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Fertility and productivity index of some Soils in El-Sharkia Governorate, Eastern Nile Delta, Egypt using remote sensing and GIS techniques.

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Abstract

The study aimed at assessing the potential of Remote Sensing (RS) and Geographic Information System (GIS) to quantify soil fertility and productivity in some soils El-Sharkia Governorate of Egypt. Field survey data, Landsat-8 ETM$^+$ image and digital elevation model (DEM), were used to define the physiographic units. The physiographic units include, overflow mantel (OM), overflow basins (OB), Decantation Basins (DB), river terraces (RT) and turtle backs (TB), clay flats (CF), alkali flats (AF) and sand remnants (SR). Soil fertility index (SFI) and Land productivity index (LPI) were based on parametric approaches using GIS.The Requier index (RI) was used taking in view of soil and topographic parameters using specific formulas, fertility and productivity classifications. There were variation in the Require index (RI). LPI for the OB and RT soil ranged from class I "excellent" to class II "good" in fertility and productivity index respectively. For DB soils, the grade of Requier Index was class "I"in fertility as well asproductivity. The productivity index'sin TBsoils were class I "excellent" in fertility to class IV "low" in productivity. For the CF soils, the Requier Index'swere class I "excellent" forfertility and class III "average" for productivity. TheRI is mainly affected by soil depth and soil texture.

Keywords: El-Sharqia Governorate, land productivity, Soil fertility, Riquier index.

Introduction

Soils cover most lands of the earth, but they are limited and largely a non-renewable **(Blum, 2006**). Land meets three needs of the human being that are essential to survival and development: food, clothing, and shelter **(Deininger et al., 2007; Heillel, 2009).** About 3.2 billion hectares are arable land in the world which represent about a quarter of the total land area **(Scherr, 1999; Davis and Masten, 2003).**With a majority of the world population living in rural areas in developing countries, agriculture remains a key activity for providing people food and animals with feed and employment **(Costanza et al., 1992; Pearce and Warford, 1993; Andzo-Bika and Kamitewoko, 2004)**.Agriculture is the backbone of the economy in many countries, especially the least developing ones **(UNDP, 2007)**.Agriculture is one of the world's most important activities supporting human life. Land is central to development in Africa since about 60% of the population depend on agriculture **(Fresco et al, 1994; Moyo, 2000; Dengiz and Sağlam, 2012; Mirlotfi and Sargolzehi, 2013).**Less than 3% of Egypt's land area, are arable lands. **(Zeydan, 2005; El-Bagouri, 2008)**. The Nile Delta comprises 63% of Egypt's arable land **(Abu Al-Izz, 1971 and Shehata, 2014).**Agricultural productivity is defined as "output per unit of input" or "output per unit of land area", and improvement in productivity is the results of efficient use of production **(Shafi,1984;Singh and Dhillion, (2000); and Dharmasiri, 2009).**
Factors, Land evaluation is the assessment of land performance and its production potential when used for a specified purpose, in order to identify and compar potentials of land, many factors including soil, climate must be consideved**(Dent and Young, 1981; FAO, 1976, 1983 and 1985; Rossiter, 1996; Sys et al., 1991 and 1993 and Bouma, 2002).** Land evaluation provides information on the opportunities and constrains for the use of land **(Van Lanen et al., 1991). Sys et al. (1991b and 1993)** defined land evaluation as the fitness of land for a defined use. It assesses the suitability of land for specified land uses (**FAO, 1995).** soil is the most important component of land resource, Land evaluation had its **Rossiter (1996)**, origin in land capability classification, soil survey, and the potential use is expressed in terms of the predicted response to use forms or in terms of their physical constraints **(Dent & Young, 1981 and NRCS, 2008).**

Soil fertility is fundamental in determining land productivity and is defined in terms of the ability to supply nutrients to crops (**Swift and Palm, 2000)**. Soil fertility is an inherent capacity to supply crops with nutrients in adequate amounts and suitable proportions, whereas soil productivity is a wider term of the ability of soil to yield crops **(Dengiz, 2007)**.**Darst and Stewart (2007)** reported that, understanding the principles ofsoil fertility is vital to efficient crop production. Declining soil fertility is linked to, it's productivity it's**(Sanchez and Leakey, 1997),(Sanchez, 2002)**.For most soils, thermal and moisture regimes are directly dependent on climatic conditions. They define limitations like drought, wetness, or short vegetation period, limiting toland productivity **(Fischer et al., 2002).**Human activity is important, in soil formation and effects soil productivity **(John et al., 2006).**Low of organic matter is one of the main causes of low productivity,.

A decline in organic matter causes negative effects on crop productivity (**Hossain, 2000 and Katyal et al. 2001).** Soil fertility is the basis of land productivity, and soil quality **(Wu *et al.*, 2010 and Li and Zhang, 2011).** It is difficult to define soil fertility of a given region differences in the temporal and spatial variability in soil fertility **(Zheng *et al.*, 2004).** Some factors may be considered when evaluating soil fertility to **(Li and Zhang, 2011).** Accordingly, many indicators can reflect soil fertility, such as physical, chemical and biological properties **(Filip, 2002 and Huang and Yang, 2009).**Comprehensive evaluation of soil fertility depends on mathematical methods at present **(Garey and Roopa, 2005).**Agricultural productivity is affected by physical, socio-economic and technological factors **(Kirch, 1994 and Sanchez and Leakey, 1997).** Productivity may be raised by input packages consisting of improved seeds, fertilizers, agro-chemicals and labour intensive methods **(Fladby, 1983).** Human activity is important and may have positive or negative effects on productivity **(John et al., 2006)**. An increase in crop production leads to an increase in food productivity and income **(Delgado and Lopez, 1998; Dengiz, 2007; Kokoye et al., 2013)**.

The current study was carried out on some soil of Sharkia Governorate, Eastern Nile Delta to (i) determine soil fertility and productivity potentials; (ii) assess the effects of soil fertility on soil productivity using remote sensing data and GIS techniques; and (iii) produce soil fertility and productivity map of the studied area.

Materials and Methods

Site description

El-Sharkia Governorate was selected for this study, covers an area of 457586 ha bounded by longitudes 31º20` and 32º 15` E & latitudes 29º 54` and 31º 12` N (Figure 1).

