



ISSN NO. 2320-5407

Journal homepage: <http://www.journalijar.com>

INTERNATIONAL JOURNAL  
OF ADVANCED RESEARCH

## RESEARCH ARTICLE

### SOIL SUITABILITY EVALUATION, MONITORING AND DETECTING LANDCOVER CLASSES UNDER SURFACE IRRIGATION SYSTEM IN AN AREA OF NORTHWESTERN COAST, EGYPT.

Abdel Ghaffar, M.K

Soil, Water and Environment Research Institute, ARC.

#### Manuscript Info

##### Manuscript History:

Received: 14 December 2015  
Final Accepted: 18 January 2016  
Published Online: February 2016

##### Key words:

Northwestern coastal area,  
Landcover, Soil suitability,  
Irrigation system.

##### \*Corresponding Author

Abdel Ghaffar, M.K

#### Abstract

The agricultural expansion outside the old Nile valley is one of the main objects of the Egyptian national plan and a great attention is directed to the northwestern coastal area of Egypt, due to its diverse characteristics. Therefore, the main objective of this research is to produce the landcover and geomorphological maps as well as to evaluate land suitability for irrigation system in an area of the northwestern coastal zone, Egypt. The study area lies between longitudes  $28^{\circ} 56' 30''$  and  $29^{\circ} 25' 30''$  E and latitudes  $30^{\circ} 39' 30''$  and  $30^{\circ} 56' 30''$  N, with a total area of  $991.3 \text{ Km}^2$  (236045.3 Feddan).

Landsat-8 ETM image (path 178, row 39) dated in 17 Jan 2015, geological map, Digital elevation model (DEM), and field observations were used to produce landcover and geomorphological maps. Soil suitability for surface and drip irrigation systems is based on morphology, physical and chemical properties of soil and the land (SYS et al.; 1991). Twenty soil profiles representing the main geomorphological units were allocated by GPS, exposed and the soil samples were collected from the different profile horizons for laboratory analyses.

The study area was classified firstly by unsupervised classification of Landsat-8 ETM image into seven classes, then by visual interpretation of the same image depending on previous classification and field observation into eleven landcover classes as follows: Mediterranean Sea, shoreline, backshore with tourism villages, consolidated ridges & sand dunes, sabkhas, salt marches, urban, grass land, cultivated land, industrial area and barren land. The main geomorphological units in the study area are: low relief coastal plain, medium relief coastal plain, terraced coastal plain and miscellaneous land.

The obtained results reveal that the soils are suitable for surfaces irrigation at various rating levels for the different geomorphological units where 45% of the studied soil profiles are moderately suitable, 50% are marginally suitable and 5% are currently not suitable. The potential suitability for the studied soils is to convert the surface irrigation system in the cultivated area into drip irrigation and use directly the last system to irrigate the uncultivated land (barren land). Apply the parametric method for drip irrigation system in the study area reveal that the soils are mostly moderately suitable (95% of the studied profiles) and only 5% is marginally suitable. The comparison of the two types of irrigation revealed that it would be of more benefit to irrigate by drip irrigation than surface irrigation, where the mean of land capability index (Ci) for surface and drip irrigation systems are 48.6 and 59.1 respectively. The limiting factors to these kinds of land use are mainly soil texture and salinity.

Copy Right, IJAR, 2016.. All rights reserved.

**Introduction:-**

Land cover is taken to mean a physical description of space, of the observed (bio-) physical cover of the Earth's surface. It indicates what covers the land. Distinctions are made between the following key biophysical categories: vegetation areas (trees, bushes, fields, meadows), uncultivated areas (even though this actually means there is no cover), hard surfaces (rocks, buildings) and wetlands and bodies of water (extensive bodies of water, water courses, wetlands). Land cover is 'observed' at varying distances from the Earth's surface: with the naked eye, using aerial imagery, or via satellite sensors (di Gregorio and Jansen 1997).

