

## **LAND SUITABILITY ASSESSMENT FOR SOME SPECIFIC CROPS USING REMOTE SENSING AND GIS IN EL-QAA PLAIN, SOUTH SINAI, EGYPT.**

**Metwaly, M.M.A.\* and A.M. El-Araby\*\***

**\* Data reception, Analysis and Receiving Station Affairs Division, NARSS, Cairo, Egypt.**

**\*\* Soil Sci. Dept., Fac. of Agric., Ain Shams Univ., Cairo, Egypt.**

### **ABSTRACT**

In Egypt, the excessive population growth and the lack of food security were the guide to increase production in unit area, expand the cultivated land horizontally, and to utilize the land with respect to its potentiality in an appropriate way. Therefore, this study aims to integrate soil qualities (or characteristics) with remote sensing data and Digital Elevation Model (DEM) into a Geographic Information System (GIS) to produce a database for the land resources and the soil map, and assess the current and potential suitability of some specific crops in El-Qaa plain, South Sinai, Egypt. Two SPOT5 images were classified using unsupervised classification technique. The base map of the study area was used in the field to check, confirm, correct and modify the physiographic mapping unit boundaries. Four sample areas were selected. 26 soil profiles were taken to represent the different mapping units in the study area. Morphological description and soil sampling were collected for laboratory analyses. The physiographic units were classified into subgroup level on the basis of the key to soil taxonomy. the results show that soils in the study area include: sand sheet (Low, moderate, and high) classified as Typic Torripsamments and Typic Haplocalcids, Bajada classified as Typic Torripsamments and Sodic Haplocalcids, Basin classified as Typic Torriorthents, Wadi classified as Typic Torripsamments and Sodic Haplocalcids, Dry sabkhas classified as Typic Aquisalids, and Wet sabkhas classified as Sodic Psammaquents. The main land qualities of the different mapping units were selected and crop requirements of 21 crops were rated and matched to obtain the current and potential land suitability. The suitability of the selected crops currently not suitable in the different mapping units. The main limiting factors are texture, salinity and alkalinity, nutrient availability and calcium carbonate content, only in sabkhas added flooding, drainage, and soil depth. The potential suitability in the different mapping units refers that soils can be highly (S1), moderately (S2), and marginally (S3) suitable with a proper management practices and fertilization, and can not be suitable due to soil texture in all mapping units except in sabkhas where the limiting factors are texture, salinity and alkalinity, flooding, drainage, and soil depth which can not be enhanced in the near future. The results obtained can be employed by landuse planners (decision makers) to select areas suitable for the selected crops production.

**Keywords:** Soil mapping, Soil Quality, Land use requirement, Land Suitability, Remote Sensing, GIS, South Sinai.

### **INTRODUCTION**

In Egypt, the excessive population growth and the lack of food security were the guide to increase production in unit area, expand the cultivated land horizontally, and to utilize the land with respect to its potentiality in an appropriate way. Sinai Peninsula could be considered as one of the most promising areas for sustainable development. Under these circumstances, the government of Egypt decided to implement the "National Plan for Development of Sinai" (NPDS). The plan aims at achieving comprehensive development of Sinai over the period from 1994 to 2017. EL-

Qaa Plain is ranked as the high priority development area in South Sinai, which has from the natural resources what makes it able to begin new societies (agriculture, industry, tourism,...etc.). The desert immigration is considered to be the core resolution to re-draw the demographic map of Sinai Peninsula which is important for the national security of Egypt. Sustainable agricultural development is important issue to face the increasing population with the limitation of natural resources. Therefore, the policy of the horizontal expansion of agricultural land represents a very great importance for Egypt. Moreover, optimal landuses and the good management practices must be studied to select and put into practice those landuses that will best meet the needs of the people while safeguarding resources for the future generations for the biggest achievement of sustainable agricultural development. Land suitability classification is the process of appraising and grouping specific types of land in terms of their absolute or relative suitability for a specific kind of use. Qualitative suitability classification as an empirical assessment is based on assumed relationships being defined as a variable, which may be land quality, land characteristics or function of several land characteristics that has an understood influence on the output from or the required inputs to a specific kind of land use FAO (1976). Land evaluation approach is based on the matching of qualities of different land units in a specific area, with the requirements of actual or potential land use. The results of land evaluation should be useful for rational land use planning FAO (1993).

