APPLICATION OF REMOTE SENSING AND GIS FOR SOIL MAPPING OF El-HASANA CENTRAL SINAI, EGYPT

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ABSTRACT:

An Area of about 3500 km2 located in the central part of Sinai Peninsula was selected to examine the capability of Landsat TM data for soil mapping, in erosional - depositional landform under severe aridic conditions. The interpretation of a satellite image, combined with field investigation is found to be useful for producing a soil consociation map at scale (1 : 100,000). The mapped units were defined mostly based on their soil characteristics, geomorphology, and landuse. The main geomorphic units were; main wadis, tributaries, sloping lands, pediplains, hills and domes. Digital image processing including, principal component analysis and unsupervised classification techniques was performed in two sites in Wadi El-Arish. Site selection was carried out based on the availability of soil data and the potentiality for agricultural landuse. Five soil classes could be distinguished in site (1) based on their spectral reflectance. The classified soil classes were; wadi terrace, gravely plain, flood plain wadi bottom and playa. The reflectance characteristics and the total area for each class were calculated. However, in the other site (2), where there is no soil data available, only four classes were identified. The soil characteristics of each classified units were determined, and the effect of vegetation cover, land use, and soil erosion on spectral characteristics were discussed.

1. Introduction

Several studies were carried out to investigate the characteristics and distribution of land resources in Sinai Peninsula. Abdel Hady et.al. (1980) used Landsat MSS images to produce soil maps at a scale of (1:250,000) according to Soil Taxonomy Classification System. The studies performed by GARPAD/REGWA Reconnaissance Soil Survey (1981), and Semi-Detailed Soil Survey (1984), dealt with the north-western part of the peninsula. The Reconnaissance Soil Survey only considered the texture of soils as the criterion of differentiation. No international classification system was applied. These surveys formed the background for the Land Master Plan, Hammad (1986). Japan International Cooperation Agency (JICA,1989) carried out a soil survey at a grid of one kilometer. Then the soil was classified according to the USDA Soil Taxonomy and related to the land forms . Desert Institute (1981) investigated the soils of ten regions in Sinai. A classification was made according to Soil Taxonomy. These studies were performed for Dames & Moore, and form the background of pedological considerations in Sinai Development study.

The main objective of this study is to demeonstrate the capability of Landsat TM data for mapping the soils of El Hasana re-

gion, Central Sinai Peninsula, using different remote sensing techniques

2. General Characteristics

El Hasana region is located in the central part of Sinai Peninsula, between Latitudes 300 00' and 300 30' N, and Longitudes 330 35' and 340 05' E, Fig.(1).

The central part of Sinai consists of subhorizontal Mesozoic and Tertiary sediments, creating the plateau of Gebel El Tih and Gebel Egma which are drained by the northerly flowing affluents of Wadi El Arish. North of latitude 300 N, the topography comprises low alluvial plains which are broken by large uplifted Mesozoic domes and anticlines , Said (1990). Wadi El Arish covers a pronounced area in the study region. It crosses a number of mountain blocks cutting deep narrow passages called daika; otherwise it cuts its channel through Pleistocene sediments which are of fluviatile origin. According to Sneh (1982) the sedimentary features indicate a long history of aridity extending into the Pleistocene.

The climatological conditions of Sinai Peninsula play an important role in shaping Sinai's landscape and in controlling the ecology of the peninsula. Extreme aridity, long hot rainless summer periods, and mild winters in which storms rarely occur are the main climatological condition of the Peninsula.

