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# Soil Quality as Indicated by Physical and Chemical Properties in Some Tanta Areas, Nile Delta, Egypt Using Remote Sensing and GIS Techniques.

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## Abstract

The present study aimed at assessing the physical and chemical quality of the soils in Tanta area of El-Gharbia Governorate, Egypt. Its area is 33760 ha (located between longitudes 30°45′ and 31°20′ E and latitudes 30°35′ and 31°15′ N). The mapping units in the study area: overflow basin (OB), high river terrace (RT1), moderate river terrace (RT2), low river terrace (RT3). Nine soil profiles were selected to represent Tanta area soils in addition to 18 soil samples. Twelve physio-chemical parameters which used to assess soil quality were chosen to evaluate soil quality including; texture (T), drainage (D), effective depth (P), parent materials (M), rock fragment (R), slope gradient (S), hydraulic conductivity (H), water holding capacity (W), electrical conductivity (C), soil reaction (O), exchangeable sodium percentage (G) and calcium carbonate (N). Results showed that Tanta district could be classified into one class according to the physical quality measures (moderate), while results of chemical quality index revealed two classes (high and moderate). Over 44% of the soil of Tanta area is of moderate soil quality index while 55.51% is of low soil quality index according to both physical and chemical parameters. The low soil quality dominates the areas characterized by shallow depth, poor drainage and hydraulic conductivity. The results demonstrated that management of soil practices should be carefully associated with soil characteristics.

**Keywords:** Soil quality, Tanta district, Nile Delta, Remote sensing and GIS.

## Introduction

Egypt is one of the most old countries worldwide. It is located geographically in the northeastern corner of Africa (between latitudes of 22° and 32° N and longitudes 25° and 37° E) **(Zahran and Willis, 2009; Negm et al., 2017 and Embabi, 2018).**The Nile Delta in Egypt, with its fringes, covers an area of 22,000 km$^2$. The Nile Delta was formed during flood seasons by Nile sediments during the Late Miocene as an apron in the North Delta embayment. Its sediments are coarse, derived from the elevated Tertiary rocks of the Eastern Desert. Sediments of the ancient Niles, called the Paleonile, Prenile, and Neonile, cover wide tracts along the eastern and western margins of the delta **(Said 1981)**. The oldest sedimentary rocks penetrated in the Nile Delta are the shallow marine Late Jurassic carbonates, which are overlain un conformably by the Early Cretaceous sediments that interbedded carbonate-clastic sequence un conformably underlies the earliest Tertiary sediments, which is un conformably overlain by the Late Eocene-Early Oligocene shale section **(Younes, 2015).** Central part of Nile Delta is classified by sedimentary non-consolidated deposits belonging to the quaternary area that is differentiated into four different deposits: young deltaic, Fluvio-marine, young Eolian, and old Eolian **(Abu-hashim, 2015)**. **El-Asmar and Hereher (2011) and Embabi (2018)** recorded that Nile Delta with its triangular shape is a nearly flat plain. Its surface slopes gently northwards, where the difference in elevation between its apex in the south and the Mediterranean coast is +18 m **(Sestini, 1992).** According to **Moustaf (2000)** Geology of the Nile Delta areas is largely divided into two geologic units; Nile River alluvium and undifferentiated basement rocks. The soils are sandy texture outside the cultivated areas in the Delta, whereas very high clay content exists in this Delta producing some infertile black-alkali soils as well as saline soils **(Negm, 2017).** The soils of alluvial and alluvio-marine deposits contain loam and clay to clay-loam. According to **Omran (2017)** most of the Nile Delta soils are recent alluvial soils and most soils are originated from the ancient Nile sediments, which are mostly derived from igneous and metamorphic rocks of the Abyssinian Plateau. The major landscape in El-Gharbia is the flood plain and these soils are originated from Nile sediments before High Dam construction. They are developed from sediments of Ethiopian plateau transported by Nile River and subsequently deposited in both the valley and Delta **(El-Baroudy, 2015).**

Land evaluation used to describe and quantify the sustainable productive capacity of land **(Mackay et al., 2018),** it is an integral part of land use planning, has been established as one of the preferred methods to support sustainable land use management. In essence, land evaluation aims to compare and match each potential land use with the properties of individual parcels of land, also called land units **(De la Rose (2005); Palm et al. (2007); Niekerk, (2010); Liniger et al. (2011) and Govers et al. (2013)**. Based on **Daneshvar (2017)** Land suitability evaluation mainly focuses on environmental attributes that refers to the spatial, ecological and social configurations of land use development in urban planning. Hence, a multi-criteria evaluation method is used in order to find out the sustainable balance to assess the suitability index of land units for sustainable urban development **(Joerin et al., 2001 and Hossain and Das 2010).**