This study aims to integrate soil qualities (or characteristics) with remote sensing data and Digital Elevation Model (DEM) into a Geographic Information System (GIS) to produce a database for the land resources and the soil map, and assess the current and potential suitability of some specific crops in El-Qaa plain, South Sinai, Egypt.

## **MATERIALS AND METHODS**

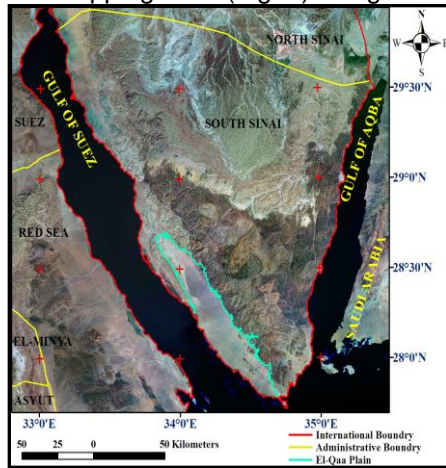
### **Study area**

El-Qaa plain is located between longitudes 33° 20' - 34° 10' E and latitudes 27° 46' - 28° 41' N with total area of about 1742.6 km<sup>2</sup> (Fig. 1). The plain is bounded from the north by Wadi Feiran, from the east by mountainous area of south Sinai, from the west by the Gulf of Suez, while towards the south; it is limited by the red sea. The plain rises up to 200 m above sea level (asl), sloping gently towards the southeast of the peninsula (Fig. 2). El-Qaa plain could be considered as one of the driest parts of Egypt (Ayyad and Ghabbour, 1986). Soil temperature regime is Hyperthermic and the soil moisture regime is Torric except for soils that have high water table, soil moisture regime is Aquic. The southern mountainous massif is a triangular mass of mountains with its apex at Ras Mohammed to the south, formed of igneous and metamorphic rocks, chiefly granites; it is intensively rugged and dissected by a complicated system of deep Wadis (Said, 1962; 1990). The geomorphology of El-Qaa Plain in general has been described briefly as: a) The Eastern Mountainous Region, b) The Western Sedimentary Hills, and c) The Central Plain (Said, 1962; El-Refai, 1984; and Shendy, 1984). Soils in southern Sinai can only be found in El-Qaa Plain and some wadis, where the rest is mountainous area (NARSS, 1995). The underground water is considered the main source of water supply in El-Qaa Plain. It exists in several aquifers, namely

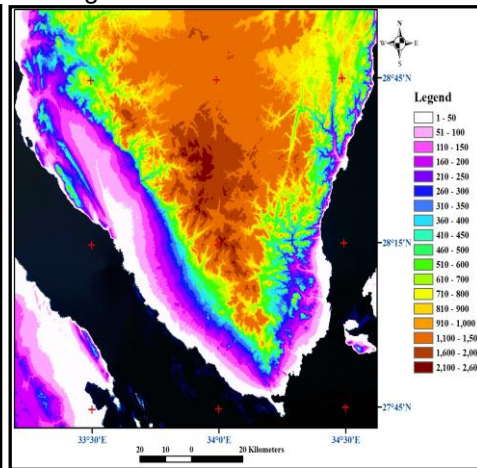
basement rocks, Nubian sandstones and Quaternary deposits (El-Shazly et al., 1974; Dames and Moore, 1985; WRR and JICA, 1999). Agriculture is mainly practiced in the middle sector of El-Qaa plain near El-Tur City on the Red Sea coast, where parts of the plain are recently cultivated. Among the main cultivated plants are wheat (*Triticum aestivum*), alfa-alfa (*Medicago sativa*), maize (*Zea mays*), date palm (*Phoenix dactylifera*) and various vegetables (Abd El-Ghani and Amer, 2003).

**Remote sensing materials:**

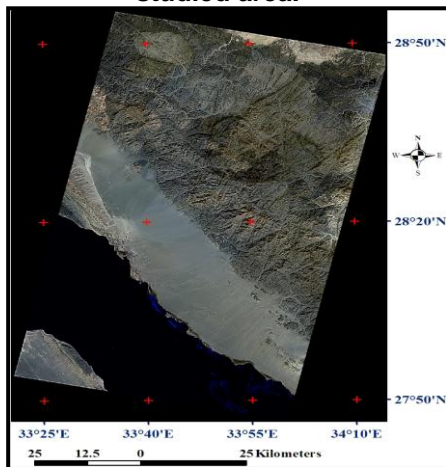
- 2 SPOT5 images (118-292, 118-292 dated 23/10/2006, with spatial resolution 10 m) (Fig. 3) were classified into several classes (clusters) using unsupervised classification technique; each class represents different mapping units (Fig. 4) using ERDAS Imagine 9.2 software.



