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Application of remote sensing technology towards the identification at the existing soil units and their capability in some areas, south-east, Egypt

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Abstract

Syal area forms one of the islands those exist in the south eastern region of Egypt. It is the subject of this study, which aims to identify the main geomorphic units and the associated soils using landsat TM imagery and an appropriate field study.

Seven geomorphic units were identified via an unsupervised TM image classification. These are namely beach, Sabkhas, river terraces, flood plains, deltaic plains, main valleys and tributaries.

Seven profiles representing the associated soils of the identified geomorphic units were studied morphologically and soil samples were collected for laboratory analysis.

The soils were classified according to Soil Survey Staff (1998) as following:

Typic Torripsamments for beach soils and *Typic Haplosalids* for Sabkhas and river terraces. The soils of flood plains,deltaic plains, the main valleys and tributaries were classified as *Typic Torrifluvents.*

The data of soil capability reveal that the soils of the flood plains and deltaic plains were relatively high, where they belong to the IV and 111 classes. The rest of the soils have different classes of lower capability.

The limiting factors for agricultural development are water, sandy texture and the severity of climate.

The measurements at the spectral reflectance of the main terrene features reveal that channel 5 (1.55-1.75 ^m) is the most appropriate channel to study the dry sandy calcareous soils of salty and gravely surface, rocky soils and dry swamps. The water bodies appear as completely dark with channel 6 (10.4-12.5 /Mn), where most of the incidant energy are absorbed.

Keywords: Syal area - Spectral reflectance of terrain features – land evaluation.

Introduction

The southeastern region of Egypt forms one of the most promising regions for sustainable development. The area has a significant potentiality of natural resources. Basta and Saleep, (1971), NARSS (1996) and NRC (2000). The long coastal plain is almost flat and characterized by a high soil potentiality for agricultural production.

Remote sensing provides valuable information about the natural resources and the environmental conditions. Beaumont (1989) used landsat data for mapping soil condition in the frame of a general soil mapping. Abdel-Samie et al (1992) used Landsat MSS and

TM imagery for detailed mapping of a limited area. Gad et al (1995), used landsat MSS and TM data for mapping and monitoring of salt affected soils.

The purpose of the current investigation is to study the geomorphic features to use them as a base for soil mapping. Landsat TM data are used as a main source of information, which are incorporated in a representative field study.

A particular purpose also, is to figure out the spectral signature of different geomorphic and soil units. This information will have beneficial advantages in the future for the remote sensing reconnaissance.

Location and environmental settings of me study area

The study area represents a part from the southeastern desert zone of Egypt, which is limited between latitudes 22° 00' and 23° 30'N and longitudes 34° 30' and 37 00' E Map (1) and Fig. (1). This zone covers an area of about 2000km2 exhibiting three groups of major landforms; the Bahada plain. Coastal plain and Islands. The Bahada plain is the major geomorphic unit and mainly formed of the Fan of Wadi Kraf. Channels of the Wadi divide the land surface into several braided branches; only few of them reach the Coastal line.

The Coastal plain takes a general curved form changing from west-east direction to south-east-north west and to north-south trend. The Coastal line is irregular due to the development of sub-fans by the branches of the Wadi. The Sabkhas occupies a narrow strip along most of the whole coast. The maximum width of the Sabkhas is about two kilometers in the central section of the coast. Sand barriers and spits were formed along marine margins resulting in the formation of some small lagoons.

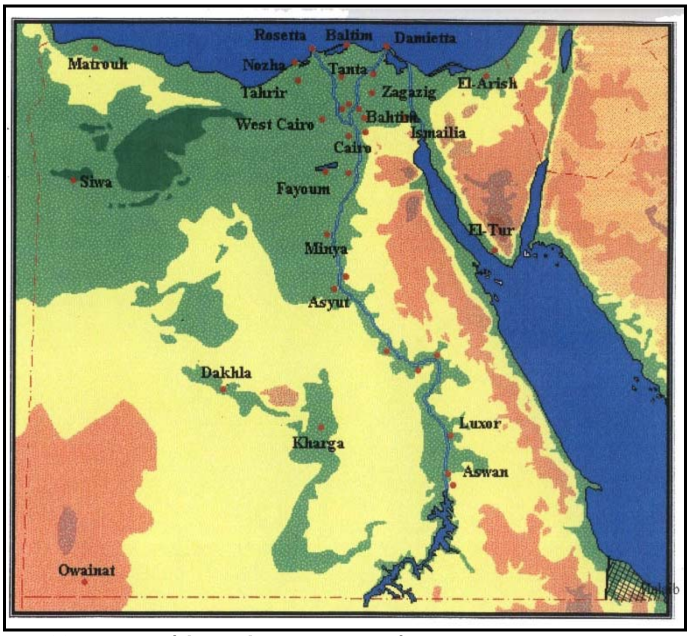
There are two groups of islands, Syal and Rwabi islands. Coral reefs appear as three successive fringing reefs, parallel to the coastline. Most probably, they represent three cycles of reef formation (El-Rakaiby et al., 1996).