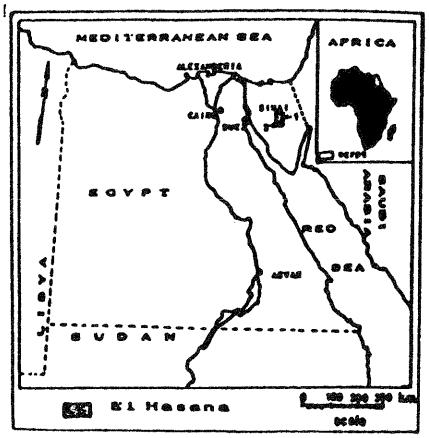

Fig. (1): Location of the study area, El-Hasana, Central Sinai, Site(1) - Talaat El-Badan, Site (2) - Wadi El-Bruk - Wadi El Arish

3. Procedures

1. Interpertation of Landsat TM, False Colour Composite image (bands 2,4 and 7), at a scale of 1:100,000. Landsat Scene characteristic are (Path:175, Row: 39, Thematic Mapper Sensor, Date: 24/12/86).
2. Soil sampling, laboratory analysis, and classification were carried out acording to USDA (1984).
3. Image processing was performed through the following steps:
   - Selecting two sites in El-Hasana region, with high agricultural potentiality as pilot areas,
   - Filtering and Principal Component Analysis (PCA) technique have been performed to delineate wadis boundaries from the surrounding uplands,
   - Digitizing the wadis boundaries in the two sites,
   - Applying the unsupervised clas sifica tion to site 1 (Talaat El-Badan area) with the following parameters (bands selected were 2, 3, 4, and 7; minimum distance between clusters = 5; Maximum allawable cluster radius = 7).
   - Correlating the ground truth data with the out put results.
   - The same technique was performed to site 2 (Wadi El Bruk - Wadi Al Arish area).
   - The classified soil units were characterized and mapped.

4. Results & Discussion

4.1 Landsat image interpretation:

The interpretation of false colour composite image, bands 2, 4, 7, fig. (2) enable in producing a phasiographic map of El-Hasana region at a scale of (1:100,000). The terrain analysis of the studied area reveals that the main landform units were;

a) desert domes and hills, such as Gebel Yelleq (1090m), Gebel Halal (890m) Gebel El-Monsharh (567m), Gebel El-Bruk (403m), and Gebel El- Hasana (349m);

b) Synclinal lowlands (foot slopes or hamada) between the above mentiond anticlines (hills & domes);
c) Part of the great pidmont plain, which dominates most of north Sinai region; and
d) Wadis which could be divided into two types namely; main wadies, and Tributaries. The defferentiation was carried out based on their width, soil depth and slope gradient.

4.2 Site Selection and Soil Characterization

The produced soil consociation map was used to select a number of sites in which soil samples were collected from representative soil profiles. The obtained analytical data were presented following the coding system of FAO (1990), table (1). These data were used to classify the mapped soils according to Soil Taxonomy (1990). Torriorthents, Torrifluvents, Torripsamments, and Haplorthents were the main soil groups in the study area.

The number and degree of limitations for agricultural use in Wadi regions found to be relatively low comparing to the other geomorphic units. Therefore, two areas covered mostly with Wadi El-Arish were selected for detailed investigation using digital image processing techniques. The first window located east of El-Hasana city between Lat. 300 20' and 300 30' N, and Long. 330 50' and 340 05' E. The second window is located north of Nakhl city between Lat. 300 03' and 300 17' N, and Long. 330 40' and 330 55' E. The total area for site 1 and site 2 were 637.3 km2 and 280.3 km2 respectiviely.

4.3 Digital Image Processing:

Filtering and Principal Component Analysis (PCA) techniques were performed to enhance and delineate the wadis boundaries. The unsupervised classification technique was performed using Thematic Mapper data (bands 2, 3, 4 and 7) of wadi region (site1) fig. (3). Twenty classes including soils, rocky lands and soil covered with natural vegetation were produced. Each class has special reflectance characteristics in the four studied bands. Five soil classes were discriminated in Site 1, namely playa, wadi terrace, gravely plain, flood plain, and wadi bed. The mixed soils are grouped in a separate class. The latter includs ploughed and cultivated fields. The total area of soil class and its spectral mean values in each band were presented in table (2). Each soil class is characterized after field and laboratory investigations. The mapped soils were classified according to Soil Taxonomy (1990).

