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Assessment of land sustainability in different regions of the Nile Delta, Egypt, using GIS and remote sensing techniques

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Abstract

The aim of the study was to assess the sustainability of the soils in some regions of the Nile Delta through five parameters (productivity, security, protection, economic viability and social acceptability). The area, lies between latitudes 31° 36' 50.2″ and 30° 34' 35.4″ N and longitudes 30° 21' 59.5″ and 32° 18' 15.8″ E, and occupies 9994.55 km^2 (999455.83 ha). The landscapes were Flood plain, Aeolian plain and Lacustrine deposits. Thirty soil profiles were dug and an sustainability Land Management Index SLMI model was designed using the spatial geoprocessing tool of ArcGIS (program of producing soil maps) by integration biophysical, socioeconomic and environmental factors for soils of each map. Three SLMI classes were outlined:1: (Class II) representing 54.42% (544187.17 ha) of the total area; it is found in units decantation basins (DB), overflow basins (OB), overflow mantles (OM), high river terraces (RT1) and moderate river terraces (RT2); 2: (Class III) covering 12.86% (128595.43 ha) of the total area, it is found in unit low river terraces (RT3) and relatively high clay (CF1) and 3: (Class IV) did not meet sustainability and found in units sand sheets (SS), relatively low clay (CF2) and wet sabkha (WS), with a total area of 157330.47 ha (15.72% of the total area).

Keywords: Land sustainability, Nile Delta, ArcGIS, Remote sensing and GIS.

Introduction

Agricultural sustainability defines an economically, environmentally, and socially balanced farming system that conserves the viability of resources for future generations **(Diver, 1996; Norman et al., 1997; Bell, et al 2001 and Santiago-Brown et al. 2015).** Handling of soils must be in a sustainable way in order to maintain the function of all ecosystems **(Rao and Rogers, 2006; Ceotto, 2008; Bockstaller et al., 2009 and Hillel, 2009).** Global issues of the 21st century like food security, demands of energy and water, climate change and biodiversity are associated with the sustainable use of soils **(Lal, 2008, 2009; Jones et al., 2009 and Lichtfouse et al., 2009).** Land sustainability practices involve meeting current and future needs maximizing the net benefit without compromising the ability of future generations to meet their needs **(WCED, 1987; USAID, 1988; Smyth and Dumanski, 1993 and Tilman et al., 2002).** In Egypt , biophysic elements (productivity, security, protection) and socio-economic ones (economic viability and social acceptability) were used in studies concerning sustainability constraints.**(Nawar, 2009; Abdel Kawy et al., 2012; Ali & Shalaby, 2013; El Bastawesy et al., 2013and Abdel Kawy & Darwish, 2014).**

Agriculture is a complex system that combines social economy and natural ecology to provide adequate outputs **(Andzo-Bika and Kamitewoko, 2004; Li and Yan, 2012; Kokoye et al., 2013; Kumhálová and Moudr, 2014; Verburg, 2015; Rashed, 2016; Rasmussen, 2018 and Scown et al., 2019).** Characteristics of geographic information systems involve their capabilities for data analysis and spatial modeling. These analyses include map overlaying, reclassification, proximity analysis, optimum correlation and other cartographic modeling techniques **(Burrough and McDonnell, 1998; Nehme and Simões, 1999; Aronoff, 2000 and Valenzuela 2004).** Remote sensing (RS) gives a picture of the agricultural activities with high revisit frequency **(Zhongxin et al., 2004).** It measures a large number of physical aspects and can play a role in assessing sustainability **(Becker, 1997 and Shanmugapriya et al., 2019).** The Geographic Information Systems (GIS) manipulates, stores and updates referenced data. It integrates referenced datasets included in spatial modelling **(Raza et al., 2018).** GIS and RS can be used for mapping of land suitability for crop production **(El Baroudy, 2011; Saleh and Belal, 2014 and Mishelia and Zirra, 2015).** Therefore, the aim of the present study was to evaluate agricultural land sustainability parameters in different regions of the Nile Delta, Egypt using GIS and remote sensing techniques.

Materials and Methods

Location of the study area

The study area is located in the Nile Delta between latitudes 31° 36' 50.2″ and 30° 34' 35.4″ N and longitudes 30° 21' 59.5″ and 32° 18' 15.8″ E with an area of 9994.55 km^2 (999455.83 ha). It lies in Kafr El-Sheikh, Gharbia, and Dakahlia Governorates (Figure 1)

The Delta is located in the North of Egypt, where the Nile branches off and empties into the Mediterranean Sea. The Delta is in North Egypt where the Nile spreads and drains into the Mediterranean Sea

(Shalaby, 2012). It is the richest agricultural land in Egypt with its economic and financial heart and includes the most densely populated governorates in Egypt where 50% of its population lives on it **(Haars et al., 2016).** It consists of 5 Governorates: Gharbia, Dakahliea, Kafr-El-Sheikh, Monofiya, and Damietta. Topographically, the elevation of the area varied from 0 to 20 m above the mean sea level (a.m.s.l.).The study area includes the following three governorates (Kafr El-Sheikh, Gharbia and Dakahliea)

