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# Evaluation of Optimum Cropping Systems and Identify Soil Limiting Factors for Improvement of Agriculture Management by Spatial Modeling

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## ABSTRACT

Rice is the main source of calories and protein for about half of world population and also considers one of the most vital bases of employment and income for people in villages. This research presents a case study around Manzala lake, Egypt to model and produce high accuracy maps of land suitability for rice. The proposed model was used to assessment land suitability under the current situation (CS) and optimal scenario (OS). The results under CS showed that about 26% of total area is fall within the moderately suitable class and marginally suitable class (74%) class. Managing options relied on the CS assessment were projected to reduce some soil restriction factors, a fixed values were 2 dS/m for salinity, 7.8 for pH and 4 % for $CaCO_3$.Under OS scenario showed very good results, as all of study area covered by moderately suitable compared with 26% of study area under CS. The results showed the significance of appropriate management to achieve outstand change in soil suitability and reach to agriculture sustainability.

***Keywords:*** Land suitability, proposed model, rice crop. optimal scenario

## INTRODUCTION

The economic activity in Egypt is agriculture and more than half of the population depending on it, contributing to about 20% and 30% of foreign exchange earnings and commodity exports. (CAPMAS 2015). The rapid increase of the world's population is causing huge pressure on natural resources (Santana-Cordero etal 2016 and , Hanh *et al*., 2017). This pressure causes a lot of problems for both of land and water systems (Tengberg *et al* 2016), So to reduce the degree of these human influences, the suitable land-use and management strategies are required (Lal,2009 and Brevik 2016). The main Land evaluation objective of is to improve and increase the potentially of lands for human uses ( FAO, 2007 and Rossiter, 1996). Crop-land suitability analysis of is essential requirement to achieve the best usage of the available land resources for sustainability of agricultural production (Perveen *et al*., 2007). Status of land suitability is depending on inherent soil properties e.g.; parent materials, soil texture and depth and other soil characteristics that can affected by management of human e.g., drainage, salinity, nutrient concentration and vegetation cover FAO, 1985 and FAO, 1993). Rice is the main source of calories and protein for about half of world population and also considers one of the most critical sources of employment and income for people in rural regions (FAO, 2003). About half million hectares of Egypt cultivated by rice with average yield of 10 tons/ha (Khattab, 2019). Rice cultivation is essential to reduce soil salinity and conserve status of fertility in some areas of Northern Delta (Badawi and Ghanem, 2007). The system of geographic information system (GIS) is allow users gather, manage, analyse, and recover large amount of data collected from different sources (Aronoff, 1991). Inverse distance weighting' (IDW) predict values at un-sampled sites relied on the measurements from the surrounding sits with certain weights assigned to each of the measurements. (Ali and Moghanm, 2013).The main purpose of this study is to assessment of land suitability adjacent to Manzala lake under current situation and optimum scenario to map and model of land suitability for rice cultivation in study area and identify land suitability limiting factors.

## MATERIALS AND METHODS

It could be summarize methodology of this research in the following flowchart Fig (1):

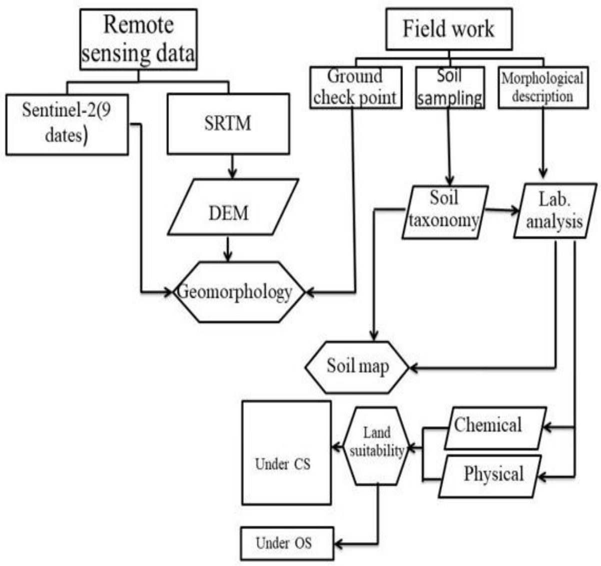


**Fig.1. Methodology flowchart of current research**

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**Investigated area**

The investigated area sited in the northern part of Nile delta of Egypt at coordinates 31° 3′ 66″–31° 30′ 06″ N; 31° 18′ 12″–32° 5′ 34″ covering an area of about 3361.07 km$^2$(Fig. 2 ). Mediterranean climate is consider the main climate in this area therefore, in winter rain is little and a warm arid in summer while the maximum precipitation was about 40 mm in January (source: Damietta Station) .In December and January, the potential evaporation is vary from 3.2 mm/day to 5.4 mm/day. Temperatures vary from about 18 °C to 31 °C in January (coldest month) and August (hottest month), respectively. The temperature regime of soil could be definite as ‘‘Thermic’’ and the soil moisture regime as ‘‘Torric’’. (USDA, 2010), the area is defined by latter part of the Miocene and the beginning of Pliocene periods also, Quaternary and Holocene is form the surface of the area. cotton, rice, corn, clover, barley and beans are the main crops in the studied area (Belal, 2001).