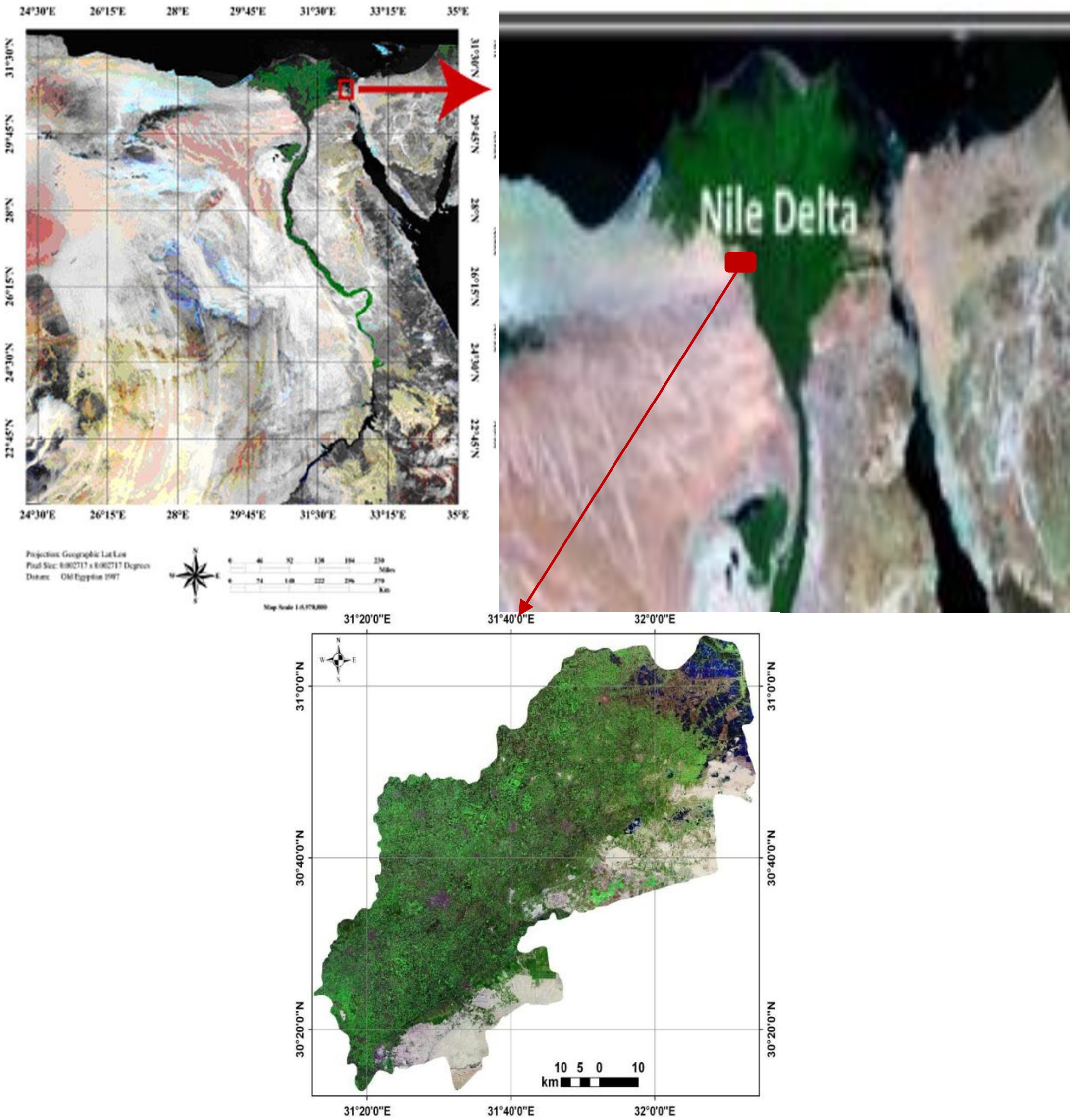

Fig.(1):Location of the studied area.

The area belongs to the late Pleistocene which is represented by the deposits of the Neonile **(Said, 1993).**The area is, bounded to the North by Dakahlia Governorate, to the eastern north by Lake Manzalah, to the East by Ismailia Governorate, to the West by Dakahlia and Kalubia Governorates and to the south by Ismailia Governorate and Cairo: Ismailia desert road. It is divided locally to eleven divisions: Minyet El-Qamh, Abo_Hammad, Belbies, Dyarb Nigm, Zagazig, El-Ibrahimia, Hehia, Abo-Kabier, Faqus, Kafr Saqr and El-Hessinia. According to the **USDASoilTaxonomy (2014),** the soil temperature regime, is thermic and, the soil moisture regime is torric.

Mapping units extraction

The Digital Terrain Model (DTM) was analyzed with the aid of the satellite image analysis, Based on the field survey, digital terrain analyses and soil analyses, the land classes are upresented in eight soil mapping units (SMU). Each mapping unit is identified by a color. Consistent nomenclature is essential for understanding the relationships and differences among mapping units and for correlating the soil units with those elsewhere, in order to make use of the whole body of existing knowledge about soil genesis and behaviors.

Field survey

A reconnaissance survey was made in the area in order to gain an appreciation of the broad soil patterns and characteristic. The primary mapping units were verified based on the pre-field interpretation and the information gained during the survey. Then, thirteen soil profiles were dug representing the different soil mapping units of the Governorate. The soil profiles were dug to a depth of 60 cm. Soil samples were taken from soil layers 0-30 and 30 -60. Morphological features were outlined according to **FAO (2006).** The soils were classified to the sub great group level on the basis of the key to soil taxonomy **(USDA, 2014).** The soil samples were geo-referenced using GPS ‘‘MAGELLAN-GPS NAV DLX-10 TM’’.

Soil analyses

The soil samples were air-dried, crushed softly, and passed through a 2-mm sieve to get the ‘‘fine earth.’’ The fine earth was analyzed in the laboratory forchemical analyses, carried out according to **USDA (2004) and Bandyopadhyay (2007).**

Geology and Geomorphology

El-Sharkia governorate include, Neonile deposits, Pre-Nile deposits, stabilized dunes, sabkha deposits and marsh, silt, clay and evaporates **(GPC and CONOCO, 1987).** According to**Ball (1939),** the soil have groundwater resources, reservoirs and discharging drainage canals Throughout the long ages during which river terraces were being formed in the Nile valley, immense quantities of gravels and sand were carried by the Nile into the sea, where they spread out around the rivers mouths in forming the, delta.