Information on land cover and land use is urgently required for policy-making, business and administrative purposes. In policy-making, it forms the basis for gauging developments and opting for development program. In farming, the data are required for agricultural statistics, subsidy policy and the monitoring thereof, and also for determining the thrust of future farming policy (Meinel and Hennersdorf, 2002).

The continuous increase of human pressure on our limited natural resources, including water and cultivated area requires proper management of such resources. The agricultural expansion outside the old Nile valley is one of the main objects of the Egyptian national plan (Darwish et al, 2006). A great attention is directed to the northwestern coastal area (NWCE) of Egypt, due to its diverse characteristics. Therefore, studies on management of natural resources in such regions are considered of vital importance (Ali, 2008). Generally, sustainable development is a primary objective and an urgent problem to be addressed by our society (Campanga, 2005).

According to FAO methodology (1976); land suitability is strongly related to land qualities including erosion resistance, water availability and flood hazards which are derived from slope and length, rainfall and soil texture. SYS et al. (1991) suggested a parametric evaluation system for irrigation methods which was primarily based on physical and chemical soil properties.

Using irrigation, farmers have to apply a lot of water to the crops and soil. In order to avoid land degradation, irrigation water and techniques must be compatible with the soil properties. For this reason, it is necessary to evaluate the suitability of land for irrigation.

**Study area:-**

The study area is located in the northwestern coast of Egypt. It extend from El-Hamam in the east to El-Alamin on the west and lies between longitudes  $28^{\circ} 56' 30''$  and  $29^{\circ} 25' 30''$  E and latitudes  $30^{\circ} 39' 30''$  and  $30^{\circ} 56' 30''$  N, with a total area of  $991.3 \text{ Km}^2$  (236045.3 Feddan); Fig. (1).

**Climate:-**

The climatic conditions of the study area are typically arid to semi-arid, characterized by a long hot dry summer, mild winter with little rainfall, high evaporation with moderately to high relative humidity. Table (1) postulates the average meteorological data (1971-2000) from Alexandria station (data from ministry of agriculture and land reclamation -2007). The annual rate maximum temperature is  $25^{\circ}\text{C}$ . The Mediterranean coastal zone of Egypt receives noticeable amounts of rainfall, especially in winter. The annual rainfall is low as it does not exceed 16.6 mm. The maximum monthly rainfall is 55.6 mm in December. Precipitation is considered as the main source of recharge of groundwater aquifers in the northwestern Mediterranean coastal zone and affects greatly the amount of water stored in such aquifers. The relative humidity plays an important role in the amount of evaporation and evapotranspiration. The values of relative humidity are relatively high in summer months. Prevailing winds at the study area are chiefly directed southwest in the winter months while being northwest in the summer months. The lowest and highest wind velocities are recorded in October and March, respectively. Evaporation data indicate that the lowest values of evaporation are recorded in January while the highest values are monitored in July. With such high annual evaporation, both irrigation water and energy costs required for irrigation would be very high.

