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Physiographic Units Delineation and Land Evaluation of North Sinai Coastal Soils using Remote Sensing and Geographic Information Systems

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THE COASTAL belt in north Sinai is considered as one of the most important promising area for agriculture. The study area is located between longitudes 32° 15' and 34° 15' east and latitudes 30° 45' and 31° 15' north. The study aims at the physiographic units delineation and the evaluation of the study area for irrigated agriculture. Evaluation will be aided by geographic data integration and analysis by the modern techniques of remote sensing and geographic information systems (GIS).

The physiographic units resulted from the geographic data (geologic, topographic and satellite image, ETM acquired in 2008) are: (1) Fluvial Aeolian plains, (2) Sand Dunes, (3) Aeolian plains, (4) Wadi plain, (5) Sabkhas, (6) Sandy Beaches and (7) High Lands. These units were verified by in situ data capture and laboratory analysis. Twenty five soil profiles were excavated, morphologically examined, classified and sampled to represent the soil types prevailed in the former units.

The soil properties (wetness, texture, depth, $CaCO_3$, gypsum and salinity and alkalinity) were quantified and evaluated for irrigated agriculture. Suitability classes map (S1, S2, S3 and NS) were produced.

The land suitability classes of the study physiographic units are as follows:

- Soils of fluvial Aeolian plains are of class S2 with minor areas of S1.
- Soils of sand dunes are dominated by class S2 with inclusions of S3 and N classes.
- Both of Aeolian plains and wadi plains are dominated by S3 with less abundant by S2.
- Soils of the sabkhas are dominated by S3 and N classes.
- The high land soils are of N suitability class and those of sandy beaches exert S2 class.

Recently, the management of desert soils in Egypt is receiving a special attention. The government of Egypt has paid a great attention to Sinai by supplying the Nile water to limited areas in the northern sector for the purposes of agriculture development. Sinai Peninsula is one of the promising regions in connection with the hopeful agricultural development in Egypt. El-Shiekh Gaber canal (The part of El-Salam Canal in eastern region of Suez Canal) is one of the main irrigation projects in Sinai. The majority of Sinai still has limited water resources. North Sinai requires more effort in harmonizing the use of its water and land resources through a controlled system, rather than an illegal harmful cultivation and uses.

Sinai Peninsula covers an area of 61000 km^2 extending between longitudes 32° 21⁻ and 34° 53⁻ E and latitudes 27° 44⁻ and 31° 19⁻ N in a triangular shape. It is bounded in the north by the Mediterranean Sea. The Gulf of Suez and Suez Canal are bounding the peninsula to the west and the Gulf of Aqaba and Egypt-Palestine border to the east.

Geology of the studied area

Studies carried out by Said (1962) and El-Shazly *et al.* (1975) revealed that:

The Mesozoic Formations

They are widely distributed through the southern part of north Sinai and are primarily formed of a series of clastic sediments of cretaceous. They include Jurassic and cretaceous Formation. The Jurassic include formation which is constituted of limestone with marl intercalations sand limestone in the upper part. The Cretaceous include Maghara and Hallal Formations. The Maghara Formation represents the early Cretaceous sandstone indicating important Kaoline deposits, while the Hallal Formation is formed of alternate beds of dolomite, limestone, marl and clay. These are commonly rich in fossils.

Tertiary formation

These formations are represented by Pliocene Formations which occupy north part Sinai Peninsula and generally composed of shale intercalated with marl and fossiliferous limestone (Bier El-Abd Formation).

Quaternary Formation

These Formations are represented by surface deposits of Pleistocene and Holocene Formations which cover a large part n of the area especially north of Gabal Maghara. They comprise continental and epicontinental deposits ranging from unconsolidated sand and silt to limestone, claystone and sandstone.

This study aims at defining the physiographic units of North Sinai coastal belt soils and evaluating their soils for irrigated agriculture. Such belt contains the most promising areas for sustainable agriculture.

Material and Methods

The study area is located between longitudes 32° 15' and 34°15' east and latitudes 30° 45' and 31° 15' north (Fig. 1). The mean minimum and maximum annual temperature in the study area are 11.4°C and 31.5°C, respectively (Egyptian Meteorological Authority, 1996). This indicates hyperthermic temperature regime (American Soil Taxonomy, USDA, 2006). The total precipitation registers 100.7 mm /year, indicating torric moisture regime.