Hydrogyology

The sediments of the area are of hydrogeological importance as theybelong to the Quaternary era. The Quaternary aquifer represents the main source of ground water in the area,and is underlined by Pliocene plastic clay that acts as an aquiclude, especially in the flood plain area around Zagazig **(Rizzini et al., 1978; El Hefny, 1980; Said, 1981 and Serag El Din, 1989).**The lateral and vertical variations in the facies of the Quaternary sediments, render their classification into render distinguishable horizons. Each of which has its own properties. These horizons are: a) Nile silt, sandy clay and clayey sand (Holocene). b) Fine and medium sands with related sediments (Late Pleistocene). c) Coarse sands and gravels (Early Pliocene)(**Atwa, 2010**).

Satellite Data Processing

The Landsat ETM+ image and SRTM data were processed in ENVI 5.1 software to identify landforms and establish the soil database **(Dobos *et al*., 2002 and Zinck and Valenzuela, 1990).** A semi detailed survey was carried out to obtain the soil patterns, land forms and the landscape characteristics.

Fertility and Productivity Indices

The fertility and productivity potentials are determined from indices recommended by **Sanchez et al. (1982)** andcalculated using an equation defined by **Requier et al. (1970) ,**landmodifiedby**Raji (2000).**

Productivity Index (PI)

The Productivity Index (PI) is determined according tothe following equation:

$$PI = H \times D \times P \times T \times FI \times 100 \quad \ldots\ldots \times 100 \quad \text{Eq. (1)}$$

Where, H is the moisture contant, D is the drainage, P is effective depth, T is the texture/structure, and FI = fertility index.Each factor is rated on a scale of 0 to 100. The resultant is the index of productivity (between 0 and 100).

*Fertility Index (*FI*)*

The fertility Index (FI) is determined according to the following equation:

$$FI = N \times O \times C \times M \times A \times 100 \quad . \quad \ldots\ldots\ldots\ldots \times 100 \quad \text{Eq. (2)}$$

N = soil reaction (pH), O = organic matter, C = nature of clay taken as CEC/ cmmolc/ per kg clay, M = mineral reserve and A= soil salinity in EC as ds m-1.Each factor is rated on a scale of 0 to 100. The resultant is the index of fertility (between 0 and 100).

The rating of the fertility and potentiality of the soils was done according to the grading system in Table 6. Diagnostic factors of each thematic layer were assigned values of factor rating identified in Tables **7 to15.** The rating of the fertility and productivity of the soils was done according to the grading system in Table 16.

Table 1. Definition of soil moisture and organic matter

Soil moisture content (H)		Organic matter in A1 horizon (O)	
H1	Rooting zone below wilting point all the year round	**O1**	Very little organic matter, less than 10 g kg-1
H2	Rooting zone below wilting point for 9 to 11 months of the year H2a: 11, H2b: 10, H2c: 9 months,	**O2**	Little organic matter, 10-20 g kg-1
H3	Rooting zone below wilting point for 6 to 8 months of the year H3a:8, H3b: 7, H3c: 6 months,	**O3**	Average organic matter content, 20-50 g kg1
H4	Rooting zone below wilting point for 3 to 5 months of the year H4a:5, H4b: 4, H4c: 3 months,	**O4**	High organic matter content, over 50 g kg-1
H5	Rooting zone above wilting point and below field capacity for most of the year	**O5**	Very high content but C/N ratio is over 25 g kg-1

Table 2. Definition of soil depth and slope

Soil depth (P)		Slope (E)	
P1	Rock outcrops with no soil cover or very low cover	**E1**	Flat 0-2%
P2	Very shallow soil, <30 cm	**E2**	Slightly 2-6%
P3	Shallow soil, 30-60 cm	**E3**	Moderately 6-12%
P4	Fairly deep soil, 60-90 cm	**E4**	High 12-20%
P5	Deep soil 90-120 cm	**E5**	Very high 20-30%
P6	Very deep soil >120 cm	**E6**	Steep 30% +

Table 3. Definition of soil drainage and reserves weatherable mineral

Drainage (D)		Reserves of weatherable mineral in B horizon (M)	
D1a	Marked waterlogging, water table almost reaches the surface all year round	**M1**	Reserves nil to very low
D1b	Soil flooded for 2 to 4 months of year	**M2**	Reserves fair
D2a	Moderate waterlogging, water table sufficiently close to surface to harm deep rooting plants	**M2a**	Minerals derived from sands, sandy materials or ironstones
D2b	Total waterlogging of profile for 8 days to 2 months	**M2b**	Minerals derived from acid rocks
D3a	Good drainage, water table sufficiently low not to impede crop growing	**M2c**	Minerals derived from basic or calcareous rocks
D3b	Waterlogging for brief period (flooding), less than 8 days each time.	**M3**	Reserves large
D4	Well drained soil, deep water table; no waterlogging of soil profile	**M3a**	Sands, sandy materials or ironstone
		M3b	Acid rock
		M3c	Basic or calcareous rocks

Table 4. Definition of soil texture and structure of root zone, pH of A horizon, soluble salt content and cation exchange capacity**.**