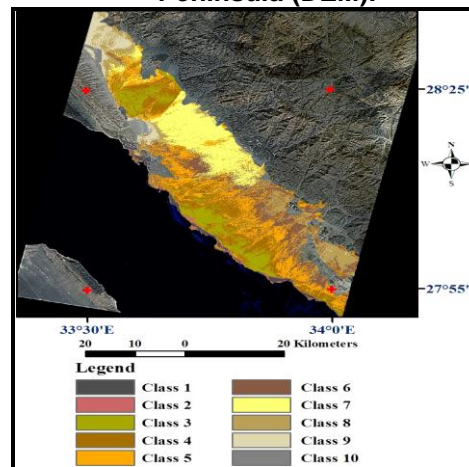
**Fig. (1): The location of the studied area.**



**Fig. (2): The altitude of Sinai Peninsula (DEM).**



**Fig. (3): SPOT5 Mosaic of Study Area.**



**Fig.(4):Unsupervised Classification.**

**The field works was carried out as follows:**

- The base map of the study area which was obtained from the unsupervised classification and visual interpretation (using ERDAS Imagine 9.2, and ARCGIS 9.2 software) by draping SPOT5 image over DEM to get the feel of natural 3D terrain (Dobos *et al.*, 2002; Aksoy *et al.*, 2009) was used in the field to check, confirm, correct and modify the physiographic mapping unit boundaries.
- Four sample areas were chosen. These sample areas were selected so that they run across the study area passing through the different landforms.
- Detailed morphological description of 26 soil profiles selected to represent the different landforms was recorded on the basis outlined by FAO (2006).
- 75 disturbed soil samples were collected for determining different soil properties.
- According to the field works, boundaries between the different mapping units (in the initial base map) were demarcated. The physiographic units were identified.
- Soil (Physical and Chemical) analyses were carried out according to the standard method published by Page *et al.*, (1982) and Baruah and Barthakur (1997).
- The physiographic units were classified into the subgroup level on the basis of the key to soil taxonomy (USDA, 2006).
- The soil quality indicators were selected for land evaluation and their diagnostic soil characteristics listed in Table (1). Selection of these land qualities was based on a review of published literature and experimental reports, regional experience, consultation with the experts on land evaluation and data collected in the field.
- Actual and potential Land suitability classification for some specific crops was done according to FAO (1976) depending on soil rating after (Sys *et al.*, 1991) by using limitation method with criteria number and intensity of limitation by matching land qualities (or characteristics) with crop requirements. Crop requirements for the selected crops were determined by (Sys *et al.*, 1993).

**Table (1): The soil quality indicators.**

<b>Soil Quality</b>	<b>Diagnostic Soil Characteristics</b>
Topography	Slope %
Flooding hazard	Flooding class
Oxygen availability	Drainage, coarse fragments
Moisture availability	Texture.
Nutrient availability	CEC, pH, base saturation, sum of basic cations, OC
Adequacy of foothold for roots	Depth, calcium carbonate content, gypsum
Salinity & Alkalinity	EC <sub>e</sub> , ESP

## **RESULTS AND DISCUSSION**

**Physiography and Soils:**

The main terrain units were recognized and delineated by analyzing the main landscape that extracted from the satellite image draped over DEM with the aid of the previous geomorphologic and topographic maps and intensive field survey. Table (2) shows soil characteristics of the different mapping units in the study area. Table (3) and Fig. (5) show the obtained results of the main physiographic units. Table (4) and Fig. (6) represent soil Taxonomic units according to USDA (2006) in the study area.