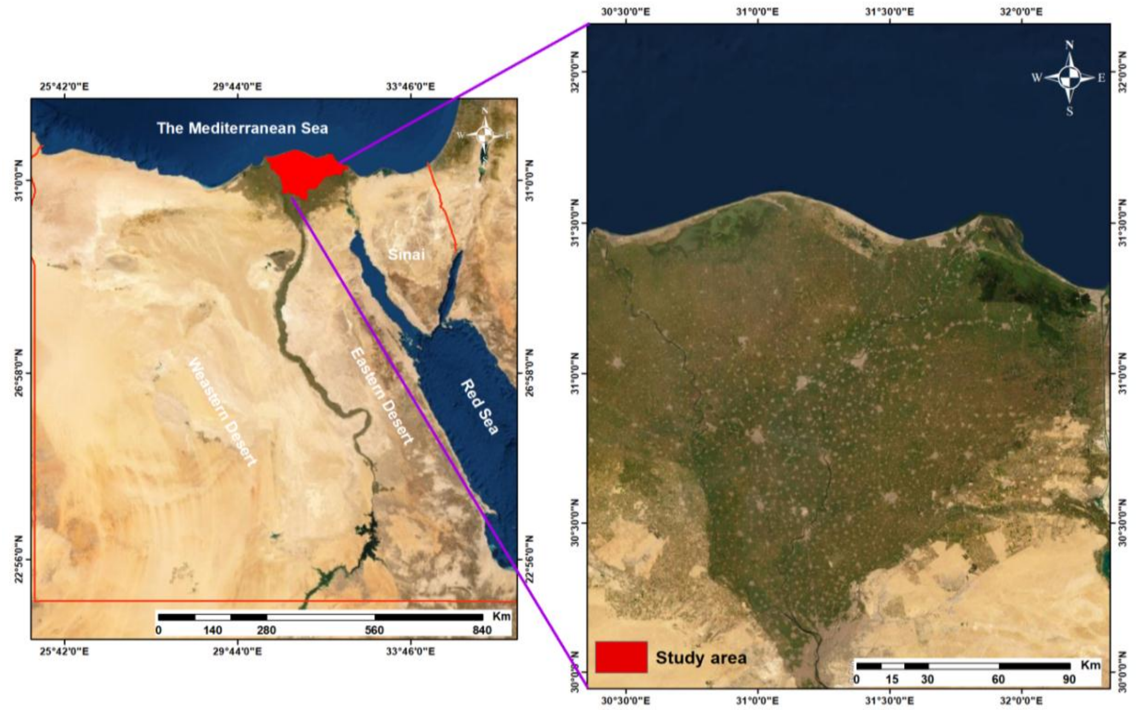

Figure 1: Location of the studied area

Geomorphology and geology of the study area

There are three major geomorphic units in the Nile Delta, namely: young deltaic plain, old deltaic plain and young Aeolian plain **(El-Fayoumy, 1968).** The land of Nile Delta belongs to the late Pleistocene era which is represented by the deposits of the Neonile which lowers its course at a rate of 1m every 1000 years **(Hagag, 1994 and Said, 1993). CONOCO (1987)** characterized the delta in the following geologic units: **Neonile deposits, Nile silt deposits**, **Prenile deposits**, **Protonile deposits, Sabkha deposits**, **Sand dunes and Quaternary marine deposits**

The Neonile deposits are clay, silt, very fine-grained sand, fragments. The **Nile silt deposits are** fine grained sediments of silt and clay. The **Prenile deposits are** medium-coarse sand with few clay intercalations. The **Protonile deposits are** soft clay, shale, siltstone, streaks of very fine sandstone and thin limestone. The **Sabkha deposits are** salt-flats very saline soil lying above shallow land. **Sand dunes** are sand ridges created by the wind. **Quaternary marine deposits are** common in the low parts, and terrestrial deposits in high parts.

Field studies and laboratory analyses

Soil surveys and laboratory analyses were conducted **USDA (2014)**. Socio-economic data were obtained from central agency for mobilization and statistics. Ground Position System (GPS) was used to locate the site of each profile (latitude and longitude). Thirty soil profile were dug to represent the study area. Soil and water samples were collected from profile.

Satellite Data:

Satellite remote sensing of large number of digital data and images were collected to increase the information availability. Digital image processing was executed using ENVI 5.1 and the Arc-GIS 10.2 software (**Lillesand and Kiefer (2007).** Digital image processing was performed using ENVI 5.1 software.

