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SOIL MAPPING WITH THE AID OF REMOTE SENSING TECHNIQUES AND GIS

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ABSTRACT

The aim of the current study is to employ the advanced techniques of remote sensing and GIS to assess the soil mapping of large areas.

The study area is located at the north east of the Nile Delta. It occupies the entire area of El-Ismaillia Governorate and covers an area of about 2800 km^2.

The ASTER data showed that the physiographic units of the area under investigation were fluvio- marine deposits, river terraces, outwash plain, plain, wadi, wind blown sand, sand dunes, Nile deltaic deposits, depression and rocky land.

The soil map of the studied area generated from the produced physiographic map of the area and the morphological features combined with analytical data of the studied soil profiles. The soil map showed the following subgroups: Typic Haplotorrerts (14%), Typic Torriorthents (25%), Typic Torripsamments (50%), Vertic Torrorthents (2.6 %), Gypsic Haplosalids (2.3 % of the total study area).

INTRODUCTION

Agriculture is an important component of the Egyptian economy and essential for food supply. A great burden is put upon agriculture to increase the national income. Therefore, much attention has been paid on huge agricultural projects

Soil survey and classification are important and even are essential for land use planning and management programmes for agricultural development. The information that is obtained through soil survey investigation may define the soil qualities and identify the soil capability for agriculture.

However it is very important to maintain and conserve the land qualities which can be achieved through successful management programs and continuous and tedious monitoring. Remotely sensing data provide cheep and easy means for assessment and monitoring of agricultural projects.

Ghabour and EL - Taweel (1998), used landsat-5 TM image to identify the physiography of Um-Shaihan area, Northern Sinai Governorate .They could map four geomorphologic units in the area, namely, wadi, floodplain, aeolian sand deposits and sand dunes. The soil of flood plains and terraces are classified as Xeric Torrifluvents, while the soils of aeolian deposits are classified as Xeric Quartzipsamments.

Rajeev and Saxena (2004), experienced the soil mapping using remote sensing data. IRS-1C PAN merged data were interpreted visually in conjunction with Survey of India (SOI) toposheet and available ground data to prepare the physiography-land use (PLU) map. The PLU delineation explained a three-tier approach comprising landform, slope and land use characteristics of a given parcel of land.

Zhou and Wang (2003), developed a machine-learning approach for automated building of knowledge bases for soil resources mapping by using a classification tree to generate knowledge from training data. The knowledge base developed by classification tree was used by the knowledge classifier to perform the soil type classification using Landsat Thematic Mapper bi-temporal images and geographical information system data. The accuracy assessment and analysis of the resultant soil maps suggested that the knowledge bases built by the machine-learning method was of good quality for mapping distribution model of soil classes over the study area.

The aim of the current study is to employ the advanced techniques of remote sensing and GIS to assist the soil mapping of large areas.

MATERIALS AND METHODS

The case study area is located at the north east of the Nile Delta between longitudes 31º 45' 13" and 32º 27' 10" E and latitudes 31º 07' 12" and 30º 12' 22" N, (Fig. 1). It occupies the area of El-Ismaillia Governorate. It is bordered from the north by El-Manzala Lake and the east by the Suez Canal, by El-Temsah Lake to the south and from the west by El-Sharqia Governorate. It covers an area of about 2800 km^2 (about 666490 fed.). The selected area for the current study has potentialities for agricultural use.