Concerning the soils, there are two types, the dominant one is the coarse textured fluvial sediments, while the second one is the salt Sabkhas soils along the coastal strip, (NRC, 2000). Zaghloul (1996) concluded that the ground water resources in Halayb-Shalatein area, exist in four types of aquifers, namely; fractured basement; Nubian Cretaceous sandstone, Miocene limestone and Nubian Cretaceous sandstone, and Miocene limestone and Wadi deposits. The ground water of the fractured basement rock is considered the best water quality, compared with the other types.

Materials and Methods

Landsat thematic mapper (TM) of 1992 was selected as it covers the study area (Fig. 2) and characterized as cloud free. Other documents including topographic maps, at scale of 1:50.000, geological map and ecological site descriptions were available. System corporation "Magellan" GPS NOV DLX-10 TM was used in the determination of sites, elevations, longitudes and latitudes.

Image enhancement techniques were applied on the TM image to improve the qualities of data for the visual interpretation. Geometric correction was carried out by using a number of ground control points (G.C.P's) taken in the field by GPS. The (GCPs) represent well defined locations (e.g cross roads, comers,...). Radiometric balance and high pass filter techniques were used to improve the final products of the false color composite (FCC), which combined bands 2,4 and 7, rendered to blue, red and yellow respectively. Unsupervised classification of the color composite (Fig. 2) was carried out, as a step towards a hybrid classification outcome. Field work was designed as a base for the visual interpretation and unsupervised classification. The field investigation lead to collect the morphological characteristics of each monitored land unit. Feeding the



Map (1) Location of the southeastern region of Egypt

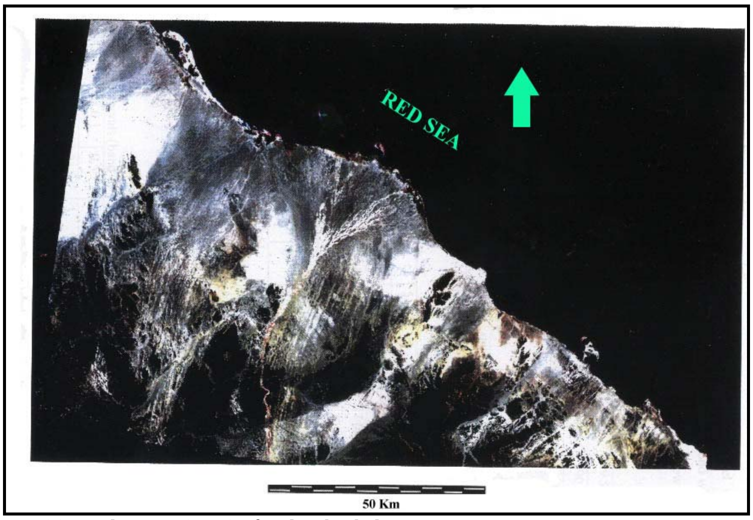


Fig. (1) Landsat TM (FCC) of Halayeb-Shalatein previous information back in the unsupervised image classification resulted in the classified TM false color composite of Syal area (Fig. 3), which incltudea twelve photomorphic units, seven of them represent the main geomorphic units namely: Beach, Sabkhas, Marine Terraces, Alluvial Plain, Delta Plain, Main Wadies and Tributaries. Seven profiles were. selected to represent the soils of the main geomorphic units. The profiles were described morphologicaly according to the FAO guidelines^ (1990). Soil samples were collected for laboratory analysis. Table (1) demonstrates some soil characteristics of the representative soil profiles. Eventually the soils were classified according to of (Soil Survey Staff 1998).