Assessment of Sustainable land management Index (SLMI)

The **Smith and Dumanski (1993)** system of International Framework for Evaluating Sustainable Land Management (FESLM) , modified by **El-Nahry (2001)** was used for evaluating land sustainability. The following formula was used:

Sustainability Index (SI) = (A x B x C x D x E)

Where, A = productivity index, B = security index, C = protection index, D = economic viability index and E = social acceptability index

Table1 shows classes and ratings of Sustainable Land Management.

Table1. Class and rating limits of Sustainable Land Management Index (SLMI)**.**

Value	Land use/management status	Class
0.6 to 1.0	Meets the sustainability requirements	I
0.3 to 0.6	Marginally but above threshold of sustainability	II
0.1 to 0.3	Marginally but below threshold of sustainability	III
0 to 0.1	Does not meet sustainability requirements	IV

Results and Discussion

Geomorphologic features.

The geomorphic units were identified by analyzing the landscape extracted from the satellite imagery with the aid of Digital Elevation Model (DEM). The obtained results are shown in Figure 2. The geomorphic units comprised, Flood plain, Aeolian and Lacustrine deposit plains.

The Flood plain includes the following landforms: 1- decantation basins (DB), 2- overflow basins (OB), 3- overflow mantle (OM) 4- river terraces (RT), 5- levees (L). The aeolian plain includes the following landforms: 1- sand sheets (SS), 2- hummock areas (HA) and 3- costal sand bar (CSB). The lacustrine deposits includes the following landforms: 1- relatively high clay (CF1), 2- relatively low clay (CF2), 3- wet sabkha (WS), 4- dry sabkha (DS) and swamps(S).

The obtained data reveal 15 landforms as follows: 1) Decantation basins (136374.14 ha, forming 13.64% of the total area). 2) Overflow basins (177624.92 ha, 17.77 % of the total area). 3) Overflow mantle (33278.71 ha, 3.32 % of the total area). 4) River terraces (303064.51 ha, 30.31% of the total area). 5) Levees (7674.61 ha, 0.76% of the total area). 6) Sand sheets (56412.61 ha, 5.64 % of the total area). 7) Hummock areas (4772.11 ha, 0.47 % of the total area). 8) Costal sand bar (7339.50 ha, 0.73 % of the total area). 9) Relatively high clay (22440.32 ha, 2.24 % of the total area). 10) Relatively low clay (47852.72 ha, 4.78 % of the total area). 11) Wet sabkha (53065.14 ha, 5.30 % of the total area). 12) dry sabkha (7726.24 ha, f 0.77% of the total area). 13) Swamps (25470.35 ha, 2.54 % of the total area). 14) Water bodies (95186.87 ha, 9.52 % of the total area). 15) Fish bonds (14053.22 ha, 1.40 % of the total area).

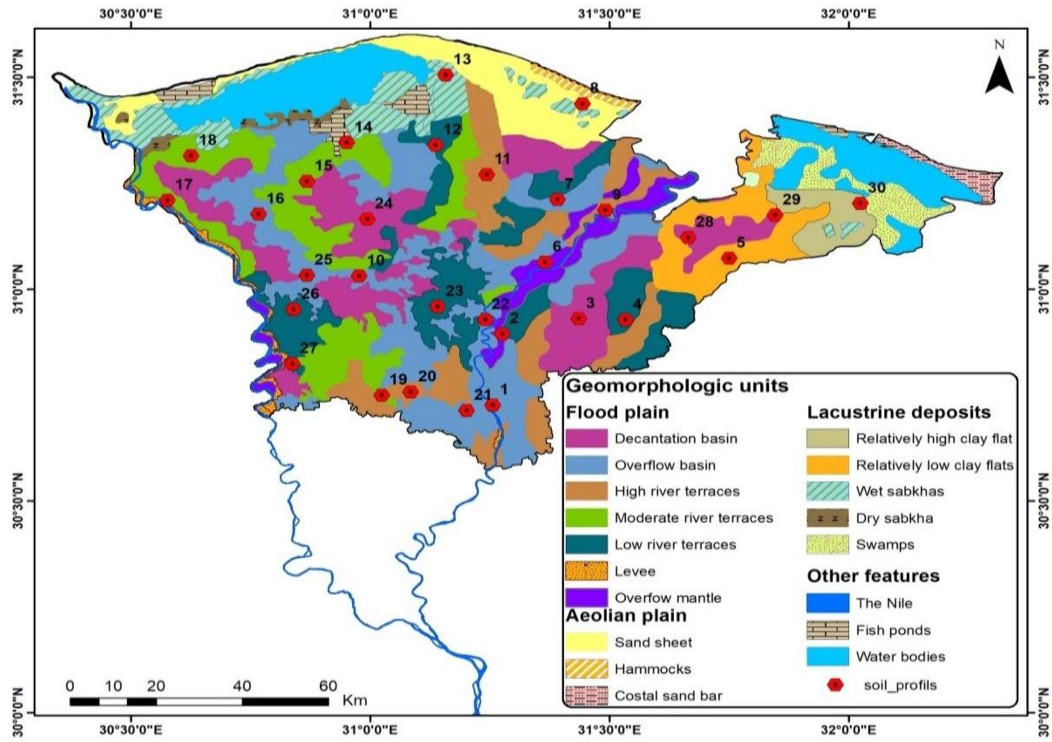

Fig. 2 Geomorphology of the study area and profiles location

Assessment of the land sustainability

Sustainability Index (**SI)** considers the 5 following criteria **(Smith and Dumanski 1993)** productivity (A), security (B), protection (C), economic viability (D) land social acceptability (E) .

