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A Numerical Approach to Land Suitability for Wheat Cultivation in the North-Western Coast Region of Egypt

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WHEAT is considered the most strategic crop for Egypt as well as some other developing countries. The present study is conducted to evaluate the land suitability of the north-western coast region of Egypt for wheat cultivation using Sakha-8 cultivar to perform the suggested approach. The area covers approximately 393680 feddan. The soils of this area are mostly sandy to sandy loam. They are rich in their lime content and fluctuate in salinity level. They were classified into Typic Salorthids, Typic Torripsamments, Lithic Torripsamments, Typic Torriorthents, Typic Calciorthids, Calcic Torripsamments and mixture of Typic Calciorthids with Typic Orthents. The obtained data indicated that the study area could be grouped into three land suitability classes for wheat. The classes S1, S2 and S3 cover almost 50, 29 and 6 % of the total area respectively. Soil salinity, drainage conditions and low fertility of the soils were the main limiting factors.

Keywords: Wheat, Sakha-8, Land suitability, North-Western coast region.

Wheat (*Triticum* sp.) is considered the most strategic crop for Egypt as well as some other developing countries. Although, bread is the essential food constituent for most of the Egyptians, there is, for tens of years, a wide gap between the wheat local production and consumption. Great attention and efforts have been paid by the Egyptian Government and scientists to narrow that gap. Their plans are based on increasing the area of wheat cultivation; enhancing the production per area unit and breading new wheat varieties that suit the newly reclaimed land. These soils may suffer mostly from low soil fertility, soil salinity, shortage of irrigation water or low quality and drought stress.

Several authors had conducted various experiments to insure the suitability of wheat cultivars for different soils and climatological conditions. Bassiouny (1985), found that Sakha-8 ranked first to grain yield followed by Sakha-61 and Sakha-69 when they were sowed under saline conditions. In some experiments at Wadi Sudr, South Sinai, Hegazi *et al.* (1998) found that Sakha-8 was superior than Sakha-92 in the number of grains per spike,number of spikiest per spike, spike length, spike weight and the harvest index. Moreover, the growth of Sakha-8 cultivar surpassed other cultivars under saline conditions (Ashour & Selim, 1994). Sowing Sakha-8 and Sakha-92 on the slopping of furrows of sandy loam seed bed under saline irrigation water, improved the wheat yield characters more

than the broadcasting or drill in rows sowing, (Hassan & Hassan, 1994). They stated that these results may be due to improvement of the seed bed and/or more tolerance to saline irrigation water. This sowing method were recommended by different researches (Bernstien *et al.,* 1975 and Ayers & Westcot, 1981) for cultivation of wheat to be irrigated with saline water.

The assessment of land performance for specific land utilization purposes is called land evaluation. Such evaluation is essential in the process of land use planning because it may guide decisions on land utilization in a way that the natural resources are optimally used and that a sustained land management is achieved (Tang *et al.*,1991).

Land suitability classification is an approach in land evaluation that concerns the appraisal and grouping of specific areas of land in terms of their suitability for defined uses (FAO, 1976). These methods established several ways to estimate the potential crop production from either land characteristics or qualities. Such approaches are the Storie Index method (Storie, 1976), the Square Root method (Khiddir, 1986) and the Sys' Parametric method (Sys & Verheye 1978; Sys, 1985 and Sys *et al.,* 1993).

The present study is conducted to evaluate the land suitability of the north-western coast region of Egypt, for the wheat cultivation using Sakha-8 cultivar to perform the suggested approach.

Material and Methods

Study area

The study area is located in the north-western coast region of Egypt and is bounded by latitudes 29° 05′ 24′′ and 29° 57′ 36′′ N and longitudes 30° 33′ 36′′ and 31° 03′ 00′′ E. It is a part of El-Hamam Canal command area, which starts from the end of El-Nasr Canal to El-Alamain region of almost 55km long. The area covers approximately 393680 feddan (1655 km^2) (Fig. 1).