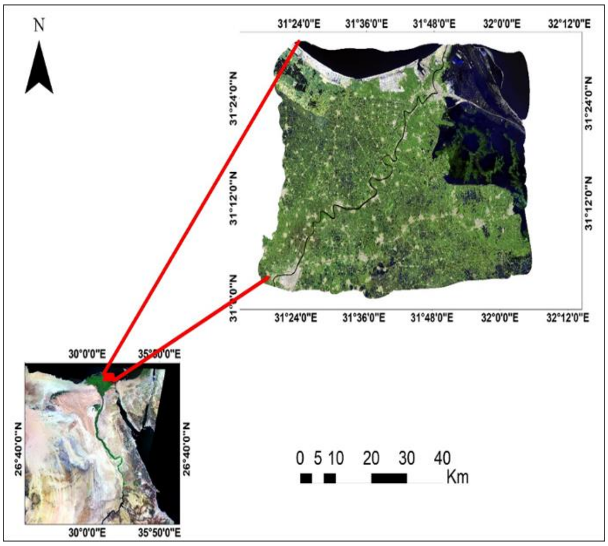



**Fig.2. Location of study area**

**Data of remote sensing**

**Sentinel-2 image**

The Sentinel-2 image acquired in 21-7-2020 integrated with the Digital Elevation Model (DEM) to produce the landform map of the study area. The bands 2, 3, 4 and 8 (spatial resolution 10 meters) have been used. Sentinel Application Platform (SNAP) and ENVI 5.3 software were used for image processing including spectral subset sampling band, radiometric calibration and atmospheric correction with was performed.

The shuttle radar topography mission (SRTM) and landform mapping

DEM is defined as a 3D electronic model of the land’s surface (Brough, 1986). SRTM is one of the most important earth space surveys using accurately situated radar to map its surface with resolution (30m) and it can be provide better imagining of the terrain integrated with controlled imagery sources (Ali and Moghanm, 2013). Arc-GIS 10.4.1 software was used to produce Digital Elevation Model (DEM) of study area from SRTM image (Fig.3). The data extracted from DEM (surface elevation, slope% and slope direction) can help in production of landform and soil type maps (Lee *et al*., 1988). The landform map has been extracted from Sentinel-2 image and SRTM . The landform units were definite and categorized into groups then the map legend was established according to Zinck and Valenzuela (1990).

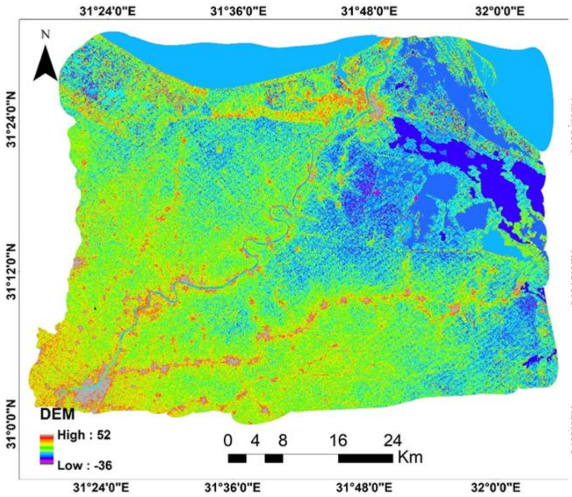



**Fig.3. SRTM image of study area**

**Soil database and laboratory analysis**

A preliminary landform map generated from interpretation of satellite image and DEM. Field survey was done to check landscape characteristics and landform units accuracy. A total of seventeen soil profiles were dug to represent different mapping units (Fig.4). Morphology description of soil profiles was carried out on the basis outlined by FAO (2006). Soil samples have been collected from the different landforms in which represent small units and avoid urban areas and water bodies. Samples were analysed according to soil survey laboratory methods manual (USDA, 2004).

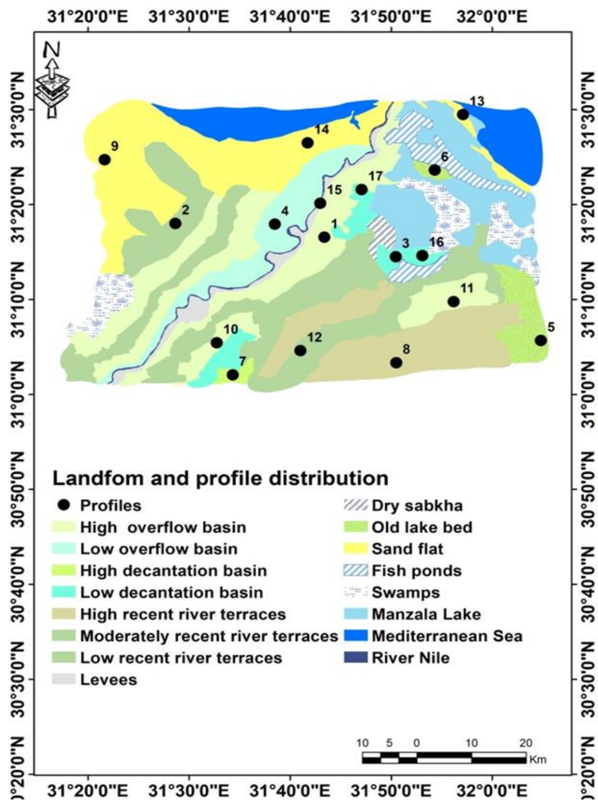



**Fig.4. Profiles distribution over landform**

**Assessment of land suitability**

Three objective indicators were used to evaluate the land suitability: (soil fertility, chemical and physical indices) according to (El Baroudy, 2016). To calculate the land suitability, the following equation was used integrated with GIS spatial model

$$LSI= (SFI* PPI* CPI)^{1/3} \quad (1)$$

**Where,** **LSI is land suitability index, SFI is soil fertility index, PPI is physical properties index and CPI is Chemical properties index.**