Reflectance characteristics of the main land units were measured vertically in the field using the Exotech model 100 AX field radiometer, in view of helping the process of image analysis and classification. The selected field radiometric measurements representing five channels (Ch's) of different wave lengths as following:

Ch. 1 (0.45-0.52 urn), blue. Ch.2 (0.52-0.60 urn), green.

Ch.3 (0.63-0.69 urn). Red. Ch.4 (0.76-0.90 urn). Near infrared.

Ch.5 (1.55-1.75 urn) Mid inferred.

A parametric land capability classification system was followed to evaluate the existing land resources for agricultural use according to (Younes et al, 1995).

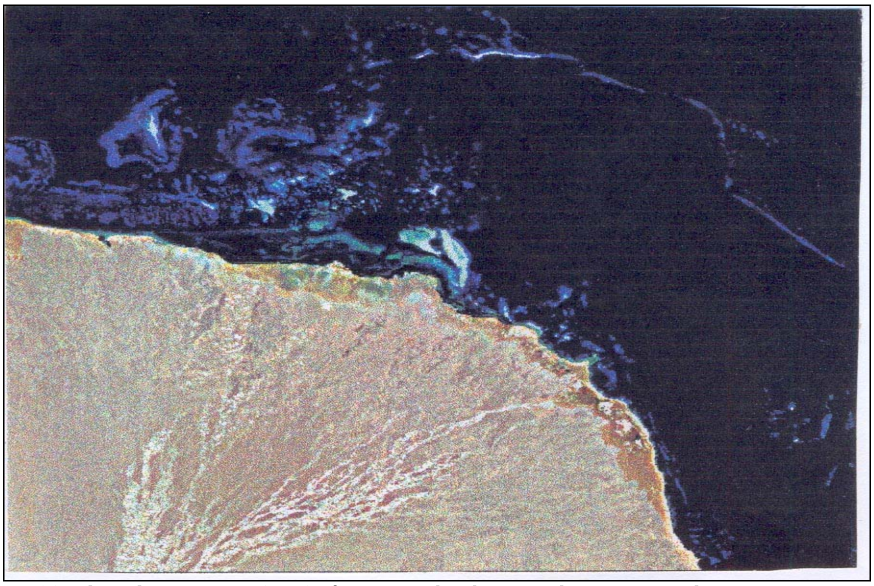


Fig (2) False color composite (FCC) of TM image bands 2, 4, and 7 covering syal area.

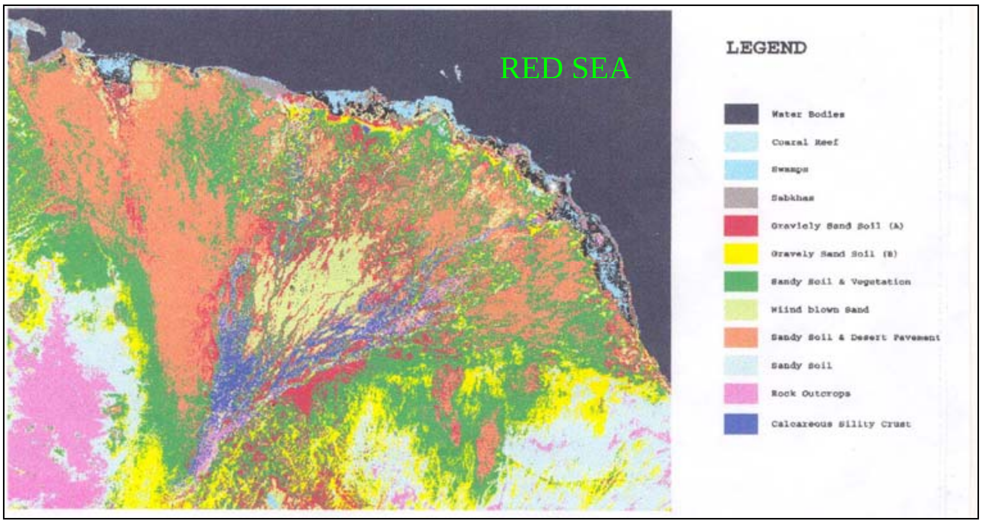


Fig (3) Recorded unsupervised classified image for syal area.