Soil investigations

The area was surveyed and represented by ten soil profiles which were distributed over the various soil types of the area (Fig.1). These profiles were morphologically described according to (USDA, 2002) and sampled for analytical determinations.

Grain size distribution was determined by dry sieving for the light textured soils and by mechanical analysis for the heavy textured ones (Soil Conservation Servic, 1984). Soil pH was measured in 1:2.5 soil-water suspension and the electrical conductivity (EC) in the saturated soil paste extract (USDA, 1991). The soluble cations and anions were determined in the saturated paste extract, (USDA, 1991). Total carbonates as calcium carbonate content was conducted by the calcimeter, (Nelson, 1982). Organic carbon content by Walkle and CEC were determined according to Black *et al.* (1982). According to the obtained data the studied soils were classified.

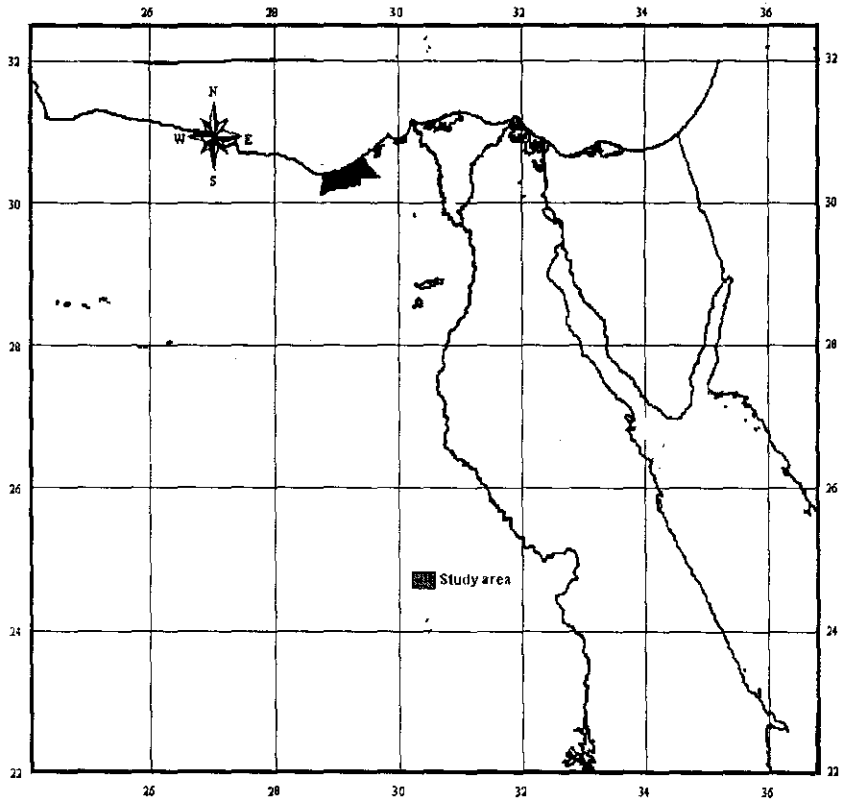

Fig .1. Location of the study area .

Land suitability method

Ghabour *et al.* (2004) compared two methods to calculate the suitability index and found that the Square Root method is more reliable than Storie method. Therefore, the first was used in the current study and it depends on giving more concern to the soil parameter which is given the minimum rating value. According to this method (Khiddir, 1986), the land suitability index (SI) is calculated as follows:

SI= minimum rating value * $\sqrt{\frac{A}{100} * \frac{B}{100} * \ldots}$

where: A, B ... are the rating values of different soil parameters besides the minimal one.

Digitizing soil map .

The map sheet no 1-B at scale 1:100.000 of the Soil Map of Egypt was optically scanned and transformed into digital picture format. The digital picture was imported into the Arc View 3.1 soft ware and was digitized on screen to produce the soil digitized map of the study area. This output was used as a base map to perform the areal distribution of the land suitability results and the location of the soil profiles as well.

