Plant Archives Vol. 20, Supplement 1, 2020 pp. 1469-1476 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

SUSTAINABILITY OF OLD CULTIVATED SOILS IN EL–FAYOUM GOVERNORATE, EGYPT

Wael Abd El-Kawy[a]*, Ali Abd El-Hameed[a], Tolba Saleh[b] and Batool Abdel Aziz[a]
[a]Department of soil science, Faculty of Agriculture, Cairo University ,Cairo , Egypt
[b]Department of soil science, Faculty of Agriculture, Fayoum University ,Cairo , Egypt
*Corresponding Author: dr_wael_kawy@yahoo.com

Abstract

The main objective of this work is to evaluate sustainable land use management (SLM) through biophysics and socio-economic elements for the purpose of combating and tackling sustainability constraints that preclude the agricultural development. From the geomorphological point of view, three main landscapes were identified in El–Fayoum depression: (1) Alluvial plain deposits; (2) Fluvio-Lacustrine plain deposits; and (c) Lacustrine plain deposits. The studied area was dominated by specific physical and chemical degradation processes with different classes, which lead to break down the equilibrium of soil stability. Geomorphologic map was obtained by using Landsat 8.0 ETM+ Enhanced image dated to year 2018 coupled with digital elevation model into ENVI software version 5.2.Thirty three soil profiles were selected to represent the main geomorphic unites at the study area. Soil profiles were morphologically described according to FAO guidelines (2006), USDA (2014) was used to classify the different Soil profiles according to the morphological description of the investigated profiles and physical and chemical properties of the collected soil samples according to USDA (2014) and US Soil Survey Staff (2014). ArcGIS version 10.5 used for mapping soil variables, modeling and GIS work for the current study. Sustainable Land use management (SLM) was extracted from the perspective of productivity, security, protection, economic viability and social acceptability factors. Two SLM classes were recognized at the studied area as follows: Class III: Marginally but below the threshold of sustainability 0.1–0.3 dominant at the alluvial deposits, representing 47.85 % of the agricultural areas, Class IV: Do not meet the sustainability requirements 0 – 0.1dominant at the fluvio-lacustrine deposits and lacustrine deposits.

***Keywords*:** Sustainable land use management; remote sensing; GIS; El – fayoum governorate, Egypt

Introduction

Sustainable agriculture is an “integrated system" using the taxonomy of "levels" of practices from a spectrum supporting socio-ecologically sustainable food systems. The levels are: improving system efficiency to reduce the use of inputs, replacing more sustainable inputs into farming systems, redesigning systems based on agro-ecology, establishing connections between producers and consumers to support a socio-ecological system and establishment of food system based on farm-scale practices. De Longe *et al.*, (2016). The principles for agricultural sustainability in developing countries are: i. Land-use efficiency and Productivity; ii. Maximum use of internal resources and minimal use non-renewable resources; iii. Effective and profitable production, with a focus on maximum net farm income; iv. Conservation of natural resources that support agricultural production; and v. maximum use of locally appropriate farming practices and natural resource-conservation strategies Zhen & Routray. (2003) and Pretty, (2008). Sustainable land management (SLM) in agriculture is very complex. An International framework for Evaluating Sustainable Land Management (FESLM) was recently developed to provide a base for addressing these issues. SLM combines technologies, policies and activities aimed at integrating socioeconomic principles with environmental concerns so as to simultaneously satisfy the five pillars of SLM: maintain the enhance production services (Productivity), reduce the level of production risk (security), protect the potential of natural resources and prevent degradation of soil and water quality (protection), be economically viability and be socially acceptability. Sustainable land management is defined as a system that combines technologies, polices and activities aimed at integrating socio-economic principles with environmental concerns to simultaneously maintain or enhance production and services, reduce the level of production risk, protect the potential of natural resources , be economically viable, and be socially acceptable Smith and Dumanski (1993). Recently, SLM in some parts of the Nile Delta was carried out by some authors (Abdel Kawy and Ali, 2007; El- Nahry and Abdel Kawy, 2013; Abdel Kawy, 2013; Abdel Kawy and Darwish, 2014; Yousif *et al.*, 2020 a,b)

The main objectives of this work are to:

1- Create physiographic soil map of the study area using remote sensing techniques.
2- Evaluate sustainable land use management (SLM) through biophysics (productivity, security, protection) and socio-economic (economic viability and social acceptability) elements at the study area.
3- Study the sustainability constraints, which are precluding the agricultural development.

Material and Methods

Study area

EL-Fayoum Governorate is occupying a depression located at west of the Nile at 90 km southwest of Cairo between latitudes 28°56′ and 29°28′ N and longitudes 30°15′ and 31°05′ E (Fig. 1). The studied area is represented by an area of 1783.38 km^2. Based on Egyptian Meteorological Authority (2016), Climatologically Normal for Egypt, (2018) and Soil Survey Staff, (2014), the soil temperature regime of the studied area is defined as Thermic and soil moisture regime as Aridic. Ecological description of the studied area extracted from EEAA (2009). The geological units of this study area were extracted from the geological map of Egypt (scale 1:500,000) produced by CONCO (1989). Said (1990), Said (1993) and Said (2017) mentioned that the studied area belongs to the Late Pleistocene that is represented by the deposits of the neonile as shown in (Fig. 2).