According to **Wander et al. (2002); Blum (2003); Schjonning et al. (2004) and Novak et al. (2010)** Soil quality is a measure of the ability of soil to carry out particular ecological and plant productive, has interconnections with management practices, productivity and other aspects as well as human health **(Doran, 2002 and Zornoza et al., 2015).** The concept of soil quality integrates physical, chemical and biological properties of soil for a specific land use and an account of the soil's ability to provide ecosystem and social services through its capacities to perform its functions under changing conditions **(Karlen et al., 1997; Seybold et al., 1997; Wang and Gong, 1998; Southorn and Cattle, 2004; Wienhold et al., 2004 and Shukla et al., 2006).** Soil quality has gained impetus, many methods such as land use capability classification **(Klingebiel and Montgomery, 1961)**, soil quality cards and test kits **(Craig and Arlene, 2002)**, soil quality index method **(Doran and Parkin, 1994 and Doran and Jones, 1996)**, dynamic variable soil quality method **(Larson and Pierce, 1994)**, Soil Management Assessment Framework (SMAF) **(Andrews et al., 2004)**, and Cornell Soil Health Assessment (CSHA) have been developed to determine quality scores. These two methods are used by many researchers, and their effectiveness in sustainable use of soil is evident **(Karlen et al., 2008; Rashidi et al., 2010; Adeyolanu et al., 2013 and Karlen et al., 2014)**. Land uses and management practices have significant influences on soil quality. It is reported that differences in fertilization, cropping system and farming practices were the main factors influencing soil quality at field scale **(Liu et al., 2010).** Usually, factors such as excessive tillage, planting system, excessive fertilizer use, changes in land use, organic fertilizer use, and applied planting rotation directly affect soil quality **(Cambardella et al., 2004; Liebig et al., 2004; Nael et al., 2004; Ozgoz et al., 2013; Yao et al., 2013; Nakajima et al., 2015 and Sacco et al., 2015)**. Some studies also showed tillage management and manure application are among the important factors affecting soil quality **(Shirani et al., 2002 and Yang et al., 2004).** Soil quality( SQ ) indicators are a composite set of measurable physical, chemical, and biological attributes which relate to functional soil processes and can be used to evaluate SQ status, as affected by management **(Karlen et al., 1997;Arshad and Martin, 2002 and Allen et al., 2011)**. Direct measurement of the soil quality indicators is time-consuming and expensive. Soil quality assessment is essential to monitor the agricultural systems in order to maintain its sustainability **(AbdelRahman and Tahoun, 2019).** The agricultural soils in El-Gharbia governorate are characterized by high soil productivity depending on its chemical and physical properties **(Mohamed et al., 2015).** Tanta soils are within the area that was classified as Vertisols **(Afify et al. 2011). Afify et al. (2008)** showed that these Vertisols in Nile Delta are highly suitable for the common cultivated crops that were highly adapted with this alluvium.

The present study aimed at (i) identifying and evaluating soil quality of Tanta district in El-Gharbia Governorate depending on soil physical and chemical characteristics. (ii) Producing thematic maps of soil quality index in Tanta area for proper future planning.

## Materials and Methods

### *Location of Study Area*

Tanta district of the El-Gharbiya Governorate is located in the heart of delta midway between Damietta and Rashid between longitudes 30°45′ and 31°20′ E and latitudes 30°35′ and 31°15′ N (Fig. 1). It covers an area about 337.6 km$^2$ (33760 ha) out of 1942 km$^2$ (194200 ha) of the El-Gharbiya governorate **(Belal and Moghanm, 2011; Mohamed et al., 2015; Masoud, 2016; Masoud et al., 2016 and Shokr et al., 2016).**

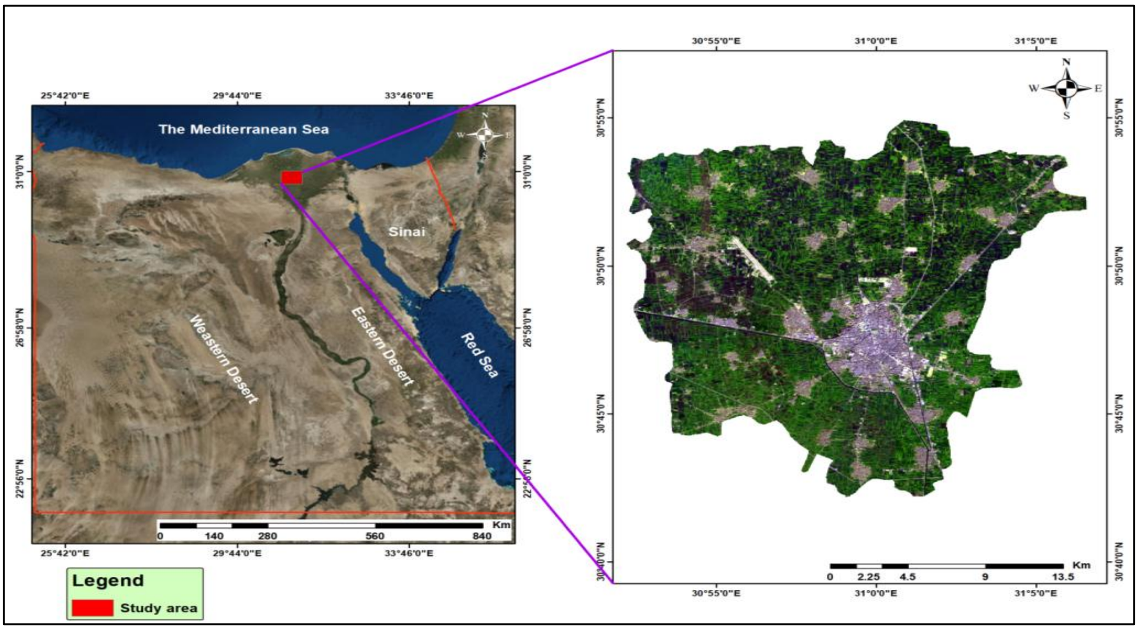

**Fig. 1:** Location map of the study area.

*Climate of study area*

The climate in the Nile Delta is generally Mediterranean with hot summers and mild winters **(Zahran and Willis, 2009; Ismael, 2015 and Masoud et al., 2016).** Average temperatures are 18$^0$ C in winter and 31$^0$ C in summer. Precipitation ranges from 22 to 200 mm/year. Annual rainfall is 50 mm mostly in winter. Figure 2 shows the climatology diagram of El-Gharbia (2010-2018).