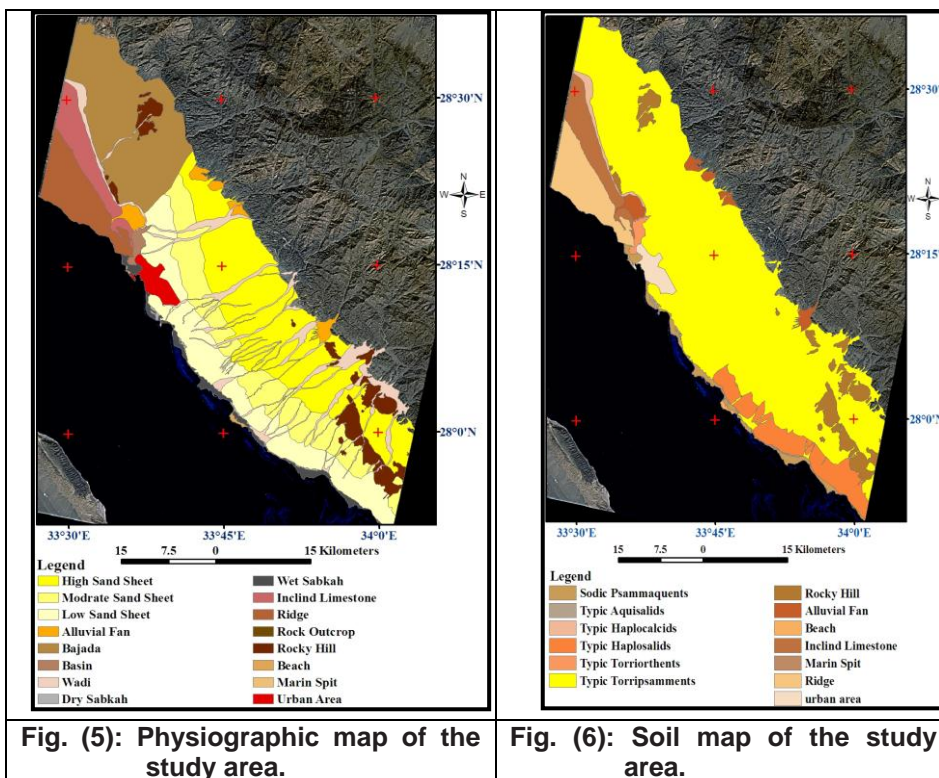
**Table (3): Physiographic legend and areas of the different mapping units.**

Physiographic units	Landform	Mapping units	Area (Km <sup>2</sup> )	Total area %
Sand Sheets (SS)	- Low sand sheets - Moderately sand sheets - High sand sheets	LSS	252.4	14.48
		MSS	217.9	12.50
		HSS	430.1	24.68
			900.4	51.67
Bajada	Bajada	BJ	317.5	18.22
Wadis	Wadis	W	147.6	8.47
Basin	Basin	BS	9.4	0.54
Sabkhas (SK)	- Dry Sabkhas. - Wet Sabkhas.	DSK	3.9	0.22
		WSK	33.5	1.92
			37.4	2.15
Alluvial Fan	Alluvial Fan	AF	33.3	1.91
Ridge	Ridge	RD	106.2	6.09
Inclined Limestone	Inclined Limestone	IL	72.3	4.15
Rocky Hill	Rocky Hill	RH	88.7	5.09
Urban Area	Urban Area	UA	26.8	1.54
Beach	Beach	BE	2.8	0.16
Marine Spit	Marine Spit	MS	0.2	0.01
<b>Total area</b>			1742.6 km <sup>2</sup> (414,904.8 Feddans)	

**Table (4): Soil taxonomy of the study area.**

Physiographic units	Landform	Mapping units	Kind of mapping unit	Soil taxonomy	Profile No.
Sand sheets (SS)	- Low sand sheets	LSS	Ass.*	Typic Torripsamments Typic Haplosalids	15,22,24 20,21,25,26
	- Moderately sand sheets	MSS	Con.**	Typic Torripsamments	8,10,29
	- High sand sheets	HSS	Con.	Typic Torripsamments	30,31,33,34
Bajada	Bajada	BJ	Ass.	Typic Torripsamments Sodic Haplocalcids	3,4,5,6,7 2
Wadis	Wadis	W	Ass.	Typic Torripsamments Sodic Haplocalcids	13,32 1
Basins	Basins	BS	Con.	Typic Torriorthents	17
Sabkhas (SK)	- Dry Sabkhas	KF1	Con.	Typic Aquisalids	19
	- Wet Sabkhas	KF2	Con.	Sodic Psammaquents	28
Alluvial fan	Alluvial fan	AF			
Ridge	Ridge	RD			
Inclined limestone	Inclined limestone	IL			
Rocky hill	Rocky hill	RH			
Urban area	Urban area	UA			
Beach	Beach	BE			
Marine spit	Marine spit	MS			

\* Association      \*\* Consociation



**Land Suitability for Crops:**

Actual and potential suitability calculated according to FAO (1976) depending on soil rating after (Sys *et al.*, 1991) deals with land qualities (or characteristics) coupled with crops requirements for the selected crops which determined by (Sys *et al.*, 1993).

