A PROPOSED MODIFIED LAND CAPABILITY SYSTEM FOR EVALUATING SANDY SOILS IN WESTERN NILE DELTA REGION

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ABSTRACT

This study aimed to evaluate soils of about 200.000 feddan for irrigated agriculture in the western desert of Egypt. The evaluation process was conducted using Sys and Verheye 1974 system and the proposed one derived from Sys and Verheye 1974. The proposed system is trial designed to fit the local environmental conditions of the investigated area. Modification proposed concerned, soil texture, soil salinity level, CaCO_3 content. Two other parameters were introduced to those of Sys and Verheye 1974, i.e, hydraulic conductivity and quality of irrigation water. Also soil parameters were divided into physical properties (P) which include soil texture, profile depth, drainage conditions, slope and hydraulic conductivity and chemical ones which include EC_e , ESP, CaCO_3 , gypsum and irrigation water quality (EC_{iw}). Another method for calculation was also introduced. Results of applying the proposed evaluating systems are completely different than those resulted by using Sys and Verheye 1974. It is thought that the obtained results are more realistic and fit the present field condition and soil outcome.

Keywords: Proposed system, land capability, Desert soils.

INTRODUCTION

Agricultural expansion in the desert areas is one of the main objectives of the national Agricultural expansion plan in Egypt to cover food demand of excessively increasing population. Western Nile Delta region is one of the most prospective areas due to its agricultural potentialities.

Several systems of land evaluation have been elaborated. Storie (1937) proposed the rating of different soil profile characteristics such as texture, slope, drainage, alkalinity, fertility, and erosion. The final product of his formula is the Storie index expressed in percentage. The soils are classified into six grades according to the proposed Storie index rating ranges, (Storie, 1976). Riquier *et al.* (1970), set up a parametric approach for general land evaluation with specific reference to arable land, pasture, forest and tree cultivation. In the same respect several reports by FAO (1976, 1983 and 1985) have been published dealing with land evaluation criteria for rural purposes and irrigation practices. Preliminary approaches have been published by several investigators in Egypt mostly directed towards the capability categories for agricultural objectives, Ibrahim (1983) and Erian (1986).

Several systems for land evaluation in Egypt have been introduced. The system of Abdel Muttalec and Hussien (1985) was the first, who assured that environmental factors should be included in land evaluation. However calculation methods involved are tedious and could subject results for errors. Abd El-Sattar (1999) applied several evaluation systems for the soil of certain geomorphic units in Western Nile Delta and concluded that most of those systems have to be revised. Ahmed (2007) in his study on soils of some

wadis adjacent to Elba mountain stated that most previous systems for land evaluation do not consider environmental conditions prevailed in the soils of Egypt. He proposed land capability classification system for the sandy soil in the desert of Egypt (CISS) by modifying upper and lower limit of values assigned for factors affecting plant growth and soil productivity. In the present study a proposed system for evaluating soils of Wadi El-Natron region is introduced. The proposed system is modified from that Sys and Verheye 1974 and others. However trails on developing local systems for land evaluation should be continue in all direction. Proposed systems should be tried and further modified by different specialized investigators in order to be validated and find out a most suitable land evaluating systems for the soils of Egypt.

MATERIALS AND METHODS

The area under investigation is located in the west of the Nile Delta between Longitudinal $30^{\circ} 11' 12''$ and $30^{\circ} 54' 58''$ E and latitudinal $30^{\circ} 13' 23''$ and $30^{\circ} 34' 41''$ N Fig (1). The area extends for about 37 Km length (from north to south) and 30 Km average width (east to west) with an area of 200.000 feddans approximately. Morphological descriptions of the profiles selected to represent the studied area (16 profiles) were carried out according to FAO (1990) guidelines. Physical and chemical properties were carried out according to the standard method published by Page *et al.* (1982) and (Baruah and Barthakur, 1997). Results of the physical and chemical properties of the studied soils which are used in calculating evaluation parameters are present in table (1 and 2). Detailed geomorphological and pedological characteristics of those soils are published the authors Zakarya , Y.M. (2009) elsewhere.

The climatological data of the studied area taken from Wadi El Natrun and Nubaria meteorological stations indicate that the studied area has thermic soil and temperature regime and torric soil moisture regime.