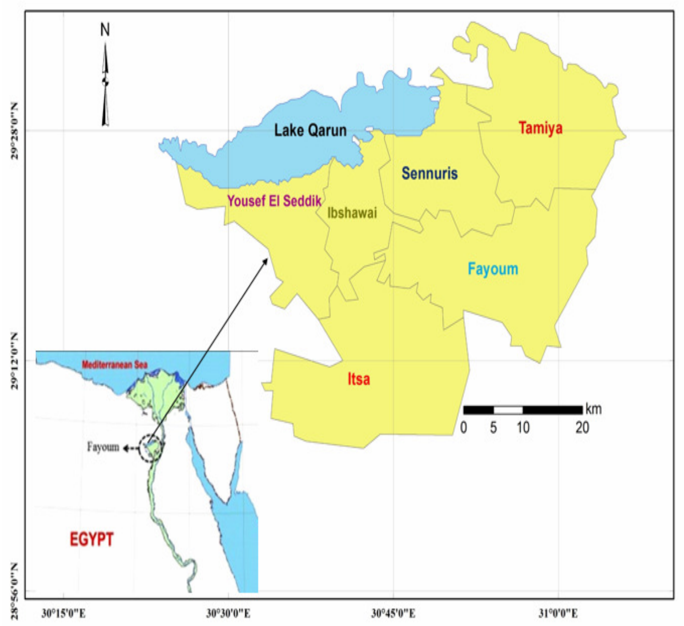

Fig. 1: Location of the studied area.

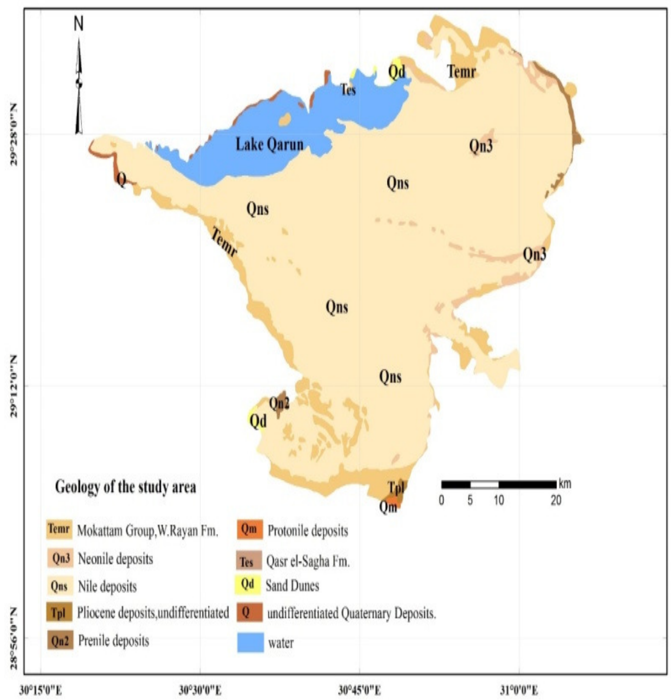

Fig. 2: Geological Map of study area according to CONOCO (1989).

Landform Mapping

Physiographic map of the study area has been produced using physiographic analysis according to Zinck and Valenzuala (1990). Geomorphologic map was obtained by using Landsat 8.0 ETM+ Enhanced image dated to year 2018 (Fig. 3) coupled with digital elevation model (Fig. 4) and topographic maps at scale of 1:100,000 covering the study area, produced by the Egyptian General Survey Authority (EGSA) into ENVI software version 5.1 ITT., (2009) and Dobos *et al.* (2002). The soil profiles locations were selected in transects to cover all mapping units. Collected soils samples were analyzed according to USDA (2014) and US Soil Survey Staff (2014). Soil Taxonomy was produced using USDA (2014).

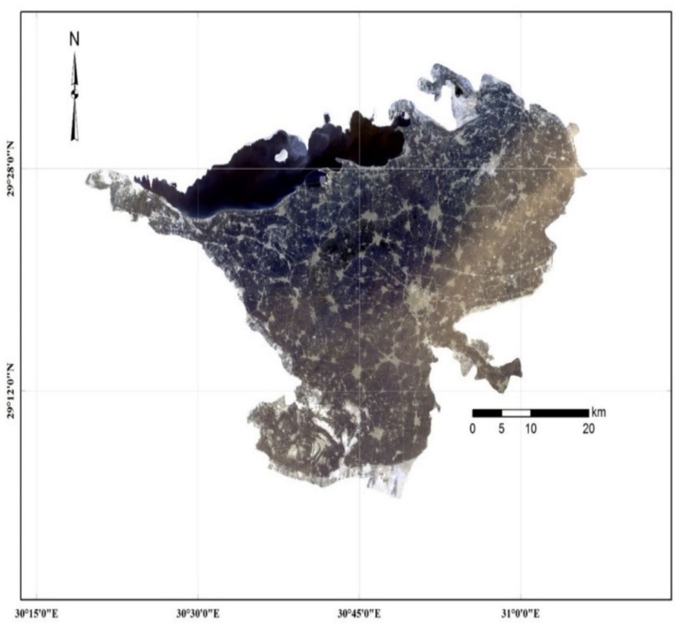

Fig. 3: Enhanced ETM+8 satellite images dated to year 2018.