**The following equations was used to calculate SFI:**

$$SFI= ( N*P*K/SOM*Zn)^{1/5} \quad (2)$$

**Where;** **N is available nitrogen, K is available potassium, SOM is soil organic matter and Zn is available zinc**

**The following equations was used to calculate PPI**

$$PPI=(A*B*C*D*E*F*G)^{1/7} \quad (3)$$

**Where** **A is drainage, B is texture, C is depth, D is topography, E is surface stoniess, F is hardpan and G is hydraulic conductivity**

**The following equations was used to calculate CPI**

$$CPI= (H*J*I*M)^{1/4} \quad (4)$$

**Where** **H is salinity hazards, J is ESP, I is CaCO3 and M is soil reaction.**

Rated the parameters were depending on experts' suggestions and a review of literature (FAO 1976 & 1985; Sys *et al*., 1991 & 1993; Rezaei *et al*., 2006; Maleki *et al*., 2010; Ashraf *et al*., 2010; Mustafa *et al*., 2011; Halder, 2013; Chen, 2014). Scores ranging from 0.2, to 1, for the worst conditions and the best conditions respectively, Table (1). Scores and classes of each parameter and land suitability were showin in Tables 2 and 3.

**Table 1 .Factor rating of land quality parameters for rice cultivation in the study area according to FAO (1976) and Sys *et al*. (1993).**

| Soil quality parameter | Diagnostic factor | Units | Parameter score 1 | 0.8 | 0.5 | 0.2 |
|---|---|---|---|---|---|---|
| Soil fertility | N | mg/kg | >2000 | 1000-2000 | <1000 | - |
| | P | mg/kg | >25 | 10-25 | <10 | - |
| | K | mg/kg | >60 | 30-60 | <30 | - |
| | Organic matter | g/100 g | >2 | 1-2 | 0.5-1 | <0.5 |
| | Zn | mg/kg | >0.7 | 0.5-0.7 | <0.5 | |
| $SFI= ( N*P*K/SOM*Zn)^{1/5}$ | | | | | | |
| Physical properties | | | | | | |
| Drainage (A) | | | Poor | Moderately poor | Good | Very Poor |
| Texture (B) | | | CL, SiCL, SiL, C, SC | L, SCL, SIC | Si, SL, FSL | C, S, LS |
| Depth (C) | | cm | >50 | 25-50 | 15-25 | <15 |
| Topography (D) | slope | Slope | 0-2% | 2-4% | 4-6% | >6% |
| Surface stoniness (E) | >2 mm | % | <20 | 20-35 | 35-55 | >55 |
| Hard pan (F) | | cm | >90 | 90-50 | 50-20 | <20 |
| Hydraulic conductivity(G) | | $cm\ h^{-1}$ | <0.5 | 0.5-2 | 2-6.25 | >6.25 |
| $PPI=(A*B*C*D*E*F*G)^{1/7}$ | | | | | | |
| Chemical properties | | | | | | |
| Salinity hazard (H) | | $dS\ m^{-1}$ | 0-3.1 | 3.2-4 | 4.1-5 | >5.1 |
| ESP (J) | | g/100 g | 10 | 10-20 | 20-30 | >30 |
| $CaCO_3$ (I) | | g/100 g | 0-5 | 5-15 | 15-20 | >20 |
| Soil reaction (M) | pH | - | 5.5-7.3 | 7.4-7.8 | 7.9-8.4 | >8.4 |
| $CPI= (H*J*I*M)^{1/4}$ | | | | | | |

***CL=Clay loam, SiCL= Silty clay loam, SiL= Silty loam, C= Clay, SC= Sandy clay, L= Loam, SCL= Sandy clay loam, SIC= Silty clay, Si= Silt, SL=Sandy Loam, FSL= Fine Sandy Loam, C= Clay, S= Sandy, LS= Loamy sand**

**Table 2 .Scores and classes of each parameter**

| SFI classes | | |
|---|---|---|
| **SFI** | **score** | **class** |
| High quality | >0.9 | H |
| Moderate quality | 0.9-0.7 | M |
| Low quality | 0.7-0.5 | L |
| Very low quality | <0.5 | VL |
| PPI classes | | |
| PPI | score | class |
| High quality | >0.75 | H |
| Moderate quality | 0.75-0.5 | M |
| Low quality | 0.5-0.25 | L |
| Very low quality | <0.25 | VL |
| CPI classes | | |
| CPI | score | class |
| High quality | >0.9 | H |
| Moderate quality | 0.9-0.7 | M |
| Low quality | 0.7-0.5 | L |
| Very low quality | <0.5 | VL |

**Where: H= High quality, M= Moderate quality, L=Low quality and VL= Very low quality**

**Table 3. Scores and suitability classes**

| Suitability | Score | class |
|---|---|---|
| Highly suitable | S1 | 1-0.8 |
| Moderately suitable | S2 | 0.8-0.6 |
| Marginally suitable | S3 | 0.6-0.4 |
| Unsuitable | N | <0.4 |

Suggest optimal scenario (OS) of land suitability in study area

**The proposed optimal scenario (OS) in the study area was calculated using the following equation:**

$$OS = CS – URs \quad (5)$$

**where;** **OS: optimal scenario; CS: current situation; URs: units of reduction after (Abd-Elmabod, *et al*., 2019).**

The reduction units were identified based on evaluation to meet the suggested OS stable value to reach S2 (moderately suitable ) class in final suitability class of study area. The fixed values were 2 dS/m for soil salinity,4% for CaCO3% and 7.8 for pH . Chosen of soil variables is depending on properties that could be managed such as EC, CaCO3% and pH , without consideration the interaction between them. The remain properties such as soil texture, soil depth were not considered due to these properties are not modified easily.