Productivity Index (**PI**) was calculated according to the following equation

PI = A/100 x B/100 x C/100 x D/100 x E/100 x F/100 x G/100 x H/100 x I/100 x J/100 (Eq. 1):

Where, A= relative yield (RY), B= organic carbon (OC) %, C= Soil reaction(pH), D=cation exchange capacity (CEC),E= oxygen availability, F= salinity (EC),G= Soil sodicity (ESP) , H=Texture ,I= Parent material and J= Rock Fragments.

Calculating the Security Index according to the following equation :

Security Index = A/100 x B/100 x C/100 ……… (Eq. 2):
Where, A= moisture availability, B=water quality and C= Crop residues %.

Calculating the Protection Index according to the following equation:
Protection Index = A/100 x B/100 x C/100 …….. (Eq. 3):
Where: **A=** erosion hazards including wind and water erosion, **B=** flooding hazards and **C=** cropping systems. Formula integrates these indicators.

Calculating the Economic Viability Index according to the following equation:
Economic Viability Index = A/100 x B/100 x C/100 x D/100 x E/100…… (Eq. 4):
Where, **A** = benefit cost ratio, **B=** difference between farm gate price and the nearest main market price, **C =** availability of farm **labor**, **D =** size of farm holding and **E =** percentage of farm produce sold in market.

Calculation of Social Acceptability Index according to the following equation:
Social Acceptability Index = A/100 x B/100 x C/100 x D/100 x E/100 x F/100 x G/100 ………… (Eq.5):
Where,
A= Land tenure, B = Support for extension services, C = Health and educational facilities in village, D = Percentage of subsidy for conservation packages, E= Training of farmers in soil and water conservation techniques, F= Availability of agro-input within 5- 10 km range and G = Village road access to main road.

SLMI was calculated for the different map units according to the following equation:
Sustainability Index (SI) = A x B x C x D x E …………… (Eq. 6):

Assessment of Productivity (A):
Productivity is the quantity of yield from agricultural operations **(Moghanm, 2015).** Table 2 shows the characteristics of the productivity parameters. The parametric evaluation system of the index is given in Table 3. Each parameter has a scale of 0.0 to 1.0. Figure 3 shows that, the productivity practices in all **map units** meet the requirements of sustainability where the productivity index ranged from 0.42 to 0.90.

Table 2 A: Productivity indices of the landforms

Mapping unit	Nutrient availability												Depth of water table(cm)			EC dsm^{-1}			Alkalinity (ESP)		
	RY (%)			OC (%)			pH			CEC											
	S	R	V	S	R	V	S	R	V	S	R	V	S	R	V	S	R	V	S	R	V
DB	10	9	90	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100
OB	10	10	100	10	10	100	10	10	100	10	10	100	10	9.5	95	10	10	100	10	10	100
OM	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100
RT1	10	9	90	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100
RT2	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100
RT3	10	10	100	10	10	100	10	10	100	10	10	100	10	9.5	95	10	10	100	10	10	100
SS	10	8	80	10	8.5	85	10	10	100	10	9	90	10	10	100	10	10	100	10	9	90
CF1	10	8	80	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100
CF2	10	8	80	10	10	100	10	10	100	10	10	100	10	9.5	95	10	10	100	10	10	100
WS	10	8	80	10	9.5	95	10	10	100	10	10	100	10	9.5	95	10	8	80	10	10	100

RY (%)= Relative yield, S= score, R= rank, V: value=(SR), OC= organic carbon

Table 2B Cont.: Productivity indices of the landforms

Mapping unit	Texture			Available (mgkg^{-1}) N			P			K			Total
	S	R	V	S	R	V	S	R	V	S	R	V	
DB	10	10	100	10	10	100	10	9	90	10	9.5	95	**0.76**
OB	10	10	100	10	10	100	10	9	90	10	9.5	95	**0.81**
OM	10	10	100	10	10	100	10	9	90	10	9.5	95	**0.85**
RT1	10	10	100	10	10	100	10	9	90	10	10	100	**0.81**
RT2	10	10	100	10	10	100	10	9	90	10	10	100	**0.90**
RT3	10	10	100	10	10	100	10	9	90	10	9.5	95	**0.81**
SS	10	9	90	10	10	100	10	9	90	10	9.5	95	**0.42**
CF1	10	10	100	10	10	100	10	9	90	10	9.5	95	**0.68**
CF2	10	10	100	10	10	100	10	9	90	10	9.5	95	**0.65**
WS	10	9.5	95	10	10	100	10	9	90	10	10	100	**0.49**

Security Assessment (B)

Table 4 shows characteristics of the security parameters on map unit level. The parametric evaluation system of the indices was given in Table 5.Each parameter has a scale of 0.0 to 1.0. Figure 4 show that, security practices in all map units meet the requirements of sustainability where it ranged from 0.53 to 1.00.