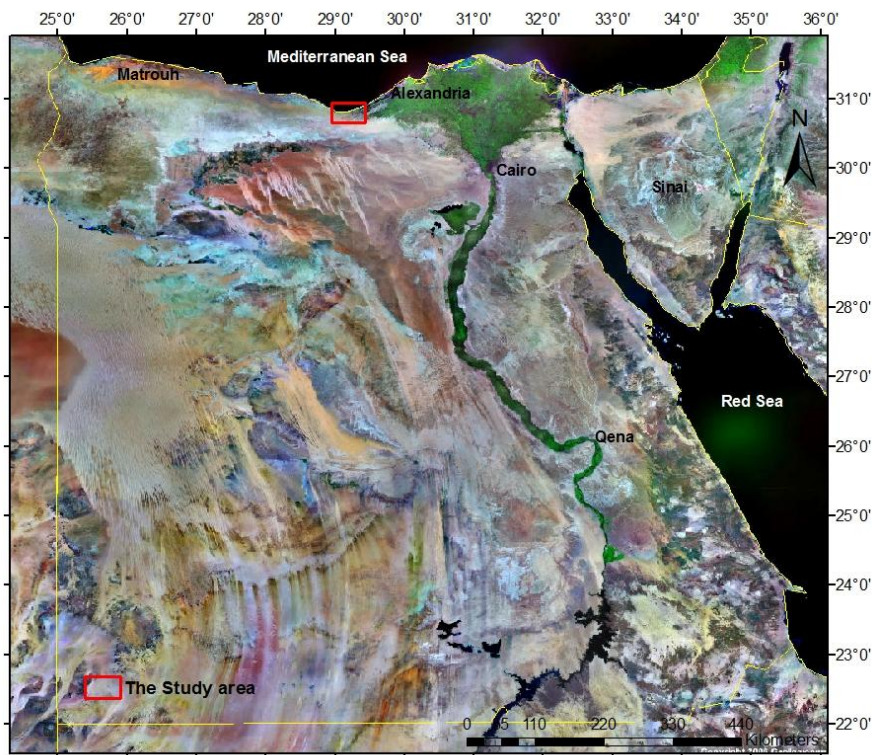


Fig. (1): Location map of the study area

Table (1): Mean monthly climatological data of Alexandria station (1971-2000)

Month	Temperature (C°)			Rainfall (mm)	Relative Humidity (%)	Wind Velocity (km/h)	Avg. Eto (mm/d)
	Max.	Min.	Mean.				
Jan.	18,40	9,10	13,50	54,90	70,00	7,50	2,20
Feb.	19,30	9,30	14,10	26,60	68,00	7,50	2,60
Mar.	21,30	10,80	15,80	12,90	65,00	7,80	3,40
Apr.	23,50	13,10	18,30	4,20	65,00	7,30	4,10
May.	26,60	16,40	21,20	1,50	67,00	6,80	4,90
Jun.	28,60	20,20	24,30	0,00	69,00	6,80	5,70
Jul.	29,70	22,00	25,90	0,00	72,00	7,40	5,80
Aug.	30,60	22,70	26,50	0,30	71,00	6,80	5,50
Sep.	29,60	21,10	25,60	1,00	68,00	6,20	4,90
Oct.	27,60	17,60	22,50	9,30	68,00	5,30	3,70
Nov.	24,20	14,40	19,10	33,10	69,00	5,80	2,70
Dec.	20,30	10,80	15,20	55,60	70,00	7,00	2,30

ETo: Reference Evapotranspiration

### Geology:-

The northern part of Egypt including, the north Western Desert, the Nile Delta and north Sinai lie in the unstable shelf area. The main part of Egypt west of the river Nile is covered by thick sequences of relatively undisturbed sedimentary strata of Paleozoic, Mesozoic and Cenozoic age (Said, 1990). The north part of the Western Desert is covered mainly by thin blanket of Miocene rocks forming a vast persistent limestone plateau. It extends from the western side of the Nile valley and delta in the east to El-Salum in the west and the Mediterranean coastal plain in the north to the Qattara and Siwa depression in the south (El-Bastwasy, 2008). The geology surface of the study area is essentially dominated by sedimentary rocks of Tertiary and Quaternary ages (Fig. 2). The Quaternary is exposed in the coastal plain, wadis and raised beaches. The Pliocene and Miocene of the Tertiary is exposed major part of the tableland, the Miocene is forming the surface beds of the tableland. The geology is characterized by the presence of a plateau formed, essentially of Tertiary Miocene, mainly composed of limestone and sand stone reaching the shoreline at several areas. The coastal zone to the north of the Miocene plateau is covered by Quaternary deposits which rest with conformable and / or unconformable relation of the Tertiary deposits. These deposits are mainly represented by the Holocene deposits of coastal sand dunes, lagoonal and alluvial deposits and the Pleistocene oolitic limestone ridges and old lagoonal deposits. The Quaternary carbonate ridges in the present area are cemented into moderately hard limestone except the coastal ridge which is mostly less cemented (Zahran, 2008).