Table (1) some soil characteristics of the selected profile

Profile No.	Land unit	Depth cm.	pH	Ec dS/m	$CaCO_3$ %	Gravel %	Particle size distribution						texture	CEC Meq/100 gsoil
							VCS	CS	MS	FS	VFS	SI&CL		
1	Beach	0-20	7.8	17.2	2.3	30.0	26.2	18.4	20.1	22.5	6.2	3.6	Gcs	2.0
		20-60	7.7	18.0	3.5	41.1	29.8	15.9	21.0	28.8	4.4	0.6	GCS	0.6
		60-80	7.6	27.3	3.8	33.5	33.1	19.4	19.2	5.5	5.5	3.3	GCS	2.7
2	Wet & dry sabkhas	0-15	7.4	44.5	3.6	30.6	22.4	19.0	27.6	24.5	6.0	2.5	GCS	2.1
		15-40	7.6	24.0	1.5	5.1	15.2	11.2	19.1	33.0	15.0	6.2	FS	4.9
		40-60	7.7	35.2	12.9	3.4	82.0	16.2	20.2	20.5	7.2	1.9	CS	1.8
3	Marine terraces	0-25	7.4	80.0	2.6	9.5	186	25.0	33.9	18.7	2.0	1.8	CS	1.3
		25-50	7.3	48.0	0.8	25.4	41.7	20.1	15.2	8.0	10.0	5.0	GCS	4.0
		50-85	7.6	21.5	1.5	39.2	4.0	9.5	39.0	42.2	4.9	0.4	GMS	0.5
4	Alluvial plain	0-35	8.6	0.2	2.2	7.8	8.2	4.7	12.3	60.0	12.8	2.0	FS	1.8
		35-80	9.0	0.2	3.0	2.9	7.2	10.9	24.8	43.5	9.1	4.5	FS	3.9
		80-100	8.4	0.9	2.1	1.6	2.2	2.7	28.9	57.9	5.5	2.8	FS	2.5
5	Delta plain	0-35	9.2	0.2	2.4	6.8	21.7	16.5	17.4	28.2	13.4	2.8	FS	2.4
		35-65	9.3	0.2	3.1	26.5	23.4	21.0	26.0	23.0	5.3	1.3	GCS	1.2
		65-110	9.2	0.3	2.7	25.0	24.5	16.7	27.6	16.9	7.6	3.7	MS	3.0
6	Main wadis	0-20	9.1	0.6	2.8	11.6	9.7	11.9	186	24.6	14.7	2.5	FS	3.0
		20-65	8.4	2.8	4.5	12.2	16.0	21.6	33.4	24.6	3.8	0.69	CS	1.5
		65-110	8.6	2.1	4.7	9.8	31.1	21.9	36.3	23	3.5	1.4	CS	2.1
7	tributaries	0-20	8.1	2.9	1.9	59.5	28.3	23.8	26.8	15.8	4.4	0.9	VGCS	0.8
		20-50	8.0	6.1	3.7	47.7	32.7	23.4	21.9	19.0	2.4	0.6	GCS	0.6
		50-80	8.0	2.8	1.2	45.8	46.6	22.4	17.7	6.4	1.4	0.5	GCS	0.5

Where; V=very, G= gravely

Results and Discussion

1. Mapping of geomorphological units and soils associations:

The false color composite (Fig. 2), reveals that syal area could be subdivided into a number of photomorphic units. Each one is characterized by particular spectral characteristics (i.e. color, texture, pattern, and boundary. The area takes the shape of a fan. The length from the fan apex, ahead to the coast line is about 30 km while the width is 20 km. Braided channel network spreads on the surface, only few of them reach the coast line. The sabkhas occupies a narrow strip along the coast. The middle of the sabkhas is about 2 kilometers in the central section of the coast. Sand barriers and spits were formed along the marine margins resulting in the formation of small lagoons. The unsupervised classification of TM false color composite supported by a field investigation made it possible to combine the photomorphic units (PMLPS) to represent the main geomorphic units. The spectral signature of each unit was detected in different spectral bands.

2. Characteristics of the geomorphic unit and soils associations

2. 1. Beach

The beach land, profile (1) is characterized by an almost flat landscape, sloping very gently towards the sea. Most of its surface is covered by a thin salt crust. Coastal dunes and gravely surfaces often exist within the beach. Natural plants are scarce, Mangrouf trees grow in the vicinity of sea coast. Profile (1) Table (1) shows that the soil salinity, expressed by EC values, are high (17.2 to 27.3 dS/m. The high salinity is related to the vicinity from sea coast. Calcium carbonate contents range between 2.3 to 3.8 exceeding in the lower horizons and related to the existence of sea shells. PH values range between 7.6 and 7.8, and are inversely related to the depth. The soils are often classified as Typic Torripsamments.