Texture and structure of root zone (T)		pH of A horizon (N)	
T1	Pebbly, stony or gravelly soil	**N1**	pH: 3.5-4.5
T1a	Pebbly, stony or gravelly > 60 % by weight	**N2**	pH: 4.5-5.0
T1b	Pebbly, stony or gravelly from 40 to 60 %	**N3**	pH: 5.0-6.0
T1c	Pebbly, stony from 20 to 40 %	**N4**	pH: 6.0-7.0
T2	Extremely coarse textured soil	**N5**	pH: 7.0-8.5
T2a	Pure sand, of particle structure		
T2b	Extremely coarse textured soil (> 45% coarse sand)		**Soluble salt content (A)**
T2c	Soil with non-decomposed raw humus (> 30% organic matter) and fibrous structure	**A1**	< 0.2 %
T3	Dispersed clay of unstable structure (ESP > 15%)	**A2**	0.2-0.4 %
T4	Light textured soil, fS, LS, SL, cS and Si	**A3**	0.4- 0.6 %
T4a	Unstable structure	**A4**	0.6- 0.8 %
T4b	Stable structure	**A5**	0.8- 1.0 %
T5	Heavy-textured soil: C or SiC	**A6**	> 1.0 %.
T5a	Massive to large prismatic structure	**A7**	Total soluble salt (including Na2CO3) 0.1-0.3%
T5b	Angular to crumb structure or massive but highly porous	**A8**	0.3-0.6%
T6	Medium-heavy soil: heavy SL, SC, CL, SiCL, Si	**A9**	> 0.6%
T6a	Massive to large prismatic structure		**Cation Exchange Capacity (C)**
T6b	Angular to crumb structure (massive but porous	**C0**	Exchange capacity of clay < 5 cmolc/kg
		C1	Exchange capacity of clay < 20 cmolc/kg (probably kaolinite and sesquioxides)
T7	Soil of average, balanced texture: L, SiL and SCL	**C2**	Exchange capacity of clay from 20 to 40 cmolc/kg
		C3	Exchange capacity of clay >40 cmolc/kg

Note: fS: fine sand, LS: loamy sand, SL: sandy loam, S: Sand, C: Clay, Si: Silt, SiC: Silty Clay, CS: Course sand.

Table 5. Ratings of different soil and land characteristics

Factors	**Crop Growing**	**Pasture**	**Tree Crop**	**Factors**	**CropGrowing**			**Pasture**	**Tree Crop**
		H		**D**	**H4,H5**		**H2,H3**		
H1	5	5	5	D1	10		40	60	5
H2a*	10	20	10	D2	40		80	100	10
H2b	20	20	10	D3	80		90	90	40
H2c	40	30	10	D4	100		100	80	100
H3a	50	30	10	P					
H3b	60	40	20	P1		5		20	5
H3c	70	60	40	P2		20		60	5
H4a	80	70	70	P3		50		80	20
H4b	90	80	90	P4		80		90	60
H4c	100	90	100	P5		100		100	80
H5	100	100	100	P6		100		100	100
		N		**T**					
N1	40	60	80	T1a		10		30	50
N2	50	70	80	T1b		30		50	80
N3	60	80	90	T1c		60		90	100
N4	80	90	100		**H4,5,6**	**H3**	**H1,2**		
N5	100	100	100	T2a	10	10	10		
N6	80	90	100	T2b	30	20	10		
O	**H1H2H3 D3D4**	**H4H5D1D2**		T2c	30	30	30		
O1	85	70		T3	30	20	10	Thesame ratingas	The same ratingas

O2	90	80	T4a	40	30	30	for	fortree
O3	100	90	T4b	50	50	60	pasture	crops
O4	100	100	T5a	50	60	20		
O5	70	70	T5b	80	80	60		
	C		T6a	80	80	60		
C0	85		T6b	90	90	90		
C1	90		T7	100	100	100		
C2	95		**A**	**T1,2,4**	**T5,6,7**			
C3	100		A1	100	100			
M	**H1H2H3**	**H4**	A2	70	90			
M1	85	85	A3	50	80			
M2a	85	90	A4	25	40			
M2b	90	95	A5	15	25			
M2c	95	100	A6	5	15			
M3a	90	95	A7	60	90			
M3b	95	100	A8	15	60			
M3c	100	100	A9	5	15			

Table 6.Land productivity and fertility and classes and rating**.**

Land Productivity/Fertility Classes defined by Riquier et al. (1970) and Sanchez et al. (1982), modified by Raji (2000)			**Percentage %**
Class		**Rate**	
PI	FI	**Excellent**	**65-100**
PII	FII	**Good**	**35-64**
PIII	FIII	**Average**	**20-34**
PIV	FIV	**Low**	**8-19**
PV	FV	**Extremely low**	**0-7**

Results and Discussion

Geomorphologic features and soils.

The geomorphologic units were identified by analyzing the landscape extracted from satellite imagery with the aid of Digital Elevation Model (DEM). The geomorphology map of the investigated area (Figure 3) shows three main landscapes as follows:

1) Flood plain containing overflow mantle (OM), overflow basin (OB) and decantation basin (DB), river terrace (RT) and turtle back (TB). The soils in this landform were classified into Vertic Torrifluvents, Typic Torrifluvents and Typic Torripsamments.
2) Fluvio-lacustrine plain with five landforms; clay flat (CF) and alkali flat (AF). The soils in this landform were classified into Typic Natriargids and Typic Aquisalids.
3) Aeolian Marineplain including sandy remnants (SR). The soils in this landform were classified as Typic Torripsamments. The obtained results, as shown in Table7.

Table 7. Landforms and soils of the investigated area.

Landscape	Relief	Landform	Mapping unit	Profile No.	Soil Classification	Area (ha)	Area %
Flood plain	Almost flat to gently undulating	Overflow mantle	OM	_	Vertic Torrifluvents	34658	7.60
		Overflow basin	OB	4,5,7	Vertic Torrifluvents	50712	11.10
		Decantation basin	DB	1,8,9	Typic Torrifluvents	123191	26.92
		River terrace	RT	3,2	Vertic Torrifluvents	73895	16.15
		Turtle back	TB	6	Typic Torripsamments	1511	0.33
Fluvio-lacustrine plain	Almost flat to gently undulating	Clay flats	CF	13,10,11,12	Typic Natriargids	48681	10.64
		Alkali flats	AF	_	Typic Aquisalids	10975	2.41
Aeolian plain	Gently undulating	Sandy remnants	SR	_	Typic Torripsamments	79325	17.34