Fig. (1) Location of the study area.

Evaluation of the studied soils were carried by two systems: Sys and Verheye (1974) and another system proposed by the authors derived from Sys and Verheye (1974) by modified the upper and lower limits assigned for different soil factor. Also two other factors were added to the formula of land evaluation, i.e, hydraulic conductivity and quality of irrigation water. Detailed explanation of the proposed formula will be explained hereafter.

RESULTS AND DISCUSSION

Land evaluations of the studied soils were carried according to the most common system used for irrigated agriculture, i.e Sys and Verheye 1974. Evaluating the studied soils according to that system was found to be peculiar table (3). Most of the soils were placed in class V (profile 3, 4, 9, 10, 11, 12, 13 and 14) which means that these soils are unsuitable. While soils represented by profiles (5, 6, 7, 8 and 16) fitted class IV, which means that these soils are almost unsuitable. Exception being soils represented by profiles (1 and 2) which occurred in class III (slightly suitable) and soils represented by profile (15) which were placed in class II and ranked as suitable soils for irrigated agriculture. The obscurity of Sys and Verheye system (1974) is that these results are far away from the actual field observation and reality. Soils evaluated in classes IV and V are actually productive soils cultivate with different fruit trees (grapes, citrus and mango) and another portion of them are cultivated with vegetables such as tomatoes, potatoes, green and colored peppers and peanuts. It is certain that Sys and Verheye system is not suitable to evaluate the soils of the studied area. Sys and verheye system 1974 is based on granulometrical and phisico – chemical characteristics.

Table (3): Land Capability classes of the studied soils according to Sys and Verheye (1974).

Landscape	Prof. No.	Land characteristics and their ratings							CI	Class
		Texture (A)	Salinity/ Alkalinity (E)	CaCO ₃ (C)	Gypsum (D)	Depth (B)	Drainage (F)	Slope (G)		
River terraces	1	65	90	95	90	100	100	100	50	III
	2	65	90	95	90	100	100	100	50	III
	3	30	100	95	90	100	100	100	26	V
	4	30	100	95	90	100	100	100	26	V
	5	50	95	95	90	90	100	100	37	IV
	6	50	95	100	90	100	100	100	43	IV
	7	65	65	100	90	100	100	100	38	IV
	8	55	65	95	90	100	100	100	31	IV
	9	30	95	95	90	90	100	100	22	V
Old deltaic plain	10	30	70	95	90	90	100	100	16	V
	11	25	70	95	90	90	100	100	13	V
	12	30	95	95	90	100	100	100	24	V
Wind blown sand	13	30	100	95	90	100	100	100	26	V
	14	30	100	95	90	100	100	100	26	V
Wadi El Natrun Complex	15	75	100	95	90	100	100	100	64	II
	16	50	95	100	90	100	100	100	43	IV

*CI – Capability index

According to them soil characteristics influencing land suitability for irrigated agriculture are as follows:

A = rating of soil texture

B = rating of soil depth

C = rating of CaCO₃ status

D = rating of gypsum status

E = salinity/alkalinity rating

F = drainage rating

G = slope rating.

Then capability index for irrigation (Ci) is calculated according to the formula:

$$CI = A * (B/100) * C/100 * D/100 * E/100 * F/100 * G/100$$

The capability classes are defined according to the value of the capability index as follows:

Capability index (CI)	Class	Definition
>80	I	Excellent
60-80	II	Suitable
45-60	III	Slightly suitable
30-45	IV	Almost unsuitable
<30	V	Unsuitable

In the present study soil constrains responsible for decreasing soil grades to the forth of fifth grade are mainly soil texture, salinity and alkalinity. Soil texture is noncorrectable properties, but both salinity and alkalinity are correctable ones especially in sandy soils. Therefore, it is proposed to review the limits or values assigned for different soil properties in Sys and Verheye system in order to cope with different soil environmental conditions in the studied area. The following modifications were proposed to fit the sandy soils cultivated in the desert of Egypt:

1–Quality of irrigation water is taken into consideration during land evaluation.