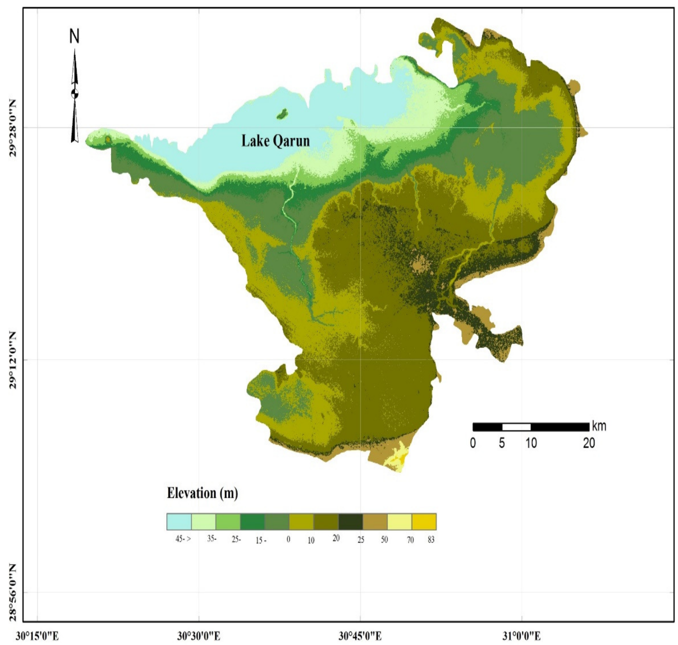

Fig. 4: The digital elevation model of the study area.

Field work

The soil profiles locations were selected in transects to cover all mapping units. Thirty-three soil profiles were taken to represent different mapping units. Detailed morphological description was recorded for each of the studied soil profiles on the bases outlined by guideline for soil profile description according to FAO, (2006).

GIS work

ArcGIS 10.0 was the main GIS platform used in this study. GIS tool is applied to manage soil databases developed for the study area, mapping soil variables and modeling.

Socio-Economic Studies

The required data for the social and economic studies at the investigated area were extracted from governmental reports according to CAPMS. (2014 a,b), CAPMS., (2015 a,b,c,d), CAPMS., (2016 a,b,c,d) and CAPMS., (2017 a,b). The agricultural Statistics and yield productivity of winter and summer crops were extracted from EASMA., (2009), EASMA., (2010), EASMA., (2011), EASMA., (2012), EASMA., (2013), EASMA., (2014), EASMA., (2015) and EASMA., (2016).

Sustainable Land use management (SLM)

Indicators of the international framework for evaluating sustainable land use management after Dumanski, J., (1997) were used as inputs for the designed SLMSM modified by the author adding Soil sealing caused by urban sprawl as important element reduce the sustainability at the study area. Sustainability index and associated values and classes are shown in (Table.1).

Table 1: Sustainability index, values, and classes, after Dumanski, J. (1997).

Land use / management status	Values	Class
Meet the sustainability requirements	0.6 – 1	I
Marginally but above the threshold of sustainability	0.3 – 0.6	II
Marginally but below the threshold of sustainability	0.1 – 0.3	III
Do not meet the sustainability requirements	0 – 0.1	IV

Results and Discussion

Soil physiography

Satellite images interpretation indicated that investigated area includes three main landscapes: Alluvial plain deposits, Fluvio-lacustrine plain deposits and Lacustrine plain deposits with 16 landforms the area as shown in (Fig. 5). The soil correlation between physiographic and taxonomic units was designed after Elberson and Catalan as shown in (Table.2).

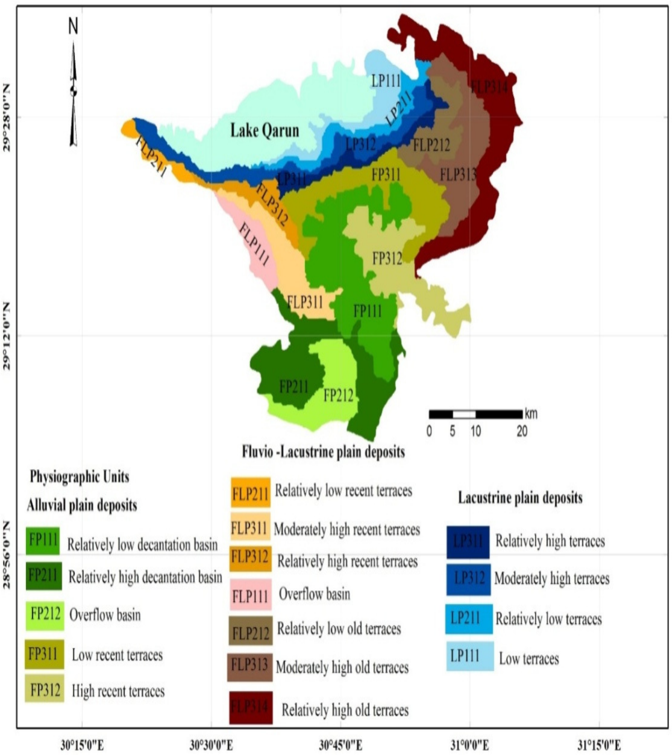

Fig. 5: Physiographic soils map of the study area, modified after Ali,R.R. and Abdel Kawy, W.A., (2013).

Table 2: Geomorphology and soil map of the study area.