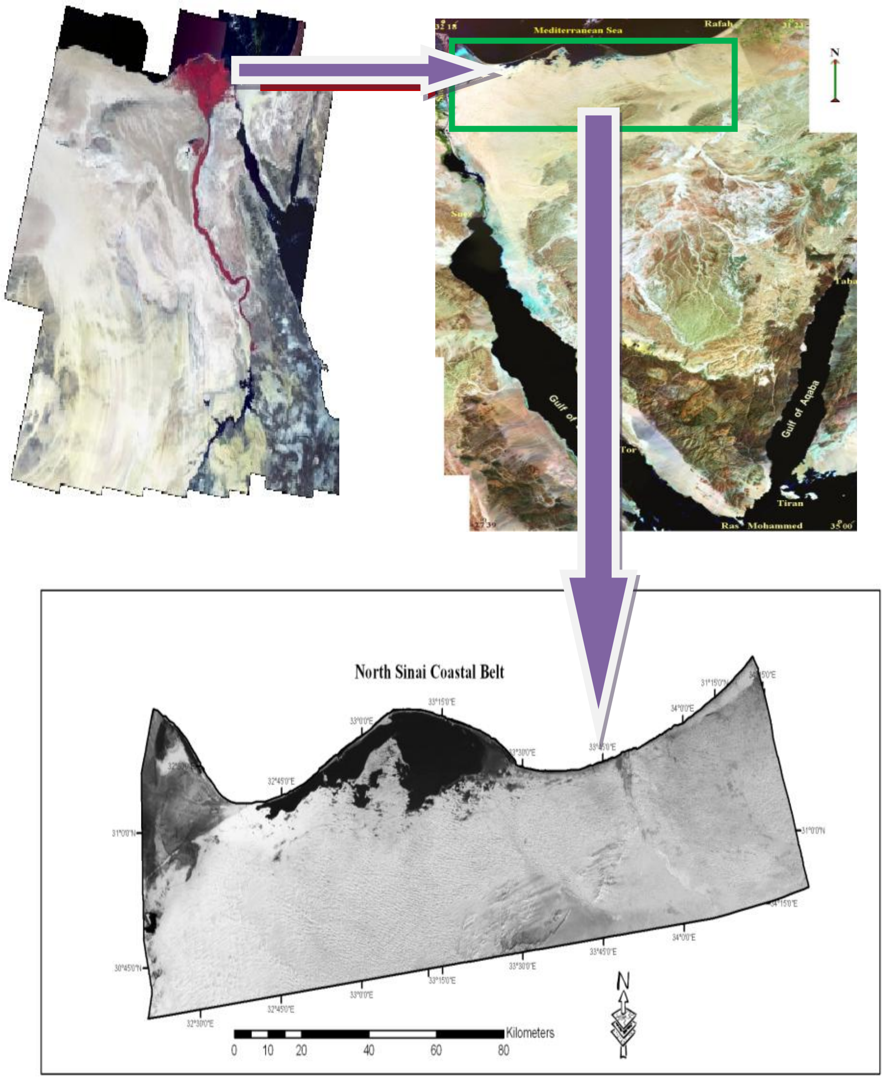

Fig.1. Location map of the study area.

The spatial data used are four ETM images (Path 175 & 176 and Row 38 & 39, acquisition date 2008, Fig. 2) and topographic map (1:100,000 scale, with Geographic WGS projection, Fig. 3).

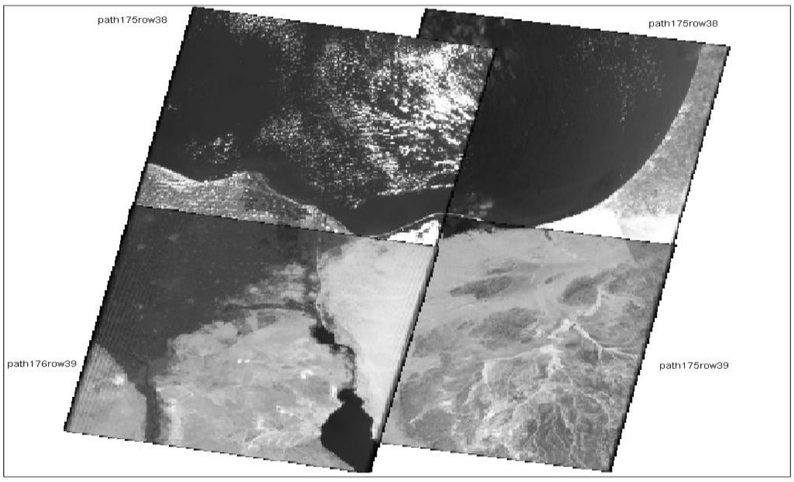

Fig. 2. Multispectral ETM images covering the study area.

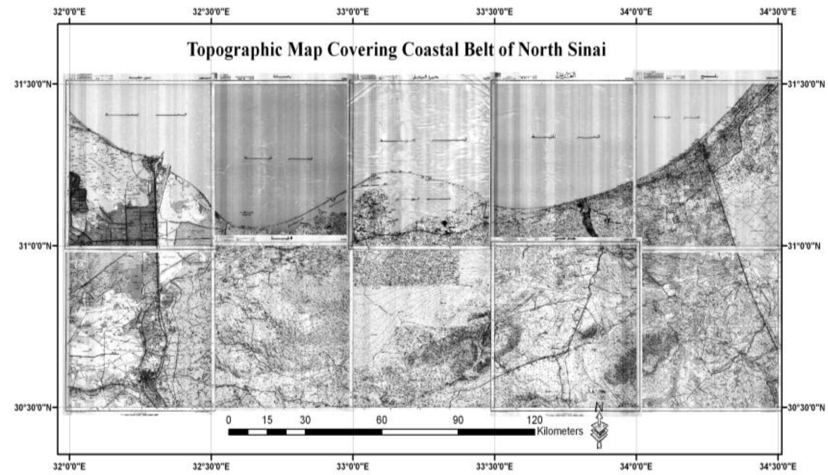

Fig. 3. The topographic Maps (1:100000) Covering the study area.

The GIS operations can be summarized as follows:

1. Extracting the spots height and contour lines from the topographic maps to create the corresponding vector layers by on screen digitizing aided by in Arc GIS-9.
2. The contour lines and the spot height were analyzed in Arc GIS-9. The TIN structure was produced and the profile graph (Fig. 4). Moreover, the Digital Elevation Model (DEM) is created (Fig. 5).

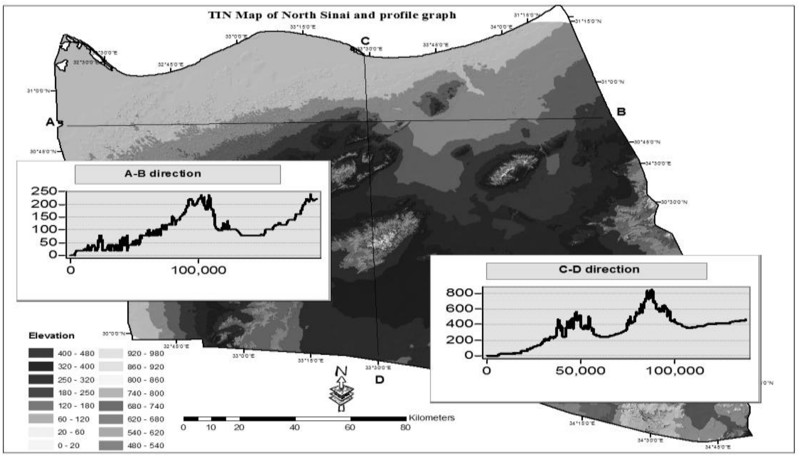

Fig.4. TIN map and profile graph for two transects in the study area.