The same technique was applied to site 2, where there is no enough soil data availabe. The classified image , fig. (4), shows the presence of five soil classes including the mixed soil. The similarity in reflectance characteristics between the discriminated soil classes in the two sites was the criterion used to define the soil class in site (2).

The main soil characteristices and the taxonomic classification of the soils mapping units could be summerized as follows:

1. Soils of wadi terraces; are almost flat,moderately deep, high lime and / or gypsum content, moderately to highly saline, gravely sandy clay loam or loamy sand. These soils could be classified as Typic Torriorthents.
2. Soils of the outwash; are deep, coarse to moderately coarse texture, high gypsum and/or lime content, highly saline. The soil surface is covered with desert pavement and scattered natural vagetation. The coarse texture and the absence of diagnostic horizons or features were the main reason to group these soils in Typic Torriorthent subgroup.
3. Soils of the flood plain; are undulating, having calcareous crust, deep, sandy texture, highly saline, highly calcareous The soil surface is covered with dense vegetation. Typic-Torrifluvents was the main subgroup in this mapping units. In some parts of the flood plain, gypsic or calcic horizon were noticed

Table (1): Soil characterictics of the main Landform units in El-Hasana region

Terran Compenent / Landform symbole / Soil Attributes	Wadies		Sloping Land			Plains		
	Narrow	Wide	Steep	Mod. Steep	Gent. Steep	Sandy	gravely	rocky
	FW1	FW2	FO1	FO2	FO3	DPV1	DPV2	DPO1
Slope Gradiant (%)	8 - 15 (R)*	2 - 5 (G)	30 - 60 (T)	15 - 30 (S)	2 - 5 (G)	0 - 2 (F)	0 - 2 (F)	2 - 5 (F)
Soil depth (cm)	50 - 100 (M)	100 - 150 (D)	30 - 50 (S)	30 - 50 (S)	50 - 100 (M)	150 (D)	150 (D)	30 - 50 (D)
Structure	Single Grain (N)	Massive (M)	Single Grain (N)	Single Grain (N)	Single Grain (N)	Anglar (R)	Anglar (R)	Single Grain (N)
Texture	Sandy (S)	S/Sandy loam (S/LS)	Sandy (S)	Sandy (S)	Sandy (S)	Sandy (S)	Sandy (S)	Sandy (S)
Gravels (%)	5 - 15 (C)	2 - 5 (F)	15 - 40 (M)	40 - 80 (A)	15 - 40 (M)	2 - 15 (C)	15 - 40 (M)	15 - 40 (M)
Salinity (ECe) (mmohs/cm)	4 - 8 (M)	< 4 (L)	8 - 16 (H)	8 - 16 (H)	< 4 (L)	< 4 (L)	4 - 8 (L)	> 32 (S)
Lime content (%)	> 40 (H)	> 40 (H)	> 40 (H)	> 40 (H)	> 40 (H)	10 - 40 (H)	> 40 (H)	10 - 40 (H)
Drainage	Well (W)	Well (W)	excessivily (E)	Well (W)	Well (W)	Well (W)	excessivily (E)	excessivily (E)
Water table depth	deep (D)	deep (D)	deep (D)	deep (D)	M. deep (M)	deep (D)	deep (D)	deep (D)

* FAO (1990)

Table (2): Statistics of Soil spectral reflectances and the area of each soil class in the studied Sites