Table3 Security indices of the landforms units

Mapping unit	Moisture availability (Day/Year			Water quality dSm^{-1}			Crop residues %			Total
	S	R	V	S	R	V	S	R	V	
DB	10	10	100	10	10	100	10	10	100	**1.00**
OB	10	10	100	10	10	100	10	10	100	**1.00**
OM	10	10	100	10	10	100	10	10	100	**1.00**
RT1	10	10	100	10	10	100	10	10	100	**1.00**
RT2	10	10	100	10	10	100	10	10	100	**1.00**
RT3	10	10	100	10	10	100	10	10	100	**1.00**
SS	10	7	70	10	9.5	95	10	8	80	**0.53**
CF1	10	10	100	10	10	100	10	10	100	**1.00**
CF2	10	10	100	10	10	100	10	10	100	**1.00**
WS	10	10	100	10	8	80	10	10	100	**0.80**

Protection Assessment(C)

Table 6 shows the protection parameters. The parametric evaluation system is given in Table 7. Each parameter has a scale of 0.0 to 1.0. Figure 5 show that, the protection practices in all map units meet the requirements of sustainability where it ranged from 0.53 to 1.00.

Table4: Protection indices of the landforms units.

Mapping unit	Erosion hazard			Flooding hazard			Cropping system			Total
	S	R	V	S	R	V	S	R	V	
DB	10	10	100	10	10	100	10	10	100	**1.00**
OB	10	10	100	10	10	100	10	10	100	**1.00**
OM	10	10	100	10	10	100	10	10	100	**1.00**
RT1	10	10	100	10	10	100	10	10	100	**1.00**
RT2	10	10	100	10	10	100	10	10	100	**1.00**
RT3	10	10	100	10	10	100	10	10	100	**1.00**
SS	10	7	70	10	9	90	10	8.5	85	**0.53**
CF1	10	10	100	10	9	90	10	10	100	**0.90**
CF2	10	10	100	10	10	100	10	10	100	**1.00**
WS	10	10	100	10	8	80	10	7	70	**0.56**

S= score, R= rank, (S*R) = value

Economic viability Assessment (D)

Table 8 shows characteristics of the economic viability parameters on map units level. The parametric evaluation system of the index was given in Table 9. Each parameter has a scale of 0.0 to 1.0. Figure 6 shows that, the economic viability index ranged from 0.35 to 0.80. Economic viability practices in all map units meet the requirements of sustainability.

Table 5 Economic Viability Indices of the landform units

Mapping unit	Benefit cost ratio			Difference between farm gate price and nearest main market price %			Availability of farm labor			Size of farm Holding Fadden			Percentage of farm product sold in market			Total
	S	R	V	S	R	V	S	R	V	S	R	V	S	R	V	
DB	10	10	100	10	8	80	10	10	100	10	10	100	10	10	100	**0.80**
OB	10	10	100	10	8	80	10	10	100	10	10	100	10	10	100	**0.80**
OM	10	10	100	10	8	80	10	9	90	10	9	90	10	10	100	**0.64**
RT1	10	9	90	10	8	80	10	10	100	10	9	90	10	10	100	**0.64**
RT2	10	10	100	10	8	80	10	9	90	10	10	100	10	10	100	**0.72**
RT3	10	8	80	10	8	80	10	10	100	10	10	100	10	10	100	**0.64**
SS	10	9	90	10	8	80	10	8	80	10	10	100	10	9	90	**0.51**
CF1	10	8	80	10	8	80	10	9	90	10	8	80	10	10	100	**0.46**
CF2	10	9	90	10	9	90	10	8	80	10	8	80	10	10	100	**0.51**
WS	10	7	70	10	10	100	10	8	80	10	8	80	10	8	80	**0.35**

Social Acceptability Assessment (E)

Table 10 shows the characteristics of the social acceptability parameters on map unit level. The parametric evaluation system of the index was given in Table 11. Each of these seven parameters is on a scale from 0.0 to 1.0. Figure 7 shows that, the social acceptability practices in all map units meet the requirements of sustainability, where the social acceptability index ranged from 0.29 to 0.90.