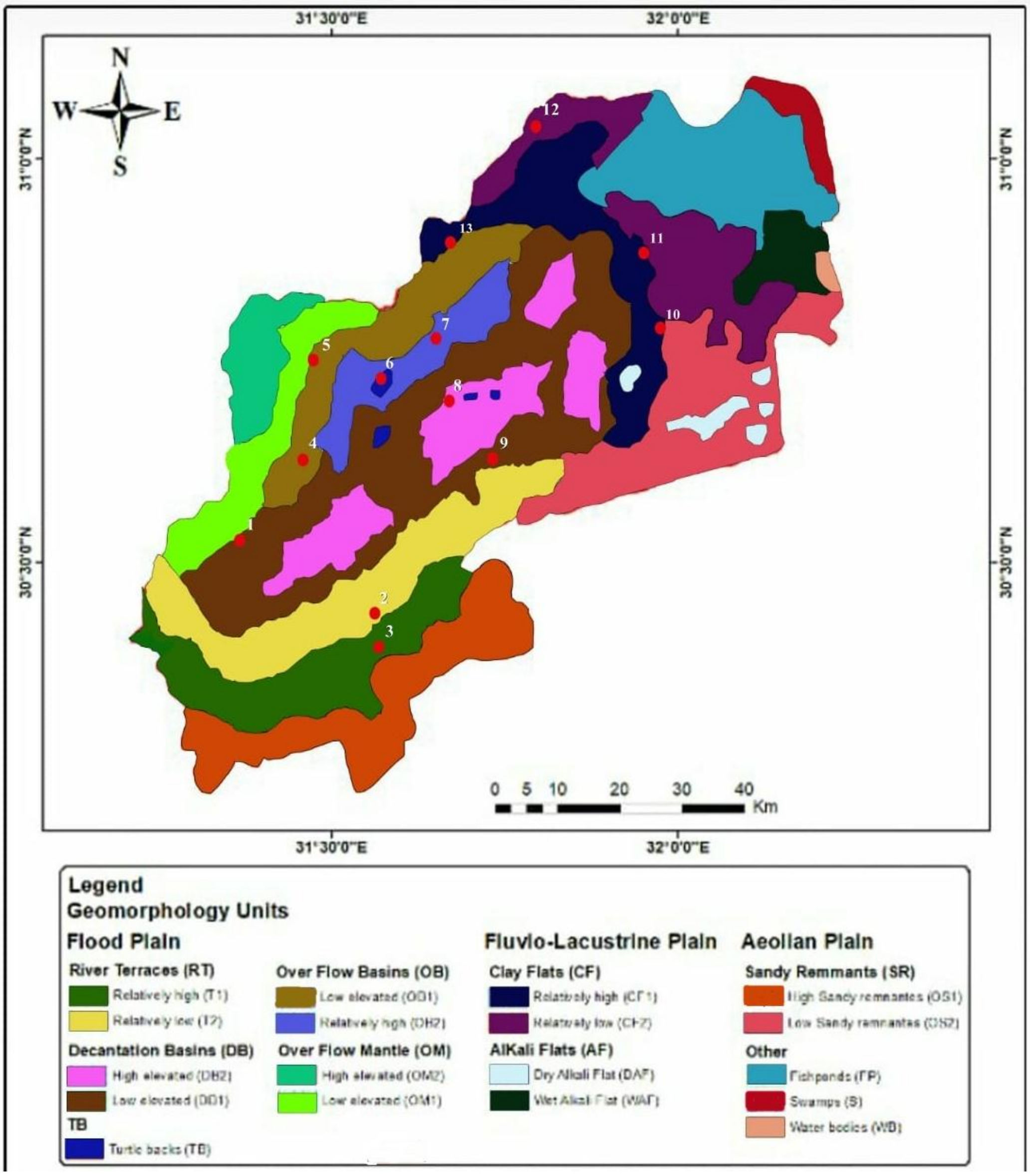

Fig. 2: Geomorphologic map of the study area.

Fertility and productivity Index Model and rating.

In this model, interpretation criteria are modeled based on traditionally incorporate soil properties (**Requier etal., 1970).** The structure organization of the Requier model is summarized in Figure 2.

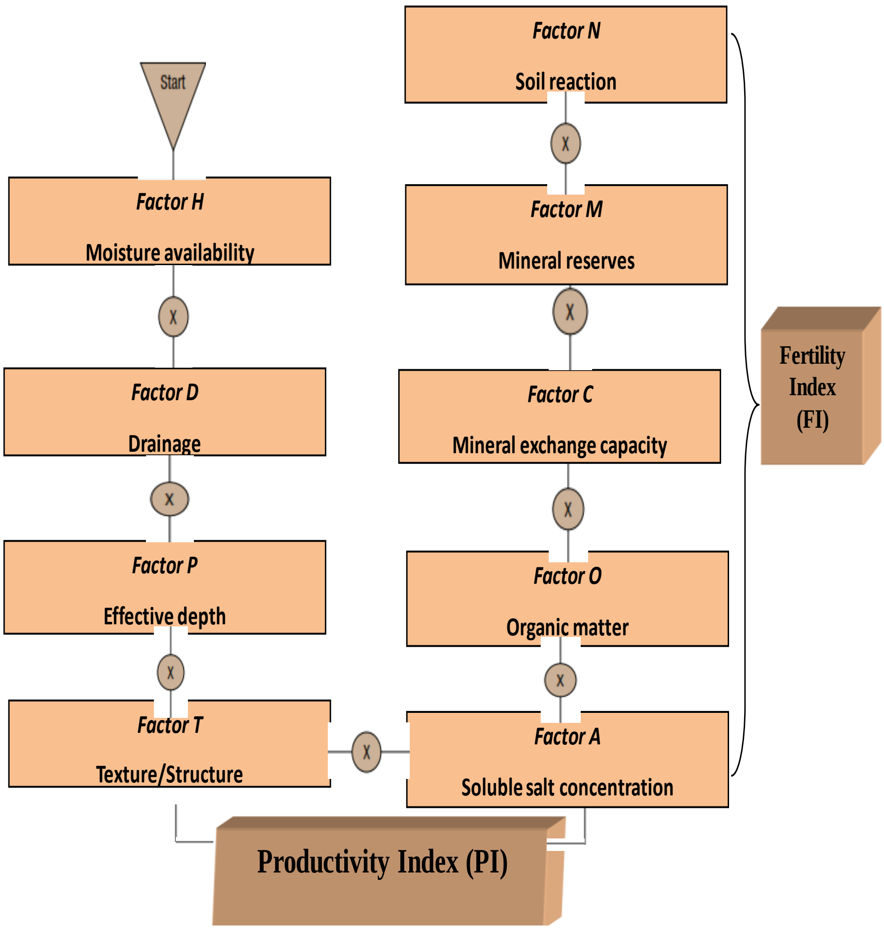

Fig. 3: Model of the fertility andProductivity Index.