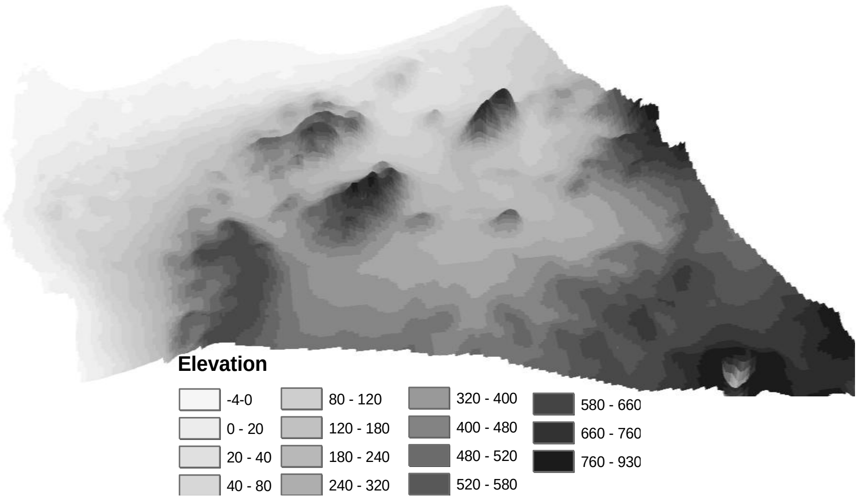

Fig.5. The digital elevation model (DEM) of the study area.

On the light of the DEM and TIN maps and the previous studies of Zink and valenzula (1990) and Doeko goosen (1967), visual interpretation was carried out to delineate the physiographic mapping units of the study area.

The field work was carried out to define the soil components of the different physiographic units. Twenty five soil profiles were allocated by the global positioning system (GPS) to represent the different physiographic units of the study area (Fig. 6). Profile pits were dug to 150 cm depth or to impervious layer or a permanent water table, morphologically described (FAO, 1999), classified and sampled for laboratory analysis.

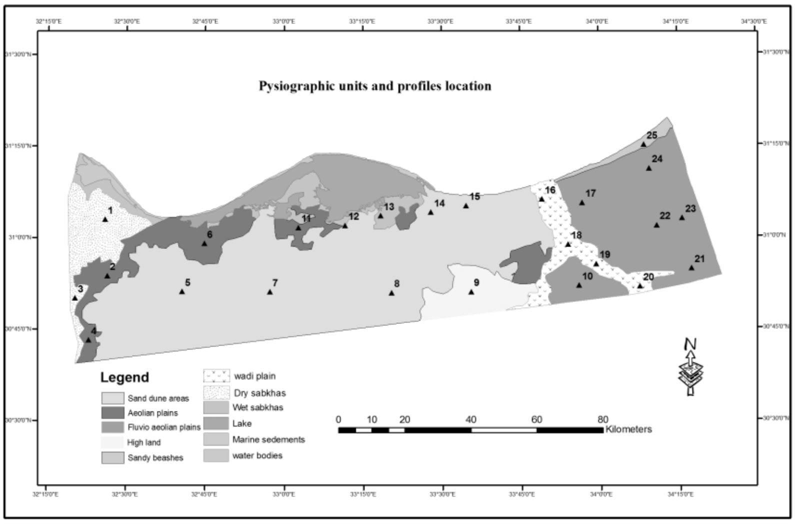

Fig.6. The physiographic units of Coastal Belt and profiles location of the study area.

The soil samples were air dried, crushed, sieved through a 2-mm diameter sieve and subjected to laboratory analyses. Particle size distribution was carried out according to Bashour and Sayegh (2007). pH was determined in the saturated soil paste (Bashour and Sayegh, 2007). Total salinity (ECe) and soluble cations and anions were determined in saturated soil paste extract (Jackson, 1975). Sulphate was calculated by subtracting total anions from total cations. Organic matter content was determined according to the modified procedure in Jackson (1975). Gypsum content was determined by precipitation with acetone (Bashour and Sayegh, 2007). Total carbonates were determined using Bashour and Sayegh (2007) method.

Land capability for irrigated agriculture (Sys and Verheye, 1978) is the commonly used by the FAO System for the arid conditions. Seven land characteristics are considered in this system (slope, wetness, texture, depth, $CaCO_3$, gypsum and salinity/ alkalinity rating) to calculate the suitability index and corresponding suitability class.

Suitability classes are arbitrary defined according the value of the index as follows:

Suitability class		Suitability index (CI)
S_1	suitable	> 75
S_2	moderate suitable	75-50
S_3	marginally suitable	50-25
N	not suitable	< 25

Results and Discussions

The visual interpretation of DEM (Doeko Goosen, 1967), (supported by the auxiliary spatial themes, geology, images and previous studies) is carried out to identify the physiographic mapping units of the study area: Fluvial Aeolian plains, Sand Dunes, Aeolian plains, Wadi plain, Sabkhas, Sandy Beaches, and High Lands (Fig.6). Complementary field truth and laboratory analyses were carried out to produce soil mapping units. For high accuracy merging data help in identify different units. Also, merging data assists in separate the soils from basement rocks and sharpening the boundaries between both of urban areas and arable soils, water logged lands and water bodies.

The current investigation provides information on the dominant soils in the different physiographic units of the study area.

The soils of the different physiographic units are evaluated for irrigated agriculture. The land characteristics that are necessary to apply the evaluation equation will discuss as follows:

The fluvial aeolian plain soils are represented by profiles Nos.10, 17, 21, 22, 23 and 24. The particle size classes majority in the control section is sandy (Profiles Nos. 17, 21 and 24, Tables 1 and 2) with less dominancy of clay (Profile No. 23), fine loamy (Profile No. 22) and sandy over fine loamy (Profile No. 10). The top soil particle class is dominated by sandy.

The soils are considered sodic if the pH $\geq$ 8.5 and ESP $\geq$ 15 and considered non-sodic if pH $<$ 8.5 and ESP $<$ 15. Accordingly, soils of such unit are non sodic.

