.24	0.00	44.60	15.74	4.11	17.71	SCL
	80-130	0.90	8.25	0.00	39.11	11.83	2.52	17.31	SCL
5	0-20	1.93	7.80	0.82	45.55	23.43	0.93	20.13	CL
	20-40	1.93	8.18	0.45	51.38	18.34	0.96	20.53	CL
	40-60	1.86	8.26	0.12	44.32	13.49	1.08	19.33	CL
	60-80	2.00	8.31	0.00	41.41	15.05	0.90	18.52	CL
	80-140	2.12	8.25	0.00	60.52	19.20	0.69	16.10	L
6	0-20	2.42	7.90	1.04	42.86	21.85	0.85	18.12	SCL
	20-40	1.95	8.31	0.51	48.55	14.67	0.90	17.31	SCL
	40-100	1.85	8.36	0.43	37.84	6.64	0.35	16.91	SCL
	>100	2.31	8.25	0.00	48.19	19.31	0.80	18.92	CL
7	0-20	1.92	7.99	1.09	41.41	26.15	1.63	21.34	SC
	20-40	1.88	8.14	1.05	47.84	15.91	1.69	18.52	SCL
	40-90	1.99	8.08	0.94	39.93	17.81	0.76	16.10	SCL
	>90	2.22	8.14	0.00	38.97	17.54	1.19	14.90	SCL
8	0-20	1.29	7.80	0.96	40.61	21.36	0.68	18.52	L
	20-50	1.21	8.03	0.69	40.63	23.81	0.76	18.92	CL
	50-80	1.31	8.16	0.18	41.41	16.64	0.28	17.71	SCL
	>80	1.30	8.23	0.00	59.05	19.59	0.48	16.10	SCL
9	0-30	1.43	7.86	0.96	40.66	21.72	0.93	20.94	SC
	30-60	1.48	7.98	0.51	51.76	20.39	3.34	17.71	CL
	60-120	1.93	8.16	0.00	43.75	18.41	0.66	16.51	C
10	0-20	3.49	7.80	0.95	41.41	22.69	14.89	18.12	SCL
	20-40	2.00	8.13	0.65	47.66	23.52	15.73	16.51	SCL
	40-70	2.04	8.16	0.35	36.72	11.87	19.10	14.09	SCL
	70-100	2.60	7.99	0.00	30.67	6.34	22.75	12.08	SL
	100-140	3.65	7.95	0.00	23.56	17.23	24.16	10.87	SL

Cont.

*** SL: Sandy Loam SCL: Sandy Clay Loam CL: Clay Loam C: Clay L: Loam**

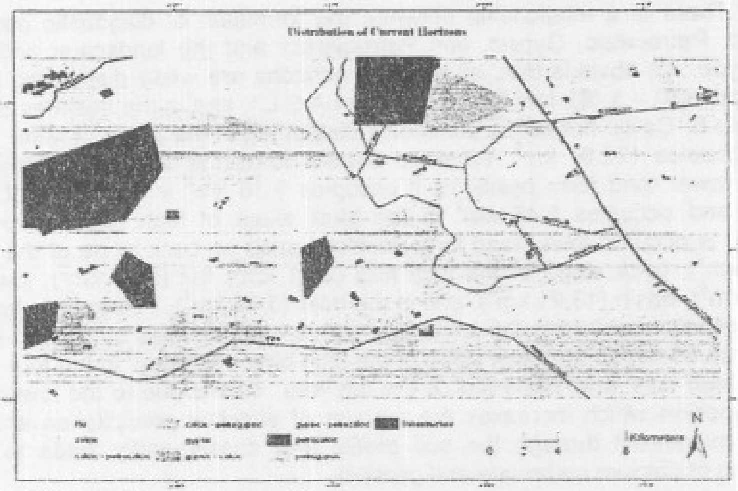
Table 3: Continued.