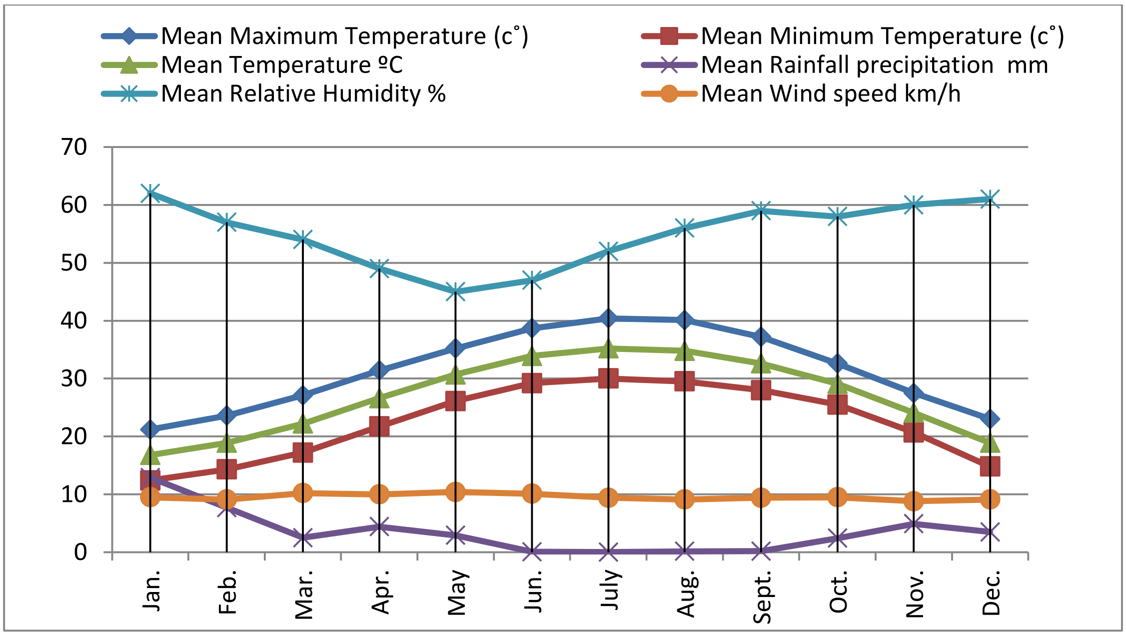

**Fig.2:** Climate graph of El-Gharbia (2010-2018).

*Geology and geomorphology of study area*

Tanta and its suburban are built on the Holocene soils made up of flat-lying alluvial plain averaging 8.5 m above mean sea level ranging between 11 m at the south and 6 m at its northern part. Soils are represented in the Nile delta by the Holocene Bilqas formation. This forms the top layer of the flood plain of the modern Nile made up of silty clay, brown at the top and gray in the lower part, constituting the agricultural soil of the delta **(Masoud, 2016).** The study area lies in Tanta and lies in a semi-arid climate zone.

*Field Work and Laboratory Analysis*

Based on the pre-field interpretation and information gained during the reconnaissance, eighteen samples were collected from nine profiles. Morphological Description of soil profiles, which represent the different geomorphic units were carried out according to the guidelines for soil description

**(FAO, 2006).** The laboratory analyses of soil samples that collected and analyzed using the Methods of Soil, Plant and Water Analysis (**Estefan et al., 2013).**The analyses include, soil Samples preparation, particle size distribution, Soil color **(Anon, 1975)**, soil pH, organic matter concentration, free CaCO3 content, Hydraulic conductivity, electric conductivity (dS/m),bulk Density, particle density, soil porosity, soil moisture content, gypsum content, cation exchange capacity (cmol/kg soil),exchangeable sodium percentage, available N and available P, K, Fe, Mn, Zn, and Cu. Using the field work and laboratory analyses data, the soils classify with the World Reference Base on USDA Soil Taxonomy**(USDA, 2014).**

*Soil Quality Index (SQI).*

The physical and chemical soil quality are determined from the indices recommended by **El-Nagaar et al. (2013)** and calculated using the following equations:

***Equation of physical soil quality Index (PQI)***

The physical quality index (PQI) was estimated for the different mapping units of the study area as the following equation:

**Physical Soil Quality Index (PSQI) = (T × D×P × M×S × R ×H×W)$^{1/8}$……………………………………Eq.(1)**

Where PSQI is the Physical Soil Quality Index, T is the texture, D is the drainage, P is effective depth, M is parent material, S is the slope gradient, R is the rock fragments, H is the hydraulic conductivity, and W is the water holding capacity. Each factor is rated on a scale from 1 to 2, the actual percentages being multiplied by each other. The resultant is the index of quality (between 1.13 and 1.45).

***Equation of chemical soil quality Index (CQI)***

The chemical quality Index (CQI) was estimated for the different mapping units of the study area as the following equation:

**Chemical Soil Quality Index (CSQI) = (C×O×G×N)$^{1/8}$……………………………………………Eq.(2)**

Where CSQI is the Chemical Soil Quality Index, C= electric conductivity (EC), O = soil reaction (pH), G= exchangeable sodium percentage (ESP), and N= calcium carbonate ($CaCO_3$). Each factor is rated on a scale from 1 to 2, the actual percentages being multiplied by each other. The diagnostic factors of each thematic layer were assigned values of factor rating identified in Tables 1, 2,3,4,5 and 6.The rating of soil quality of the soils was done according to the grading system in Table 8.

**Table 1.** Definition of texture and slope gradient

| Texture (T) | | | | Slope gradient (S) | | | |
|---|---|---|---|---|---|---|---|
| **Class** | **Texture** | **Description** | **Index** | **Class** | **Slope gradient(%)** | **Description** | **Index** |
| **T1** | L, SCL, SL, LS, CL | Good | 1.00 | **S1** | <6 | Very gentle | 1.00 |
| **T2** | SC, SiL, + SiCL, | Moderate | 1.33 | **S2** | 6-18 | Moderately | 1.33 |
| **T3** | Si, C, SiC | Poor | 1.66 | **S3** | 18-35 | Steep | 1.66 |
| **T4** | S | Very poor | 2.00 | **S4** | >35 | Very steep | 2.00 |

Soil texture: L: loam, SCL: sandy clay loam, SL: sandy loam, LS: loamy sand, CL: clay loam, SC: sandy clay, SiL: silty loam, SiCL: silty clay loam, Si: silt, C: clay, SiC: silty clay, S: sand.