The data show that soils majority are non saline with less abundance of moderately saline (ECe values ranged from 0.35 to 11.75 $ds.m^{-1}$). $CaCO_3$ content varies from 8.8 to 284 g/ kg with general increase depthwise. Gypsum content shows minute values being in the range of 3.1 to 14.1 g/kg. Organic matter content is in negligent values, it ranges between 0.1 to 3.8 g/kg.

The sand dune soils are represented by profiles Nos.5, 7, 8, 12 and 15 (Tables 1, 2). The data show that the dominant particle size class is sandy with less dominance of coarse loamy. The soils are non-sodic as pH values ranged from 7.2. to 8.3 . The data show that majority of the soils are non saline with less abundance of strongly saline, where EC_e values ranged from 0.62 to 31.3 $ds.m^{-1}$. $CaCO_3$ content is very low (ranges from 2.1 to 45 g/ kg). Gypsum content, however, varies from 2.3 to 69.6 g/kg. Organic matter content is scarce and not exceeds 1.6 g/kg.

The aeolian plain soils are represented by profiles Nos. 2, 4, 6 and 11. The dominant textural class is sandy with less dominancy by coarse loamy. These soils are non-sodic (pH values range from 6.7 to 7.8). Majority of the soils are non saline, exceptionally soils of profile No.12 which are moderately saline. Gypsum and lime contents are very low. Organic matter content is in negligent values not exceeding 4.5 g/kg.

The Wadi plain soils are represented by profiles Nos. 16, 18, 19 and 20. These soils show heterogeneous particle size classes in the control section, *i.e.,* sandy, loamy over sandy, sandy over clayey and fine loamy (Table 1). Soil salinity of the control section range between non- and strongly saline. The soils are non-sodic as pH values, range from 6.8 to 8.1. $CaCO_3$ content ranges between 4.6 and 410.0 g/kg, gypsum content range from 5.1 to 29.1 g/kg. Organic matter content is in scarce ranges from 0.1 to 9.1 g/kg.

The sandy beaches soils are represented by profile No.25. Table 1 reveals that these soils have sandy texture class. The soils are non-sodic as pH values ranged from 7.8 to 8.2. The soils are non saline, and exert scarce lime, gypsum and organic matter contents.

The high land soils are represented by profile No. 9. The soils are moderate deep and exert coarse loamy textural class as shown Table 1. The soils non-sodic (pH values range from 7.2 to 7.5) and non saline as ECe values range from 1.8 to 2.91 $ds.m^{-1}$. $CaCO_3$ and gypsum content are in low values showing an increase depthwise. Organic matter content is very scarce owing to the scarce precipitation, very poor vegetation cover and very high organic matter decomposition.

The Sabkha soils are represented by profiles Nos. 1, 3 and 13. These soils exert varieties in textural classes, *i.e.,* sandy and fine loamy over sandy in the control section (Tables 1,2). The soils are non-sodic as PH values which range from 6.6 to 8.27. The control section exert strongly saline soils with less abundance of moderately saline as ECe values which ranges from 3.11 to 147.5 $ds.m^{-1}$. $CaCO_3$ content ranges between 18.0 and 65.0 g/kg (Table 3).

The land suitability of the study area can be summarized (Fig. 7) as follows;

- Soils of fluvial Aeolian plains are of class S2 with minor areas of S1.
- Soils of sand dunes are dominated by class S2 with inclusions of S3 and N classes.
- Both of Aeolian plains and wadi plains are dominated by S3 with less abundant by S2.
- Soils of the sabkhas are dominated by S3 and N classes.
- The high land soils are of N suitability class and those of sandy beaches exert S2 class.

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TABLE 1. Particle size distribution and some chemical properties of the northern coastal belt soils of Sinai.

Geomorphic unit	Profile No.	Depth, cm	Particle size distribution (%)					Textural class	$CaCO_3$ g.kg	Gyp. g.kg	O.M. g.kg
			Coarse sand	Fine sand	Total sand	Silt	Clay				
Fluvial aeolian plain	10	0-13	65.7	29.3	95	1.0	4.0	sand	42. 0	5.2	1.8
		13-40	61.8	28.3	90.1	2.5	7.5	sand	61.0	6.9	0.8
		40-85	40.1	7.0	47.1	18.0	35.0	sandy clay loam	284. 0	8.4	1.0
		85-120	25.6	19.4	45	15.0	40.0	sandy clay	192.0	8.9	1.1
	17	0-15	42.5	47.3	89.8	6.7	3.5	sand	18.0	14.1	3.8
		15-50	31.8	60.7	92.5	2.5	5.0	sand	43.0	8.4	1.2
		50-120	24.7	68.6	93.3	4.2	2.5	sand	43.0	8.7	2.5
		120-150	35.1	59.9	95	4.0	1.0	sand	43.0	8.6	0.2
	21	0-20	54.5	38.0	92.5	5.0	2.5	sand	63.0	5.2	3.8
		20-40	62.7	25.3	88	7.5	4.6	sand	67.0	10.4	2.1
		40-120	55.0	32.5	87.5	5.0	7.5	sand	33.0	10.4	1.2
	22	0-23	38.6	26.4	65	10.0	25.0	sandy clay loam	142.0	3.5	2.7
		23-52	39.3	25.7	65	12.5	22.5	sandy clay loam	188.0	3.4	1.8
		52-85	35.2	26.8	62	13.0	25.0	sandy clay loam	217.0	3.9	0.7
		85-120	41.3	31.2	72.5	12.5	15.0	sandy loam	184.0	6.2	0.5
	23	0-15	40.1	32.4	72.5	12.5	15.0	sandy loam	16.0	6.1	0.3
		15-60	39.3	25.7	65	12.5	22.5	clay loam	8.80	4.5	0.0
		60-115	35.2	26.8	62	13.0	25.0	clay loam	47.0	3.1	0.7
		115-150	41.3	31.2	72.5	12.5	15.0	loamy sand	64. 0	5.4	0.4
	24	0-20	29.0	58.5	76.5	2.5	10.0	loamy sand	63.0	5.2	0.2
		20-100	32.3	53.7	94	3.0	11.0	loamy sand	75.0	7.0	0.1
		100-150	50.6	25.9	70.5	8.5	15.0	sandy loam	100.0	8.8	0.1
Sand dune	5	0-30	67.6	30.4	98	1.5	0.5	sand	02. 1	5.2	1.0
		30-90	46.0	48.5	94.5	3.0	2.5	sand	11.0	3.4	0.3
		90-150	42.0	54.5	96.5	1.0	2.5	sand	16.0	2.6	1.6
	8	0-25	71.9	24.1	96	1.9	2.1	sand	08.3	5.9	0.2
		25-90	68.5	26.0	94.5	1.3	4.2	sand	15.0	6.9	1.5
		90-150	58.2	36.0	94.2	3.5	2.3	sand	06.3	10.3	0.3
	7	0-20	77.2	16.8	94	2.5	3.5	sand	02.1	6.9	1.3
		20-80	74.6	20.0	94.6	3.6	1.8	sand	13.0	8.8	0.5
		80-120	77.1	19.9	97	1.8	1.2	sand	13.0	8.8	1.0
	12	0-15	54.2	41.5	95.7	1.6	2.8	sand	25.0	55.0	0.5
		15-70	71.5	20.4	91.9	3.6	4.5	sand	21.0	16.0	1.0
	14	0-25	73.06	10.62	83.68	10.51	5.81	loamy .sand	24.5	1.8	0.3
		25-75	72.20	11.95	84.15	9.50	6.35	loamy Sand	16.5	2.3	0.4
		75-150	69.61	12.01	81.62	13.13	5.25	loamy .sand	39.3	2.5	0.3
	15	0-20	49.3	28.2	77.5	7.5	15.0	sandy loam	33.0	69.6	0.4
		20-65	31.0	44.1	75.1	10.0	15.0	sandy loam	45.0	24.0	1.0
		65-100	41.3	31.2	72.5	12.5	15.0	sandy loam	36.0	11.0	0.3