P. NO.	Depth Cm	EC $dS.m^{-1}$	pH	O.M %	Total $CaCO_3$ %	Active $CaCO_3$ %	Gypsum %	C.E.C. Meq.100 g $soil^{-1}$	Texture*
11	0-20	1.41	8.06	0.57	45.32	24.40	0.51	16.91	SCL
	20-60	0.84	8.31	0.37	51.95	17.62	0.53	16.10	SCL
	60-80	1.53	8.18	0.00	45.24	21.09	0.62	14.49	CL
	80-120	1.43	8.21	0.00	55.21	19.77	1.45	13.69	CL
12	0-20	5.77	8.25	0.55	33.05	25.38	17.81	16.10	SCL
	20-60	3.35	8.33	0.34	40.67	20.17	23.09	14.90	SCL
	60-80	3.11	8.28	0.00	39.15	18.71	33.71	14.09	CL
	>80	2.33	8.25	0.00	50.61	18.38	21.96	12.08	CL
13	0-20	6.33	8.06	0.55	39.11	16.77	13.66	20.13	CL
	20-40	4.33	8.25	0.52	41.41	16.53	29.94	18.52	CL
	40-80	4.42	8.27	0.45	45.24	15.47	40.34	16.51	CL
	>80	2.97	8.34	0.00	53.68	18.63	18.20	15.70	CL
14	0-20	1.77	7.99	1.22	37.78	22.82	0.79	16.51	SCL
	20-40	1.49	8.15	0.97	39.15	22.26	1.01	16.10	SCL
	40-60	1.70	8.20	0.76	46.78	18.00	0.69	15.30	SCL
	60-90	1.75	8.21	0.00	61.74	19.65	0.64	13.29	CL
	>90	1.82	8.14	0.00	55.98	21.05	0.72	14.09	CL
15	0-20	1.55	7.89	1.26	40.68	23.33	2.23	17.31	SCL
	20-40	1.43	8.26	0.98	43.63	21.61	3.18	16.51	SCL
	40-70	1.39	8.35	0.39	50.79	19.22	3.86	16.10	CL
	70-90	1.47	8.37	0.00	63.29	19.31	0.43	14.90	CL
	>90	1.50	8.35	0.00	60.30	20.17	0.38	15.30	CL
16	0-20	1.21	7.98	1.10	44.48	23.32	2.22	17.71	SCL.
	20-40	1.21	7.93	0.61	50.44	24.21	2.67	16.91	SCL
	40-110	1.06	8.23	0.34	39.88	14.89	4.17	15.30	SCL
17	0-30	5.31	7.80	0.65	41.41	24.00	23.34	16.10	CL
	30-60	3.98	7.86	0.63	39.82	21.84	28.65	14.49	SCL
	60-90	3.61	7.86	0.48	32.69	19.91	34.27	13.29	SCL
	>90	4.00	7.78	0.00	38.10	21.64	27.92	11.68	SCL
18	0-20	1.71	7.80	0.86	40.70	23.94	19.35	16.10	SCL
	20-40	1.67	7.84	0.51	47.43	24.12	20.78	15.70	SCL
	40-60	1.85	7.97	0.18	45.24	13.52	35.64	13.69	SCL
	60-80	2.85	7.85	0.00	26.42	11.91	30.33	11.68	SL
	>80	2.78	7.85	0.00	31.06	11.95	38.23	12.08	SCL
19	0-20	1.40	7.76	0.91	35.84	20.54	0.63	16.91	SCL
	20-40	1.35	7.84	0.82	43.59	22.23	0.67	15.70	SCL
	40-90	1.25	8.04	0.63	33.60	9.68	0.51	14.49	SCL
	>90	1.15	8.23	0.00	38.50	9.57	0.94	11.68	SCL
20	0-20	5.00	7.95	0.79	29.36	24.17	8.54	16.10	SCL
	20-40	2.92	7.99	0.59	31.25	22.59	23.45	14.90	SCL
	40-70	2.79	8.04	0.38	33.13	9.38	17.73	13.29	SCL
	70-100	3.10	7.97	0.00	33.88	7.60	34.44	10.47	SL

* SL: Sandy Loam SCL: Sandy Clay Loam CL: Clay Loam C: Clay L: Loam

Table 4: Tabulate area between land use and land form.