## RESULTES AND DISSCUSSION

**Geomorphologic units of study area**

The results showed that three physiographic units are the main units in the investigated area these units are flood plain, the lacustrine plain and the marine plain.

Flood plain represents the major landscape in the study area including 8 landforms (high overflow basins, low overflow basins, high decantation basins, low decantation basins, high recent river terraces, moderately recent river terraces, low recent river terraces and levees) with an area of 2154.93km$^2$ (64.12%). The lacustrine plain was formed by deposits of flood plain and also characterized by Holocene Era lacustrine sediments; this landscape includes a lot of landforms i.e. fish ponds, dry sabkha, old lakebed and swamps with area (100.54km$^2$, 21.95 km$^2$,187.98 km$^2$,313.31 km$^2$, respectivly. Sand flats are represent main plains landscape in study area and cover about 582km$^2$ (17.3%) as shown in Table (4) and Fig.(5).

**Table 4. Landforms units of investigated area**

| Landscape | landforms | Mapping unit | Area (Km2) | % |
|---|---|---|---|---|
| Flood plain | High overflow basins | HB | 620.17 | 18.45 |
| | Low overflow basins | LB | 205.95 | 6.13 |
| | High decantation basins | HD | 16.69 | 0.5 |
| | Low decantation basins | LD | 106.00 | 3.15 |
| | High recent river terraces | HT | 398.36 | 11.85 |
| | Moderately recent river terraces | MT | 258.16 | 7.68 |
| | low recent river terraces | LT | 476.10 | 14.17 |
| | Levees | L | 73.50 | 2.19 |
| Lacustrine plain | Fish ponds | F | 100.54 | 2.99 |
| | Dry sabkha | DS | 21.95 | 0.65 |
| | Old lakebed | OL | 187.98 | 5.59 |
| | swamps | S | 313.31 | 9.32 |
| Marine plain | Sand flat | SF | 582.35 | 17.33 |
| | Total area | | 3361.1 | 100% |

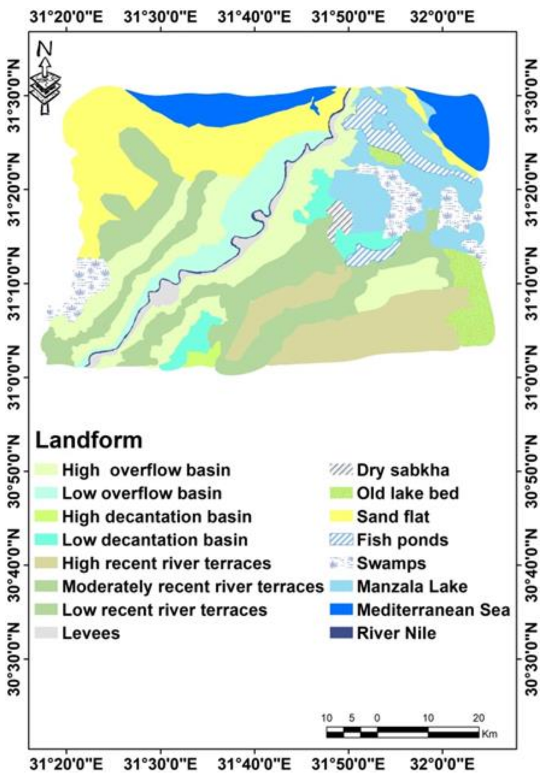



**Fig.5. Geomorphology map of study areaz**

**Soil properties within study area**

The results as shown in Fig. (6) revealed that the dominate texture is differ between loamy, sandy loam, loamy sand, sandy clay loam and sand. Depth of water table ranges from 35 to 120 cm. The average values of EC ranging from 2.16 to 96.56 ds/m. The high values dominate the soil of dry sabkha in lacustrine landscape .

Exchangeable sodium percentage (ESP) values fluctuating between 0.74 and 8.31 % where the high values represent the lower layer . The $CaCO_3$% content spatial distribution in the investigated area reveals that the highest value was in sand flat unit in northeast of Manzala lake. The results are expected as this unit located near to lake. The soil organic matter (SOM%) reveals that it varies between 0.14and 0.64%, the low content is due to dry climatic condition, which encourages decomposition of organic matter. The lowest average value of soil pH (8.2-8.6) in alluvial and marine deposits respectively, this is corresponding spatially with the distribution of organic matter and $CaCO_3$ over the study area.

The saturated hydraulic conductivity (HC). 0.53-14 cm/hour. soil hydraulic characteristics is strongly controlled by soil texture (Sperry *et al*. 1998, Hacke *et al*. 2000, Sperry and Hacke 2002), as saturated hydraulic conductivity of soil is a function of pore size; coarser textured soils have larger pores(Jury *et al*. 1991). In general, soils of Egypt suffer from deficiency in macronutrients Ali and Moghnam 2013). Available nitrogen is low. Available phosphorus is low (less than 15ppm),. The available potassium is low in all profiles studied (less than 400 ppm). Concentration of zinc is differing between 0.46 to 1.1 mg/kg.