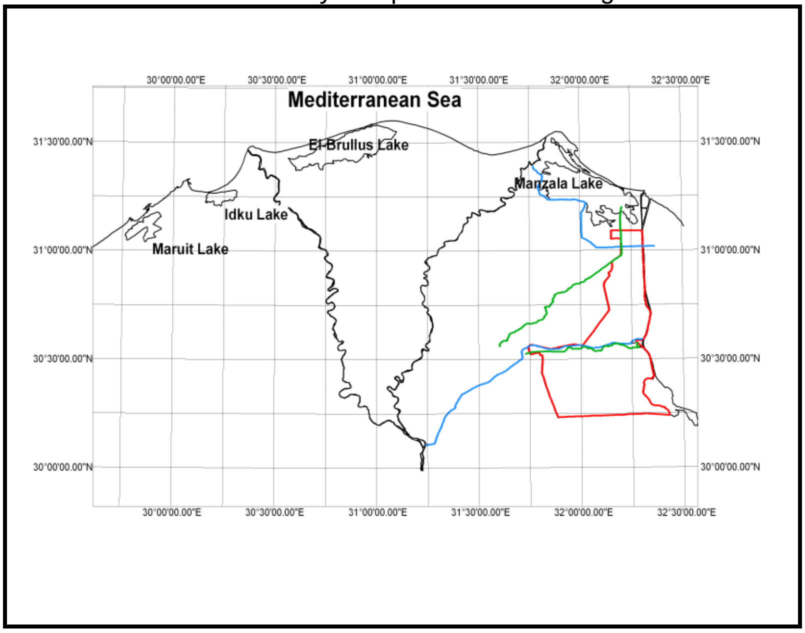

Figure (1): Location map of the case study area

A number of 11 sheets of topographic map at scales 1:50,000 and one sheet at 1:100,000, covered the area, were scanned, geo-referenced and digitized using ERDAS software. Four sheets of the Soil Maps of Egypt at a scale of 1: 100,000 covered the study area.

Two Landsat ETM+ images (path 176 - row 38 and 39 acquired on 11/11/2000) with a Projection UTM (Projection type: UTM, Spheroid name: WSG 84, Datum name: WSG 84, UTM zone 36 N) were obtained. They were geometrically corrected images and covered the study area. A mosaic was assembled of Landsat ETM+ images and reprojected into the ETM system. This mosaic was used as master map to georeference the ASTER images of the study area using image- to image geometric correction module in ERDAS IMAGINE 8.4. The resampling method Nearest Neighbour was selected to resample those images.

Four ASTER scenes that covered the study area and acquired on 26-2-2005, 2-2-2002 (the first two scenes), 31-5-2001 (the last two ones) were ordered. Each scene has 14 spectral bands and covers 60 x 60 km. They were geometrically and radiometrically corrected. These scenes were then joined together to create a mosaic representing the case study area.

Contour segment map was created from the topographic map and used to produce a Digital Elevation Model (DEM) of the study area using ILWIS software. The ASTER colour composite of bands 6, 3 and 1 was draped over the DEM to create a 3D view of the study area. The geopedological approach, (Zinck, 1988) for the physiographic units interpretation was, then, applied to the 3D view. The visual interpretation, by employing the geopedological approach, was conducted to produce soil map. The soil units were checked, then after, in the field. Sixteen soil profiles were selected in the area, morphologically described following FAO (2006) and sampled for laboratory analyses according to Black et al (1982) and De Coninck (1978). They were then classified according to Keys to Soil Taxonomy, (USDA, 2006).

Sixteen soil profiles (Fig. 2) were selected according to the produced physiographic map of the area as well as the variations of the landscape and soils in the field. They were dug, morphologically described on the bases outlined by FAO (2006) and tentatively classified according to USDA (2006). A total number of 37 soil samples representing the different layers of the selected profiles were collected for Lab analyses.

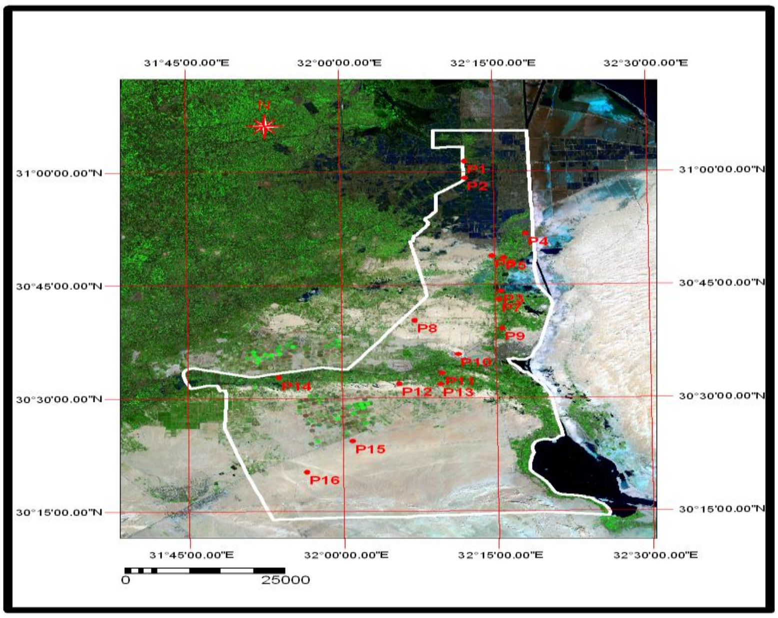

Figure (2): Location map of the selected soil profiles on a CC of ETM+ bands 7, 4 and 2

RESULTS AND DISCUSSION

Physiography of the area

The interpretation of the remotely sensed data for mapping the physiographic units of the area under investigation had been implemented through visual interpretation of the 3D view of the colour composite of ASTER data band 6, 3 and 1. The 3D view was created by draping the colour composite over the DEM which was generated from the digitized contour map of the area.