Current land suitability for crops in the different mapping units is shown in Table (5). The potential soil suitability for crops depends upon the limiting factors and the possibility of soil improvement in the different mapping units is shown in Table (6) and Fig. (7).

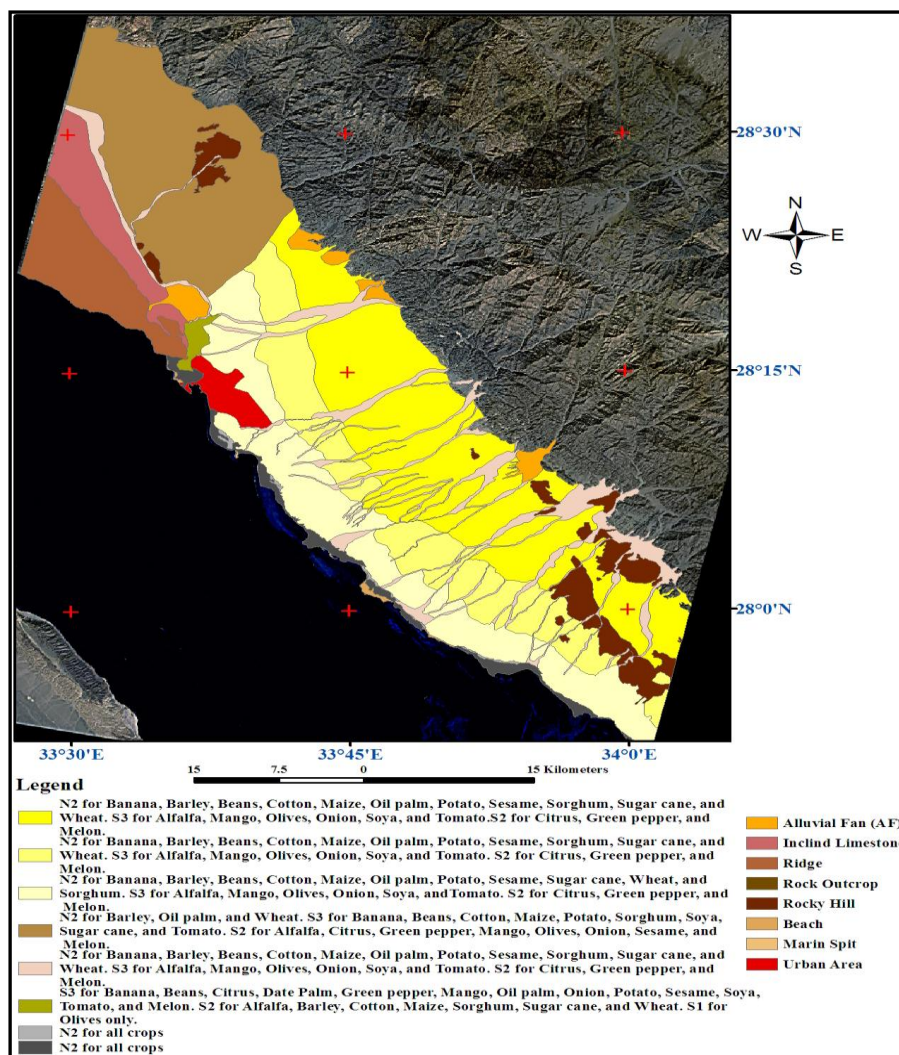
Table (5): Current land suitability for selected crops in the different mapping units.

		Sand sheets			Bajada	Wadi	Basin	Sabkhas	
		LSS	MSS	HSS				Dry	Wet
1	Alfalfa	N1	S3	S3	N1	N1	N1	N2	N2
2	Banana	N2	N2	N2	N1	N2	N1	N2	N2
3	Barley	N2	N2	N2	N2	N2	N1	N2	N2
4	Beans	N2	N2	N2	N1	N2	N1	N2	N2
5	Citrus	N1	N1	N1	N1	N1	N1	N2	N2
6	Cotton	N2	N2	N2	N1	N2	N1	N2	N2
7	Date Palm	N1	N1	N1	N1	N1	N1	N2	N2
8	Green pepper	N1	N1	N1	N1	N1	N1	N2	N2
9	Maize	N2	N2	N2	N1	N2	N1	N2	N2
10	Mango	N1	N1	N1	N1	N1	N1	N2	N2
11	Oil palm	N2	N2	N2	N2	N2	N1	N2	N2
12	Olives	N1	S3	S3	N1	S3	N1	N2	N2
13	Onion	N1	N1	N1	N1	N1	N1	N2	N2
14	Potato	N2	N2	N2	N1	N2	N1	N2	N2
15	Sesame	N2	N2	N2	N1	N2	N1	N2	N2
16	Sorghum	N2	N2	N2	N1	N2	N1	N2	N2
17	Soya	N1	N1	N1	N1	N1	N1	N2	N2
18	Sugar cane	N2	N2	N2	N1	N2	N1	N2	N2
19	Tomato	N1	N1	S3	N1	N1	N1	N2	N2
20	Melon	N1	N1	N1	N1	N1	N1	N2	N2
21	Wheat	N2	N2	N2	N2	N2	N1	N2	N2