**Soil taxonomy of study area**

Based on laboratory analysis and guide of USDA (2014), most of study area classified as *Typic Torrifluvents* then, *Typic Torripssaments* covering about 1113 Km$^2$ (37.8%) and 1102 km$^2$ (37.4%) of study area respectively. *Lithic Calciargids(*13.5%), *Lithic Haplocalcids (*7%) *Typic Haplocalcids (*3.6%) and *Salic Haplocalcids (*0.7% ) of study area, Fig.(7).

**Land suitability**

The land suitability of rice in the study area was calculated according to the proposed model by (El Baroudy, 2016), calculating of land suitability depending on three indicators, soil fertility, soil physical properties and soil chemical properties.

**Soil fertility index (SFI)**

The SFI of investigated area is varied from low (L) and very low (VL) covering area of 1568.12 Km2 and 1379.08 Km2, respectively. The low quality class dominate HB,HT, LT and L mapping units due to deficiency of Macro elements (N,P,K) and organic matter while the very low quality class occurred in remain units due to decrease in macro, micro elements and soil organic matter as shown in Table 5 and Fig. 8

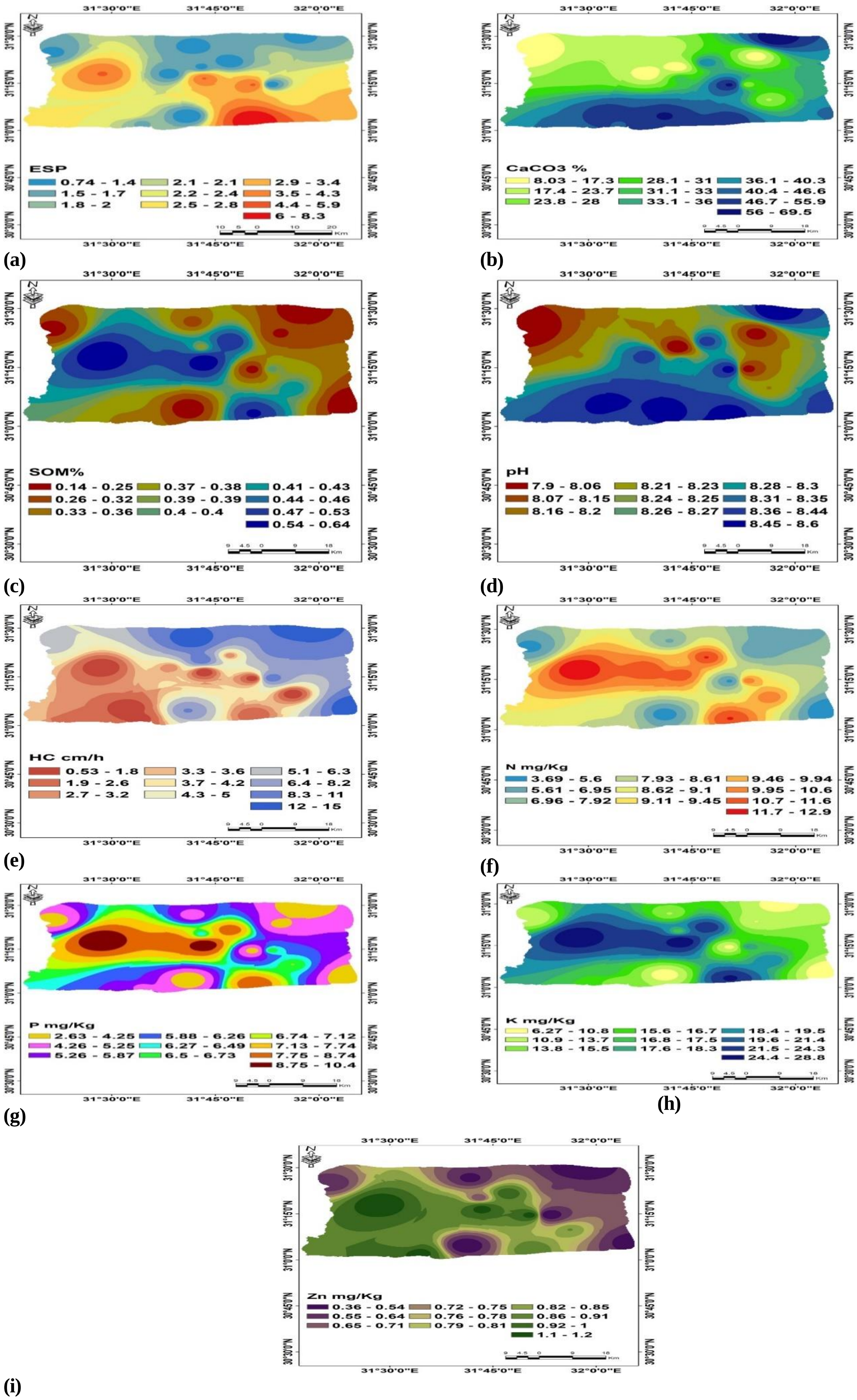



**Fig.6. Interpolated map of some fertility, physical and chemical properties in study area**

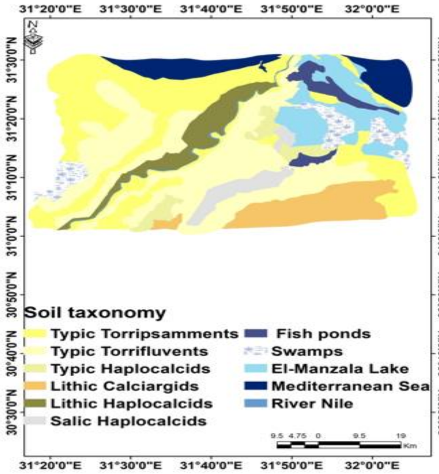



**Fig.7. Map of study area taxonomy**

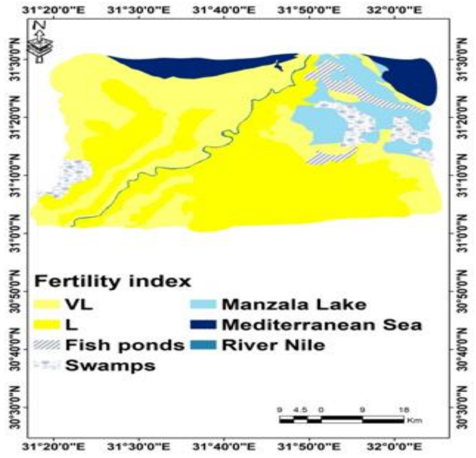



**Fig.8. Fertility index of study area**

**Table 5 .Areas of SFI of study area**

| Fertility index parameters | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Mapping units** | **Nitrogen (mg/kg)** | **Phosphorus (mg/kg)** | **Potassium (mg/Kg)** | **SOM %** | **Zn (mg/kg)** | **Final index** | **Class** |
| HB | 0.5 | 0.8 | 0.5 | 0.5 | 1 | 0.63 | L |
| LB | 0.5 | 0.5 | 0.5 | 0.2 | 1 | 0.48 | VL |
| HD | 0.5 | 0.5 | 0.5 | 0.2 | 1 | 0.48 | VL |
| LD | 0.5 | 0.5 | 0.5 | 0.20 | 1 | 0.48 | VL |