Determination of Soil Fertility index

An area of 297990 ha (65.14% of the total) showed high fertility and consists of excellent class (I). The soils are of **OB, DB, RT, TB, and CF** mapping units. The remaining area of 124958ha (27.35 % of the total) showed a low fertility and consists of very low and nona-available lands (V and VI). Fertility classes of the study area varies from “excellent” to “non-available” due to different limiting factors (Figure 4). The parametric evaluation system of Riquier fertility index are given in Tables 8 to 11 , and their map is shown in Figure 5 using GIS.

Table 8. Values of the factors of soil fertility of the studied soils of the investigated area.

Mapping unit	**Soil pH (N)**	**Organic Matter (O) (gkg^{-1})**	**Cation Exchange Capacity (C) (Cmolc kg^{-1})**	**Mineral reserve in B horizon (M)**	**Salinity" as EC (A) (ds m^{-1})**
OB	7.89	15.5	45.2	Sands, sandy materials or ironstone	1.15
DB	7.91	13.8	42.5	Minerals derived from basic or calcareous rocks	2.28
RT	7.83	13.5	22.7	Minerals derived from basic or calcareous rocks	1.34
TB	7.91	14.5	45.0	Minerals derived from sands, sandy material or ironstone	1.22
CF	7.91	26.5	43.5	Basic or calcareous rocks	1.16

Table 9. Soil characteristics of the investigated area**.**

Mapping unit	**Soil pH (N)**	**Organic Matter O)((gkg$^{-1)}$**	**Cation Exchange Capacity (C) (Cmolc kg^{-1})**	**Mineral reserve in B horizon (M)**	**Salinity "as EC** (A) **(ds m^{-1})**
OB	N5	O2	C3	M3a	A1
DB	N5	O2	C3	M2c	A1
RT	N5	O2	C2	M2c	A1
TB	N5	O2	C3	M2a	A1
CF	N5	O3	C3	M3c	A1

Table 10. Score assessment of soil fertility index of the study area.

Mapping unit	**Soil pH (N)**	**Organic matter content (O) (gkg$^{-1)}$**	**Cation exchange capacity (C) (Cmolc kg^{-1})**	**Mineral reserve in B horizon (M)**	**Salinity "as EC** (A) **(ds m^{-1})**	**Require Fertility Index (RFI)**	**Grade**
OB	100	90	100	90	100	81.0	**I**
DB	100	90	100	95	100	85.5	**I**
RT	100	90	95	95	100	81.2	**I**
TB	100	90	100	85	100	76.5	**I**
CF	100	100	100	100	100	100.0	**I**

Table 11: Soil Fertility Index of the study area

Requier Fertility Index RLPI (%)	**Grade**	**Class**	**Mapping unit**	**Area (ha)**	**Area %**
65_100	**I**	Excellent	**OB,DB,RT, TB and CF**	297990	65.14
35_64	**II**	Good	___	___	___
20_34	**III**	Average	___	___	___
8_19	**IV**	Low	___	___	___
0_7	**V**	Extremely Low	___	___	___

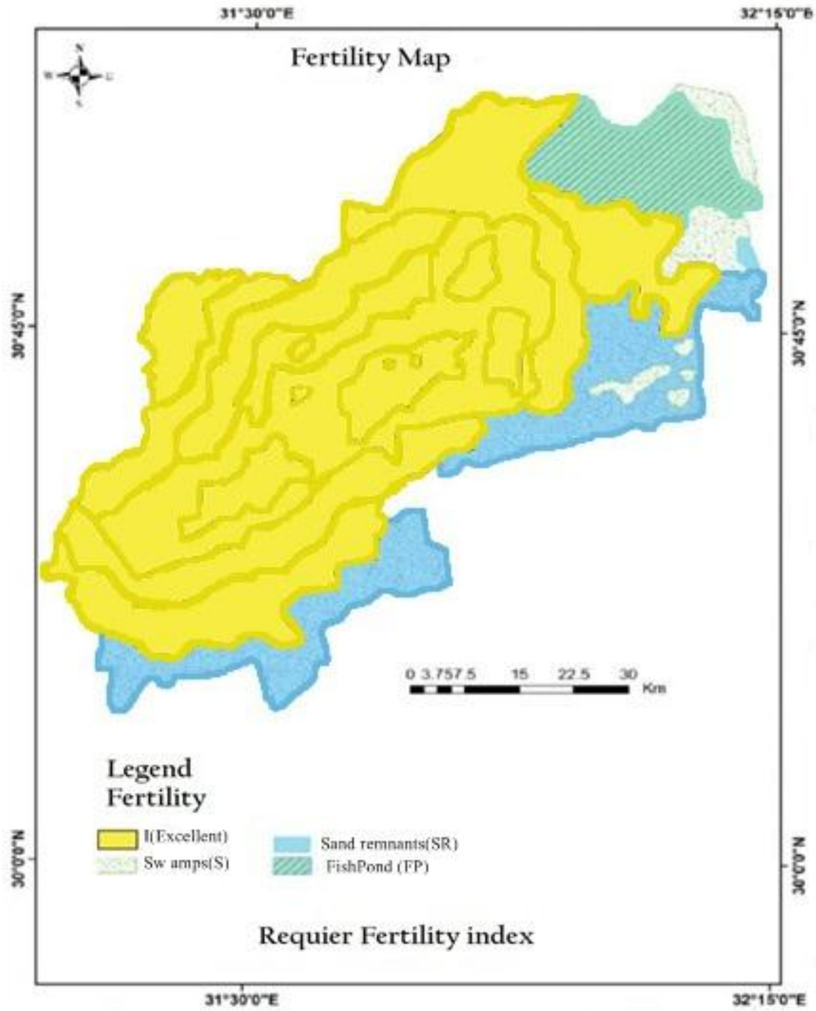

Fig4. Soil Fertility index map.

Determination of Land Productivity index.