The classified image (Fig. 3) shows the physiographic units, the northern portion of the area occupied by the fluvio - marine deposits. This area was formed from Nile alluvium and Lake El-Manzala deposits. This physiographic unit covered almost 14% of the area in concern. The river terraces covered a considerable area of the middle part of the study area. It had an area of approximately 45% of the total area under investigations. The outwash plain represented nearly 13% of the area and located in the southern portion and to the north of the rocky land which covered almost 7% and laid along the southern boarder of the study area. Small area of about 1.5% of the area was found to be wadi and was bordering the northern edge the outwash plain.

Wind blown sand unit represented approximately 7% of the study area. It was located in the middle part and extended from east to west. Two areas of sand dunes were laying to the west in the middle portion of study area and represented almost 4.4% of the entire area under investigation. The Nile deltaic deposits formed about 2.6% of the study area and were located to the west of the middle part. A plain physiographic unit was found to the south of the fluvio - marine unit. It covered nearly 2% of the study area.

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The main depression unit was located to the east in the middle proportion of the study area and found to occupy about 2.3% of the total area under investigation. It was low situated area and characterized mostly by high water table level or submerging.

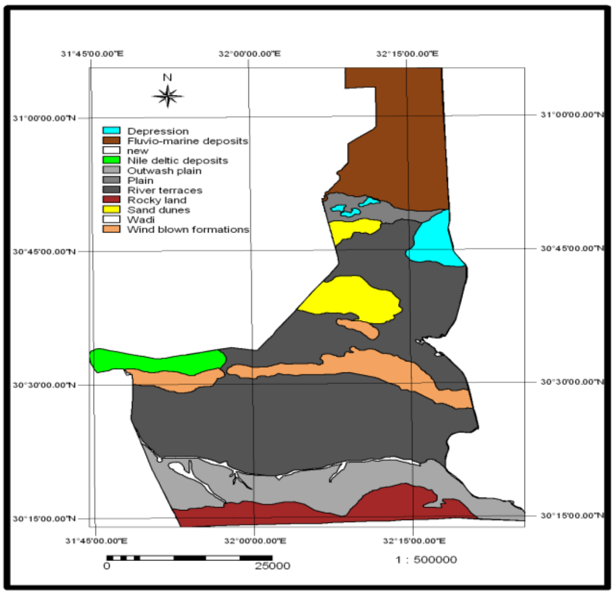

Figure (3): Physiographic units of the case study area

FAO (1966), described two landscapes to the east of Nile Delta; a) fluvio-marine flats and b) river terraces. Both were originated from fluvial and deltaic origins. Between these two landscapes, there is a wide transitional zone, strongly affected by wind action and consisting of nearly flat plains, gypsiferrous swamps, gypsiferrous sandy soils, wind blown sandy soils, with dunes or hummocky relief and small strip of transitional soils.

Table (1): Area of the physiographic mapping units of the case study area

Physiographic units	Area	
	km²	fed
Depression	65.60	15620.00
Nile deltaic deposits	72.64	17294.25
Outwash plain	364.22	86719.81
Plain	57.73	13744.51
River terraces	1302.45	310107.20
Sand dunes	122.95	29274.52
Wadi	32.25	7678.11
Wind blown formations	198.54	47271.91
Fluvio-marine deposits	387.54	92271.39
Rocky land	195.34	46508.71
Total area	2799.26	666490.42

Soils of the area

The soil map of the studied area, (Fig. 4) and the areal coverage, (Table, 2) were generated from the produced physiographic map of the area and the morphological features, (Table, 3), combined with analytical data, (Table 4), of the studied soil profiles. The soil map showed that the soils of El-Ismaillia Governorate belong to five subgroups distributed over the entire area of the governorate at different localities and various acreages.