| HT | 0.5 | 0.5 | 0.5 | 0.5 | 1 | 0.57 | L |
| MT | 0.5 | 0.5 | 0.5 | 0.2 | 0.5 | 0.42 | VL |
| LT | 0.5 | 0.8 | 0.5 | 0.50 | 1 | 0.63 | L |
| L | 0.5 | 0.5 | 0.5 | 0.5 | 1 | 0.57 | L |
| DS | 0.5 | 0.5 | 0.5 | 0.2 | 0.8 | 0.46 | VL |
| OL | 0.5 | 0.5 | 0.5 | 0.2 | 0.5 | 0.42 | VL |
| SF | 0.5 | 0.5 | 0.5 | 0.2 | 0.5 | 0.42 | VL |
| **Area (km2)** | **L=1568.12** | | **VL=1379.08** | | | | |

**Physical properties index (PPI)**

As shown in Table (6) and Fig.(9), about 1134 Km2 of study area is high quality and around 1813 km2 is under moderate class. These results are expected soil coarse texture and adverse saturated hydraulic conductivity.

**Chemical properties index (CPI)**

It can be conclude from Table (7) and Fig. (10) that the CPI classes are moderate quality, low and very low quality in the study area. Those classes area are 258.16, 755.55 and 1933.50. The very low quality due to high salinity, high values of $CaCO_3$ % content and high pH.

**Table 6 .Areas of PPI of study area**

| Physical index parameters | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Mapping units** | **Drainage** | **Texture** | **Depth** | **Slop** | **Stoniness** | **Hardpan** | **H.C. cm/h** | **Final index** | **Class** |
| HB | 0.2 | 0.8 | 1 | 1 | 1 | 1 | 0.8 | 0.77 | H |
| LB | 1 | 0.2 | 0.8 | 1 | 1 | 1 | 0.5 | 0.77 | H |
| HD | 0.8 | 0.5 | 1 | 1 | 1 | 1 | 0.8 | 0.88 | H |
| LD | 0.2 | 0.5 | 1 | 1 | 1 | 1 | 0.8 | 0.72 | M |
| HT | 1 | 0.5 | 1 | 1 | 1 | 1 | 0.8 | 0.91 | H |
| MT | 0.2 | 0.2 | 1 | 1 | 1 | 1 | 0.2 | 0.64 | M |
| LT | 0.2 | 0.8 | 1 | 1 | 1 | 1 | 0.8 | 0.77 | H |
| L | 1 | 0.2 | 1 | 1 | 1 | 1 | 0.5 | 0.80 | H |
| DS | 1 | 0.5 | 1 | 1 | 1 | 1 | 0.8 | 0.91 | H |
| OL | 0.2 | 0.2 | 1 | 1 | 1 | 1 | 0.2 | 0.64 | M |
| SF | 0.2 | 0.2 | 1 | 1 | 1 | 1 | 0.2 | 0.64 | M |
| **Area (Km2)** | **M=1134.49** | **H= 1812.72** | | | | | | | |