Table (6): Potential land suitability for selected crops in the different mapping units.

		Sand sheets			Bajada	Wadi	Basin	Sabkhas	
		LSS	MSS	HSS				Dry	Wet
1	Alfalfa	S3	S3	S3	S2	S3	S2	N2	N2
2	Banana	N2	N2	N2	S3	N2	S3	N2	N2
3	Barley	N2	N2	N2	N2	N2	S2	N2	N2
4	Beans	N2	N2	N2	S3	N2	S3	N2	N2
5	Citrus	S2	S2	S2	S2	S2	S3	N2	N2
6	Cotton	N2	N2	N2	S3	N2	S2	N2	N2
7	Date Palm	S2	S2	S2	S2	S2	S3	N2	N2
8	Green pepper	S2	S2	S2	S2	S2	S3	N2	N2
9	Maize	N2	N2	N2	S3	N2	S2	N2	N2
10	Mango	S3	S3	S3	S2	S3	S3	N2	N2
11	Oil palm	N2	N2	N2	N2	N2	S3	N2	N2
12	Olives	S3	S3	S3	S2	S3	S1	N2	N2
13	Onion	S3	S3	S3	S2	S3	S3	N2	N2
14	Potato	N2	N2	N2	S3	N2	S3	N2	N2
15	Sesame	N2	N2	N2	S2	N2	S3	N2	N2
16	Sorghum	N2	N2	N2	S3	N2	S2	N2	N2
17	Soya	S3	S3	S3	S3	S3	S3	N2	N2
18	Sugar cane	N2	N2	N2	S3	N2	S2	N2	N2
19	Tomato	S3	S3	S3	S3	S3	S3	N2	N2
20	Melon	S2	S2	S2	S2	S2	S3	N2	N2
21	Wheat	N2	N2	N2	N2	N2	S2	N2	N2





**Fig. (7): Potential land suitability of the study area.**

**Conclusion**

Soils in the study area include: sand sheet (Low, moderate, and high) (252.4, 217.9, and 430.1 km<sup>2</sup>) classified as Typic Torripsamments and Typic Haplosalids. Bajada (317.5 km<sup>2</sup>) classified as Typic Torripsamments and Sodic Haplocalcids. Wadis (147.6 km<sup>2</sup>) classified as Typic Torripsamments and Sodic Haplocalcids. Basin (9.4 km<sup>2</sup>) classified as Typic Torriorthents. Dry Sabkhas (3.9 km<sup>2</sup>) classified as Typic Aquisalids, and Wet Sabkhas (33.5 km<sup>2</sup>) classified as Sodic Psammaquents.

The suitability of the selected crops currently not suitable in the different mapping units. The main limiting factors are texture, salinity and

alkalinity, nutrient availability and calcium carbonate content, only in sabkhas added flooding, drainage, and soil depth.