This is done by adding one more parameter (Wi) to Sys and Verheye equation. Rating of this factor is shown in table (4).

2– Another soil parameter is also considered i.e soil hydraulic conductivity, as depth of impermeable layer will affect growth of plant rooting system. Table (5) shows the rating of this factor.

3– Rating limits of soil salinity (EC_e), soil alkalinity ESP, CaCO₃ and soil texture are also modified based on actual field experience, and the state of soil production, modification proposed are shown in table(6).

Table (4): Proposed rating of EC_{iw} of irrigation water (Wi).

EC _{iw} dS/m	Rating
< 0.6	100
0.6 – 1.1	95
1.1 – 1.4	80
1.4 – 1.7	65
1.7 – 3.2	50
> 3.2	20

Table (5): Proposed rating of Hydraulic Conductivity (H) according to (Mckenzie et al., 2002).

H. C (mm/hr)	Definition	Rating
< 1	Very slow	>25
1 – 5	Slow	50 – 75
5 – 20	Slow to moderate	75 – 100
20 – 60	Moderate	100 – 75
60 – 130	Moderate to vast	75 – 50
> 130	Very vast	50 – 25

Table (6): Proposed rating of soil salinity (EC_e), ESP, CaCO₃ and textural classes.

EC _e dS/m	Rating	ESP %	Rating	CaCO ₃ %	Rating	Texture		
						Textural class	Rating	
							< 15 % gravel	>15 % gravel
0-2	100	<5	100	<5	100	Cl / SiCL	100	90
2-4	90	5-10	90	5 – 10	80	SCL	95	85
4-6	70	10-15	70	10 – 15	75	L / SiL/Si	100	80
6-8	50	15-20	60	15 – 25	60	SiC/C-60%	90	95
8-10	40	20-25	40	> 25	50	SC	85	90
10-16	30	>25	20			SL	90	80
>16	20					C+60%	65	70
						LS	85	75
						S	75	65

4 – Calculation of capability index (Ci) of Sys and Verheye was also modified according to the following:

Different soil factors affecting land evaluation are divided into:

- Physical factors (P) include soil texture (A), soil depth (B), drainage (F), slope (G) and hydraulic conductivity.

- Chemical factors (C) include salinity(S), exchangeable sodium percentage (E), CaCO₃ (C), gypsum content (D) and irrigation water quality (Wi), then following equations were followed:

$$\text{Log (P)} = [\log (A*B*F*G* H)] / 5$$

$$\text{Log(C)} = [\log (S* E* C*D *Wi)] / 5$$

$$\text{CI} = P*C / 100$$

Instead of Sys and Verheye 1974 equation:

$$\text{CI} = A*(B/100)*C/100*D/100*E/100*F/100*G/100$$

5 – Capability indices of different classes were calculated according to the values Sys and Verheye 1974. Applying the proposed equation for evaluating the sandy soil of the studied area, different results were obtained compared to their evaluation according to the original Sys and Verheye (1974) system. These differences are explained in the following:

- Higher capability indices (Ci) were obtained for most soils, table (7):

Soils represented by 50 % of the studied profiles (3, 4, 5, 9, 12, 13, 14 and 15) attained Ci more than 80 %, therefore they are placed in class I (excellent). The data shows that the CI values from 82 to 92. These soils were characterized by available water for irrigation from El Nasr canal and

artisan well, EC_w varied from (0.35 – 1.1 dS/m), very deep profile, well drained, slope less than 1 %, hydraulic conductivity moderate to vast, their soil salinity less than 4 dS/m, the ESP was less than 15%, CaCO₃ less than 10% and less than 0.3% gypsum. The main limiting factor was texture and the capability of this soil is also affected by slightly salinity and sodicity limitation in some profiles (5, 9 and 12). Those soils have slight constraints concerning texture or salinity. Slight salinity in sandy soils irrigated by good quality water (W_i >95 %) is not a problem and can be corrected very easily. However the other constraint, i.e. soil texture is considered noncorrectable properties. The main problem of sandy texture is that related to their fertility and plant nutrient level, and this is not a limitation nowadays under the new fertigation practices.