**Table 2.** Definition of parent material and rock fragments.

| Parent material (M) | | | | Rock fragments (R) | | | |
|---|---|---|---|---|---|---|---|
| **Class** | **Parent material** | **Description** | **Index** | **Class** | **Rock fragment (%)** | **Description** | **Index** |
| **M1** | Lime stone, dolomite, non-friable, sand stone, hard limestone layer | Coherent | 1.00 | **R1** | >60 | Very stony | 1.00 |
| **M2** | Marine limestone, Friable | Moderate | 1.66 | **R2** | 20-60 | Stony | 1.33 |
| **M3** | Calcareous clay, clay, sandy formation, alluvium, colluvium | Soft to friable | 2.00 | **R3** | < 20 | Slightly stony | 2.00 |

**Table 3.** Definition of Soil depth and Drainage.

| Soil depth (P) | | | | Drainage (D) | | | |
|---|---|---|---|---|---|---|---|
| **Class** | **Soil depth(cm)** | **Description** | **Index** | **Class** | **Drainage** | **Description** | **Index** |
| **P1** | >75 | Deep | 1.00 | **D1** | Well drained | Good | 1.00 |
| **P2** | 30-75 | Moderate | 1.33 | **D2** | Imperfectly drained | Moderate | 1.33 |
| **P3** | 15-30 | Shallow | 1.66 | **D3** | Poor drained | Poor | 2.00 |
| **P4** | <15 | Very shallow | 2.00 | | | | |

**Table 4.** Definition of Hydraulic Conductivity and Water holding capacity.

| Hydraulic Conductivity(H) | | | | Water holding capacity(W) | | | |
|---|---|---|---|---|---|---|---|
| **Class** | **Hydraulic Conductivity(cm/h)** | **Description** | **Index** | **Class** | **Water holding capacity (%)** | **Description** | **Index** |
| **H1** | <0.5 | Good | 1.00 | **W1** | >50% | Good | 1.00 |
| **H2** | 0.5-2 | Moderate | 1.33 | **W2** | 50-20% | Moderate | 1.33 |
| **H3** | 2-6.25 | Poor | 1.66 | **W3** | 20-15% | Poor | 1.66 |
| **H4** | >6.25 | Very Poor | 2.00 | **W4** | <15% | Very poor | 2.00 |

**Table 5.** Definition of Electrical Conductivity (EC)andSoil Reaction (pH).

| Electrical Conductivity(C) | | | | Soil Reaction (O) | | | |
|---|---|---|---|---|---|---|---|
| **Class** | **Electrical Conductivity (dS/m)** | **Description** | **Index** | **Class** | **Soil Reaction** | **Description** | **Index** |
| **C1** | <4 | Low | 1.00 | **O1** | 5.5-7 | Low | 1.00 |
| **C2** | 4-8 | Moderate | 1.33 | **O2** | 7-7.8 | Moderate | 1.33 |
| **C3** | 8-16 | High | 1.66 | **O3** | 7.78-8.5 | High | 1.66 |
| **C4** | >16 | Very high | 2.00 | **O4** | >8.5 | Very high | 2.00 |

**Table 6.** Definition of Exchangeable Sodium percentage (ESP) and Calcium carbonate ($CaCO_3$).

| Exchangeable Sodium percentage (G) | | | | Calcium carbonate (N) | | | |
|---|---|---|---|---|---|---|---|
| **Class** | **Exchangeable Sodium percentage (%)** | **Description** | **Index** | **Class** | **Calcium carbonate (g/Kg)** | **Description** | **Index** |
| **G1** | <10 | Low | 1.00 | **N1** | <50 | Low | 1.00 |
| **G2** | 10-15 | Moderate | 1.33 | **N2** | 50-100 | Moderate | 1.33 |
| **G3** | 15-20 | High | 1.66 | **N3** | 100-150 | High | 1.66 |
| **G4** | >20 | Very high | 2.00 | **N4** | >150 | Very high | 2.00 |

## Result 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 one main landscape is flood plain can be divided into four landforms as follows (table 7):

1) Overflow basins (OB) covered 17.29 % (5838 ha) of the total area. The soils in this landform were classified into VerticTorrifluvents and TypicTorrifluvents.
2) High River terraces (RT1) covered 24.71 % (8344 ha) of the total area. The soils in this landform were classified into VerticTorrifluvents and TypicTorrifluvents.
3) Moderate River terraces (RT2) covered 55.51% (18739 ha) of total area. The soils in this landform were classified into VerticTorrifluvents.
**4)** Low River terraces (RT3) covered 2.49% (839 ha) of total area. The soils in this landform were classified into TypicTorrifluvents.

**Table 7.** Landforms and soils classification of the investigated area.

| Landform | Mapping unit | Profile No. | Soil Classification | Area (ha) | Area % |
|---|---|---|---|---|---|
| **Overflow basins** | **OB** | 2, 3 and 4 | Profile 2:VerticTorrifluvents<br>Profile 3:TypicTorrifluvents.<br>Profile 4:VerticTorrifluvents. | 5838 | 17.29 |
| **High River terraces** | **RT1** | 1 and 9 | Profile 1:TypicTorrifluvents.<br>Profile 9:VerticTorrifluvents. | 8344 | 24.71 |
| **Moderate River terraces** | **RT2** | 5, 6 and 8 | VerticTorrifluvents. | 18739 | 55.51 |
| **Low River terraces** | **RT3** | 7 | TypicTorrifluvents. | 839 | 2.49 |
| **Total area (ha)** | | | | 33760 | 100.00 |