Site No.	Class No.	Landform sub unit	Soil Units	Spectral mean values				Area		
				Band 2	Band 3	Band 4	Band 7	%	Km 2	acres
1	1	Playa	PL	118.40	176.50	136.50	124.50	1.94	2.42	605.0
	2	Wadi Terraces	WT	95.10	146.50	117.80	119.70	7.03	8.75	2187.5
	3	Gravely plain	GP	104.10	156.80	122.40	113.50	28.01	34.86	8715.0
	4	Flood plain	FP	94.60	143.00	112.70	106.30	25.44	31.66	7915.0
	5	Wadi bed	WB	87.50	131.90	103.90	97.50	15.60	19.40	4850.0
	6	Mixed & follow land	ML	77.80	116.00	91.20	84.00	6.04	7.50	1875.0
2	1	Wadi Terraces	WT	103.91	169.63	134.80	126.87	6.27	16.20	4050.0
	2	Gravely plain	GP	104.50	157.50	123.70	114.20	31.99	79.00	1975.0
	3	Flood plain	FP	94.30	143.30	114.30	108.00	20.69	51.00	12750.0
	4	Wadi bed	WB	74.45	113.45	103.20	95.05	19.22	47.40	11850.0
	5	Mixed land	ML	80.01	121.20	98.10	89.60	2.06	5.00	1250.0

and hence, the soil were classified as Typic Gypsiorthids or Typic Calciorthids.

4. Soils of the wadi bottom; are moderately deep, fine sand to silty , highly calcareous , moderately to slightly saline, no gravels in the surface. Theannual erosion and deposition processes in this soil reduces the chance of diagnostic horizon formation. The soils were classified as Typic Torriflarent.
5. Mixed soils; are fallow or ploughed field which are located mainly in the flood plain or the outwash plain. The presence of organic materials or moisture content or cultivation are main factors affect soil reflactance.
6. Playas; are flat, deep, saline, highly calcareous, and fine to medium texture. This soil class is distingwished only in area 1, where the wadi is much more flatter and wider than that of area 2. Typic Torrifluvents and locally Salic Torriorthents were the main Taxonomic units in this region.

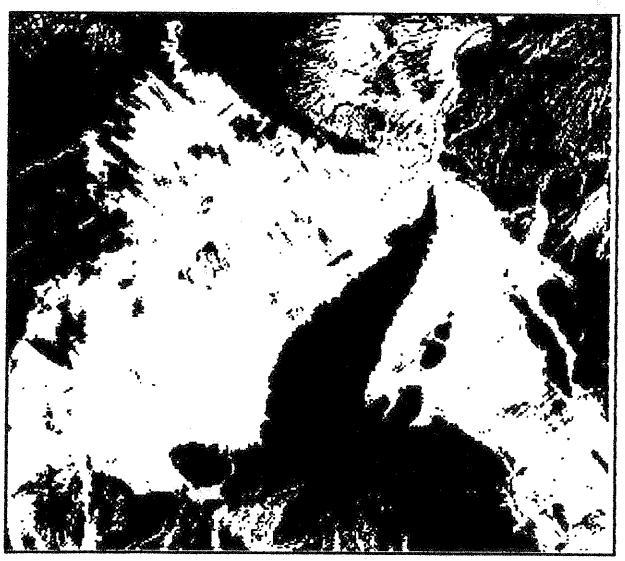

Fig. (2) - False Colour Composite image of Landsat TM data (bands 2, 4, 7) of Talaat El-Badan area

5. Conclusion

Physiographic map shows the soil consociations in El-Hasana region, Central Sinai, was produced baseds upon Landsat TM data. The visual interpretation of FCC image, 1:100,000, reveals that the main landform units in the study area are Wadies, plains, sloping lands and hilly areas. Two sites in the main wadis are subjected to unsupervised digital image classification. This technique inables to discriminate between the soils of wadi bottom, flood plain, wadi Terrace, gravely plains and playa. The total area for each soil type could be determined.