2. 2. Sabkhas

The Sabkhas area is exhibited by sandy saline dry or wet shallow soils. The topography ranges betweens almost flat to undulating. The ground water table fluctuates, where a salt crust often formed on the land surface

*The soil profile contains either a salic or a gypsy horizon. The description of the representing soil profile (2) shows the existence of the iron oxide and Mn mottles, which are related to anaerobic conditions and gleyzation process. The plant cover is scarce except some salt tolerant grasses. The dominant texture is fine sand to gravely coarse sand. The E.C ranges between 44.5 dS/m at surface and 24.0 dS/m in subsurface layer. The soils are nearly calcareous, where CaCOa ranges between 3.6 in the surface layer and 12.9 in the subsurface. PH values range between 7.4 and 7.7 , showing an inverse relation with soil salinity. The soil are classified as Typic Haplosalids.

2. 3. Marine terraces

The marine terraces are represented by profile (3) Table (1). They are gravelly sandy marine terrace (i.e. Coarl Reef). The sediments are dominated by reddish color, as they were formed in more moist climatic conditions. They also combine calcareous aggregates and marine shells. The topography exhibits an undulating landscape, where features of water erosion prevail. The soils are characterized by a very high salinity (EC ranges between 21.5 to 80.0 dS/m). Calcium carbonate content ranges between 0.8 to 2.6%, while pH ranges between 7.4-7.6. The soil Are classified as Typic Hapiosalids.

2. 4. Alluvial Plain

The alluvial plain is composed of alluvial soils, covered often by recent sandy sediments in forms of deltas and alluvial fans. The surface layer is almost covered by desert pavements, which indicate the activities of wind erosion. Profile (4) Table (1) represents this land type, which is dominated by a fine sandy texture. It is remarkable that the E,C and the $CaCO_3$ Values are low, ranging between (0.2-0.9 dS/m) and (2.1-3.0%) respectively. The pH ranges between 8.4 to 9.0. The soils were classified as Typic Torrifluvents.

2. 5. Delta plain

The delta plains are composed of the sediments, which were resulted by the weathering of the high lands, and transported by the fluvial action. The topography is almost flat, gently sipping towards the sea. A thin crust of fine sediments is formed on the surface. The water erosion is indicated by the existence of gullies, while erosion is indicated by the presence of the gravelly surfaces. The delta plains are represented by profile (5), Table (1), where the soil texture ranges between fine sand and gravely coarse sand. The soils are classified as Typic Torrifluvent.

2. 6. Main Wadis

The main Wadis are well recognizable land types in both high mountains and low level regions. They are recognized in the satellite images by their specific pattern. Plant cover exists in the Wadis, as water is supplied from the runoff and seepage. The main wadis could be divided into wadi bottom flood plain and wadi terraces. The soils are represented by profile (6) Table (1), showing a fine to a coarse sandy texture, while the gravel content varies between 9.8 and 12.2%. pH varies between 8.4 and 9.1, while E.C is low and ranges between 0.6 and 2.8 dS/m. The CaCO3 content is also low and ranges between 2.8-4.7%. The soils are classified as Typic Torn/Invents.

2. 7. Tributaries

Tributaries also are recognized land type. They have been gauged on rock land in ancient times as a result of rainfall and thunder action. Profile (7) Table (1), shows that the soils are nearly similar to those of the main wadis, with more of gravel percentage. The soils are also classified as Typic Torrifluvents.

3. Land evaluation of the study area:

Table (2) summarizes the characteristics of the main factors, controlling the land suitability for agricultural land use. These factors include climate, wetness, salinity and sodicity, slope and hazard of erosion, soil depth, texture, structure, and CaC03 content. Table (3) shows the capability class and limitation factors for each land type. Most of the soils belong to class IV, in which soils can be used for agricultural purposes after improving the soil conditions. Usage of irrigation and addition of hydrophilic amendments are recommended to overcome the limitation of climate and texture, and hence other factors. The closed soils to the beach are classified as V and VI degree of capability, where they include many of limitation factors.