The potential suitability in the different mapping units refers that soils of sand sheet can not be suitable for Banana, Barley, Beans, Cotton, Maize, Oil palm, Potato, Sesame, Sorghum, Sugar cane, and Wheat, and moderately (S2) to marginally (S3) suitable for Alfalfa, Citrus, date palm, Green pepper, Mango, Olives, Onion, Soya, Tomato, and Melon. Soils of Bajada can not be suitable for Barley, Oil palm, and Wheat, and moderately (S2) to marginally (S3) suitable for Alfalfa, Banana, Beans, Citrus, Cotton, date palm, Green pepper, Maize, Mango, Olives, Onion, Potato, Sesame, Sorghum, Soya, Sugar cane, Tomato, and Melon. Soils of Wadis can not be suitable for Banana, Barley, Beans, Cotton, Maize, Oil palm, Potato, Sesame, Sorghum, Sugar cane, and Wheat, and moderately (S2) to marginally (S3) suitable for Alfalfa, Citrus, Date Palm, Green pepper, Mango, Olives, Onion, Soya, Tomato, and Melon. Soils of basin can be highly suitable (S1) to marginally (S3) suitable for the selected crops. Soils of Alkali flat (dry and wet sabkhas) are not suitable for the selected crops. The potential suitability in the different mapping units refers that soils can be highly (S1), moderately (S2), and marginally (S3) suitable with a proper management practices and fertilization, and can not be suitable due to soil texture in all mapping units except in sabkhas where the limiting factors are texture, salinity and alkalinity, flooding, drainage, and soil depth which can not be enhanced in the near future.

The results obtained can be employed by landuse planners (decision makers) to select suitable areas for the selected crops production. Outputs of selected crops enable the user to select management options (practices) to alleviate identified limitations. Investigation of the reasoning process provides the opportunity of assessing the possibility of improving suitability by specific management option(s) (practices). Researchers can also use this information to focus on more detailed and meaningful research options in plant breeding, nutrition, water requirements and soil management within the different suitable area.

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تقييم صلاحية التربة لبعض المحاصيل باستخدام الاستشعار من بعد و نظم المعلومات الجغرافية بسهل القاع، جنوب سيناء، مصر.

محمد محمود أحمد متولى\* و أحمد محمد العربي\*\*

\* شعبة إستقبال وتحليل البيانات وشنون المحطة الارضية- الهيئة القومية للاستشعار من بعد وعلوم الفضاء- القاهرة- مصر.

\*\*قسم الاراضى- كلية الزراعة- جامعة عين شمس- القاهرة- مصر.

زيادة النمو السكانى والازمة الغذائية كان حافزا لزيادة الانتاج وزيادة المساحة المزروعة افقيا واستخدام الاراضى بناء على قدراتها طريقة مناسبة. لذلك تهدف هذه الدراسة الى التكامل بين جودة التربة (أوصائص التربة) وبيانات الاستشعار من بعد ونموذج الارتفاعات الرقمية (ثلاثى الأبعاد) من خلال نظم المعلومات الجغرافية للإنتاج قاعدة بيانات للموارد الارضية، تم استخدام صور القمر الصناعى الفرنسى SPOT5 للإنتاج خريطة الأساس، وبناءاً على الاعمال الحقلية والتحليلات المعملية لعينات التربة المختلفة المأخوذة تم التحقق والتأكد وتصحيح وتعديل الحدود بين الوحدات المورفولوجية المختلفة. تم تقسيم الاراضى بمنطقة الدراسة بناء على التقسيم الأمريكى. تم تقييم صلاحية التربة (الحالية والكامنة) لعدد ٢١ محصول مختلف باستخدام نظام منظمة الاغذية والزراعة 1976, FAO على اساس معدلات Sys., et. al., 1991 ومقارنتها بالاحتياجات المحصولية المقدره بواسطة Sys., et. al., 1993. صلاحية التربة للمحاصيل المختلفة الحالية تشير الى ان التربة غير صالحة فى جميع الوحدات الخرائطية، العوامل المحددة الرئيسية هى القوام، الملوحة، القلوية، توافر العناصر الغذائية، ومحتوى كربونات الكالسيوم، فقط فى السبخات يضاف اليهم الغمر، الصرف، وعمق التربة. صلاحية التربة للمحاصيل المختلفة الكامنة تشير الى ان التربة يمكن ان تكون عالية ومتوسطة ومحدودة الصلاحية فى ظل عمليات ادارة وتسميد مناسبة، ويمكن ان تكون غير صالحة بسبب قوام التربة كعامل محدد فى جميع الوحدات الخرائطية المختلفة، فيما عدا السبخات حيث ان العوامل المحددة هى القوام، الملوحة، القلوية، الغمر، الصرف، وعمق التربة. النتائج المتحصل عليها يمكن ان توظف بواسطة المخططى للاستخدام الاراضى (متخذى القرار) لتحديد المناطق الصالحة للإنتاج المحاصيل المختلفة بمنطقة الدراسة.