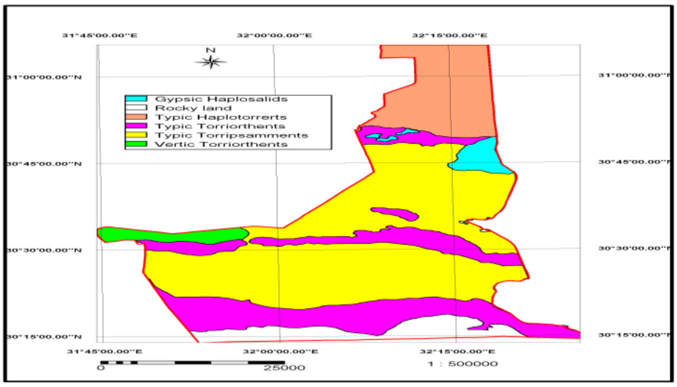

Figure (4): Soil map of the case study area

Table (2): Area of the soil mapping units of the case study area

Soil unit	Area	
	km²	fed
Gypsic Haplosalids	65.60	15620.00
Typic Haplotorrerts	387.54	92271.39
Typic Torriorthents	652.74	155414.35
Typic Torripsamments	1425.40	339381.72
Vertic Torriorthents	72.64	17294.25
Rocky land	195.34	46508.71
Total area	2799.26	666490.42

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Table 4: Chemical analyses of the studied soil profiles

Profile No.	Depth Cm	EC dS/m	pH	Soluble cations in meq/l				Soluble anions in meq/l			OM %	Gypsum %	CaCO$_3$ %
				Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{2-}	SO_4^{2-}			
1	**0-20**	2.60	8.21	4.80	4.46	16.44	0.30	15.65	3.85	6.33	0.83	1.55	7.71
	20-60	5.27	8.25	10.23	9.38	32.19	0.90	32.76	6.97	12.33	0.26	3.66	2.79
2	**0-40**	3.12	8.60	6.48	5.92	18.66	0.14	18.38	3.21	9.00	0.33	1.78	3.91
	40-50	4.06	8.36	11.36	9.30	19.29	0.65	25.56	4.65	9.67	0.08	6.17	1.34
	50-90	4.32	8.42	12.00	10.31	20.62	0.27	24.56	4.84	13.33	0.26	4.22	2.91
3	**0-30**	66.3	7.72	154.84	96.9	391.16	20.1	500.6	9.85	151.67	0.48	25.13	0.78
	30-80	60.5	7.68	137.88	87.01	355.04	25.07	482.3	9.07	113.33	0.87	22.45	3.58
4	**0-30**	4.62	8.03	14.68	8.13	23.13	0.26	29.30	4.71	11.67	0.74	2.98	6.82
	30-80	5.01	8.41	15.15	10.19	24.50	0.26	23.84	6.07	19.67	0.24	3.81	6.59
5	**0-20**	0.88	8.31	1.44	1.63	5.52	0.21	5.73	1.49	1.33	0.67	1.02	3.02
	20-60	2.18	7.54	4.32	9.51	7.35	0.62	11.66	3.71	6.33	0.64	4.81	0.22
	60-100	2.92	7.75	7.92	2.28	18.92	0.08	14.93	3.70	10.33	0.27	5.29	3.91
6	**0-25**	1.02	7.83	1.44	1.04	7.41	0.31	4.91	1.42	3.67	0.28	1.47	3.80
	25-35	4.12	8.07	12.6	4.96	23.34	0.30	23.52	4.71	12.67	0.01	3.67	2.01
	35-90	2.93	8.38	10.08	7.90	10.88	0.44	8.60	2.75	17.67	0.48	2.23	4.02
7	**0-20**	4.71	7.88	6.40	7.00	31.47	2.23	32.94	4.87	9.00	2.07	1.55	3.35
	20-110	1.51	8.55	2.92	1.87	9.72	0.59	6.64	3.26	5.33	0.05	1.11	2.91
8	**0-20**	3.25	8.46	11.52	5.22	15.58	0.18	21.84	4.68	5.67	0.71	1.91	3.02
	20-50	2.25	8.60	4.01	3.56	14.83	0.10	11.83	4.69	5.67	0.12	1.23	4.36
	50-120	1.63	8.16	3.98	5.23	6.76	0.33	8.52	3.21	4.33	0.14	2.36	2.12
9	**0-30**	2.32	8.24	6.98	5.99	9.85	0.38	8.90	2.59	11.33	0.05	1.44	2.23
	30-110	2.56	8.15	8.88	5.16	11.25	0.31	13.96	4.27	8.03	0.12	3.45	2.79
10	**0-30**	1.56	7.98	4.98	3.55	6.79	0.28	7.91	2.17	5.33	0.12	2.45	4.02
	30-120	0.64	7.84	1.01	0.29	5.00	0.10	3.32	1.08	1.67	0.17	0.23	4.36
11	**0-50**	3.55	7.77	9.20	6.27	19.56	0.47	16.14	2.71	7.67	0.28	2.95	4.69
	50-100	2.80	7.45	3.78	11.09	13.05	0.08	13.99	4.49	9.33	0.28	1.88	3.13
12	**0-30**	2.98	7.62	8.48	6.73	14.16	0.43	16.38	4.71	8.67	0.12	2.51	2.46
	30-80	2.02	8.28	4.66	9.96	5.26	0.32	9.16	4.49	6.33	0.50	1.23	4.92
13	**0-10**	1.32	7.72	2.52	2.13	7.81	0.74	5.66	3.77	4.67	1.18	0.47	1.12
	10-40	2.09	8.74	3.38	4.68	12.76	0.08	10.25	4.28	8.67	0.10	1.25	3.27
	40-120	0.76	7.80	1.34	1.01	5.00	0.25	4.09	1.07	3.33	0.32	1.08	3.91
14	**0-35**	2.43	7.82	7.32	4.42	12.57	0.08	10.39	4.71	9.00	2.18	1.20	2.35
	35-80	1.06	8.10	3.14	1.49	6.59	0.38	5.72	3.07	1.67	0.01	1.01	4.69
15	**0-10**	3.28	7.60	10.44	6.82	15.21	0.33	17.56	4.49	10.67	0.01	2.43	2.46
	10-120	2.56	7.44	8.64	8.10	8.81	0.05	12.83	4.79	7.67	0.05	1.11	5.25
16	**0-20**	2.57	7.46	4.98	3.96	16.57	0.18	13.77	3.64	8.00	0.01	1.47	3.46
	20-120	1.15	8.14	1.74	0.89	8.77	0.10	5.28	3.37	2.67	0.01	1.01	2.79