4. Spectral Characteristics of different land unites:

Table (4) & Fig (4) represent the spectral signature of different land types, as reflected in different wave length. The obtained data reveal that most of land units give their highest reflectance in Ch.5 wave length (1.55-1.75 pm), where the calcareous silt crust and rock lands give a reflectance ratio of 92.8% while the reflectance ratio with sandy soils, gravely soils and swamps are 87.6 and 76.8% respectively. Water bodies and sabkhas give their highest reflectance (62 and 48.4%) respectively with Ch.l, wave length (0.45-0.52 pm). All land types give their lowest reflectance with Ch.2 (0.52-0.6 pm) while for water bodies give their lowest reflectance in Ch.5 where most of the incident energy is absorbed.

Table (2) General characteristics of the sopil units

Major land form	Symbol	Soil mapping unit	Texture	Structure	Slope	$CaCO_3$	Salinity class	Soil depth	Drainage condition	Surface stoniness	Classification
Beach	1	Sand deposite	S	N	F	SL	H	S	P	N	*Aquic quartzpsamments*
Wet & dry sabkhas	2,3	Coarse texture	L/S	WF	F	M	E	M/S	P	V	*Typic Aquisalids*
Marine terraces	5	Plain with view desert pavement	S	WF	G/U	M	M	M/D	E	E	*Typic torriorthents*
Alluvial plain	7	Sandy delta plain	S/L	MoMe	F	SL	SL	D	W	F	*Typic torripsamments*
Delta plain	8	Wide wadi	S/L	MoMe	G	SL	SL/M	D	W	F	*Typic Torrifluvents*
Main plain	10	Narrow wadi	S/L	MoMe	G	M	SL	D	W	M	*Typic Torrifluvents*
Tributaries	11		S	WF	ST	M	M	S	M	A	*Typic Torrifluvents*

Where: S= sand, shallow M = moderate U= undulating
L= loam SL= small, slightly D= deep
W F = weak fine E =excessive MoMe= moderately medium
N= structureless, no stores V =few W= well
F= flat ST=steep A= abudant
P= poor G=gently sloping

Table (3) Land capability classification of the studied area

Land unit	Capability class	Limiting factor
Beach	VI	C, t, w, s, d
Wet & dry sabkhas	IV,V	C, t, w, s
Marine terraces	V, VI	C, t, s, d
Alluvial plain	III, IV	C, t
Delta plain	III,V	C, t
Main wadis	IV	C, t
tributaries	V	C, t ,d

Where: c = climate e = erosion w = wetness s= salinity t= texture d= depth

Table (4) Spectral reflectance of the classified land units

Channel / Land unit	1	2	3	4	5
Water bodies	62	27.2	18.4	4.4	3.6
Sabkhas	48.4	24	34.4	36.8	43.6
Swamps	62.4	34.4	52.4	38.8	71.6
Gravely	57.2	32	50	37.6	76.8
Sandly	64.8	38	61.2	46.4	87.6
Rock	67.6	40	65.6	50.4	92.4
Calcareous And silt crust	72.8	43.6	70.8	54.8	92.8

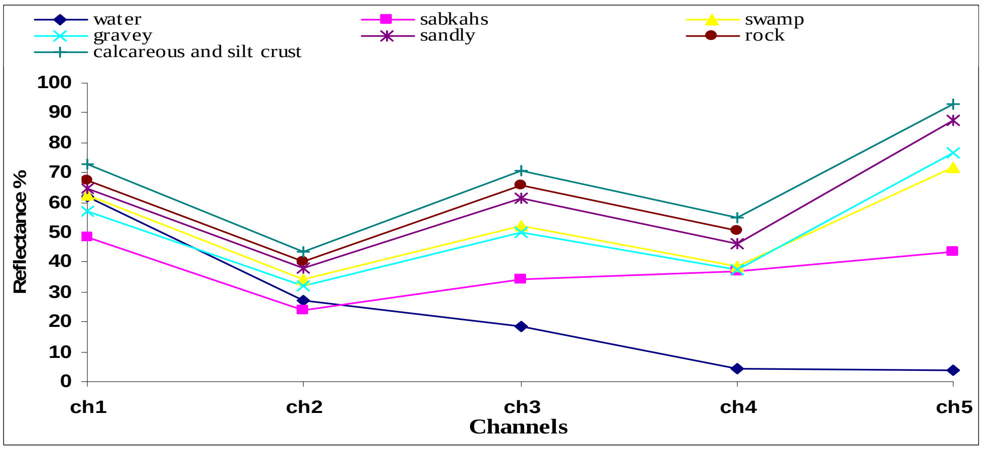


Fig. (4) Spectral signature of the different land units.