Landform	Rocky	Barren	Under Reclamation	Cultivation	Total area km^2
Foot slope	16.30	0.00	1.01	43.29	60.60
Back slope	26.03	0.42	13.83	115.83	156.11
Summit	25.73	0.38	23.48	30.15	79.74
Vale	0.00	0.00	0.00	16.25	16.25
Tread	0.00	0.00	0.00	35.40	35.40
Low hills	5.22	1.54	14.98	48.65	70.39
Basin	6.68	0.39	2.17	247.35	256.59
Riser	1.03	0.00	0.00	81.70	82.73
Total area km^2	80.99	2.72	55.47	618.62	757.80



Map 4: Distribution of current horizons.

- **Land use and soil horizons:**

From the previous discussion, it can be concluded that, there is a strong relationship between the land use type and the formation of diagnostic horizons (Calcic, Petrocalcic, Gypsic, and Petrogypsic). It's obvious that, all of these horizons are wildly distributed in the cultivated lands as shown in Table 5. Calcic horizon is commonly distributed in the cultivated lands and occupies 288.50 km^2. Gypsic horizon is common in the cultivated lands (16.63 km^2). Petrocalcic horizon is commonly occurring in the cultivated lands and occupies 32.79. km^2. Petrogypsic horizon is commonly occurred in the cultivated lands and occupies 151.33 km^2. This is due to agricultural processes and the irrigation water. Since the formation of these horizons are depend on the water availability and water movement in the soil profile, where these conditions are available in the cultivated lands. So, these horizons are common in these areas. It is worth mentioning that this region has a rainfall rate of approximately 200 mm.year^{-1}.

Table 5: Tabulate area between horizons distribution and land use.

Taxonomy	Rocky	Barren	Under Reclamation	Cultivation	Total area km^2
Calcic	42.23	0.57	18.21	288.50	349.51
Calcic - Petrogypsic	4.29	0.38	4.96	84.48	94.11
Petrogypsic	0.00	1.34	15.68	151.33	168.36
Gypsic - Calcic	10.47	0.00	4.17	15.18	29.82
Petrocalcic	19.39	0.29	10.61	32.79	63.08
Calcic - Petrocalcic	0.00	0.00	0.00	6.20	6.20
Gypsic - Petrocalcic	0.44	0.00	0.00	6.36	6.80
Gypsic	0.00	0.14	0.00	16.63	16.77
Total area km^2	76.82	2.72	53.63	601.48	**734.65**

•Land form and soil horizons:

There is a relationship between the formation of diagnostic horizons (Calcic, Petrocalcic, Gypsic, and Petrogypsic) and the landscape and land form type. It's obvious that, all of these horizons are wildly distributed in the low slopes (0 – 5 %), low hills (25 – 40 m A.S.L.), and in the basin as shown in Table 6. Calcic horizon is commonly distributed in the basin of Mina valley and occupies 123.97 km^2. Whereas Gypsic horizon is commonly distributed in the lower land form positions; it occupies 9.36 km^2 in the basin of Mina valley and occupies 5.45 km^2 in the back slope of high hills. Petrocalcic horizon is occur in lower land form positions such as back slope of the ridge (8.17 km^2), back slope of the high hills (2.51 km^2) flat (3.51 km^2), low hills (4.36 km^2), basin (13.91 km^2), and in the riser (5.55 km^2). Petrogypsic horizon is commonly occurred in the lower land forms and occupies 60.21 km^2 in the basin, 38.39 km^2 in the back slope of the high hills, 15.34 km^2 in the foot slope of the high hills, and 14.99 km^2 in the low hills. This is due to the lower land form position which increases the amount of effective precipitation and the water movement through the soil profile and consequently leads to high leaching of calcium carbonate and gypsum.