The main properties of these subgroups may be summarized n the following:

Typic Haplotorrerts

The soils belonged to this subgroup were found to be developed on the fluvio-marine landform and covered about 14% of the area. They were, generally, heavy textured soils, slightly to moderately saline having gypsum content ranged between 1.55 and 6.17% and lime fluctuated from 1.34 to 7.71%. The remote sensed data showed that the area was under agricultural use where part of it was cultivated and another part was follow soils. It was also partially occupied by fish ponds. They are among 220 thousand feddans to be reclaimed and irrigated from El-Salem canal in the region west to Suez Canal.

Typic Torriorthents

They were formed on different landforms namely wadis, plains, outwash plains and wind blown sand, therefore they were distributed at different localities over the studied area. These soils covered approximately one-fourth of the entire area under consideration. They were characterized by medium texture, non- to slight salinity, gypsum content between 0.47 and 5.29% and lime content of 0.22% to 4.92%. These soils were mostly cultivated, specially around the irrigation canals (El-Ismaillia Channel), as that appeared on the colour composite of ASTER data bands 6, 3 and 1 or 4, 3 and 2 or 3, 2 and 1 rendered into RGB, respectively. However, the rest of their areas were barren land.

Typic Torripsamments

The soil belonged to this subgroup were developed on both river terraces and sand dunes landforms. They occupied most of the middle and southern portion which represented about half of the study area. They were mainly sandy soils with deep profile, slightly to moderately saline, 1.11% to 3.45% gypsum content and 2.12% to 5.25% lime content. The ASTER data showed that most of the area was barren land and there were attempts to cultivate and reclaim some parts especially, north and South of Wadi El-Tumilat and along the Cairo – El-Ismaillia Road.

Vertic Torrorthents

This type of soil was formed on Nile deltaic deposits which represented nearly 2.6% of the total studied area and located at the west of the middle portion. This soil was characterized by clayey texture, non- to slight salinity, gypsum content of about 1% and lime content of almost 5% or less. The remote sensed data revealed that these soils were intensively cultivated with vigorous vegetation.

Gypsic Haplosalids

The gypsic soils were developed on depressions that mainly existed to the east of the middle part of the study area and covered almost 2.3% of its total area. They were heavy textured soils that had very high gypsum content up of 25% and lime to almost 7% as well as high salinity which reached to about 66 dS/m. The colour composite of ASTER bands 6, 3 and 1 coded in GB showed that considerable portion of the area occupied by swamps of deep and shallow water. However, it was noticed that there was some cultivated and newly reclaimed areas along the irrigation channels and the edges of the swamps.