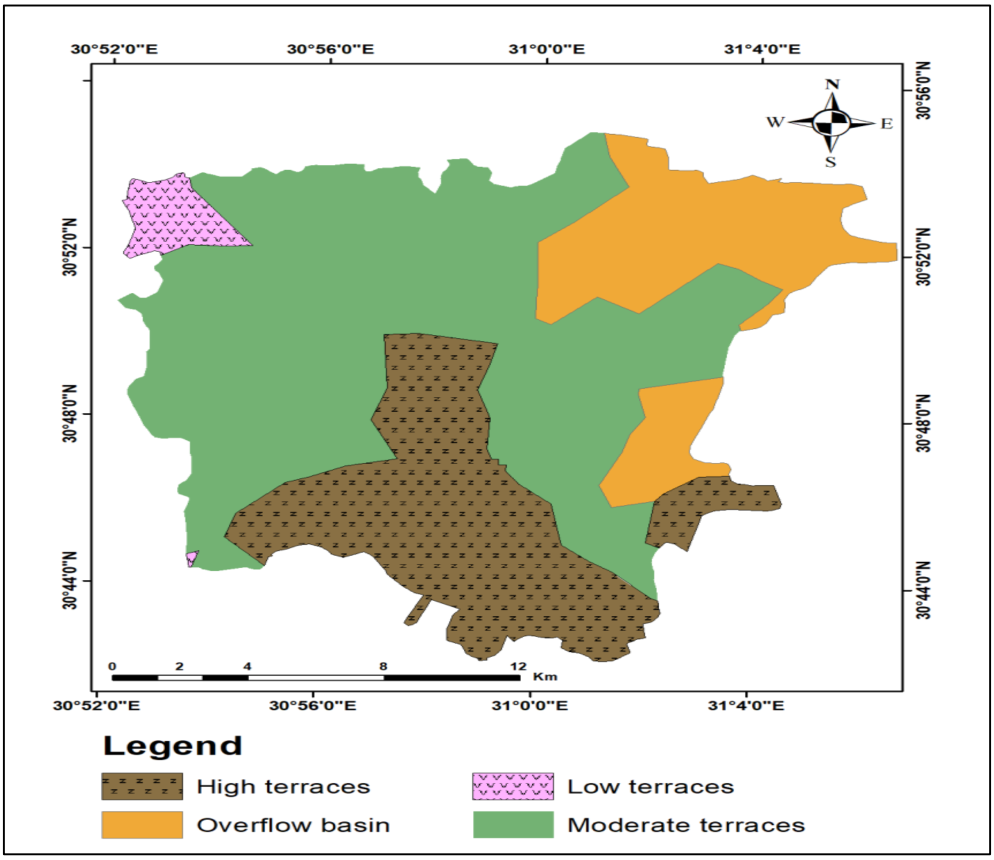

**Fig. 3:** Geomorphologic map of Tanta area.

***Soil Quality Index (SQI) and rating system.***

Twelve layers were used to assess Soil Quality Index (SQI) in the studied area, including physical and chemical properties. These layers were created in a geographic information system (GIS) using the spatial analyst tool. The Landsat 8ETM$^{+}$ image of the studied area and the digital elevation model were used to establish the main land type layer, this layer was used as a base map in the geographic information system. The SQI model established by **El-Nagar et al., (2013)**.Soil is an essential factor in evaluating the quality of an ecosystem, especially in the arid and semi-arid zones. Soil physical and chemical properties related to soil quality include water storage and retention capacity and resistance to erosion. The physical soil quality index (PSQI) was evaluated depending upon drainage condition, rock fragments (%) slope gradient (%), soil texture class, soil depth (cm), parent material, hydraulic conductivity (cm/h) (H) and water holding capacity (%) (W).The chemical soil quality index (CSQI) was evaluated depending upon electrical conductivity (dS/m) (C), soil reaction (O), exchangeable sodium percentage (cmolc/kg soil) (G) and calcium carbonate (g/kg) (N). The mathematical formula expressing Quality is as follows:

$$\textbf{Soil Quality Index (SQI)} = (T \times D\times P \times M\times S \times R \times H\times W\times C\times O\times G\times N)^{1/8}$$

Each factor is rated on a scale from 1 to 2 and the resultant index, lies between 1.13 and 1.45, and is set against a scale placing the soil in one of the following four Quality classes (Table 8):

**Table 8.** Soil quality classes and rating.

| | Grade | Rating | Class |
|---|---|---|---|
| **Soil Quality Index** | **I** | <1.13 | High quality |
| | **II** | 1.13-1.45 | Moderate quality |
| | **III** | > 1.45 | Low quality |

***Soil quality Index Model and rating system.***

In this model, interpretation criteria are modeled based on soil physical and chemical properties traditionally incorporate (**El-Nagar et al., 2013).** The structure organization of the El-Nagar model is summarized in Figure 4.