Table 6: Tabulate area between horizons distribution and land form.

Land form	Calcic	Calcic_ Petrogypsic	Petrogypsic	Gypsic_ Calcic	Petrocalcic	Calcic_ Petrocalcic	Gypsic_ Petrocalcic	Gypsic	Total area km^2
foot slope	39.25	0.59	15.34	4.81	0.06	0.00	0.00	0.00	60.04
back slope	57.89	15.02	38.39	13.98	10.68	6.16	5.52	5.45	153.09
summit	16.73	13.32	17.64	1.40	25.03	0.03	1.29	1.95	77.38
Vale	5.61	0.67	0.00	5.74	3.51	0.01	0.00	0.00	15.54
tread	10.59	0.00	12.43	0.00	0.00	0.00	0.00	0.00	23.02
low hills	34.70	11.14	14.99	3.88	4.36	0.00	0.00	0.00	69.08
basin	123.97	49.16	60.21	0.00	13.91	0.00	0.00	9.36	256.61
riser	60.76	4.21	9.36	0.00	5.55	0.00	0.00	0.00	79.89
total area km^2	349.50	94.11	168.36	29.82	63.09	6.20	6.80	16.77	**734.65**

According to the previous discussion, the formation of Petrocalcic and Petrogypsic horizons could be attributed to the following factors (Table 7):

1-Land use:

Cultivation land use is the most effective factor in the formation of Petrocalcic and Petrogypsic horizon.

2-Parent material:

This factor has a strong role in the formation of these horizons. The parent material in the studied area is Pleistocene marine calcareous deposits which lead to the formation of Petrocalcic and Petrogypsic horizons.

3-Land form:

The lower land form positions are play an important role in the formation of Petrocalcic and Petrogypsic horizons.

4-Slope gradient:

The low slope is the most suitable condition for the formation of Petrocalcic and Petrogypsic horizon. This is due to the increasing of effective water and more percolating water through the soil profile and vice versa. The dominant slope gradient in the studied area ranges between 0 - 5 % (Level to nearly level).

Table 7: The Common conditions effective in the formation of diagnostic horizons.

Horizon	Elevation m A.S.L.	Slope %	Parent marital	Land use	Depth cm
Calcic	10 - 67	0 – 0.39	Marine Calcareous deposits	Cultivated with wheat – sweet melon – tomato – maize – clover	35 – 68
Calcic – Petrogypsic	30 - 45	0.44 – 1.23	Marine Calcareous deposits	Cultivated with wheat – maize – clover	14 – 36 > 58
Petrogypsic	5 - 50	0.45 – 2.46	Marine Calcareous deposits	Cultivated with maize or prepared for cultivation	> 48
Gypsic – Calcic	34 - 48	0.23 – 1.73	Marine Calcareous deposits	Cultivated with wheat – tomato – sweet melon –	60 – 91 24 – 55
Petrocalcic	17 - 66	0.58 – 1.24	Marine Calcareous deposits	Cultivated with beans – wheat – clover	64
Calcic – Petrocalcic	46 - 49	0.51 – 0.66	Marine Calcareous deposits	Cultivated – scattered vegetation	5 – 25 > 36
Gypsic – Petrocalcic	45	0.87	Marine Calcareous deposits	Cultivation	70 – 100 > 100
Gypsic	30 - 49	0.83 – 0.89	Marine Calcareous deposits	Cultivated with maize	50 – 80

CONCLUSIONS

- The present study revealed that, GIS combined with other source of data are powerful tools for the detection of Petrocalcic and Petrogypsic horizons.

- More than 260 km^2 in the area are suffering from the occurrence of Petrogypsic horizon.
- More than 75 km^2 in the area are suffering from the occurrence of Petrocalcic horizon.
- Considerable decrease in the formation of Petrocalcic and Petrogypsic horizon can be achieved by adding more organic matter, enhancement the drainage system and use the sub soil plough.