Results and Discussion

Soil identification

The morphological soil profile description is recorded in Table 1 and reveals that the soil surface is generally flat or nearly flat. Their soil texture is mostly sandy to sandy loam and their structure is described as single grain, subangular blocky or massive. The soils are varied in their drainage conditions from well, moderately to poorly drained soils, and their dry consistency is either hard or weak. They show strong to very strong effervescence with HCl indicating that they are rich in their calcium carbonate content. The boundaries between the layers are found to be abrupt, clear and diffuse.

According to the Soil Map of Egypt (1982), the soils of the study area were classified into, Typic Salorthids (profile nos 1 and 2). Typic Torripsamments (profile nos 3,8 and 10), Lithic Torripsamments (profile nos 4 and 9), Typic Torriorthents (profile no 5), Typic Calciorthids (profile nos 6 and 7), Calcic Torripsamments and mixture of Typic

Calciorthids with Typic Orthents. Digitizing this soil map sheet produced a soil digital map (Fig. 2) which shows the aerial distribution of the soil types in the study area and their coverage area can be estimated (Table 2).

The obtained data reveals that almost two thirds of the entire study area are occupied by Typic Torriorthents, Lithic Torripsamments and the mixture of Typic Calciorthids and Typic Orthents. Typic Salorthids, Typic Calciorthids and Typic Torripsamments represent 5.6, 6.4 and 6.8%, respectively, of the total study area. Rocky surface constitutes approximately 13% of the area under investigation while, the coastal sand which was classified as Calcic Torripsamments forms about 2.4%.

Land suitability estimation

The physical and chemical characteristics of the studied soils are presented in Table 3, as averages of the obtained results of the successive layers of each soil profile. The data revealed that the soils of the studied area were characterized by light texture. The soil salinity were widely varied and ranged from non-saline (1.00 dS/m) to highly saline (28.45 dS/m). Their lime content was moderate to high as the calcium carbonate was renging between 14.10 and 32.26%. Generally, the studied soils were poor in fertility status due to their low apparent cation exchange capacity (8.94 to 19.12 meq/100g soil) as a result of the light soil texture and the very low organic matter content. In addition, the high soil salinity

and the moderate to poor drainage conditions of the soils are negatively affecting the soil fertility.

TABLE 1. Morphological description of the studied soil profiles.

Profile no.	Depth (cm)	Colour (dry)	Top	~ Text.	#Str.	*Drainage conditions	+Dry cons.	Hcl effer.	$L. Bound.	Classification
1	0-30	10YR 8/3 light yellow orange	F	S	sg	m	w	H	d	Typic Salorthids
	30-100	10YR 8/4 light yellow orange		S	sg		w	h		
2	0-30	10YR 8/4 light yellow orange	F	S	sg	m	w	H	d	Typic Salorthids
	30-100	10 YR 7/4dull yellow orange		S	sg		w	h		
3	0-20	10YR 8/3 light yellow orange	F	S	sg	m	w	H	d	Typic Torripsamm-ents
	20-100	10YR 8/4 light yellow orange		S	sg		w	H		
4	0-50	10YR 7/4 dull	F	S	sg					Lithic
	>50	yellow orange		Bed	rock	p	w	H	a	Torripsamm-ents
5	0-30	10YR 8/3 light yellow orange	F	S.L.	sb	w	w	H	a	Typic Torriarthents
	30-50	10YR 8/3 light yellow orange		S.L.	sb		h	H	d	
	50-150	10YR 7/4 dull yellow orange		S.L.	sb		h	H		
6	0-40	7.5YR 7/6 orange	F	S	sg	w	w	H	d	Typic Calciorthids
	40-80	7.5YR 6/4 orange		S.L.	sb		w	H	d	
	80-150	7.5YR 6/4 orange		S	M		h	H		
7	0-15	7.5YR 7/4 dull orange	F	S.L.	M	m	h	H	d	Typic Calciorthids
	15-32	7.5YR 7/6 orange		S.L.	sb		w	H	d	
	32-100	7.5YR 6/6 orange		S.L.	M		h	H		
8	0-20	7.5YR 7/6 orange	F	S	sg	m	w	H	d	Typic Torripsamm-ents
	20-60	7.5YR 6/6 orange		S	M		w	H	c	
	60-100	7.5YR 7/6 orange		S	M		w	H		
9	0-40	10YR 7/4 dull	F	S.L.	sb	p	w	H	a	Lithic Torripsamments
	>40	yellow orange		Bed	rock					
10	0-30	7.5YR 6/6 orange	F	S	sg	m	w	H	c	Typic Torripsamments
	30-95	7.5YR 6/6 orange		S	M		w	H		