قام بتحكيم البحث

كلية الزراعة – جامعة المنصورة  
كلية الزراعة – جامعة كفر الشيخ

أ.د / السيد محمود فوزي الحديدي  
أ.د / محمود محمد سعيد

**Table (2): Soil characteristics of the different mapping units.**

Mapping unit	Profile No.	depth (cm)	Coarse fragments %	Texture	pH	EC (dS/m)	ESP %	CaCO <sub>3</sub> %	Gypsum %	CEC (meq/100g soil)	O. C %	Slope %	Flooding	Drainage
Low sand sheets (LSS)	p15	150	25.1	S	8.2	10.2	50.7	6	0.03	5.4	0.8	Gently slope (2.1%)	F0	well
	p20	150	3.8	LS	7.8	56.7	89.8	7	0.48	8.4	1.7	Nearly level (1%)	F0	well
	p21	150	27.5	S	7.4	103.5	70.5	11	1.15	6.1	1.2	Very gently sloping (1.7%)	F0	well
	p22	150	11.0	S	8.0	23.0	53.3	10	0.11	6.1	1.0	Gently slope (2.2%)	F0	well
	p24	150	14.6	S	8.0	22.6	65.8	6	0.20	5.3	1.0	Gently slope (2%)	F0	well
	p25	150	10.5	S	7.6	71.4	77.8	15	0.36	6.5	2.1	Gently slope (2.3%)	F0	well
	p26	150	16.5	S	8.3	24.2	53.9	22	0.24	7.0	1.8	Very gently sloping (1.8%)	F0	well
Moderately sand sheets (MSS)	p8	150	10.8	S	8.2	3.7	26.3	9	0.04	5.1	1.2	Gently slope (4.4%)	F0	well
	p10	150	18.3	S	8.3	3.7	29.3	9	0.20	5.7	0.6	Gently slope (3.7%)	F0	well
	p29	150	18.6	S	7.7	16.1	74.0	10	0.04	5.1	0.7	Gently slope (3%)	F0	well
High sand sheets (HSS)	p30	150	12.9	S	8.3	8.8	32.6	6	0.06	5.0	0.6	Sloping (8.5%)	F0	well
	p31	150	20.0	S	8.1	4.4	24.2	6	0.42	7.7	1.4	Sloping (9.5%)	F0	well
	p33	150	20.8	S	8.2	6.3	46.0	8	0.04	5.5	1.0	Sloping (6.1%)	F0	well
	p34	150	19.6	S	8.0	15.4	35.8	13	0.45	5.3	1.0	Sloping (5.1%)	F0	well
Bajada (BJ)	p2	150	8.0	LS	8.0	14.7	32.5	21	0.45	9.9	1.3	Gently slope (3.7%)	F0	well
	p3	150	8.6	LS	7.9	41.4	69.5	18	0.53	12.3	1.2	Gently slope (2.1%)	F0	well
	p4	150	10.6	S	8.1	36.3	55.5	12	0.52	6.9	2.7	Gently slope (2.8%)	F0	well
	p5	150	18.4	S	8.4	3.1	31.9	8	0.05	5.3	1.4	Gently slope (2.4%)	F0	well
	p6	150	9.3	LS	8.5	17.7	80.6	7	0.34	12.1	0.7	Gently slope (3.7%)	F0	well
	p7	150	12.7	S	8.5	1.8	23.3	7	0.04	4.4	0.7	Gently slope (4%)	F0	well
Wadis (W)	p1	150	0.0	SL	7.4	32.0	41.4	36	0.37	15.7	1.8	Gently slope (3.7%)	F0	well
	p13	150	25.1	S	8.2	5.3	28.9	10	0.09	5.3	0.9	Gently slope (2.4%)	F0	well
	p32	150	24.3	S	8.4	1.1	23.8	7	0.03	3.1	0.8	Sloping (6.2%)	F0	well
Basin (BS)	p17	150	0.0	SCL	8.4	14.0	49.1	32	0.43	23.5	1.1	Gently slope (2.1%)	F0	Mod.
Dry Sabkhas (DSK)	p19	100	0.0	LS	7.6	45.2	73.4	8	0.86	13.4	1.6	Nearly level (1%)	F1	Mod.
Wet Sabkhas (WSK)	p28	60	0.0	S	7.4	101.4	88.4	5	0.42	8.2	1.5	Very gently sloping (1.4%)	F2	Imp.

**S: Sand**  
**SL: Sandy Loam**  
**LS: Loamy sand**  
**SCL: Sand clay loam**

**F0: no flooding**  
**F1: moderate flooding**  
**F2: sever flooding**

**Mod. : Moderately drained**  
**Imp.: Imperfect**