Landscape	Relief	Lithology	Landform	Mapping Unit	Area (Km^2)	Soil taxonomy unit
Flood Plain (FP)	Flat to Almost Flat (FP1)	Alluvial deposits (FP11)	Relatively low decantation basin	FP111	242.70	Typic Natriagents
	Almost Flat to Gently Slope (FP2)	Alluvial deposits (FP21)	Relatively high decantation basin	FP211	202.91	SodicTorrifluvents
	Sloping (FP3)		Overflow basin	FP212	102.38	TypicTorrifluvents
		Alluvial deposits (FP31)	Low recent terraces	FP311	157.80	TypicTorrifluvents
			High recent terraces	FP312	147.94	TypicTorrifluvents
Fluvio – Lacustrine Plain (FLP)	Flat to Almost Flat (FLP1)	Fluvio –Lacustrine deposits (FLP11)	Overflow basin	FLP111	51.58	TypicTorrifluvents
	Almost Flat to Gently Slope (FLP2)	Fluvio –Lacustrine deposits (FLP21)	Relatively low recent terraces	FLP211	24.16	Lithic Calciorthents
			Relatively low old terraces	FLP212	72.75	TypicTorrifluvents
	Sloping (FLP3)	Fluvio –Lacustrine deposits (FLP31)	Moderately high recent terraces	FLP311	98.07	Sodic Gypsiorthents
			Relatively high recent terraces	FLP312	43.28	Lithic Calciorthents
			Moderately high old terraces	FLP313	131.76	Sodic Torrifluvents
			Relatively high old terraces	FLP314	210.20	TypicTorrifluvents
Lacustrine Plain (LP)	Flat to Almost Flat (LP1)	Lacustrine deposits (LP11)	Low terraces	LP111	75.48	Sodic Torrifluvents
	Almost Flat to Gently Slope (LP2)	Lacustrine deposits (LP21)	Relatively low terraces	LP211	58.45	Sodic Torrifluvents
	Sloping (LP3)	Lacustrine deposits (LP31)	Relatively high terraces	LP311	53.05	Sodic Torrifluvents
			Moderately high terraces	LP312	110.86	Sodic Torriaquents

The physical and chemical characteristics of the representative soil profiles showed that: Soil profiles are deep and soils drainage conditions are poor to well. Soil texture classes are clay for most profiles layers. Calcium carbonate content ranges between 1.01 to 5.76% in profiles layers. Gypsum content is less than 1%. pH values ranged between 7.20 and 8.60 in the studied profiles. EC of saturation paste extracts for all profiles is ranged between 1.58 and 20.05 dS/m. OM content ranges between0.59 and 2.40%. High values of upper layers' OM in some soil profiles may be due to continuous addition of organic manures in these cultivated soils. The cation exchange capacity (CEC) ranges between 24.00 and 35.82 meq./100 g. soil, this is reflecting of high clay and organic matter content. The main portion of the exchangeable cations in these soils is occupied by Calcium. ESP values range between 9.61 and 16.51% in soil profiles layers. Available nitrogen ranges between 18.12 and 50.00 ppm in the surface layers, available phosphorus ranges between 10.12 and 30.00 ppm and available potassium ranges between 110.00 and 250.00 ppm in most of the studied soil profiles layers. Based on morphological features of this studied profiles layers and chemical analysis, the soils according to Soil Survey Staff., (2014) are classified as: Typic Torrifluvents, Typic Natriagents, Vertic Torrifluvents, Sodic Torrifluvents, Typic Calciorthents, Sodic Gypsiorthents, Lithic Calciorthents , and sodic Torriaquents as shown in (Fig.6).

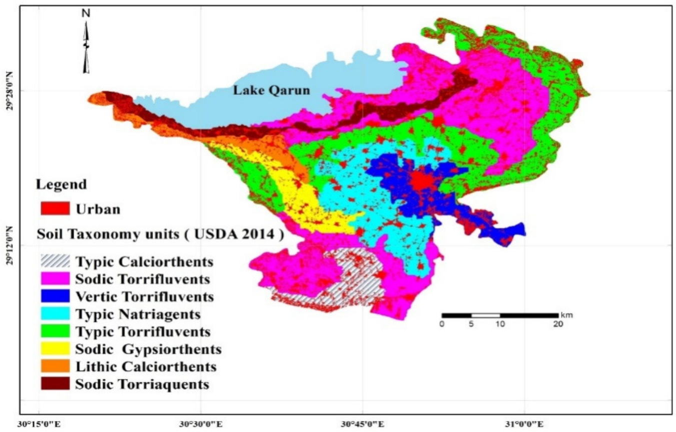

Fig. 6: Soil classification orders of the study area according to USDA (2014).

Sustainability indicators of the studied area

Five sustainability indicators {productivity (PRI), security (SI), protection (PI), economic viability (EI) and social acceptability (SOI)} could be calculated by values for input criteria.

Productivity

The results obtained from the first stage of SLM indicated that 86.7 % of the studied area meets the sustainability requirement. The productivity index in alluvial plain ranges between 0.65 and 0.9, fluvio-lacustrine plain ranges between 0.48 and 0.77 and lacustrine plain range between 0.5 and 0.73. 13.3 % of the studied area in some parts of lacustrine is marginally above the threshold of sustainability. The calculation of productivity indices is illustrated in (Table 3).

Table 3 : Productivity index of the mapping units at the study area.