~ Texture abbrev. S = sandy, S.L.= sandy loam.
# Structure abbrev. M= massive, sb = subangular blocky, sg = single grain.
+ Dry consistence abbrev. h = hard, w= weak .
$ Lower boundary abbrev. a = abrut, c = clear, d = diffuse, s = smoth .
* drainage conditions abbrev. m = moderate, p = poor, w = well .
Topography abbrev. F = flat .
HCl abbrev. H = highly.

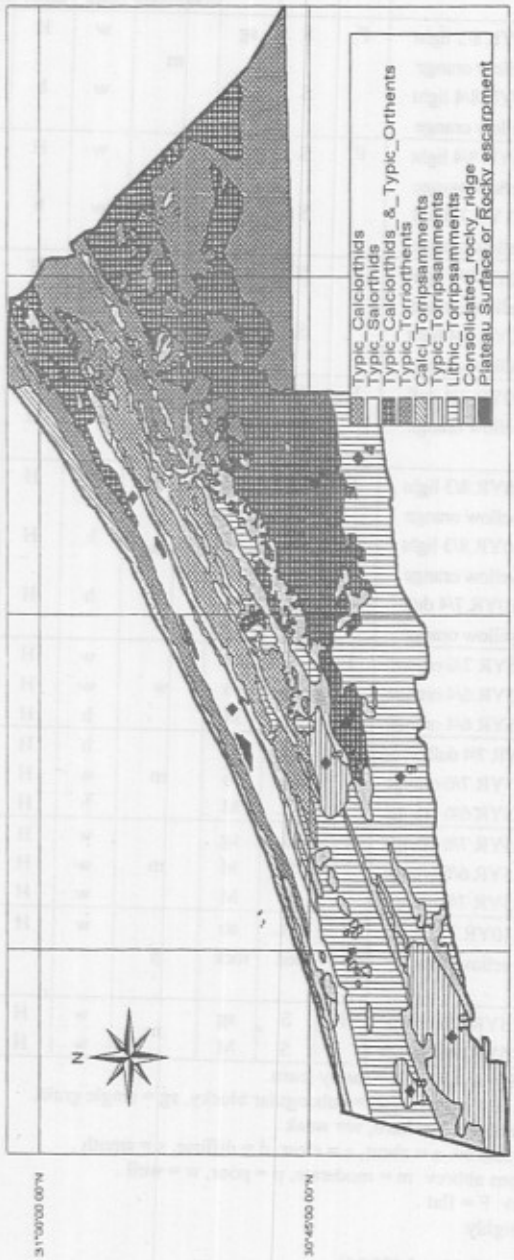

Fig.2. Soil classification map of the study area.

TABLE 2. Soil taxonomic classes and their corresponding areas.

Soil Taxonomic class	Area km^2	Area fed.	Area %
Calcic Torripsamments	39.02	9290.48	2.36
Consolidated rocky ridge	214.81	51145.24	12.99
Lithic Torribsamments	365.70	87071.43	22.12
Plateau surface or rocky escarpment	2.25	535.71	014
Typic Calciorthids	105.82	25195.24	6.40
Typic Calciorthids and Typic Orthents	367.20	87428.57	22.21
Typic Salorthids	92.69	22069.05	5.61
Typic Torriorthents	353.32	84123.81	21.37
Tupic Torripsamments	112.64	26819.05	6.81
Total area	1653.45	393678.57	100.00

TABLE 3. Soil properties, physical and chemical analyses of the studied profiles.