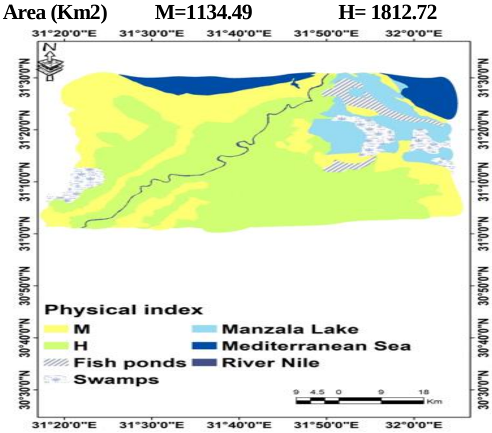



**Fig.9. Physical index of study area**

**Table 7 .Areas of CPI of study area**

| Chemical parameters | | | | | | |
|---|---|---|---|---|---|---|
| **Mapping units** | **EC dS/m** | **ESP** | **CaCO3 %** | **pH** | **Final index** | **Class** |
| HB | 0.2 | 1 | 0.2 | 0.5 | 0.38 | VL |
| LB | 1 | 1 | 0.2 | 1 | 0.67 | L |
| HD | 0.2 | 1 | 0.2 | 0.5 | 0.38 | VL |
| LD | 1 | 1 | 0.2 | 0.2 | 0.45 | VL |
| HT | 0.2 | 1 | 0.2 | 0.2 | 0.30 | VL |
| MT | 1 | 1 | 0.8 | 0.5 | 0.80 | M |
| LT | 1 | 1 | 0.2 | 0.5 | 0.56 | L |
| L | 1 | 1 | 0.2 | 0.5 | 0.56 | L |
| DS | 0.2 | 1 | 0.2 | 0.5 | 0.38 | VL |
| OL | 1 | 1 | 0.2 | 0.2 | 0.45 | VL |
| SF | 0.8 | 1 | 0.2 | 0.2 | 0.42 | VL |
| **Area ($Km^2$)** | **M =258.16** | | **L= 755.55** | | **VL 1933.50** | |

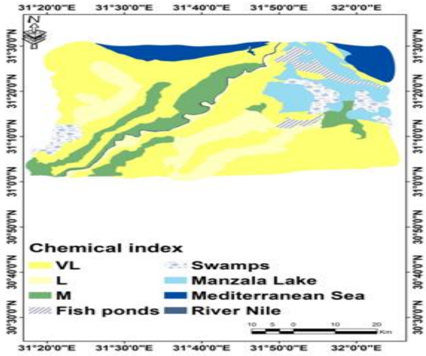



Fig.10.Chemical index of study area

## Current land suitability (CS) and optimal scenario (OS)

The results show that study area located under moderately suitable class (S2) and marginally suitable (S3) for cultivation of rice in study area. Most of study area is marginally suitable about 2192 km$^2$, while around 755 km$^2$ is moderately suitable. The low suitability in study area due to reduction in fertility and chemical properties as shown in Table (8) and Fig.(11).

Under OS of soil suitability for rice is assigned to moderate (S2) and to reach this class, the soil salinity, CaCO3 and pH should be reduced to the suggest values. A lot of soil management options of have been suggested to make reduction of soil salinity, such as leaching process using low salinity water to remove salts from soil root zone (Zalacáin *et al*., 2019).

In around 21% of the study area can be enhanced to the fixed value (2 dS/m) of salinity with 10 reduction units, 16.7 and 96.6 reduction units are needed to enhance 0.6% of0.75% respectively, of the study area.. Although, the growth rate differ strongly between plant species (Qadir, and Schubert, 2002; Jacobsen *et al*., 2012). Generally phosphorus and micronutrient availability reduced in alkaline soils and these lower level can harmfully affect plant growth (Jiang *et al*., 2017). addition of gypsum leads to reduces pH and directly affects soil aggregation (Chi *et al*., 2012; Temiz and Cayci, 2018) approximately 582.2 km$^2$ can be reached to fixed value (7.8) with 0.8 reduction units and 38.1% of study area needed to improve with 0.7 reduction unit. The calcium carbonate deposits are concentrated into layers In some soils that may be very hard and impermeable to water, 42-65 units of reduction of some units are needed to intended value (4% of $CaCO_3$%) and Fig.(12) . As shown in Fig. 13 and Table 9 ,all of study area became moderately suitable under OS.

**Table 8 .Classes of land suitability in study area**

| Final suitability index | | | | | |
|---|---|---|---|---|---|
| Mapping units | Fertility index | Physical index | Chemical index | Final index | Class |
| HB | 0.63 | 0.77 | 0.38 | 0.57 | S3 |
| LB | 0.48 | 0.77 | 0.67 | 0.63 | S2 |
| HD | 0.48 | 0.88 | 0.38 | 0.54 | S3 |
| LD | 0.48 | 0.72 | 0.45 | 0.54 | S3 |
| HT | 0.57 | 0.91 | 0.30 | 0.54 | S3 |
| MT | 0.42 | 0.64 | 0.80 | 0.60 | S3 |
| LT | 0.63 | 0.77 | 0.56 | 0.65 | S2 |
| L | 0.57 | 0.80 | 0.56 | 0.64 | S2 |
| DS | 0.46 | 0.91 | 0.38 | 0.54 | S3 |
| OL | 0.42 | 0.64 | 0.45 | 0.49 | S3 |
| SF | 0.42 | 0.64 | 0.42 | 0.49 | S3 |
| Area (Km$^2$) | S2=755.5 | S3= 2191.7 | | | |