Table 6. Social Acceptability Indices of the landform units

Mapping unit	Land tenure			Support for extension services			Healthand educational facilitiesin village			Percentage of subsidy for conservation packages			Training of farmers in soil and water conservation techniques			Availability of agro-input within 5- 10 km range			Village road access to main road			Total
	S	R	V	S	R	V	S	R	V	S	R	V	S	R	V	S	R	V	S	R	V	
DB	10	10	100	10	10	100	10	10	100	10	10	100	10	9	90	10	10	100	10	10	100	**0.90**
OB	10	10	100	10	10	100	10	10	100	10	10	100	10	9	90	10	10	100	10	10	100	**0.90**
OM	10	9	90	10	9	90	10	10	100	10	10	100	10	9	90	10	10	100	10	10	100	**0.72**
RT1	10	9	90	10	9	90	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100	**0.81**
RT2	10	9	90	10	9	90	10	10	100	10	10	100	10	10	100	10	10	100	10	10	100	**0.81**
RT3	10	10	100	10	10	100	10	10	100	10	10	100	10	9	90	10	9	90	10	10	100	**0.81**
SS	10	10	100	10	8	80	10	9	90	10	9	90	10	8	80	10	9	90	10	8	80	**0.37**
CF1	10	10	100	10	9	90	10	10	10	10	10	100	10	9	90	10	9	90	10	10	100	**0.72**
CF2	10	9	90	10	10	100	10	9	90	10	9	90	10	8	80	10	9	90	10	9	90	**0.47**
WS	10	8	80	10	8	80	10	9	90	10	8	80	10	8	80	10	9	90	10	9	90	**0.29**

a= score, b= rank, (a*b) = value

The Sustainability Index (SI)

The sustainability Index (SI) was calculated according to the following equation of five criteria as sustainability pillars, viz.:

Sustainability Index (SI) = A x B x C x D x E

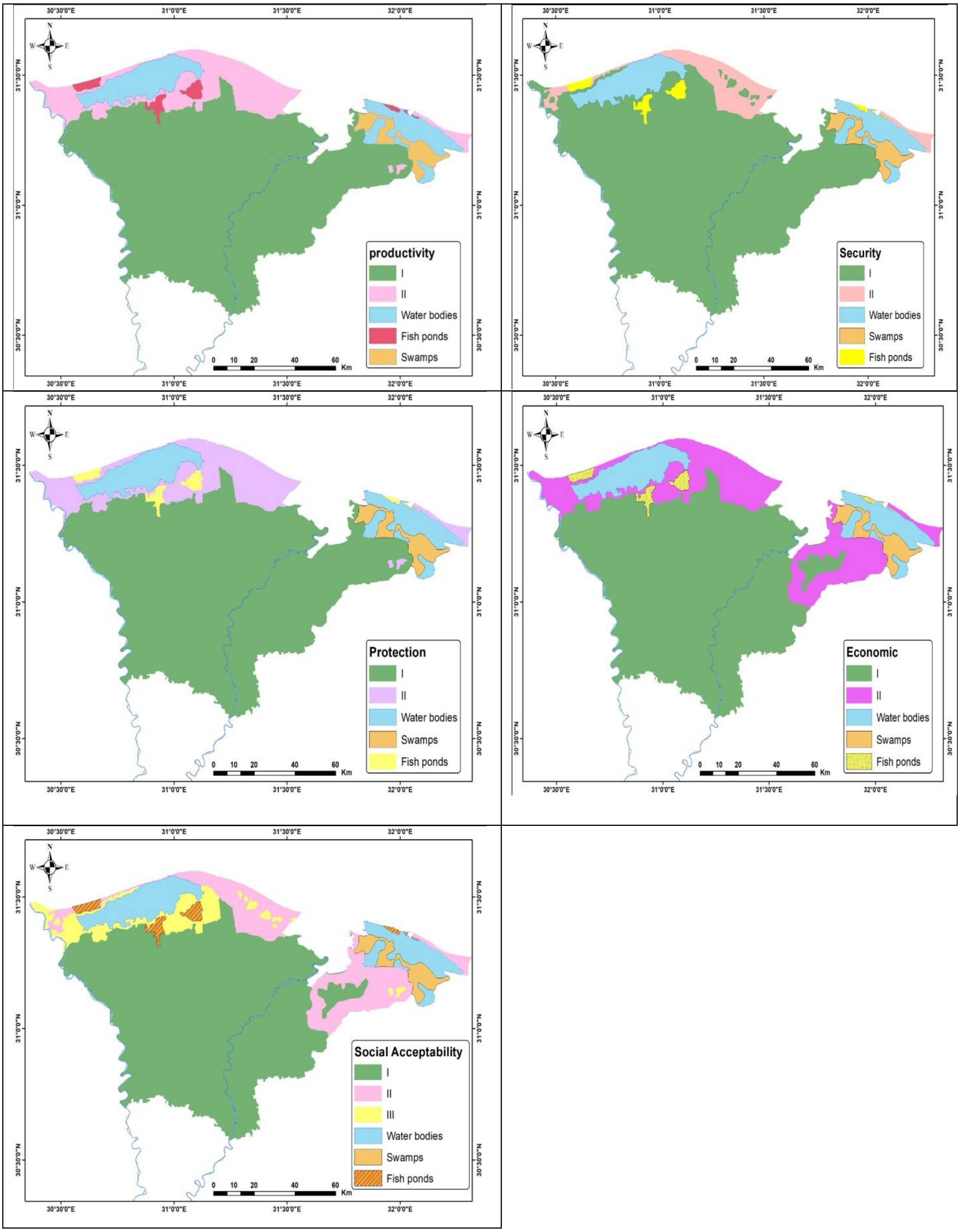

Fig.3: Maps of the Productivity index, Security index, Protection index, Economic Viability index and Social Acceptability index of the study area