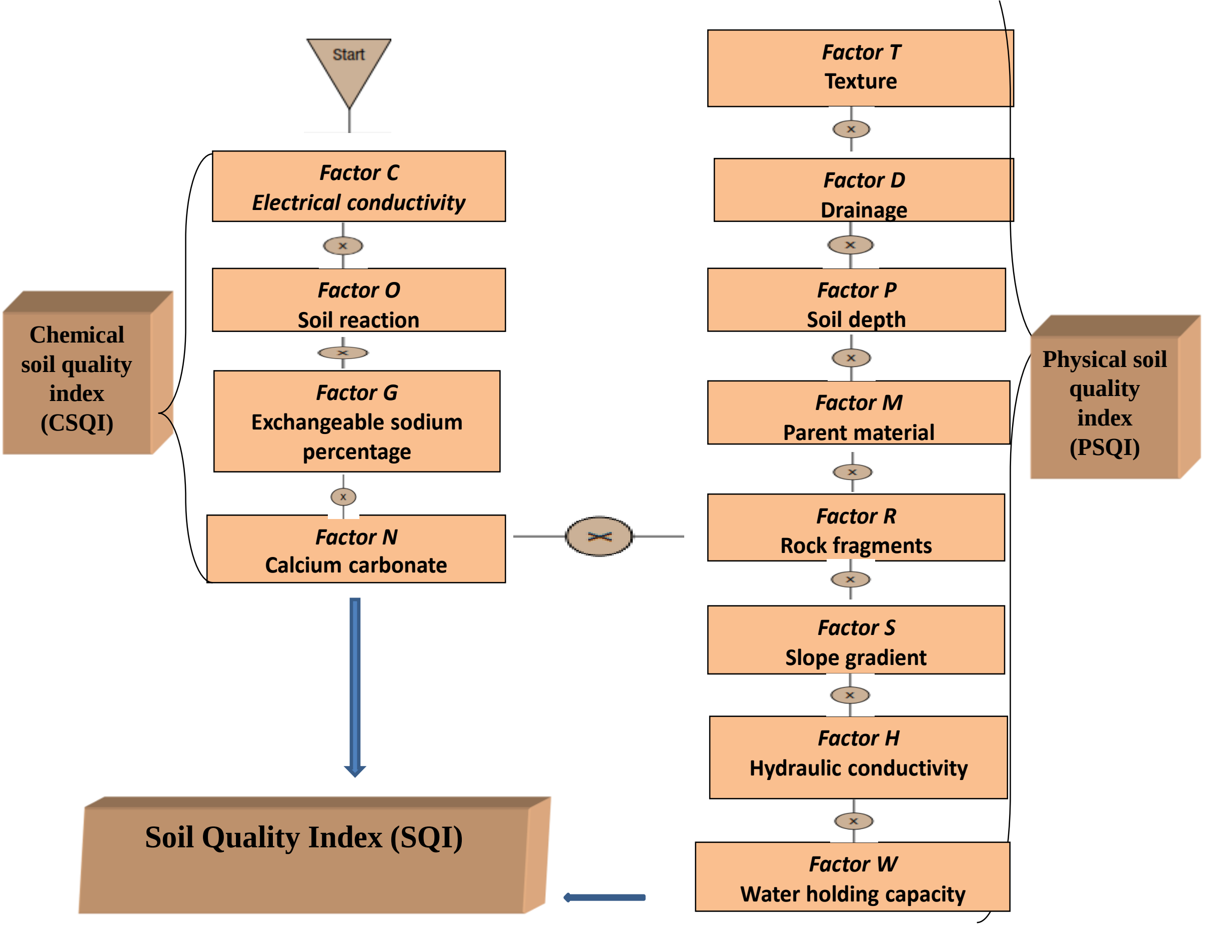

**Fig. 4:** Model of Soil Quality Index.

***Assessment of Physical Soil Quality Index (PSQI).***

The results indicate that the areas of moderate physical quality index (value = 1.13 – 1.45) represents 100 % of the total area (i.e.33760 ha). Table 9 to12 illustrates the general characteristics, classes and scores of the soil physical quality index and their map is shown in figure 5 using GIS.

**Table 9.** Values of the Physical factors of Soil Quality of the studied soils of the investigated area.

| **Mapping unit** | **Texture** | **Drainage** | **Effective depth (cm)** | **Parent materials** | **Rock Fragments** | **Slop Gradient** | **Hydraulic conductivity (cm/h)** | **Water holding capacity (%)** |
|---|---|---|---|---|---|---|---|---|
| **RT1** | Clay loam | Moderate drained | 80 | Alluvium | No stones | Flat | $3.13\times10^{-3}$ | 43.9 |
| **RT2** | Silty clay loam | Moderate drained | 86.6 | Alluvium | No stones | Flat | $2.13\times10^{-3}$ | 47.6 |
| **RT3** | Clay loam | Good drained | 100 | Alluvium | No stones | Flat | $1.59\times10^{-3}$ | 41.3 |
| **OB** | Clay loam | Good drained | 100 | Alluvium | No stones | Flat | $5.28\times10^{-3}$ | 44.6 |

**Table 10.** Soil physical characteristics of the investigated area.

| **Mapping unit** | **Texture (T)** | **Drainage (D)** | **Effective depth (P)** | **Parent materials (M)** | **Rock Fragments (R)** | **Slop Gradient (S)** | **Hydraulic conductivity ( H)** | **Water holding capacity (W)** |
|---|---|---|---|---|---|---|---|---|
| **RT1** | T1 | D2 | P1 | M3 | R3 | S1 | H1 | W2 |
| **RT2** | T2 | D2 | P1 | M3 | R3 | S1 | H1 | W2 |
| **RT3** | T1 | D1 | P1 | M3 | R3 | S1 | H1 | W2 |
| **OB** | T1 | D1 | P1 | M3 | R3 | S1 | H1 | W2 |

**Table 11.** Assessment of physical Soil Quality Index of the study area.

| **Mapping unit** | **Texture (T)** | **Drainage (D)** | **Effective depth (P)** | **Parent materials (M)** | **Rock Fragments (R)** | **Slop Gradient (S)** | **Hydraulic conductivity ( H)** | **Water holding capacity (W)** | **Physical soil quality index** | **Grade** |
|---|---|---|---|---|---|---|---|---|---|---|
| **RT1** | 1.00 | 1.33 | 1.00 | 2.00 | 2.00 | 1.00 | 1.00 | 1.33 | 1.27 | **II** |
| **RT2** | 1.33 | 1.33 | 1.00 | 2.00 | 2.00 | 1.00 | 1.00 | 1.33 | 1.32 | **II** |
| **RT3** | 1.00 | 1.00 | 1.00 | 2.00 | 2.00 | 1.00 | 1.00 | 1.33 | 1.23 | **II** |
| **OB** | 1.00 | 1.00 | 1.00 | 2.00 | 2.00 | 1.00 | 1.00 | 1.33 | 1.23 | **II** |

**Table 12.**Distribution of Physical Soil Quality Index (PSQI) of the study area

| **Physical Soil Quality Index (PSQI)** | **Grade** | **Class** | **Mapping unit** | **Area (ha)** | **Area %** |
|---|---|---|---|---|---|
| <1.13 | **I** | High quality | ___ | ___ | ___ |
| 1.13-1.45 | **II** | Moderate quality | **RT1, RT2, RT3 and OB** | 33760 | 100 |
| > 1.45 | **III** | Low quality | ___ | ___ | ___ |