Mapping Units	A	Nutrient availability									PRI
		B	C	D	E	F	G	H	I	J	
FLP314	90	100	100	100	95	100	100	100	95	95	0.77
FLP313	90	100	100	100	95	100	100	100	95	90	0.73
FLP212	100	100	95	100	95	100	100	100	90	90	0.73
FP311	100	100	100	100	95	100	100	100	100	95	0.90
LP311	90	100	100	100	85	95	90	95	90	90	0.50
LP312	90	100	100	100	95	100	100	95	95	95	0.73
LP211	90	100	100	100	95	100	100	95	90	90	0.66
LP111	80	100	95	100	95	100	100	95	90	95	0.59
FLP312	80	95	100	100	95	100	100	95	90	100	0.62
FLP311	80	100	100	100	95	100	100	100	90	95	0.65
FLP211	70	95	100	100	95	100	100	95	85	95	0.48
FP312	90	100	100	100	95	100	100	100	100	95	0.81
FP111	90	100	100	100	95	100	100	100	95	95	0.77
FLP111	90	100	100	100	95	100	100	100	95	90	0.73
FP212	90	100	100	100	95	100	100	100	95	95	0.77
FP211	90	95	100	100	95	100	100	100	90	90	0.65

Notes: The productivity index considers the value (V) of 10 indicators as determining relative Yield (%) (A), organic carbon % (B), pH (C), cation exchange capacity (CEC) in meq./100 g. soil (D), available Nitrogen in ppm (E), available phosphorous in ppm (F), available potassium in ppm (G), soil depth in cm(H), electrical conductivity (EC) in dS/m (I) and exchangeable sodium percentage (ESP) (J).

Where: productivity index (PRI) =

$$\frac{A}{100} \times \frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \times \frac{E}{100} \times \frac{G}{100} \times \frac{H}{100} \times \frac{I}{100} \times \frac{J}{100}$$

Security and protection

The security and protection indices in the different mapping units indicated that 83.4 % of the studied area meets the sustainability requirement in alluvial and fluvio-lacustrine plain. Other hand 16.6 % of the studied area in lacustrine plain are marginally above the threshold of sustainability which may be due to moisture and biomass stress, the unsuitable cropping system and Soil sealing caused by urban sprawl as shown in (Fig.7) and (Table 4) . The calculation of productivity indices is illustrated in (Table 5).

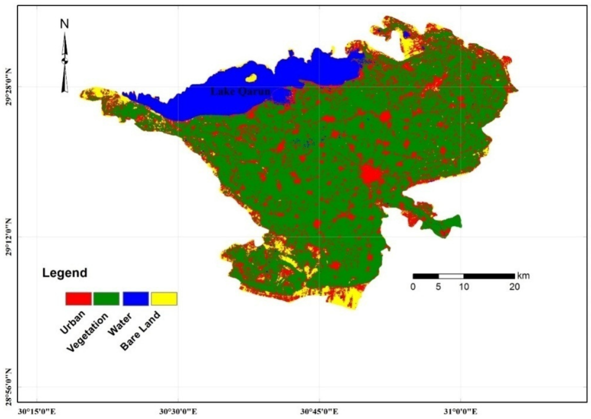

Fig. 7: Soil sealing caused by urban sprawl at the study area dated to year 2018.

Table 4: Changes in Land use /cover and Urban of the study area during the period (2003 – 2018).

Classes	Year 2003*		Year 2011*		Year 2018**	
	Km^2	%	Km^2	%	Km^2	%
Urban	165.3	8.2	219.2	10.8	411.7	19.9
Vegetation	1399.8	69.1	1350.7	66.7	1309	63.34
Water	244.8	12.1	241.3	11.9	243.5	11.8
Bare Land	215.5	10.6	214.3	10.6	102.1	4.9
Sum	2025.5	100	2025.5	100	2066	100

After Abd-Alla Gad and Ahmed El-Zeiny,(2016). *
** After the current work of the authors.

Table 5: Security index and protection index of the mapping units at the study area.

Mapping Units	Security				Protection				
	A	B	C	SI	A	B	C	D	PI
FLP314	90	90	80	0.64	100	100	70	80	0.56
FLP313	90	90	80	0.64	100	100	70	80	0.56
FLP212	90	90	80	0.64	100	100	70	80	0.56
FP311	100	100	100	1.000	100	100	90	70	0.63
LP311	80	90	80	0.58	100	100	60	90	0.54
LP312	80	90	80	0.58	100	100	60	90	0.54
LP211	80	90	80	0.58	100	100	60	90	0.54
LP111	80	90	80	0.58	100	100	60	90	0.54
FLP312	90	90	80	0.64	100	100	70	80	0.56
FLP311	90	90	80	0.64	100	100	70	80	0.56
FLP211	90	90	80	0.64	100	100	70	80	0.56
FP312	100	100	100	1.00	100	100	90	70	0.63
FP111	100	100	100	1.00	100	100	90	70	0.63
FLP111	90	90	80	0.64	100	100	70	80	0.56
FP212	100	100	100	1.00	100	100	90	70	0.63
FP211	100	100	100	1.00	100	100	90	70	0.63

Notes: The security index considers the values (*V*) of three indicators, that is, moisture availability Per month/season (A), electrical conductivity (EC) of irrigation water (B) and biomass% defined as Biomass% = percentage of crop residue ploughed back to land (C) as determining security. The erosion hazard (A), flooding hazard (B), cropping Pattern (C) and urban extension (D) indicators were used to determine the protection of the natural resources.