6. References

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Fig. (3) - Unsupervised classified image of Landsat TM data (bands 2, 4, 7) of Talaat El-Badan area

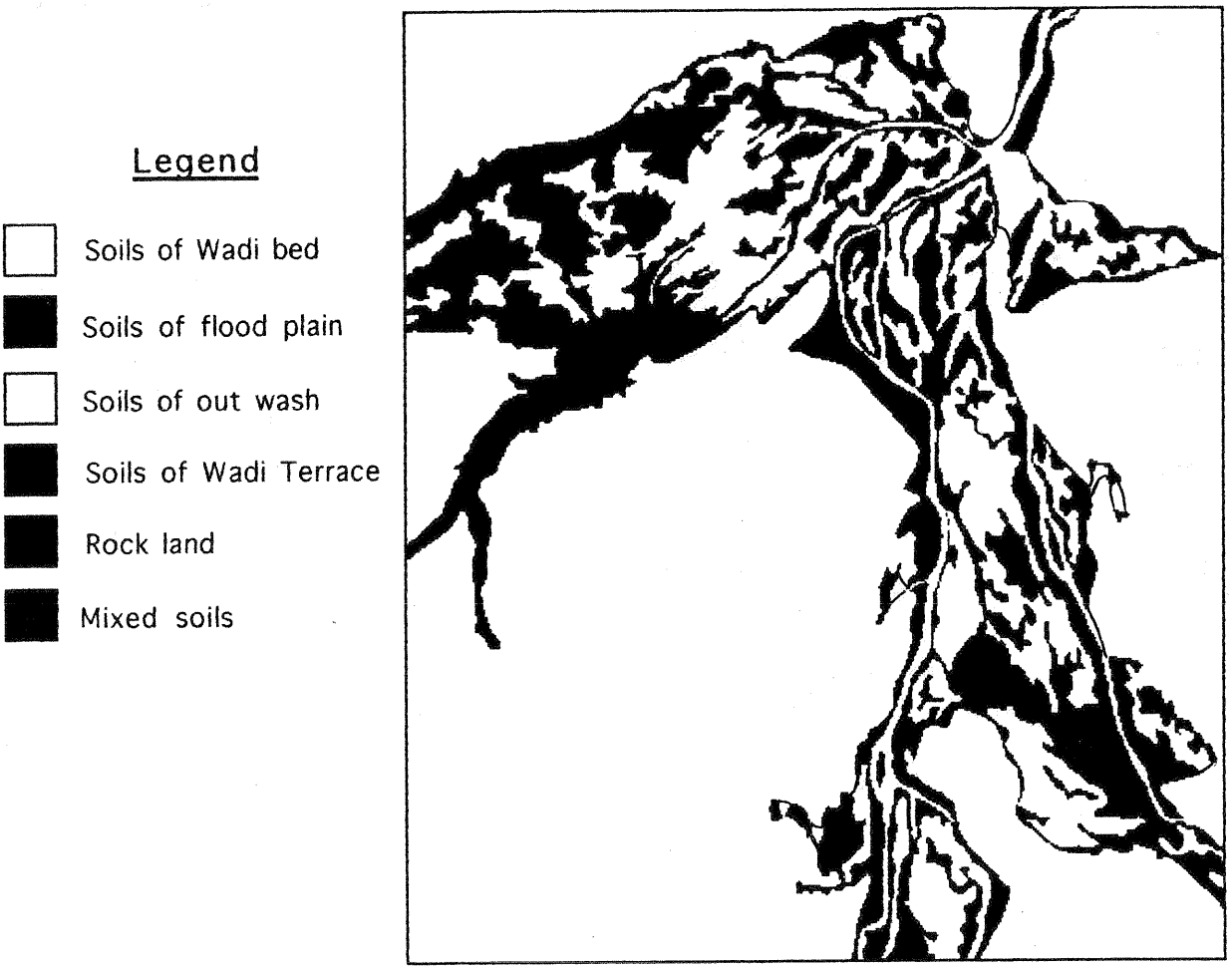

Fig. (4) - Soil map of Wadi El-Arish - Wadi El-Bruk area based on Classified Landsat Image