While most of the study area 26.92% (123191 ha) consists of excellent classe (I) in terms of agricultural use: **DB** mapping units. A portion of**OB,TB** 27.25% (124607 ha) of study has good classe (II):and 10.64% (48681 ha) of study area has average (III): **CF** mapping unit, and 0.33% (1511 ha) has poor (IV): **TB** mapping unit. The remaining 27.35% (124958ha) has extremely low (V): **OM**, **AF**and **SR**mapping units. The current study demonstrates that more than half of El-Sharkia area has productive lands.(Table14) shows scores of the Requier productivity index. Land productivity classes of the area varies from "excellent" to "extremely Low" due to different limiting factors (Table15). The limiting factors are not correctable; they are soil depth and soil texture. The parametric evaluation system of Requier index given in Tables 12 to 15 , and their map is shown in Figure 5 using GIS.

Table 12. Values of the factors of land productivity index of the studied soils of the investigated area.

Mapping unit	Moisture availability	Drainage	Effective depth (cm)	Texture / structure
OB	Rooting zone below wilting point for 3 months of the year	Well drained	>60	Clay loam
DB	Rooting zone below wilting point for 3 months of the year	Well drained	>60	Clay
RT	Rooting zone below wilting point for 3 months of the year	Good drained	>60	Clay
TB	Rooting zone below wilting point for 9 months of the year	Well drained	>60	Sand
CF	Rooting zone above wilting point and below field capacity for most of the year	Moderate drained	>60	Clay

Table13. Soil characteristics of the investigated area.

Mapping unit	Moisture availability (H)	Drainage (D)	Effective depth (P)	Texture / structure (T)
OB	H4c	D4	P4	T5b
DB	H4c	D4	P4	T5b
RT	H4c	D3a	P4	T5b
TB	H2c	D4	P4	T5b
CF	H5	D2a	P4	T5b

Table 14. Scoreassessment of Requier productivity index of the investigated area.

Mapping unit	Moisture availability (H)	Drainage (D)	Effective depth (P)	Texture / structure (T)	Fertility Index (PI)	Grade	Productivity Index (PI)	Grade
OB	100	100	80	80	81.0	I	51.8	**II**
DB	100	100	80	80	85.5	I	54.7	**I**
RT	100	80	80	80	83.4	I	41.5	**II**
TB	40	100	80	80	76.5	I	19.6	**IV**
CF	100	40	80	80	100.0	I	25.6	**III**

Table 15. Land Productivity Index of the study area.

Requier Land Productivity Index RLPI (%)	Grade	Class	Mapping unit	Area (ha)	Area %
65 – 100	**I**	Excellent	**DB**	123191	26.92
35 – 64	**II**	Good	**OB,RT**	124607	27.25
20 – 34	**III**	Average	**CF**	48681	10.64
8_19	**IV**	Low	**TB**	1511	0.33
0_7	**V**	Extremely Low	**Zero**	Zero	Zero

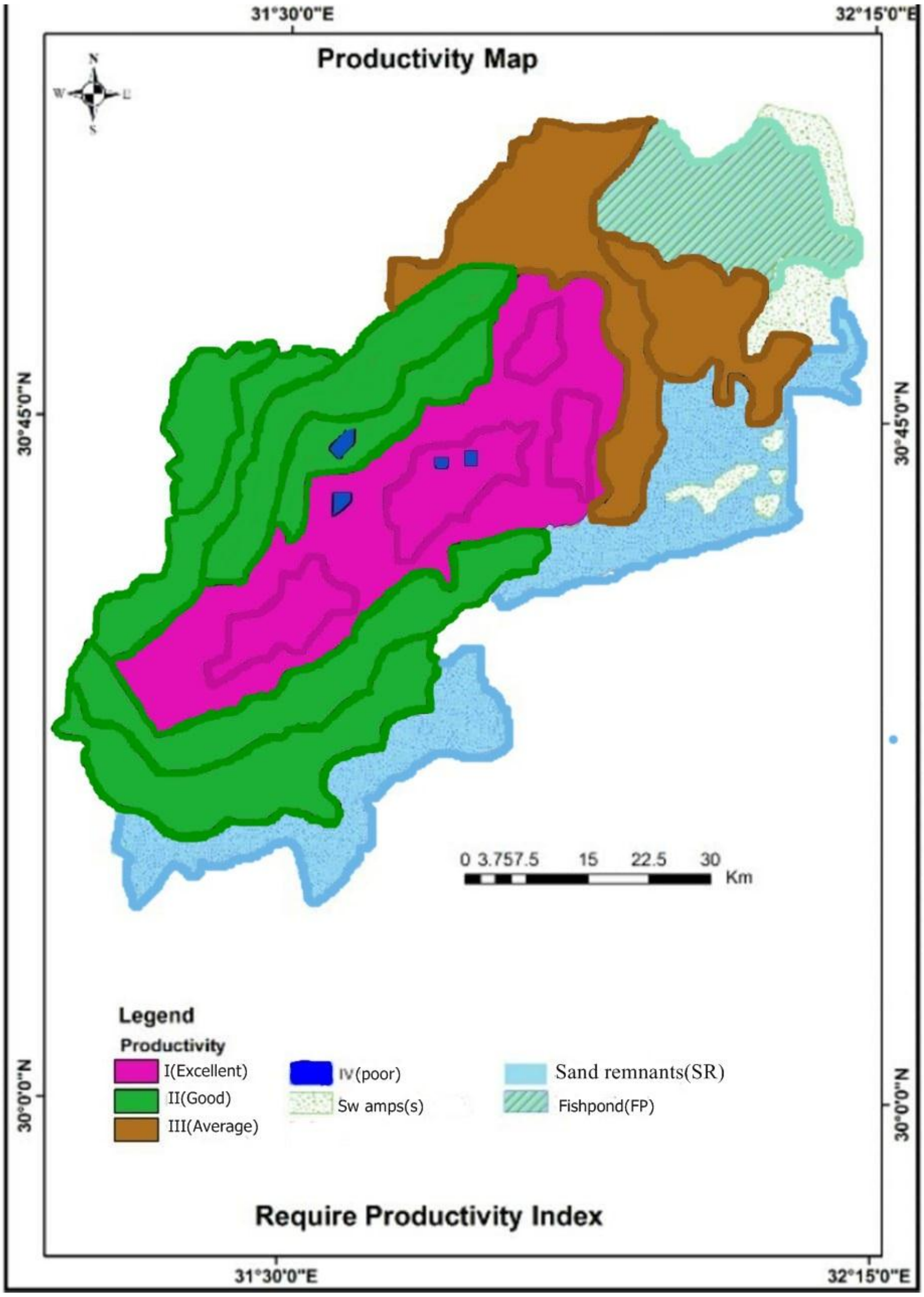

Fig 5. Productivity Index map.