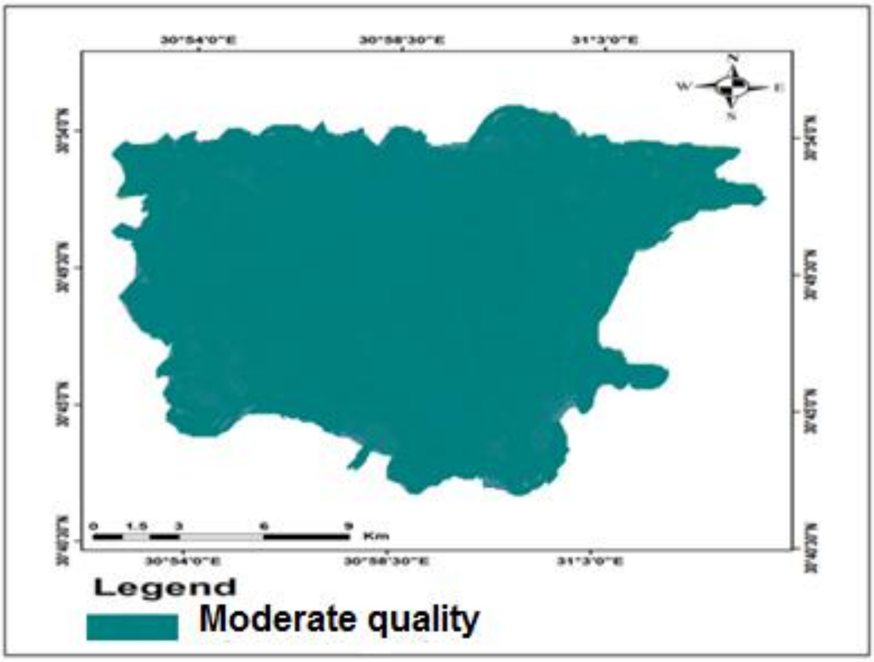

**Fig. 5:** Map of physical soil quality

***Assessment of Chemical Soil Quality Index (CSQI).***

The results indicate that the areas of high soil quality index (value <1.13) represent 19.78 % of the total area (i.e. 6677 ha) and the areas of moderate quality index (value = 1.13 – 1.45) represents 80.22 % of the total area (i.e.27083 ha). Table 13 to 16 illustrates the general characteristics, classes and scores of the soil chemical quality index and their map is shown in figure 6 using GIS.

**Table 13.**Values of the chemical factors of Soil Quality of the studied soils of the investigated area.

| Mapping unit | Electrical conductivity (C) | Soil reaction (O) | Exchangeable sodium percentage (G) | Calcium carbonate (N) |
|---|---|---|---|---|
| **RT1** | 1.79 | 7.70 | 25.31 | 26.36 |
| **RT2** | 0.79 | 7.83 | 19.22 | 22.42 |
| **RT3** | 0.71 | 7.76 | 13.36 | 11.81 |
| **OB** | 0.86 | 7.65 | 16.09 | 33.60 |

**Table 14.** Soil chemical characteristics of the investigated area.

| Mapping unit | Electrical conductivity (C) | Soil reaction (O) | Exchangeable sodium percentage (G) | calcium carbonate (N) |
|---|---|---|---|---|
| **RT1** | C1 | O2 | G4 | N1 |
| **RT2** | C1 | O3 | G3 | N1 |
| **RT3** | C1 | O2 | G2 | N1 |
| **OB** | C1 | O2 | G3 | N1 |

**Table 15.** Assessment of chemical Soil Quality Index of the study area.

| Mapping unit | Electrical conductivity (C) | Soil reaction (O) | Exchangeable sodium percentage (G) | calcium carbonate (N) | Chemical Soil quality index | Grade |
|---|---|---|---|---|---|---|
| **RT1** | 1.00 | 1.33 | 2.00 | 1.00 | 1.13 | **II** |
| **RT2** | 1.00 | 1.66 | 1.66 | 1.00 | 1.13 | **II** |
| **RT3** | 1.00 | 1.33 | 1.33 | 1.00 | 1.07 | **I** |
| **OB** | 1.00 | 1.33 | 1.66 | 1.00 | 1.10 | **I** |

**Table 16.** Distribution of Chemical Soil Quality Index (PSQI) of the study area

| Chemical Soil Quality Index (PSQI) | Grade Distribution | Class | Mapping unit | Area (ha) | Area % |
|---|---|---|---|---|---|
| <1.13 | **I** | High quality | **RT3 and OB** | 6677 | 19.78 |
| 1.13-1.45 | **II** | Moderate quality | **RT1 and RT2** | 27083 | 80.22 |
| > 1.45 | **III** | Low quality | ___ | ___ | ___ |

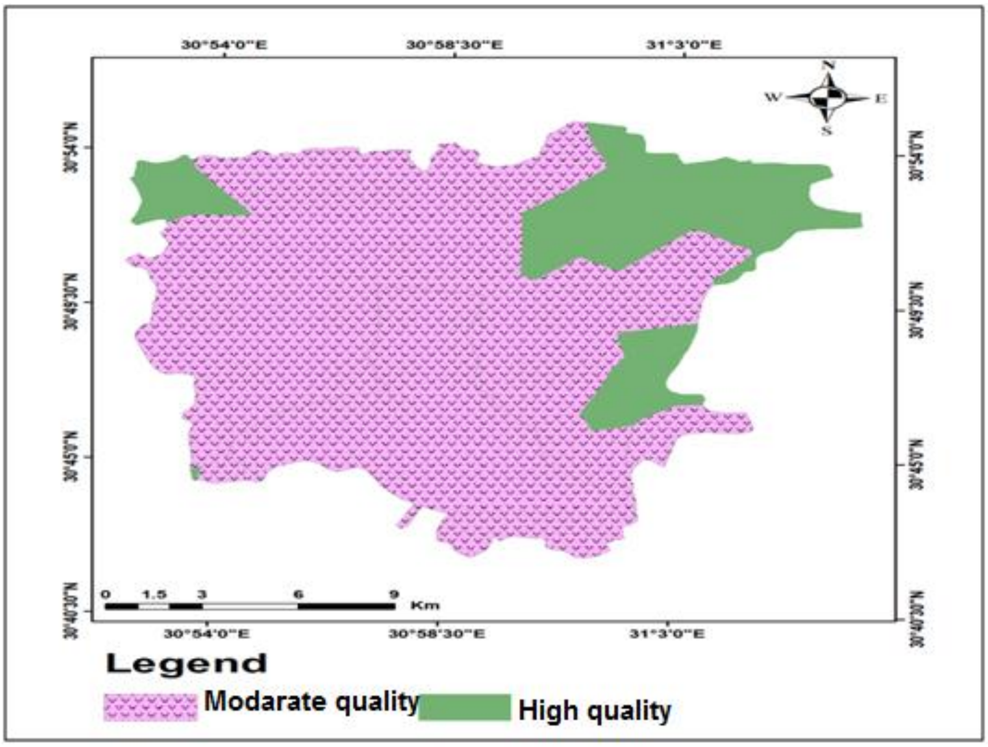

**Fig. 6: Map of chemical soil quality**

*Assessment of Soil Quality Index (SQI).*

The results indicate that the areas of moderate quality index (value = 1.13 – 1.45) represents 44.49% of the total area (i.e.15021 ha) in RT1, RT3 and OB mapping units and the areas of low soil quality index (value >1.45) represents 55.51% of the total area (i.e.18739ha) in RT2 mapping unit. The low soil quality dominates the areas characterized by shallow depth, poor drainage and Hydraulic conductivity. Table 16 illustrates the assessment of Soil quality index of the study area and the map of soil quality is shown in figure 7.