Conclusion

- • The use of satellite data proved to be useful in mapping the geomorphic land types.
- • The soil conditions are firmly related to geomorphology, hence the soil associations can be detected through.
- • Combination of field observation and soil analysis with satellite image interpretation may provide valuable information about soils..

The study area is characterized by various land types, each combines soil with particular characteristics. The most areas have agricultural potentialities are alluvial plains, delta plains and main wadis. The limitation factors can be overcome by irrigation and addition of hydrophilic amendments. The use of combined FCC of several bands rendered in different

colors for the same area is necessary for the discrimination between land units due to the fact that every feature has a unique spectral response with every band. Multi-band concert of satellite images was confirmed to be useful in discriminating features of similar spectral characteristics.

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تطبيق تكنولوجيا الاستشعار عن بعد فى التعرف على الوحدات الأرضية الكائنة وقدرتها الانتاجية فى بعض مناطق جنوب شرق مصر

محمد محمود البدوى

قسم الاراضى واستغلال المياة – المركز القومى للبحوث- الجيزة- مصر

- اختيرت منطقة سيال بمثلث حلايب والشلاتين فى جنوب شرق مصر للتعرف علـــى وحـــداتها المورفولوجيـــة ودراسة الاراضى المصاحبة لها من حيث تصنيف وتقييم قدرتها الانتاجية وذلك بالاعتمـــاد علـــى تكنولوجيـــا الاستشعار عن بعد والمدعوم بدراسة حقلية ملائمة وتقديرات معملية ضرورية .
- تم دراسة صورة مركبة (TM,FCC) بنود 2 و 4 و7 حيـــث تم تحديـــد عـــدد كـــبير مـــن الوحـــدات الجيومورفولوجية أعيد تحديدها فى اثنى عشر وحدة تناولت الدراسة سبعة وحدات منها تتميز بصفات ارضـــية محددة هى : الساحل – السبخات – الشرفات البحرية – السهول الرسوبية – السهول الدلتاويـــة – الوديـــان الرئيسيةوروافدها.
- مثلتالوحدات الأرضية بعدد 7 قطاعات ارضية تم حفرها لتمثل اهم الوحدات الجيومورفولوجية حيث جمعـــت عينات التربة بالافق المختلفة لتحليلها معمليا ولتصنيفها ولتقييم درجاتها الانتاجية تبعـــا للتقـــسيم الامريكـــى (1998).
- صنفت اراضى الساحل Typic Torripsamments.

  واراضى السبخات و الشرفات البحرية Typic Haplosalids

  اما السهول الفيضية و الدلتاوية و الوديان الرئيسية وروافدها. Typic Torrifluvents
- وجد ان اراضى السهول الفيضية و الدلتاوية ذات قدرة انتاجيةعالية نسبيا نظرا لانها تتبع الـــدرجتين الثالثـــة والرابعة. بيما جاءت اراضى باقى الوحدات الجيومورفولوجية الاخرى منخفضة بصفة عامة ومتباينة فيما بينها
- كانت اهم العوامل المحددة لقدرة الاراضى الانتاجية هى ندرة مصادر المياة وقسوة الظروف المناخية وكـــذلك سيادة القوام الرملى وما لة من قدرة عكسية على الاحتفاظ بالماء والعناصر الغذائية.
- واشارت القياسات الحقلية لانعكاس الوحدات الارضية المختلفة Ch 5 (طـــول الموجـــة 1.55 -um1.75) اكثرملائمة لدراسةالاراضى الجافة ذات السطح الجيرى الملحى .وكذلك الاراضى الصخرية كما ان نفس البند ملائم لدراسةالاراضى الرملية والحصوية وكذلك المستنقعات الجافة

- كما ان Ch5 اكثر ملائمة لدراسةالاجسام المائية حيث انها تظهر معتما تماما فى هذا البند نظرا لامتـــصاصها معظم الطاقة الساقطة عليهاولا ينعكس الا نسبة قلية منها .

توصى الدراسة بتركيز المشاريع الزراعية فى المرحلة الحالية فى مساحات محددة عند مخارج الوديان الرئيسية وذلك للاستفادة من مياة السيول والامطار والتى يمكن تخزينها فى مواسمها.