- Other soils represented by the rest of soil profiles, their C_i allocate them in classes:

II (Suitable), soils represented by profiles (1, 2, 6 and 16)

III (Slightly suitable) soils represented by profiles (8 and 11)

IV (Almost unsuitable) soils represented by profiles (7 and 10)

Soil of class II (rated as Suitable):

These soils were characterized by available water for irrigation from ground water near from soil surface (50 – 80 m depth), light texture soils, deep profile, well drained, level to nearly level sloping area, hydraulic conductivity moderate to vast (> 20 mm/hr), soil salinity (4-6 dS/m), the ESP was less than 10%, 5 to 15 % CaCO₃, less than 0.3% gypsum and the EC_w ranged between 0.6 – 1.7dS/m or (from 385 to 1088 ppm). However such water quality can be used successfully to produce several crops with slight effort in irrigation management.

Soils of class III (Slightly suitable):

Represented by only two profiles have more severe constraints, sandy texture is accompanied by a lot of gravels (>35 %) have a texture class gravelly sand, in addition to their high salinity EC_e of the surface layer (>20 dS/m) and ESP (>30 %). However the available water for irrigation from ground water was very good quality, EC_{iw} less than 0.6 dS/m. the soils characterized which were classified into capability class III have very deep profile, well drained, level to nearly level sloping, CaCO₃ less than 10% and gypsum less than 0.3% . The soils of class III can be safely used for several crops providing intensive management processes are applied.

Soils of class IV rated as almost unsuitable:

Represented only by two profiles (7 and 10) have more severe constraints than any other soils in the studied area; high gravel content (>35 %), high soil salinity EC_e is > 10 dS/m in all profile layers, ESP > 20 %. However there exist wells of good water quality, which make them suitable for some wooden trees and biofuel plants.

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نظام معدل مقترح لتقييم القدرة الانتاجية فى الاراضى الرملية بمنطقة غرب الدلتا

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تهدف هذه الدراسة الى تقييم اراضى تشغل مساحة تقدر بحوالى ٢٠٠٠٠٠ فدان فى منطقة الصحراء الغربية فى مصر. وقد تم اجراء التقييم باستخدام نظام (Sys and Verheye 1974) و النظام المقترح المستنتج من نظام (Sys and Verheye 1974) . و قد صمم النظام المقترح لى يتلائم مع الظروف البيئية لمنطقة الدراسة. و تضمنت التعديلات المقترحة كل من (قوام التربة - درجة ملوحة التربة - محتوى كربونات الكالسيوم). وتم اضافة عاملان اخران الى معادلة (Sys and Verheye 1974) و هما (درجة التوصيل الهيدرولى - درجة ملوحة ماء الرى) . و قد تم تقسيم خواص التربة الى خواص فيزيائية (P) و التى تضمنت (قوام التربة - عمق القطاع الارضى - حالة الصرف - الميل - درجة التوصيل الهيدرولى) و خواص كيميائية و تضمنت (ملوحة التربة - نسبة الصوديوم المتبادل - محتوى التربة من كربونات الكالسيوم - محتوى التربة من الجبس - ملوحة ماء الرى). و قد استخدمت كذلك طريقة اخرى للحساب. وقد اوضحت نتائج الدراسة ان النتائج المتحصل عليها من نظام التقييم المقترح مختلفة تماما عن تلك التى نتجت باستخدام نظام (Sys and Verheye 1974) . وهذه النتائج المتحصل عليها تكون اكثر واقعية و مناسبة للظروف الحقلية لمنطقة الدراسة.

Table (7): Capability classes of the studied soils according to the proposed system.