TABLE 1. Contd.

Geomorphic unit	Profile No.	Depth, cm	Particle size distribution (%)					Textural class	$CaCO_3$ g.kg	Gyp. g.kg	O.M. g.kg
			Coarse sand	Fine sand	Total sand	Silt	Clay				
Aeolian plain	2	0-19	25.8	41.8	67.6	12.5	20.0	sandy loam	25.0	60.0	3.0
		19-40	32.6	42.4	75	7.5	17.5	sandy loam	16.0	58.8	4.5
		40-80	54.9	15.6	70.5	10.5	19.0	sandy loam	21.0	3.7	2.0
		80-120	69.3	25.7	95	2.5	2.5	sand	04.0	8.4	1.0
	4	0-10	39.0	49.0	88	6.5	5.5	sand	46.0	7.0	1.0
		10:30	49.8	46.2	96	2.0	2.0	sand	21.0	5.1	0.6
		30-120	41.9	53.2	95.1	1.5	3.5	sand	19.0	14.1	1.4
	6	0-31	41.0	55.5	96.5	1.0	2.5	sand	16.0	2.6	1.6
		31-83	53.5	41.5	95	1.5	3.5	sand	16.0	5.2	1.6
		83-120	48.0	48.5	96.5	2.0	1.5	sand	11. 0	3.4	0.3
	11	0-25	60.4	37.1	97.5	1.0	1.5	sand	25. 0	1.7	1.8
		25-85	67.4	28.6	96	1.3	2.8	sand	25. 0	1.7	1.3
		85-120	68.5	29.6	98.1	1.0	1.0	sand	43. 0	5.2	1.0
Wadi plain	16	0-28	63.2	29.3	92.5	2.5	5.0	sand	108.0	10.3	2.0
		28-45	70.9	9.1	80	5.0	15.0	sandy loam	146.0	8.6	9.1
		45-120	62.2	21.3	83.5	4.6	12.0	loamy sand	184.0	10.1	7.6
		120-150	76.6	8.4	85	5.0	10.0	loamy sand	225.0	10.2	1.5
	18	0-13	72.9	16.7	89.6	5.0	5.5	sand	125.0	8.8	2.0
		13-48	65.2	20.1	85.3	8.4	6.3	loamy sand	150.0	8.9	1.0
		48-100	25.1	7.9	33	22.0	45.0	clayey	367.0	19.6	1.4
		100-120	15.0	7.5	22.5	25.0	52.5	clayey	410.0	12.7	0.1
	19	0-10	37.7	54.9	92.6	2.0	5.5	sand	92.0	6.8	2.1
		10-45	61.3	26.9	88.2	7.5	4.3	sand	92.0	5.1	1.4
		45-75	55.8	36.7	92.5	2.0	5.5	sand	4.60	8.8	1.1
		75-115	51.2	38.3	89.5	5.0	5.5	sand	21.0	7.0	0.6
		115-150	81.1	9.2	90.3	3.2	6.5	sand	16.0	7.0	0.2
	20	0-15	52.2	20.4	72.6	10.0	17.5	sandy loam	130.0	7.2	0.5
		15-75	51.2	3.8	55	15.0	30.0	sandy clay loam	301.0	26.9	1.1
		75-100	47.5	9.5	57	11.0	32.0	sandy clay loam	301.0	29.1	0.1
Sandy beaches	25	0-25	77.50	9.37	86.87	9.03	4.10	Sand	25.0	3.5	0.1
		25-75	73.06	10.62	83.68	10.51	5.81	loamy sand	130	2.3	0.3
		75-150	72.20	11.95	84.15	9.50	6.35	loamy sand	07.0	1.8	0.2
High land	9	0-24	63.9	30.1	94	1.0	5.0	sand	27.0	4.2	0.1
		24-40	50.3	20.2	70.5	20.0	9.5	sandy loam	42.0	21.0	0.1
		40-75	31.0	44.1	75.1	10.0	15.0	sandy loam	221.0	26.2	0.1
Sabkha	1	0-25	30.15	12.56	42.71	17.25	40.04	Clay	18.0	81.0	10.6
		25-75	51.30	5.21	56.51	9.75	33.05	Sandy clay loam	20.0	58.0	6.5
		75-130	65.51	19.73	85.24	5.75	9.02	loamy sand	28.6	51.0	7.3
	3	0-17	65.0	8.9	73.9	15.6	10.5	sandy loam	63.0	50.2	1.5
		17-31	65.0	21.1	86.1	6.4	7.5	sand	65.0	64.4	1.8
		31-51	72.2	14.0	86.2	8.5	5.4	loamy sand	50.0	16.5	0.7
		51-100	75.6	12.0	87.6	3.5	9.0	loamy sand	54.0	8.4	0.5
		100-120	79.0	16.8	95.8	1.7	2.6	sand	54.0	6.7	0.8
	13	0-8	54.2	41.5	95.7	1.6	2.8	sand	25.0	65.0	1.0
		8:30	71.5	20.4	91.9	3.6	4.5	sand	21.0	9.5	0.0