Where: A =productivity, B = security, C= protection, D = economic viability and E= social acceptability

Each index (criteria) has a scale from 0.0-1.0, the actual percentage being multiplied by each other. The resultant Index of Sustainability also lies between 0.0-1.0. The obtained sustainability index ranged from 0.050 to 0.58 show in table 12

Table7. Sustainability index and classes of the landform units

Maping unit	Productivity index	Security index	Protection index	Economic viability index	Social acceptability index	Total value of sustainability index	Sustainability class
DB	0.76	1.00	1.00	0.80	0.90	0.54	**II**
OB	0.81	1.00	1.00	0.80	0.90	0.58	**II**
OM	0.85	1.00	1.00	0.64	0.72	0.39	**II**
RT1	0.81	1.00	1.00	0.64	0.81	0.42	**II**
RT2	0.90	1.00	1.00	0.72	0.81	0.52	**II**
RT3	0.81	0.53	0.53	0.64	0.81	0.11	**III**
SS	0.42	1.00	0.90	0.51	0.37	0.071	**IV**
CF1	0.68	1.00	1.00	0.46	0.72	0.22	**III**
CF2	0.65	0.80	0.56	0.51	0.47	0.069	**IV**
WS	0.49	1.00	1.00	0.35	0.29	0.050	**IV**

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Results in Table 13 and Fig. 8 show four sustainability classes as follow:

Class II: Marginally but above the threshold of sustainability, It is in units DB, OB, OM, RT1 and RT2, with a total area of 544187.17 ha which represent 54.42% of the study area.

Class III: Marginally but below the threshold of sustainability, it is in the units RT3 and CF1with a total area of 128595.43 ha (12.86% of the total studied area)

Class IV: Did not meet the sustainability requirements; it is in the units SS, CF2 and WS, with a total area of 157330.47 ha (15.72% of the total studied area).

Table 8. Distribution of land sustainability index of the study area

(LSI)	Grade	Class	Mapping unit	Area (ha)	Area %
0.6–1	**I**	Meet the sustainability requirements	————	————	————
0.3–0.6	**II**	Marginally but above the threshold of sustainability	**DB**, **OB, OM, RT1 and RT2**	544187.17	54.42
0.1–0.3	**III**	Marginally but below the threshold of sustainability	**RT3 and CF1**	128595.43	12.86
0–0.1	**IV**	Do not meet the sustainability requirements	**SS, CF2 and WS**	157330.47	15.72