Landscape	Prof. No.	Physical index(P)					Chemical index (C)					P	C	CI	Class
		Texture (A)	Depth (B)	Drainage (F)	Slope (G)	HC (H)	Salinity (S)	ESP (E)	CaCO ₃ (C)	Gypsum (D)	EC _{iw} (Wi)				
River terraces	1	80	100	100	100	85	70	90	80	90	50	93	74	69	II
	2	80	100	100	100	75	70	90	80	90	80	90	82	74	II
	3	75	100	100	100	100	100	90	100	90	95	94	95	90	I
	4	75	100	100	100	85	100	90	80	90	95	91	91	83	I
	5	75	100	100	100	85	70	90	100	90	100	91	89	82	I
	6	75	100	100	100	75	70	90	75	90	100	89	84	75	II
	7	80	100	100	100	50	20	20	75	90	100	83	49	40	IV
	8	85	100	100	100	85	20	20	80	90	100	94	49	46	III
	9	75	100	100	100	100	70	90	100	90	100	94	89	84	I
Old deltaic plain	10	75	100	100	100	100	20	20	100	90	50	94	45	42	IV
	11	65	100	100	100	85	30	20	100	90	100	89	56	50	III
	12	75	100	100	100	100	100	70	100	90	100	94	91	86	I
Wind blown sand	13	75	100	100	100	100	100	90	100	90	100	94	96	91	I
	14	75	100	100	100	100	100	100	100	90	100	94	98	92	I
Wadi El Natrun Complex	15	90	100	100	100	75	100	100	100	90	95	92	97	90	I
	16	75	100	100	100	85	70	70	75	90	80	91	77	70	II

*CI – Capability index

Table (2): Some physical and chemical characteristics of the studied soil profiles.

Profile No	Land form	Soil depth (cm)	pH	EC _e dS/m at 25 °C	SP %	O.M %	CEC meq/100g	Gypsu m %	ESP %	CaCO ₃ %	EC _{iw} dS/m	Hydraulic conductivity cm/hr	Gravel % >2 mm	Particle size distribution %			Texture class
														Sand %	Silt %	Clay %	
10	Old deltaic plain	0-40	8.10	21.20	25.4	0.18	8.82	0.04	34.92	4.76	1.80	6.45	4.8	87.72	2.4	9.88	Loamy Sand
		40-100	8.07	10.60	22.8	0.11	4.75	0.03	24.00	1.43		18.87	3.5	97.64	0.26	2.10	Sand
11		0-50	7.70	20.20	26.8	0.45	8.21	0.03	35.81	4.28	0.60	8.65	21.3	89.94	0.36	9.70	Sand
		50-100	8.14	2.86	28.5	0.25	9.44	0.05	6.25	1.90		8.40	4.4	89.84	0.21	9.95	Sand
12		0-60	8.47	1.30	22.0	0.28	3.27	Nd	8.87	0.95	0.50	18.15	5.4	97.36	0.24	2.40	Sand
		60-120	8.82	1.40	27.4	0.28	8.12	Nd	11.95	2.38		6.42	19.7	87.91	1.2	10.89	Loamy Sand
13	Wind blown sand	0-30	8.22	1.26	21.4	0.25	3.64	Nd	7.97	1.43	0.50	19.32	1.8	97.01	0.29	2.70	Sand
		30-120	8.30	1.16	21.1	0.21	3.21	Nd	5.61	1.30		18.06	2.4	97.35	0.2	2.45	Sand
14		0-40	7.80	0.86	24.8	0.42	5.86	Nd	1.19	1.14	0.80	11.40	1.5	91.98	0.42	7.60	Sand
		40-120	8.84	0.47	20.8	0.25	3.15	Nd	1.27	1.43		17.93	1.9	96.54	0.26	3.20	Sand
15	Wadi El Natrun Complex	0-50	7.85	0.62	35.0	0.11	13.48	Nd	2.23	4.09	0.70	2.73	36.1	79.75	2.8	17.45	Sandy Loam
		50-80	7.97	0.57	33.6	0.11	11.1	Nd	3.15	4.76		5.50	2.7	86.88	0.6	12.52	Loamy Sand
		80-120	8.10	0.55	31.8	0.06	9.8	Nd	4.08	4.81		6.10	3.1	87.34	0.85	11.81	Loamy Sand
16		0-20	7.85	4.20	27.1	0.59	13.73	0.02	3.35	16.76	0.70	2.35	14.7	76.22	7.48	16.30	Sandy Loam
		20-45	7.91	4.12	27.1	0.46	13.5	0.02	3.85	18.20		2.53	30.2	77.9	5.9	16.20	Sandy Loam
		45-120	8.13	3.76	25.4	0.11	5.43	0.03	10.31	10.76		12.63	4.6	92.85	0.29	6.86	Sand

*EC_{iw} – irrigation water