O.M. = Organic matter. Gyp. = Gypsum.

TABLE 2. Chemical properties of the northern coastal belt soils of Sinai .

Geomorphic unit	Profile No.	Depth, cm	pH	EC (dS/m)	Soluble ions in the saturated soil paste extract (Meq./L)							E.S.P (%)
					Cations				Anions			
					Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	$SO_4^=$	Cl^-	
Fluvial aeolian plain	10	0-13	7.35	0.44	3.20	2.10	3.10	0.27	0.25	3.00	1.15	27.3
		13-40	6.90	1.35	4.30	3.56	5.30	0.34	1.20	11.00	1.30	29.1
		40-85	6.90	11.75	26.30	43.70	47.80	0.34	2.10	125.00	13.90	27.7
		85-120	7.10	10.72	41.60	35.60	29.50	0.51	0.70	96.00	31.90	22.1
	17	0-15	7.80	1.02	2.26	2.15	5.50	0.29	1.10	7.00	2.10	17.6
		15-50	7.70	2.50	12.76	7.68	4.40	0.16	0.50	22.00	2.50	11.6
		50-120	7.60	1.28	5.10	3.14	4.40	0.16	0.60	11.00	1.20	14.8
		120-150	7.60	2.47	8.60	5.50	10.30	0.3	0.90	21.00	2.80	21.3
	21	0-20	8.20	0.60	2.10	2.40	1.30	0.2	0.25	3.70	2.05	10.7
		20-40	7.50	2.21	7.50	4.25	9.80	0.55	0.50	20.00	1.60	11.3
		40-120	7.70	1.54	7.10	4.74	3.20	0.36	1.50	10.60	3.30	13.0
	22	0-23	7.70	0.64	0.50	3.10	2.70	0.2	0.50	4.00	1.90	10.5
		23-52	7.40	1.20	6.20	4.10	1.60	0.1	0.50	10.00	1.50	13.3
		52-85	7.20	4.28	13.50	15.50	13.70	0.16	1.50	38.50	2.80	8.0
		85-120	7.10	6.11	26.70	30.80	3.30	0.2	0.50	57.00	3.60	5.4
	23	0-15	7.60	0.98	4.50	3.60	1.50	0.2	0.75	3.50	5.50	12.3
		15-60	7.70	0.64	0.50	3.10	2.70	0.2	0.50	4.00	1.90	13.3
		60-115	7.40	1.20	6.20	4.10	1.60	0.1	0.50	10.00	1.50	8.0
		115-150	7.20	4.28	13.50	15.50	13.70	0.16	1.50	38.50	2.80	5.4
	24	0-20	7.50	0.79	2.80	3.00	2.50	0.27	1.40	4.00	2.50	5.2
		20-100	7.65	0.35	2.30	0.70	0.26	0.22	0.90	1.50	1.10	7.5
		100-150	7.60	0.40	1.80	1.40	0.60	0.17	0.25	2.10	1.70	4.1
Sand dune	5	0-30	7.50	0.62	1.80	2.30	1.20	0.9	0.50	3.00	2.70	4.25
		30-90	7.70	0.74	2.20	1.40	3.30	0.51	0.30	5.00	2.10	6.3
		90-150	7.50	1.19	3.40	3.40	4.60	0.53	0.25	9.00	2.70	7.2
	8	0-25	7.20	2.42	8.40	8.20	7.40	0.9	0.90	4.50	18.80	6.4
		25-90	7.40	1.35	5.20	3.10	4.70	0.5	1.10	4.00	8.40	7.5
		90-150	7.40	1.93	8.30	6.70	3.90	0.4	1.80	8.00	9.50	9.5
	7	0-20	7.50	1.53	2.10	8.30	4.50	0.44	2.50	8.00	4.80	8.4
		20-80	7.60	0.92	1.10	4.10	3.70	0.3	1.50	5.50	2.20	7.6
		80-120	7.60	0.70	2.10	2.20	2.40	0.3	0.50	4.10	2.40	6.3
	12	0-15	7.20	31.30	142.00	136.60	60.00	1.5	0.35	320.00	290.0	17.6
		15-70	7.40	12.40	37.30	32.60	36.90	0.8	0.50	82.00	46.60	16.2
	14	0-25	8.30	0.37	1.70	0.35	1.35	1.95	1.10	0.65	1.95	17.3
		25-75	8.19	0.29	1.01	0.53	1.15	1.00	1.30	0.60	1.00	12.1
		75-150	8.27	0.30	1.00	0.24	1.66	0.90	1.15	0.95	0.90	20.3
	15	0-20	7.70	14.18	35.30	61.30	54.70	1.1	1.50	137.00	31.20	26.8
		20-65	7.80	17.14	149.00	75.10	8.60	7.3	3.20	120.00	116.00	17.1
		65-100	8.20	10.76	37.30	32.60	36.90	0.8	0.50	82.00	46.60	15.5
Aeolian plain	2	0-19	6.20	27.20	76.30	142.00	140.00	2.2	3.50	340.00	17.00	10.8
		19-40	6.70	15.34	83.00	75.50	33.90	1.8	2.50	185.00	6.70	15.5
		40-80	6.80	12.27	44.20	61.00	31.50	1.5	0.50	132.00	5.70	11.8
		80-120	6.40	3.93	15.10	13.30	10.90	0.6	1.50	35.00	3.40	13.3
	4	0-10	7.30	0.79	2.20	2.58	2.70	0.42	1.60	4.50	1.80	26.2
		10:30	7.20	1.67	4.50	6.10	5.90	0.25	2.30	11.50	2.90	30.8
		30-120	7.38	1.17	3.20	2.50	5.90	0.11	0.90	8.10	2.70	20.8
	6	0-31	7.80	1.10	3.10	2.10	5.10	0.71	0.50	7.20	3.30	21.8
		31-83	7.70	0.74	2.20	1.40	3.30	0.51	0.30	5.00	2.10	20.8
		83-120	7.50	1.19	3.40	3.40	4.60	0.53	0.25	9.00	2.70	24.2
	11	0-25	7.45	0.44	1.80	1.90	0.50	0.25	0.75	2.20	1.45	11.2
		25-85	7.42	0.50	1.20	1.10	1.50	0.22	0.35	3.00	1.70	27.8
		85-120	7.33	0.76	2.60	2.00	2.70	0.24	1.30	4.50	1.80	35.8