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استخدام نظام المعلومات الجغرافية لتتبع وجود الآفاق الوراثية المتصلبة (الكلسية – الجبسية) في الاراضى المزروعة بمنطقة مريوط – مصر

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تهدف هذه الدراسة إلى استخدام نظم المعلومات الجغرافية ، والإستشعار عن بعد إلى جانب غيرها من البيانات فى عملية تتبع الأفاق الوراثية المتصلبة (الجبسية والكلسية) في الأراضي المزروعة بمنطقة مريوط – مصر ، وتقع منطقة الدراسة فى الجزء الشمالى الغربى لدلتا النيل بين خطى طول ١٣،٦٠´ ٣٥´ ٢٩° و ٣،٢٥ ´ ٥٧´ ٢٩° شرقا وبين دائرتي عرض ´١٥، ٠ ´ ٤٥ ´٣٠° و ٣٥،٤٧ ´ ٥٦´ ٣٠ ° شمالا.

باستخدام نظام المعلومات الجغرافية وبيانات الاستشعار عن بعد تم عمل خريطة الاساس لمنطقة الدراسة. تم تجميع نتائج ٣٩ قطاع أرضى من أحدث الدراسات السابقة للمنطقة ، وتم تحديد مواقع هذه القطاعات فى منطقة الدراسة . هذه القطاعات تم استخدامها كقاعدة بيانات مكانية للدراسة الحالية . وبناءا على توزيع هذه القطاعات فى منطقة الدراسة تم تحديد ٣ مساحات ممثلة تضمنت حفر ٢٠ قطاع أرضى وتم فحصهم مورفولوجيا. تم اجراء التحليلات المعملية الطبيعية والكيميائية لعينات التربةالمأخوذة من القطاعات الأرضية.

أوضحت الدراسة أن أراضى المنطقة تتبع تحت المجاميع الكبرى التالية Sub great group:
Typic Petrocalcids ،Typic Haplocalcids ،Calcic Petrocalcids ، Calcic Petrogypsids ،Petrocalcic Petrogypsids ،Sodic Haplocalcids ،Typic Calcigypsids ،Typic Haplogypsids ،Typic Haplocambids ، Typic Petrogypsids.

أظهرت نتائج الدراسة وجود أربعة أفاق تشخيصية فى منطقة الدراسة وهى الأفق الكالسى Calcic والأفق الجبسى Gypsic و الأفق الكالسى المتصلب Petrocalcic والأفق الجبسى المتصلب Petrogypsic وكان الأفق الكالسى هو الأكثر إنتشارا فى المنطقة. تم عمل خريطة التوزيع الحالى للأفاق الوراثية السابق ذكرها وكان توزيعها كما يلى : الأفق الكالسى يغطى مساحة قدرها ٣٤٩،٥١ كم^{٢} ،الأفق الجبسى المتصلب يغطى مساحة قدرها ١٦٨,٣٦ كم^{٢} ، الأفق الكالسى المتصلب يغطى مساحة قدرها ٦٣،٠٨ كم^{٢} ، الأفق الجبسى يغطى مساحة قدرها ١٦،٧٧ كم^{٢} .

كما أظهرت أيضا نتائج الدراسة أن هناك مجموعة من العوامل التى تساعد على تكوين الأفاق الوراثية المتصلبة الكلسية و الجبسية وهذه العوامل هى : إستخدام الأرض land use ، مادة الأصل parent material ، شكل سطح الأرض land form ، الانحدار slope gradient.

من هذه الدراسة يمكن استنتاج ان المناطق التى تتواجد بها هذه الأفاق الوراثية المتصلبة تحتاج الى درجة عالية من الخدمة لتجنب تأثير هذه الأفاق . هذه الدراسة تؤكد أن نظام المعلومات الجغرافية إلى جانب المصادر الأخرى للبيانات يعتبر وسيلة فعالة لدعم عملية صنع القرار.