**Table 16.** Assessment of Soil Quality Index of the study area.

| Mapping unit | Physical soil quality index | Chemical Soil quality index | Soil quality index | Grade |
|---|---|---|---|---|
| **RT1** | 1.27 | 1.13 | 1.43 | **II** |
| **RT2** | 1.32 | 1.13 | 1.49 | **III** |
| **RT3** | 1.23 | 1.07 | 1.31 | **II** |
| **OB** | 1.23 | 1.10 | 1.35 | **II** |

**Table 17.** Distribution of Soil Quality Index (SQI) of the study area.

| Soil Quality Index (SQI) | Grade Distribution | Class | Mapping unit | Area (ha) | Area % |
|---|---|---|---|---|---|
| <1.13 | **I** | High quality | ___ | ___ | ___ |
| 1.13-1.45 | **II** | Moderate quality | **RT1, RT3 and OB** | 15021 | 44.49 |
| > 1.45 | **III** | Low quality | **RT2** | 18739 | 55.51 |

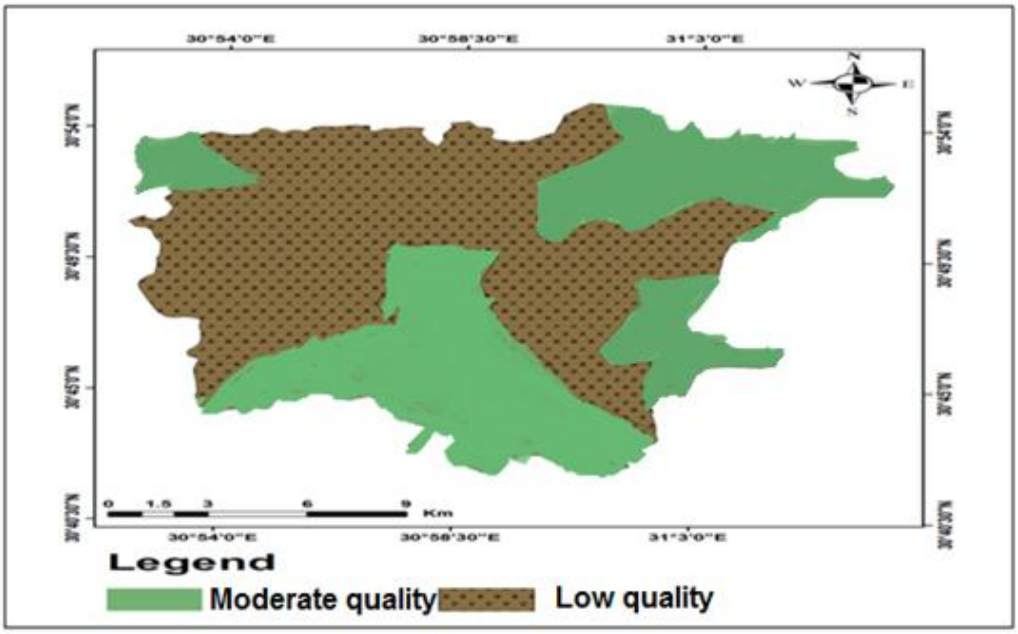

**Fig.7:** Map of Soil Quality Index.

## Conclusion

It could be concluded that the soil quality index (SQI) model could provide a valuable quantitative assessment of twelve soil characteristics with important information that could help in protecting and sustaining natural resources. In this model soil quality was evaluated based on two important soil quality indices (physical and chemical) that have great impact on that phenomenon. Remote sensing and GIS techniques are very helpful to evaluate soil quality index and produce a physiographic map of soil quality index.

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# الخصائص الطبيعية والكيميائية كمؤشر لجودة التربة فى بعض مناطق طنطا، دلتا النيل، مصر باستخدام تقنيات الاستشعار من بعد ونظم المعلومات الجغرافية.

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تهدف الدراسة الحالية الى تقييم جودة التربة الفيزيائية والكيميائية فى منطقة طنطا بمحافظة الغربية، مصر والتى تبلغ مساحتها 33760 هكتار (وتقع بين خطى طول 30° 45¯ و 31° 20¯ شرقا وخطى عرض 30° 35¯ و 31° 15¯ شمالا. وتقسم منطقة الدراسة الى وحدات خرائطية هى أحواض فيضية- شرفات نهرية عالية- شرفات نهرية متوسطة- شرفات نهرية منخفضة. وقد تم اختيار 9 قطاعات لتمثل منطقة الدراسة بالاضافة الى 18 عينة بسيطة وحيث تمت دراسة 12 مؤشر طبيعى وكيميائى والذى يعتبر اساس تقييم جودة التربة وهذه المؤشرات هى القوام ، حالة الصرف، العمق الفعال، مادة الاصل، فتات الصخور، منحدر الميل، التوصيل الهيدروليكى، السعة الاحتفاظية بالماء، التوصيل الكهربى، رقم حموضة التربة، نسبة الصوديوم المتبادل ومحتوى التربة من كربونات الكالسيوم. وبناء على نتائج هذه التحليلات اتضح ان منطقة طنطا تم تقسيمها الى مستوى واحد تبعا لجودة المؤشرات الطبيعية( المتوسط) بينما اظهرت مؤشرات الجودة الكيميائية انه يوجد رتبتين ( المرتفع والمتوسط). أكدت النتائج ان أكثر من 44% من اراضى طنطا متوسطة الجودة بينما 55.51% تعتبر اراضى منخفضة الجودة تبعا لمؤشرات التربة الطبيعية والكيميائية. وانخفاض جودة التربة يسود على خواص المنطقة بانخفاض العمق وسوء الصرف والتوصيل الهيدروليكى. ويوصى البحث بأهمية ادارة التربة من خلال الممارسات بحيث تتوافق مع خواص التربة.