TABLE 2. Contd.

Geomorphic unit	Profile No.	Depth, cm	pH	EC (dS/m)	Soluble ions in the saturated soil paste extract (Meq./L)							E.S.P (%)
					Cation				Anion			
					Ca++	Mg++	Na+	K+	HCO_3^-	$SO_4^=$	Cl^-	
Wadi plain	16	0-28	7.80	3.62	12.70	11.20	9.50	4.2	0.50	31.00	4.70	9.3
		28-45	7.80	3.70	8.56	11.60	20.00	1.9	1.50	32.30	3.20	12.6
		45-120	6.70	5.77	17.60	22.10	16.10	2.1	2.00	50.70	5.00	11.8
		120-150	7.70	4.39	16.00	18.90	7.60	1.4	0.50	38.00	5.40	9.3
	18	0-13	7.80	0.84	3.80	2.28	1.90	0.42	0.90	5.00	2.50	12.6
		13-48	6.90	12.79	53.00	41.40	57.60	0.3	0.75	120.00	32.70	10.1
		48-100	6.80	20.40	80.20	98.80	76.90	0.48	1.50	210.00	94.50	15.0
		100-120	6.80	29.10	82.90	96.70	89.20	0.53	0.45	227.00	210.00	13.1
	19	0-10	7.50	2.07	5.50	9.30	5.50	0.36	0.50	14.50	5.70	10.6
		10-45	7.50	1.69	5.80	6.70	4.10	0.2	1.20	13.80	1.90	14.4
		45-75	7.60	0.75	2.60	2.10	2.80	0.12	1.50	4.00	2.10	8.7
		75-115	7.70	0.59	1.10	2.40	2.40	0.1	0.75	3.50	1.70	16.0
		115-150	8.10	0.46	1.43	1.23	1.80	0.03	0.35	2.00	2.30	11.1
	20	0-15	6.80	12.58	37.30	48.80	58.30	1.8	1.50	150.00	12.10	15.9
		15-75	6.80	18.66	57.70	47.40	86.90	0.51	2.50	230.00	10.60	11.1
		75-100	6.40	16.37	54.50	29.10	80.40	0.46	1.50	190.00	21.30	8.5
Sandy beaches	25	0-25	7.80	0.44	1.60	1.40	1.10	0.32	0.45	2.50	1.45	2.1
		25-75	8.10	0.29	1.01	0.53	1.15	0.21	1.00	1.30	0.60	4
		75-150	8.20	0.30	1.00	0.24	1.66	0.10	0.90	1.15	0.95	5
High land	9	0-24	7.50	1.88	9.50	7.20	1.70	0.6	2.50	5.00	11.30	8.9
		24-40	7.30	2.40	13.10	5.20	4.10	1.6	3.50	6.00	14.50	17.1
		40-75	7.20	2.91	15.30	8.10	4.10	1.6	4.20	12.00	12.90	14.1
Sabkha	1	0-25	7.24	131.8	165.2	1950.0	2100.0	35.5	2.2	2000.0	2248.5	25
		25-75	7.65	87.5	180.0	2100.0	3310.0	30.0	3.2	2600.0	3016.8	35
		75-130	7.50	78.5	163.6	2630.0	3500.0	25.8	3.3	3200.0	3203.3	31
	3	0-17	6.50	133.90	676.00	267.00	1260.00	73.9	2.20	2000.00	408.00	25.5
		17-31	6.40	147.50	821.00	107.00	1791.00	51.2	2.10	2150.00	502.00	17.5
		31-51	7.70	17.14	149.00	75.10	8.60	7.3	3.20	120.00	116.00	13.6
	13	51-100	8.20	4.75	20.50	14.50	10.80	1.7	1.50	36.00	10.00	22.7
		100-120	8.20	3.11	11.00	11.40	7.60	1.1	0.50	30.00	0.60	24.4
		0-8	6.80	34.10	142.00	136.60	60.00	1.5	0.35	320.00	290.00	17.6
		8:30	7.40	10.76	37.30	32.60	36.90	0.8	0.50	82.00	46.60	16.2

ESP = Exchangeable sodium percentage .

TABLE 3. Suitability index and classes of the studied soils according to Syes &Verheye (1978).