Where: Security Index (SI) = $\frac{A}{100} \times \frac{B}{100} \times \frac{C}{100}$, Protection Index (PI) = $\frac{A}{100} \times \frac{B}{100} \times \frac{C}{100} \times \frac{D}{100}$

Economic viability

The results obtained from economic index from calculating series of values indicated that the different landforms in the marine plain and the lacustrine plain are marginally below the requirements of the sustainability , where the economic viability index in these areas range between 0.21 and 0.27. The economic viability indices in limited areas of alluvial plain and the landforms of the fluvio-lacustrine plain are marginally above the threshold of sustainability, where the economic viability index realizes the value of 0.58. The economic viability index in the rest of alluvial plain reaches to 0.65 meeting the sustainability requirements. The low economic viability in the studied area is due to low benefit to cost ratio, low availability of farm labor, small farm size, low percentage of farm production sale in markets and low off-farm income as well. (Table 6) shows the economic viability assessment.

Table 6: Economic viability assessment of the mapping units at the study area.

Mapping units	A	B	C	D	E	F	G	EI
FLP314	80	90	90	90	80	80	80	0.30
FLP313	80	90	90	90	80	80	80	0.30
FLP212	80	90	90	90	80	80	80	0.30
FP311	90	100	100	100	80	90	90	0.58
LP311	70	80	80	90	80	80	80	0.21
LP312	70	80	80	90	80	80	80	0.21
LP211	70	80	80	90	80	80	80	0.21
LP111	70	80	80	90	80	80	80	0.21
FLP312	80	90	90	90	80	80	80	0.30
FLP311	80	90	90	90	80	80	80	0.30
FLP211	80	90	90	90	80	80	80	0.30
FP312	90	100	100	100	80	90	90	0.58
FP111	90	100	100	100	80	90	90	0.58
FLP111	80	90	90	90	80	80	80	0.30
FP212	100	100	100	100	80	90	90	0.65
FP211	100	100	100	100	80	90	90	0.65

Notes: The economic viability index considers the values of seven indicators as determining economic Viability: benefit–cost ratio (A), percentage of off-farm income (B), difference between the farm gates Price and the nearest main market % (C), availability of farm labor man/feddan (D), size of farm Holding in feddan (E), availability of farm credit % (F) And the percentage of farm produce sold in Market (%) (G).

Where: Economic Index (EI) = $\frac{A}{100} \times \frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \times \frac{E}{100} \times \frac{G}{100}$

Social acceptability

The results obtained from Social index from calculating series of values indicated that the different landforms in the studied areas are marginally above the threshold of sustainability, where the Social viability index in these areas range between 0.30 and 0.58. The calculation of Social indices is illustrated in (Table 7).

Table 7: Social acceptability assessment of the mapping units of the study area.

Mapping Units	A	B	C	D	E	F	G	SOI
FLP314	90	80	100	80	80	90	100	0.41
FLP313	90	80	90	80	80	90	100	0.37
FLP212	90	80	90	80	80	90	100	0.37
FP311	90	90	100	90	80	100	100	0.58
LP311	100	80	90	80	80	90	90	0.37
LP312	90	80	90	80	80	90	90	0.34
LP211	80	80	90	80	80	90	90	0.30
LP111	80	80	90	80	80	90	90	0.30
FLP312	90	80	90	80	80	90	100	0.37
FLP311	90	80	90	80	80	90	100	0.37
FLP211	90	80	90	80	80	90	100	0.37
FP312	90	90	100	90	80	100	100	0.58
FP111	90	90	100	90	80	100	100	0.58
FLP111	90	80	90	80	80	90	100	0.37
FP212	100	90	90	90	80	100	100	0.58
FP211	100	90	90	90	80	100	100	0.58

Notes: The social acceptability index considers the values (*V*) of seven indicators as social acceptability: land tenure (A), support for extension services (B), health and education facilities in the village (C), percentage of subsidy for conservation packages (D), training of farmers on soil and water conservation (E), availability of agro - inputs within 5–10 km (F) and village roads access to main road (G).

Where: Social Index (SOI) = $\frac{A}{100} \times \frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \times \frac{E}{100} \times \frac{G}{100}$

Sustainable Land use management (SLM)

Two SLM classes were recognized at the studied area as follows: Class III: Marginally but below the threshold of sustainability0.1 – 0.3 dominant at the Alluvial deposits. Class IV: Do not meet the sustainability requirements 0 – 0.1 dominant at the Fluvio-lacustrine deposits and lacustrine deposits. As shown in (Fig. 8) and (Table 8).

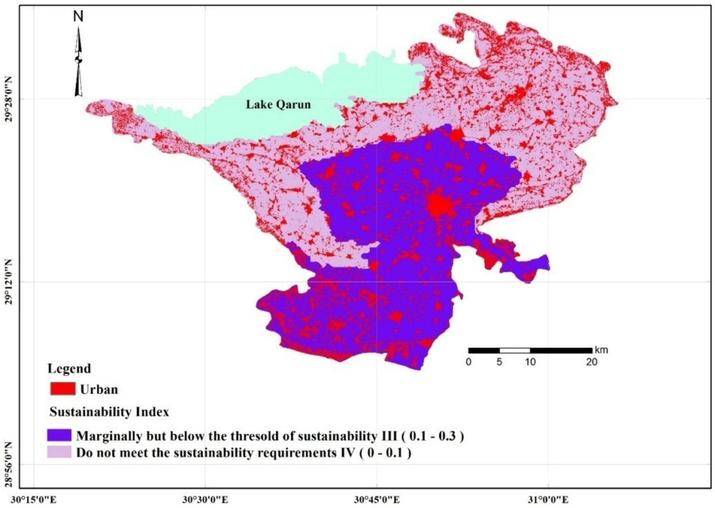

Fig. 8 : Sustainable Land use map of the study area.