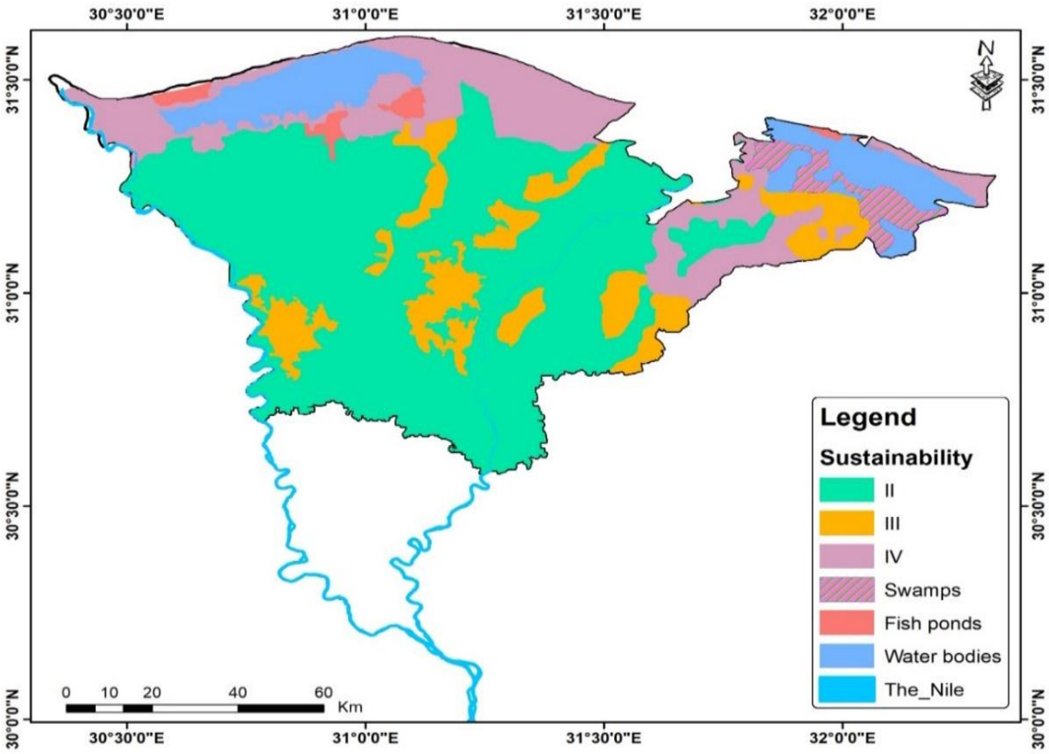

Fig. 4 Map of Sustainable land management index of the study area.

Conclusion

Using GIS to produce a model of Sustainable Land Management Index (SLMI), was done in the Nile Delta on an area of 999455.83 ha in 5 governorates: Gharbia, Dakahliea, Kafr-El-Sheikh, Monofiya, and Damietta. Assessment depended on five factors: productivity, security, protection, economic viability and social acceptability. 67.28% of the study area achieved sustainability, while 15.72% did not. Achieving sustainable land management in the agricultural land of Nile Delta region is accompanied by many obstacles as follows: 1- deterioration of land and water quality; 2- rapid population growth 3- fragmentation of holdings 4- insufficient credits.Thus SLMI requires more governmental and public efforts through 1- The use effective management of soil and water; 2- social and economic factors; 3- Educating farmers to increase crop productivity and 4- The Use of precision farming .

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تقييم استدامة الأراضي في مناطق مختلفة من دلتا النيل ، مصر باستخدام تقنيات نظم المعلومات الجغرافية والاستشعار عن بعد

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قسم الأراضى و المياه– كلية الزراعة– مشتهر– جامعة بنها– مصر.

تهدف هذه الدراسة إلى تقييم مؤشر الإدارة المستدامة للأراضي (SLMI) في بعض مناطق دلتا النيل من خلال خمسة مؤشرات (مؤشر الإنتاجية ، مؤشر الأمن ، مؤشر الحماية ، مؤشر الجدوى الاقتصادية ، مؤشر القبول الاجتماعي). تقع المنطقة المدروسة بين دائرتي عرض 31 ° 36' 50.2 ″و 30 ° 34' 35.4 ″ شمالاً وخطي طول 30 ° 21'59.5″ و 32° 18' 15.8″ شرقا ، وتبلغ مساحة منطقة الدراسة 9994.55 كيلومتر مربع. (999455.83 هكتار). تقع دلتا النيل بين فرعي رشيد ودمياط. النشاط الرئيسي في منطقة الدراسة هو الزراعة. ضمت منطقة الدراسة ثلاث مناظر طبيعية لسطح الأرض وهما السهل الفيضي والسهل الريحي والترسيبات البحرية امااالوحدات الخرائطية بمنطقة الدراسة هي الرفوف الفيضية (OM), الأحواض الفيضية (OB)، الأحواض التجمعية (DB) ، الشروفات النهرية (RT) ومنها (المرتفعة (RT1) – المتوسطة – (RT2) المنخفضة (RT3))، الفرشات الرملية (SS)، السبخات الجافة(WS) ; ترسيبات بحرية من الطين ذات منسوب مرتفع (CF1)، ترسيبات بحرية من الطين ذات منسوب منخفض (CF2) . وقد تم حفر 30 قطاع أرضي لتغطية جميع الوحدات الخرائطية بالمنطقة . تم تصميم نموذج SLMIباستخدام أدوات المعالجة الجغرافية المكانية لـ ArcGIS من خلال التكامل بين العوامل الفيزيائية الحيوية والاجتماعية والاقتصادية والبيئية للتربة في كل وحدة رسم خرائط تم تحديد ثلاث فئات من SLMI ؛ (الفئة الثانية) تمثل 54.42٪ (544187.17 هكتارًا) من المساحة الإجمالية ، وتتمثل الوحدات في الأحواض التجمعية (DB) والأحواض الفيضية (OB) و الرفوف الفيضية (OM) والشروفات النهرية المرتفعة (RT1) و الشروفات النهرية المتوسطة (RT2)، والفئة الثالثة تغطي 12.86٪ من المساحة المدروسة (أى 128595.43 هكتار) من المساحة الإجمالية ،وتتمثل في وحدات رسم خرائط الشروفات النهرية المنخفضة (RT3) و ترسيبات بحرية من الطين ذات منسوب مرتفع (CF1)، والفئة الرابعة والتي لا تلبي الاستدامة وتتمثل في الوحدات الفرشات الرملية (SS) و ترسيبات بحرية من الطين ذات منسوب منخفض (CF2) والسبخات الجافة (WS) ، بمساحة إجمالية تبلغ 157330.47 هكتارًا أى 15.72٪ من المساحة المدروسة.