Profile no.	Topo-graphy	Draina-ge conditi-ons	Grain size distribution			Text. class	Depth (cm)	$CaCO_3$ %	Appar. CEC	pH	EC (dS/m)	O.C. %
			Sand %	Silt %	Clay %							
1	F	m	78.22	15.73	6.05	S	100	32.26	15.11	7.99	28.05	0.17
2	F	m	87.49	9.36	3.15	S	100	27.57	8.94	7.96	28.45	0.09
3	F	m	89.42	6.50	4.08	S	100	14.50	10.23	7.84	16.76	0.11
4	F	p	72.52	14.45	13.03	S	50	21.49	17.13	7.58	12.90	0.09
5	F	w	72.39	11.14	16.47	S.L.	150	25.61	19.12	7.67	5.79	0.12
6	F	w	77.87	14.73	7.40	S	150	21.53	16.15	8.04	5.78	0.12
7	F	m	71.27	22.40	6.33	S.L.	100	23.12	14.20	7.99	5.03	0.16
8	F	m	81.68	10.74	7.58	S	100	14.10	16.80	7.61	9.92	0.11
9	F	p	67.35	17.50	15.15	S.L.	40	16.62	18.85	7.69	6.58	0.09

The Ministry of Agriculture (2000), published the main types and management processes for wheat cultivation in the newly reclaimed soils. It has been stated that Sakha-8 cultivar is suitable for the soils that have high soluble salts and rich in their lime content. Sys *et al.* (1993), reported the general climate soil requirements for wheat. Khodier *et al.* (1999), showed that the effect of 10 dS/m irrigation water salinity level on wheat yield was enough to select the highest grain yield genotypes for sandy soils. Finally, taking all literature data and information into consideration, a proposed Sakha-8 cultivar requirement in terms of soil characteristics was established and presented in Table 4.

TABLE 4. Landscape and soil requirements for Sakha 8 wheat cultivar.

Land characteristics	Class, degree of limitation and rating scale					
	S1	S2	S3	N1		N2
	0	1	2	3		4
	100	95 85	60	40		25
Topography (t) Slope %	0-1	1-2	2-4	4-6	-	>6
Wetness (w) drainage	good	moderate	imperfect	Poor	v. poor	v. poor
Physical soil characteristics (s)						
Texture/struct.	C.S.	M.S.	F.S.	Silt	Clay	Clay
Soil depth	>95	95-50	50-30	30-20	20-10	<10
$CaCO_3$ (%)	10-25	25-30	30-35	35-40	-	>40
Soil fertility characteristics (f)						
Apparent CEC	>15	15-10	10-7	7-5	5-3	<3
pH H_2O	7.5-8.0	8.0-8.2	8.2-8.3	8.3-8.4	-	-
EC (dS/m)	<10	10-20	20-30	30-35	>35	>35
O.C.	>0.4	0.4-0.1	0.1-0.05	<0.05	<0.05	<0.05

S1 (100-75) suitable.
S2 (75-50) moderately suitable.
S3 (50-25) marginally suitable.
N (25-0) unsuitable.

Land suitability indices (Table 5) were calculated according to the Square Root Method (Khiddir, 1986). These data indicated that the study area could be classified into three land suitability classes for wheat cultivar Sakha-8 (Fig. 3 and Table 5).

Land suitability class 1 (S1).

The calculated land suitability indices of this class varied from 78.60 to 83.34, indicating suitable soils for wheat cultivation (Table 5). These soils cover almost 50% of the study area (Table 6) and belong to Typic Torriorthents, Typic Calciorthids and the mixture of Typic Calciorthids and Typic Orthents. They are mostly characterized by sandy loam texture, well drainage conditions, moderate salinity and deep soil profiles. The expected wheat yield of Sakha-8 cultivar exceeds 75% of the optimal.