Table 8: Sustainability classes of the study area

Mapping units	PRI	SI	PI	EI	SOI	SUI	Sustainability Class	Area Km^2
FLP314	0.77	0.64	0.56	0.30	0.41	0.034	IV	210.20
FLP313	0.73	0.64	0.56	0.30	0.37	0.029	IV	131.76
FLP212	0.73	0.64	0.56	0.30	0.37	0.029	IV	72.75
FP311	0.90	1.00	0.63	0.58	0.58	0.191	III	157.80
LP311	0.50	0.58	0.54	0.21	0.37	0.012	IV	53.05
LP312	0.73	0.58	0.54	0.21	0.34	0.016	IV	58.45
LP211	0.66	0.58	0.54	0.21	0.30	0.014	IV	110.86
LP111	0.59	0.58	0.54	0.21	0.30	0.013	IV	75.48
FLP312	0.62	0.64	0.56	0.30	0.37	0.025	IV	43.28
FLP311	0.65	0.64	0.56	0.30	0.37	0.032	IV	98.07
FLP211	0.48	0.64	0.56	0.30	0.37	0.019	IV	24.16
FP312	0.81	1.00	0.63	0.58	0.58	0.172	III	147.94
FP111	0.77	1.00	0.63	0.65	0.58	0.183	III	242.70
FLP111	0.73	0.64	0.56	0.30	0.37	0.029	IV	51.58
FP212	0.77	1.00	0.63	0.58	0.58	0.163	III	102.38
FP211	0.65	1.00	0.63	0.65	0.58	0.154	III	202.91

Conclusion

According to FESLM, (1995) offers a quantified assessment of the sustainability to help the decision maker to put the priorities to increase Agriculture production. Analysis of the results concluded that numerous constraints belonging to soil productivity, social acceptability and economic viability were observed. The cornerstones for tackling sustainability constraints are to adopt new technologies, improve agricultural, health, education infrastructure, supply poor land users with non-refundable loans and offer more subsidies.

References

Abd-Alla Gad & Ahmed El-Zeiny (2016). Spatial Analysis for Sustainable Development of El Fayoum and Wadi El Natrun Desert Depressions, Egypt with the Aid of Remote Sensing and GIS Journal of Geography. Environment and Earth Science International 8(3): 1-18.

Abdel Kawy, W.A. and Ali, R.R. (2007). Agricultural Sustainability in Some Areas North Nile Delta, Egypt, Egyptian Journal of Soil Science, 47(1): 53-67.

Abdel Kawy, W.A. (2013). Using GIS modeling to assess the agricultural sustainability in Kafr El-Sheikh governorate, Nile Delta, Egypt. Arabian Journal of Geosciences 6:733–747.

Abdel Kawy, W.A. and Darwish, K.M. (2014). Sustainable multivariate analysis for land use management in El-Sharkiya, Egypt. Arabian Journal of Geosciences, 7: 475–487.

Ali, R.R. and Abdel Kawy, W.A. (2013). Land degradation risk assessment of El Fayoum depression, Egypt. Arabian Journal of Geosciences, 6: 2767–2776.

CAPMS. (2014 a). Annual Bulletin of Cooperative Activity in the Agricultural Sector, loans supply by the principle bank for development and agricultural credit. Central Agency for Public Mobilization and Statistics, Cairo, Egypt.

CAPMS (2014 b). Annual Bulletin of Health Services. Central Agency for Public Mobilization and Statistics, Cairo, Egypt.

CAPMS (2015 a). Annual Bulletin of Cooperative Activity in the Agricultural Sector, loans supply by the principle bank for development and agricultural credit. Central Agency for Public Mobilization and Statistics, Cairo, Egypt.

CAPMS (2015 b). Statistical Yearbook –Education. Central Agency for Public Mobilization and Statistics, Cairo, Egypt.

CAPMS (2015 c). Agricultural boundaries and Properties, Total reins distributed to the excluded and cultivable land according to governorates sectors. Central Agency for Public Mobilization and Statistics, Cairo, Egypt.

CAPMS (2015 d). Annual Bulletin of Health Services, Central Agency for Public Mobilization and Statistics, Cairo, Egypt.

CAPMS, (2016 a) a. Annual Bulletin of Cooperative Activity in the Agricultural Sector, loans supply by the principle bank for development and agricultural credit. Central Agency for Public Mobilization and Statistics, Cairo, Egypt.

CAPMS, (2016 b). Statistical Yearbook –Education. Central Agency for Public Mobilization and Statistics, Cairo, Egypt.

CAPMS (2016 c). Annual Bulletin of Health Services. Central Agency for Public Mobilization and Statistics, Cairo, Egypt.

CAPMS (2016 d). Annual Bulletin of Health Services. Central Agency for Public Mobilization and Statistics, Cairo, Egypt.