Geomorphic units	Profile No.	Topography	Wetness	Texture	Depth	$CaCO_3$	$CaSO_4$	Salinity & alkalinity	Capability index	Grade
Fluvial aeolian plains	10	95.0	100.0	90.0	100.0	73.0	100.0	82.0	51.2	S2
	17	95.0	100.0	65.0	100.0	100.0	100.0	85.0	52.5	S2
	21	95.0	100.0	65.0	100.0	100.0	100.0	90.0	55.6	S2
	22	100.0	100.0	100.0	100.0	75.0	100.0	95.0	71.3	S2
	23	90.0	100.0	100.0	100.0	100.0	100.0	85.0	76.5	S1
	24	95.0	100.0	95.0	100.0	80.0	100.0	95.0	68.6	S2
Sand dunes	5	95.0	100.0	60.0	100.0	100.0	100.0	100.0	57.0	S2
	7	100.0	100.0	55.0	100.0	100.0	100.0	100.0	55.0	S2
	8	90.0	100.0	50.0	100.0	100.0	100.0	100.0	45.0	S3
	12	95.0	85.0	50.0	80.0	100.0	100.0	75.0	24.2	N
	14	95.0	100.0	85.0	100.0	100.0	100.0	75.0	60.6	S2
	15	100.0	90.0	100.0	95.0	100.0	100.0	75.0	64.1	S2
Aeolian plains	2	100.0	65.0	100.0	90.0	100.0	100.0	70.0	41.0	S3
	4	90.0	100.0	70.0	100.0	100.0	100.0	80.0	50.4	S2
	6	95.0	100.0	65.0	100.0	100.0	100.0	80.0	49.4	S3
	11	95.0	100.0	45.0	100.0	100.0	100.0	82.0	35.1	S3
Wadi plains	16	100.0	100.0	80.0	100.0	80.0	100.0	95.0	60.8	S2
	18	100.0	100.0	90.0	100.0	55.0	100.0	90.0	44.6	S3
	19	95.0	100.0	45.0	100.0	100.0	100.0	90.0	38.5	S3
	20	100.0	95.0	95.0	95.0	55.0	100.0	95.0	44.8	S3
Sabkhas	1	100.0	75.0	95.0	100.0	100.0	95.0	55.0	37.2	S3
	3	100.0	100.0	85.0	100.0	95.0	100.0	45.0	36.3	S3
	13	100.0	60.0	45.0	40.0	100.0	100.0	85.0	9.2	N
Sandy Beaches	25	75.0	100.0	85.0	100.0	100.0	100.0	100.0	63.8	S2
High land	9	80.0	75.0	95.0	80.0	85.0	100.0	60.0	23.3	N

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الوحدات الفيزوغرافية وتقييم اراضى الحزام الساحلى لشمال سيناء باستخدام تقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية

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يعتبر الحزام الساحلى بشمال سيناء من اهم المناطق المحتوية على مساحات واعدة ومبشرة للاستغلال الزراعى وتمتد منطقة الدراسة بين خطى طول ¯15 °32 ، ¯15 °34 شرقا وخطى عرض ¯45 °30 ، ¯15 °31 شمالا.

تهدف هذه الدراسة الى التعرف على الوحدات الفيزوغرافية السائدة فى المنطقة وذلك للمساعدة فى دراسات الأراضى وتقييمها للزراعة المروية باستحدام معالجة المرئيات الفضائية وتكامل وتحليل البيانات المكانية (طوبغرافية وجيولوجية) وغير المكانية (الخواص الطبيعية والكيميائية للتربة).

وقد ادى استخدام تقنية دمج البيانات متعددة الاطياف مع مرئية احادية الطيف لنفس القمر الى الحصول على مرئية فضائية ذات قدرة تفريقية عالية و ذات أطياف متعددة فى نفس الوقت و المرئية المنتجة من الدمج تساعد فى فصل الحدود الطبيعية للوحدات الفيزيوجرافية المختلفة.

وأهم البيانات الجغرافية التى تم أستخدامها فى هذه الدراسة: الخرائط الطوبغرافية– الخرائط الجيولوجية– المرئيات الفضائية. ومن خلال معالجة البيانات فى حزمة البرنامج Arc GIS.9.3 تم انتاج نموذج الأرتفاعات الرقمية (DEM).

وباستخدام المنهجية العلمية المتبعة فى تفسير المرئيات الفضائية بمساعدة النموذج DEM فقد أمكن رسم الحدود الجغرافية للوحدات الفيزيوجرافية المكونة لمنطقة الدراسة. وهذه الوحدات هى : سهول رسوبية فيضية– سهول هوائية – كثبان رملية – سهول وديانية – مرتفعات – شاطئ رملى – سبخات.

ولدراسة خواص الأراضى فى منطقة الدراسة فقد تم تحديد وحفر 25 قطاعا أرضيا لتمثل الوحدات الفيزوغرافية السائدة فى منطقة الدراسة بأستخدام منظومة التموضع العالمى GPS- وتم فحص القطاعات مورفولوجيا واخذت عينات من الآفاق المختلفة الأعماق لعمل الفحوصات المعملية (الطبيعية و الكيميائية) .

وبتقييم قابلية الاراضى للاستخدام فى الزراعة المروية المستدامة تبعا لطريقة Sys and Verheye (1978) تم عمل خريطة توضح درجات الصلاحية واتضح الآتى:
أراضى السهول رسوبية فيضية : هى أراضى ذات درجة صلاحية S2 تتخللها وجود مناطق قليلة ذات درجة صلاحية S1.
أراضى السهول الهوائية وأراضى السهول الوديانية: هى أراضى تتميزبدرجة صلاحية S3 تتخللها وجود مناطق عديمة الصلاحية N.
أراضى الكثبان الرملية: هى أراضى ذات درجة صلاحية S2 تتخللها وجود مناطق قليلة ذات درجة صلاحية S1.
أراضى المرتفعات: هى أراضى عديمة الصلاحية N .
أراضى الشاطئ الرملى : هى أراضى ذات درجة صلاحية S2.
أراضى السبخات: هى اراضى ذات درجتى صلاحية S3 و N.
ووجد أن أهم العوامل التي تحد من صلاحية الأرض للزراعة هى: سيادة القوام الخشن وارتفاع نسبة الملوحة والقلوية– نسبة الكربونات – عمق الماء الارضى.