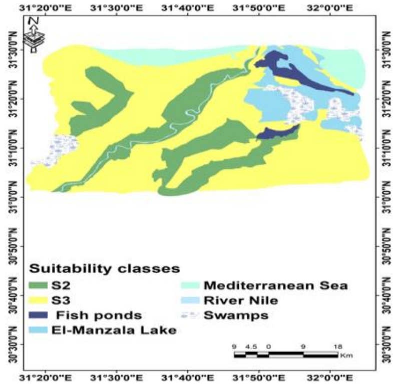
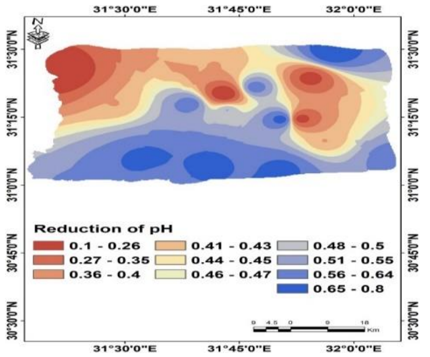
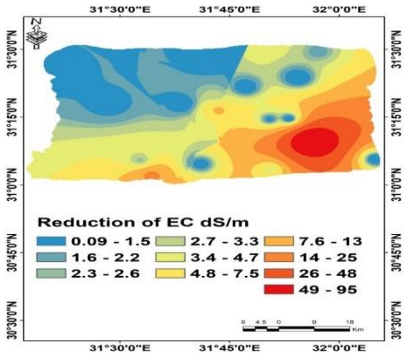


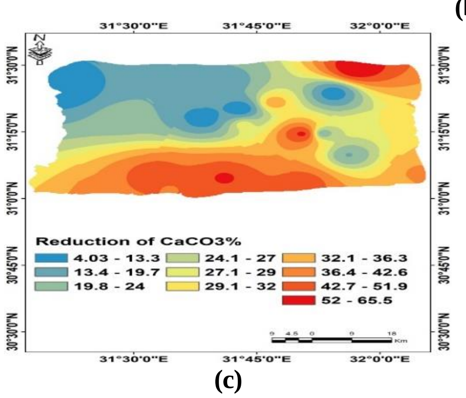

Fig.11. Land suitability under CS




(a)




(b)




(c)

Fig. 12.Reduction interpolation maps of EC, pH and CaCO3 %

**Table 9. Suitability classes under CS and OS**

| Mapping units | HB | LB | HD | LD | HT | MT | LT | L | DS | OL | SF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Suitability of CS | S3 | S2 | S3 | S3 | S3 | S3 | S2 | S2 | S3 | S3 | S3 |
| Suitability of OS | S2 | S2 | S2 | S2 | S2 | S2 | S2 | S2 | S2 | S2 | S2 |

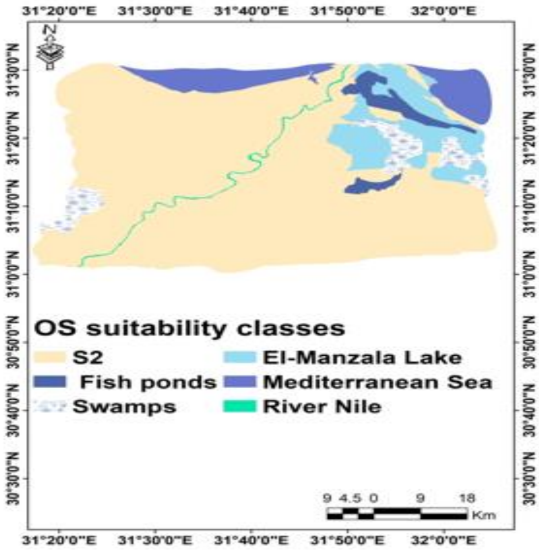



**Fig.13. Land suitability of study area under OS**

## CONCLUSION

Evaluation of land suitability can help decision makers to identify the major restricted soil factors. The spatial distribution of soil suitability classes differ from moderately to marginally suitable classes in the soils around Manzala lake. Using proposed model for land suitability evaluation in study area allowed for estimates of agriculture soil suitability for rice crop. Assessing the potential for manageable restricted factors improvement such as soil salinity, pH , and CaCO3% may help in identifying the improvement degree in soil suitability using the proposed OS. Mapping of current soil suitability and suitability under optimum scenario provides high accuracy information to decision makers for optimum land-use planning and sustainable development in the study area.

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## تقييم النظم المثلى لزراعة المحاصيل وتحديد العوامل المحددة بالتربة لتحسين الإدارة الزراعية من خلال النمذجة المكانية

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يعتبر محصول الأرز هو المصدر الرئيسي للسعرات الحرارية والبروتين لنحو نصف سكان العالم ، كما أنه يعتبر أحد أهم مصادر العمل والدخل في القرى. يهدف هذا البحث الي دراسة ملاءمة الأرض لزراعة الأرز حول بحيرة المنزلة بمصر لنمذجة وإنتاج خرائط عالية الدقة لملاءمة الأرض لزراعة الأرز. تم استخدام النموذج المقترح لتقييم ملاءمة الأرض في ظل الوضع الحالي وكذلك تحت السيناريو الأمثل. أظهرت النتائج في ظل الوضع الحالي أن 26% من مساحة المنطقة المدروسة تقع في الدرجة المتوسطة لزراعة الأرز وأن 74% تقع تحت الدرجة الأقل من المتوسطة. أما تحت الظروف المثلي فقد تم تحديد ثلاثة عوامل محددة لانتاجية الأرز في المنطقة ( الملوحة- القلوية وكربونات الكالسيوم) وتقليل قيمها الي قيم ثابتة وكانت هذه القيم الثابتة هي2 ديسيمنز / م للملوحة و 7.8 للأس الهيدروجيني و 4٪ لكربونات الكالسيوم. فأظهرت النتائج أن اصبحت كل المنطقة تحت الظروف المثلي تقع تحت الدرجة الثانية بالمقارنة ب 26٪ من المساحة المدروسة تحت الظروف الحالية وقد أظهرت النتائج أهمية الإدارة المناسبة لتحقيق تغيير في ملائمة التربة للزراعة والوصول إلى الاستدامة الزراعية.