CAPMS .,(2017 a) .Annual Bulletin of Cooperative Activity in the Agricultural Sector, Loans supply by the principle bank for development and agricultural credit. Central Agency for Public Mobilization and Statistics, Cairo, Egypt.

CAPMS (2017 b). Agricultural boundaries and Properties, Total reins distributed to the excluded and cultivable land according to governorates sectors. Cairo. Central Agency for Public Mobilization and Statistics, Cairo, Egypt.

Climatologically Normal for Egypt, (2018). The Normal for El-fayoum Governorate Station, (1980–2018), Cairo, Egypt: Ministry of Civil Aviation, Meteorological Authority.

CONOCO, (1989). Stratigraphic Lexicon and explanatory notes to the geological map of Egypt 1:500,000. In M.H. Eberhardklitzsch, F.K. List (Eds.), (pp. 263). Cairo: CONOCO Inc.

Dobos, E.; Norman, B.; Bruee, W.; Luca, M.; Chris, J. and Erika, M. (2002). The use of DEM and satellite images for regional scale soil database. Proceedings of the 17th World Congress of Soil Science, Bangkok.

Dumanski, J. (1997). Criteria and Indicators of Land Quality and Sustainable Land Management. International Training Center Journal, 3: 216–222.

EASMA (2009). Bulletin of Agricultural Statistics, Economic Affairs Sector, Ministry of Agriculture, Cairo, Egypt.

EASMA (2010). Bulletin of Agricultural statistics, Economic Affairs Sector, Ministry of Agriculture, Cairo, Egypt.

EASMA (2011). Bulletin of Agricultural Statistics, Economic Affairs Sector, Ministry of Agriculture, Cairo, Egypt.

EASMA (2012). Bulletin of Agricultural Statistics, Economic Affairs Sector, Ministry of Agriculture, Cairo, Egypt.

EASMA (2013). Bulletin of Agricultural Statistics, Economic Affairs Sector, Ministry of Agriculture, Cairo, Egypt.

EASMA (2014). Bulletin of Agricultural Statistics, Economic Affairs Sector, Ministry of Agriculture, Cairo, Egypt.

EASMA (2015). Bulletin of Agricultural Statistics, Economic Affairs Sector, Ministry of Agriculture, Cairo, Egypt.

EASMA, (2016). Bulletin of Agricultural Statistics, Economic Affairs Sector, Ministry of Agriculture, Cairo, Egypt.

EEAA (2009). Environmental Description Report of El-fayoum Governorate Statistics Bureaus, Egypt: Egyptian Environmental Affairs Agency, Environmental Press.

Egyptian Meteorological Authority. (2016). Climatic Atlas of Egypt. Published, Arab Republic of Egypt, Ministry of Transport.

El- Nahry, A.H. and Abdel Kawy, W.A. (2013). Sustainable land use management on the coastal zone of the Nile Delta, Egypt. Journal of Land Use Science, (2013) 8-1:85.

FAO (2006). Guidelines for soil description. 4th ed. Rome: Food and Agriculture Organization of the United Nations.

FESLM (1995). A Framework for evaluating sustainable land management. Smith, A., J and Dumanski, .J (authors) 1995. FAO. Rome.

ITT (2009). ITT corporation ENVI 5.1 software. 1133 Westchester Avenue, White Plains, NY 10604, USA.

Jules Pretty., (2008). Agricultural sustainability: concepts, principles and evidence. Phil. Trans. R. Soc. B (2008) 363, 447–465, doi:10.1098/rstb.2007.2163, Published online 25 July 2007.

Marcia S. DeLonge., (2016). Investing in the transition to sustainable agriculture. Environmental Science & Policy 55 ISSN 266–273.

Said, R. (1990).The geology of Egypt. (ed.).Balkema, Rotterdam, 734p.

Said, R. (1993). The River Nile; Geeology, Hydrology and Utilization. Pergamon Press, Oxford.

Said, R. (2017). The Geology of Egypt, CRC Press.

USDA, (2004). Soil survey laboratory methods manual. Soil Survey Investigation Report No. 42 Version 4.0 November, USA.

USDA (2014). Keys to soil taxonomy. 12th edn. United States Department of Agriculture, Natural Resources Conservation Service (NRCS), USA. 362.

US Soil Survey Staff (2014). Soil survey field and laboratory methods manual. Soil survey investigations report no. 51, version 2.0.; 2014. R. Burt and Soil survey staff (ed.). U.S. Department of Agriculture, Natural Resources Conservation Service.

Zink, J.A.V. (1990). Soil geographic database: structure and application examples. ITC J. vol. 3. ITC, Enschede.

Zhen and Routray (2003). Operational Indicators for Measuring Agricultural Sustainability in Developing Countries. Environmental Management, 32(1): 34–46.

Yousif, I.T.; Abdel Hady, E.M.A. and Aldabaa, A.A. (2020 a). Spatial Soil Erosion Risk Assessment Using CORINE model: A Case Study in Wadi El-Raml Watershed, North Western Coast, Egypt. Plant Archives.

Yousif, I.A.; Abdel Hady, S.H. and Aldabaa, A.A. (2020 b). Contribution of Different Land Evaluation Systems to Assess land Capability and Suitability of Some Coastal Soils in Egypt. Indian Journal of Agricultural Research. (in press).