Comparison betweenRequierfertility and productivity index

Changes in theRequire index (RI) and soil productivity are illustrated in Table 11 and Figure 6 . The landforms of the flood plain are(represented by profiles of 1 to 9). Soil Land Productivity Index LPI for the OB and RT mapping units varied from class(I) to class (II) in fertility and productivity index respectively. The main factors responsible for the low productivity index are effective soil depth and soil texture. For the DB mapping unit Requier Index indicates class I in fertility and productivity. The productivity index in the TBsoils varied from class I in fertility Index to class IV in productivity Index. Data in Table 7hows soils of the fluvio-lacustrine plain landform (represented by soil profiles of 10 to13). The Require index of the clay flats (CF) are naturally degraded as they are located near Lake El Manzala. For the CF mapping unit theRequier Index changed from class I in fertility to class III in productivity. Variations of soil productivity in this mapping unit of CF are mainly related to the decreased effective depth. Results indicate that the RI of the study area is mainly affected by soil depth and soil texture

.

Table 16. Change in the value of land productivity index between Storie and Requier Index in the study area.

Mapping unit	Requier Fertility Index (RFI)	Requier Productivity Index (RPI)	Changes
OB	81.0*	51.8	±29.2
DB	85.5*	54.7	±30.8
RT	81.2*	41.5	±39.7
TB	76.5*	19.6	±59.9
CF	100.0*	25.6	±74.4

*refers to the highest value

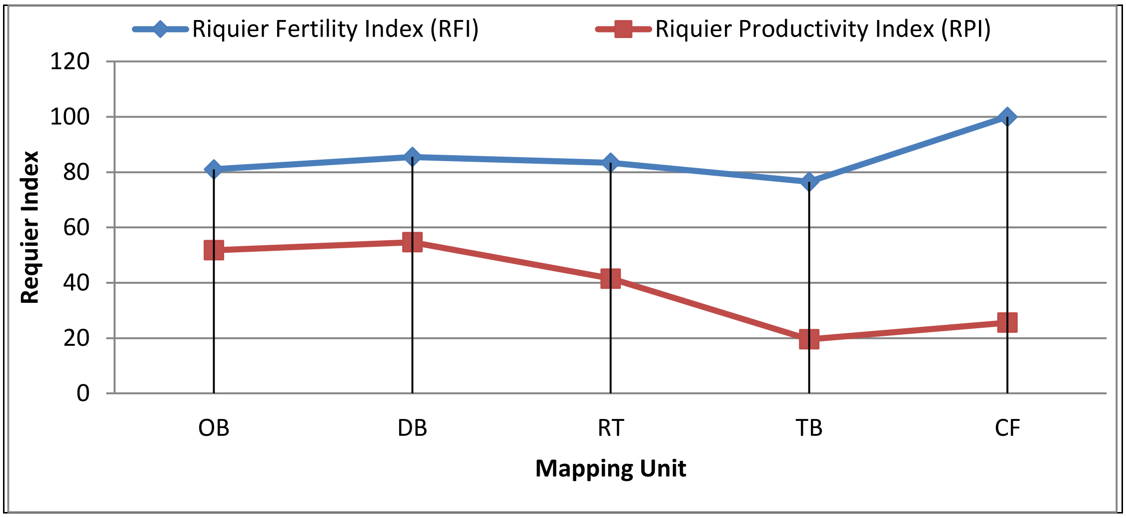

Fig. 6: Requier Fertility and Productivity index in the study area.

Conclusion

Using physical, chemical and pedological characteristics as input criteria for determining the different soil fertility and productivity classes, of soils in sharkia productivity indexesshowed a high correlation indexes with the dominant soil fertility factors of pH, organic matter, CEC, mineral reserve and soil salinity. Consequently, agriculture development in ouch soils requires proper land management that can be performed by farmers. The output maps indicateproductivity classes ofexcellent, good, average and low in the mapped pilot area. Excellent and good classes, weredominout. This showsthat the high landpotentiality of study area should be protected against any future deterioration and malpractice.

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مؤشر الخصوبة والإنتاجية لبعض أراضي محافظة الشرقية ، دلتا النيل الشرقي ، مصر باستخدام تقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية.

تهدف الدراسة الي استخدام الاستشعار عن بعد (RS) ونظم المعلومات الجغرافية (GIS) لتقييم خصوبة التربة وانتاجيتها في بعض أنواع التربة بمحافظة الشرقية. تم استخدام بيانات المسح الميداني , لاندسات 8‒ETM+ (DEM), لتحديد الوحدات الفيزيائية وتشمل كتف النهر (OM)' الاحواض الفيضية (OB)' الاحواض التجميعية (DB), الشرفات النهرية (RT)' ظهور السلاحف (TB), الشق الطيني (CF)' الشق القلوي (AF)' البقايا الرملية(SR).اعتمد مؤشر خصوبة التربة (SFI) ومؤشر انتاجية التربة (LPI) علي استخدام نظم المعلومات الجغرافية حيث تم استخدام مؤشر Requier(RI) في ضوء التربة والمعالم الطبوغرافية باستخدام معادلات محددة' وتصنيفات الخصوبة والانتاجية. كان هناك اختلاف في مؤشر التربة RT,OB التي تراوحت بين" ممتاز" الي الدرجة الثانية "جيد" في مؤشر الخصوبة والانتاجية علي التوالي. بالنسبة DB كان مؤشر التربة "ممتاز" في الخصوبة وكذلك في الانتاجية. كان مؤشر الانتاجية في TB من الفئة "الممتازه" في الخصوبة الي الفئة "الرابعه" المنخفضة الانتاجية . بالنسبة CF كان مؤشر Requierهو الفئة الاولي "ممتاز" في الخصوبة "ومتوسط" الفئة الثالثة في الانتاجية. حيث يتأثر RI بشكل رئيسي بعمق التربة وقوام التربة.