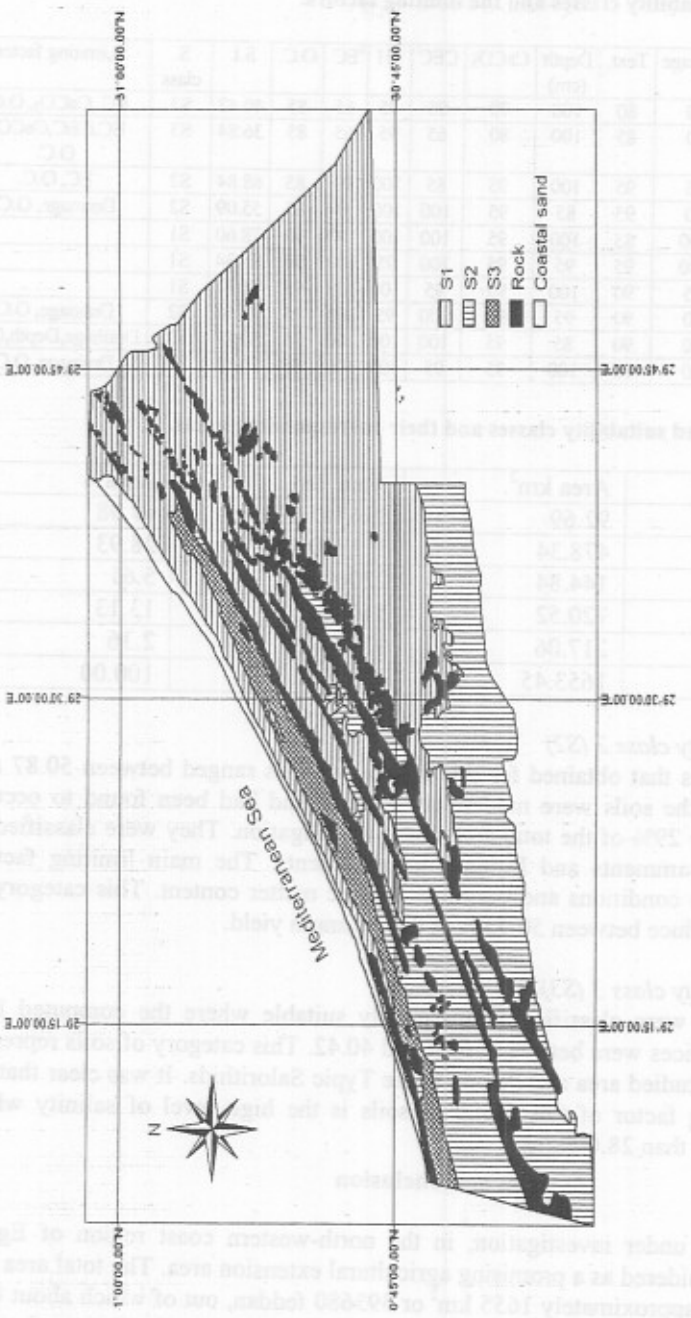

Fig .3. Land suitability classification map of the study area .

TABLE 5. Rating values of the evaluated soil characteristics, suitability indices, suitability classes and the limiting factors.

Profile no	Topo.	drainage	Text.	Depth (cm)	$CaCO_3$	CEC	pH	EC	O.C.	S.I.	S. class	Limiting factor
1	100	90	80	100	70	95	95	65	85	40.42	S3	EC ,$CaCO_3$, O.C.
2	100	90	85	100	80	65	95	65	85	36.84	S3	EC,CEC,$CaCO_3$, O.C.
3	100	95	95	100	95	85	100	90	85	68.84	S2	EC, O.C.
4	100	70	95	85	95	100	100	95	85	55.09	S2	Drainage, O.C.
5	100	100	85	100	95	100	100	100	90	78.60	S1	
6	100	100	95	95	95	100	95	100	90	83.34	S1	
7	100	95	90	100	95	95	100	100	95	81.22	S1	
8	100	90	90	95	95	100	95	100	85	72.68	S2	Drainage, O.C.
9	100	70	90	85	95	100	100	100	85	50.87	S2	Drainage,Depth,O.C.
10	100	90	95	100	95	95	100	100	85	70.83	S2	Drainage, O.C.