According to the Soil Map of Egypt, the soils of the case study area were classified into two main soil orders, namely, Aridisols and Entisols, (ASRT, 1982). The Aridisols were distributed among three subgroups, Aquollic Salorthids, Petrogypsic Gypsiorthids and Typic Gypsiorthids. The Entisols, on the other hand, were classified into Typic Quartzipsamments and Typic Torripsamments, Typic Torriorthents and Vertic Torrifluvents.

REFERENCES

ASRT, (1982). The Soil Map of Egypt. Academy of Scientific Research and Technology, Cairo Egypt. General Report.

Black, C.A.; Evans, D.D.; White, J. I.; Ensminger, L. E. and Clark, F. E. (1982). Methods of Soil Analysis. Amer. Soc. Agronomy. Inc. Publisher Madison, Wisconsin, U.S.A.

De Coninck, F. (1978). General chemistry for Soil Scientists. ITC cource, State Univ. of Gent, Belgium. p. 146.

Dubey, R. C. (1992). Satellite remote sensing and its application in agriculture. J. Maharashtra-Agric. Univ., India, 17(1): 112-122.

FAO, (1966). High Dam Soil Survey. Ministry of Agriculture, Egypt, Vol. III.

FAO, (2006). Guidelines for Soil Description. 4th edition. Rome, Italy.

Ghabour, Th. K. and El-Taweel, M. I. (1998). Soil survey and land capability classification of Um-Shaihan area. J. Agric. Sci. Mansoura Univ., 23(12): 5665-5677.

ITC, (2001). ILWIS 3.0 Academic User's Guide. International Institute for Aerospace Survey and Earth Sciences, Enschede, The Netherlands.

Rajeev, S. and Saxena, R. K., (2004). Technique of large-scale soil mapping in basaltic terrain using satellite remote sensing data. International-Journal-of-Remote-Sensing. 2004; 25(4): 679-688

Sabins, F. F. (1987). Remote Sensing Principles and Interpretation, 2nd Edition, W.H. Freeman & Co., 449 pp.

USDA. (2006). Keys to Soil Taxonomy. 10th Edition, Soil Survey Staff, Natural Resources Conservation Service, USDA, USA. p. 341.

Zhou, B. and Wang, R.(2003). Knowledge-based classification in automated soil mapping. Pedosphere-. 2003; 13(3): 209-218.

Zinck, J. A., (1988). Physiography and soils. ITC lecture notes on soil survey course

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إعداد خرائط الأراضى بإستخدام تقنيات الإستشعار عن بعد ونظم المعلومات الجغرافية

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يهدف هذا البحث إلى توظيف التقنيات المتقدمة للإستشعار عن بعد ونظم المعلومات الجغرافية فى إعداد خرائط الأراضى للمساحات الكبيرة.

و تقع المنطقه المختاره للدراسة شمال شرق دلتا النيل وتشغل مساحه محافظه الإسماعيليه بمقدار حوالى 2800 كيلو متر مربع.

ولقد أوضحت الدراسة بإستخدام بيانات الإستشعار عن بعد من نوع ASTER وجود الوحدات الفيزيوجرافيه الآتيه:

الترسيبات النهرية البحرية - الشرفات النهرية - السهول الفيضية - السهول - الأوديه - الرمال السافية - الكسبان الرملية - الترسيبات الدلتاويه - المنخفضات والأراضى الصخرية .

وقد تمت دراسة عدد 16 قطاعا أرضيا أختيرت لتمثل الوحدات الفيزيوجرافية المختلفة وكذلك التغيرات المرئية فى الحقل.

ولقد تم إنتاج خريطة الأراضى لمنطقه الدراسه من الخريطة الفيزيوجرافيه والخصائص المورفولوجيه والتحاليل المعملية للقطاعات الأرضيه الممثله للمنطقة المدروسة، ووجد أن أراضى المنطقة تنقسم إلى خمسه تحت مجموعات Subgroup وهى كالآتى:

Typic Haplotorrerts وتمثل 14% من المساحة الكلية بينما الـ Typic Torriorthents تشغل 25% من المساحة، وتحتل الـ Typic Torripsamments 50% من المساحة المدروسة، وتغطى الـ Vertic Torriorthents 2,6 % من المساحة الكلية، وأخيرا الـ Gypsic Haplosalids تمثل 2,3 % من المساحة الكلية.