TABLE 6. Land suitability classes and their corresponding areas.

unit	Area km^2.	Area fed	Area%
S1	92.69	196747.62	49.98
S2	478.34	113890.48	28.93
S3	144.84	22069.05	5.61
Rock	720.52	51680.95	13.13
unclassified	217.06	9290.48	2.36
total	1653.45	393678.57	100.00

Land suitability class 2 (S2)

The indices that obtained for this suitability class ranged between 50.87 and 72.68. Thus, the soils were moderately suitable and had been found to occupy approximately 29% of the total area under investigation. They were classified as Typic Torripsamments and Lithic Torripsamments. The main limiting factors were drainage conditions and very low organic matter content. This category of soils may produce between 50-75% of the optimum yield.

Land suitability class 3 (S3)

The soils were classified as marginally suitable where the computed land suitability indices were between 36.84 and 40.42. This category of soils represent 5.6% of the studied area and belong to the Typic Salorithids. It was clear that the main limiting factor of this group of soils is the high level of salinity which reached more than 28.0 dS/m.

Conclusion

The area under investigation, in the north-western coast region of Egypt, could be considered as a promising agricultural extension area. The total area was estimated to approximately 1655 km^2 or 393680 feddan, out of which about 85% was suitable soils for agricultural use. The current work was aiming at estimating the land suitability of the area under consideration for wheat cultivation and

Sakha-8 was selected as salinity and draught resistant cultivar. The obtained results showed that about 50, 29 and 7% of the total area were suitable, moderately suitable and marginally suitable for wheat, respectively. Soil salinity, drainage conditions and low fertility of the soils were the main limiting factors. However, these factors could be corrected and thus the wheat production can be raised, especially with breading tolerant cultivars to salinity and drought.

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معالجة رقمية لملائمة الأراضى لزراعة القمح فى منطقة الساحل الشمالى الغربى – مصر

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يعتبر نبات القمح من اكثر المحاصيل الاستراتيجية فى مصر وكذلك فى معظم البلاد النامية. وتهدف هذه الدراسة الى تحديد مدى صلاحية نبات القمح (صنف سخا ٨) للزراعة فى منطقة الساحل الشمالى الغربى فى مصر. وهذه المنطقة تقدر بمساحة ٣٩٣٦٨٠ فدان تقريبا. وتشير النتائج المتحصل عليها ان هذه الاراضى ذات قوام رملى الى رملى طمى كما يختلف عمق قطاعها الارضى كما تتميز بمحتواها العالى من كربونات الكالسيوم وباختلاف مستوى الملوحة الارضية وبناء على خريطة التربة فى مصر تم تقسيم اراضى منطقة الدراسة الى:

Typic Salorthids, Typic Torripsamments, Lithic Torripsamments, Typic Torriorthents, Typic Calciorthids, Calcic Torripsamments and mixture of Typic Calciorthids with Typic Orthents.

أوضحت النتائج انه يمكن تقسيم اراضى هذه المنطقة الى ثلاث درجات من الملائمة لزراعة نبات القمح صنف سخا ٨. فقد وجد ان ٥٠٪ من مساحة المنطقة المدروسة تعتبر ملائمة لزراعة هذا الصنف من القمح و٢٤٪ من المساحة تعتبر متوسطة الملائمة وحوالى ٥,٦٪ من المساحة ضعيفة الملائمة لزراعة هذا النوع من القمح. وتعتبر درجة الملوحة وحالة الصرف وقلة خصوبة هذه الاراضى هى العوامل المحددة الرئيسية لزراعة القمح فى هذه الاراضى.