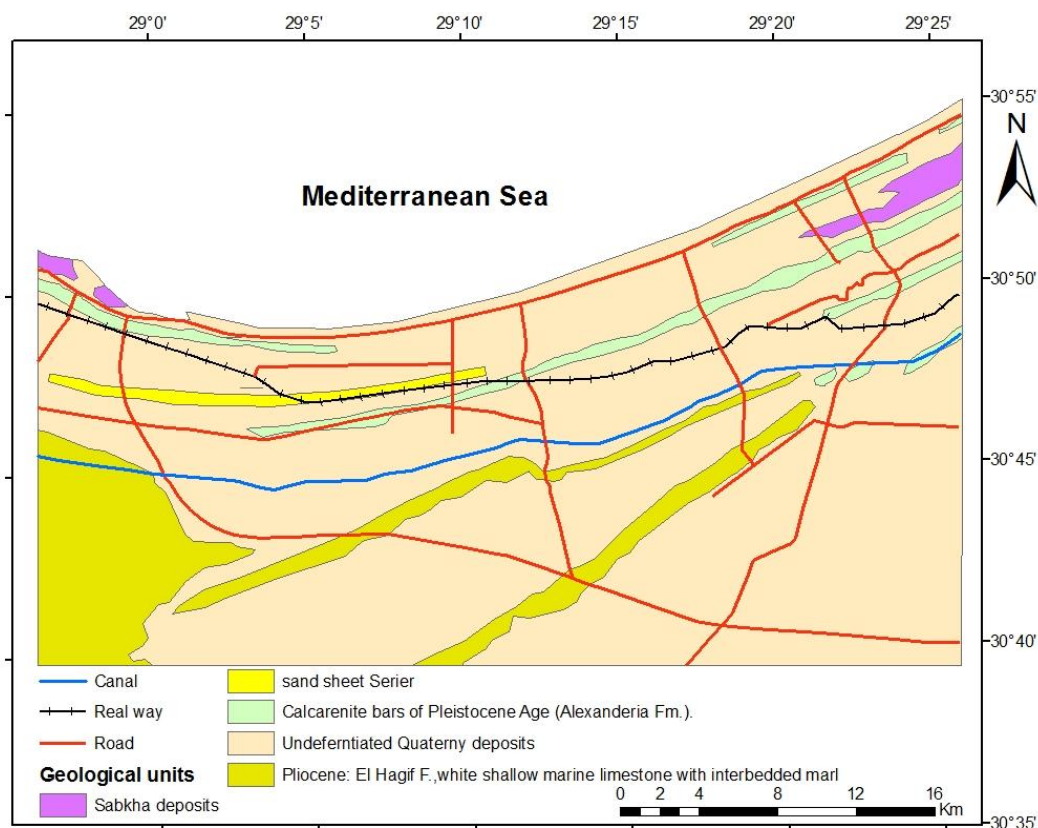


Fig. (2): Geological map of the study area, (modified after CONCO, 1987)

### Hydrological conditions:

The annual average rainfall in the study area is 178.9 mm. The rain falling on any given area in the region (NWCE) is insufficient for agriculture. The water management problem to be solved is how to increase the amount of water penetrating into the ground and how to maintain it there long enough to enable the plant root to draw adequate supplies. A small portion of the rain either runs off into the sea or infiltrates downwards (deep percolation). Much larger quantities are lost by evaporation from the surface, or by capillary rise (Mohamed, 2002).

The Nile water reaches the study area via two irrigation canals; the first is Bahieg canal, and the second is El-Hammam canal, which has been constructed recently. These two canals receive their water from El-Nasser canal.

The groundwater exists under free water table condition. The saturated thickness of the coastal aquifer is about 30 m in oolitic limestone. The groundwater flow is mostly towards the Mediterranean Sea coast (Atta et al., 2005). The coastal aquifer mostly contains brackish water that has been recharged annually by local rainfall and the Nile seepage water from El-Nasr, El-Hammam and Maryut canals. The main groundwater aquifers in the western Nile Delta of Egypt showed in Fig. (3). Guindy, (1989) classified the groundwater bearing formation in the area and surrounding into:

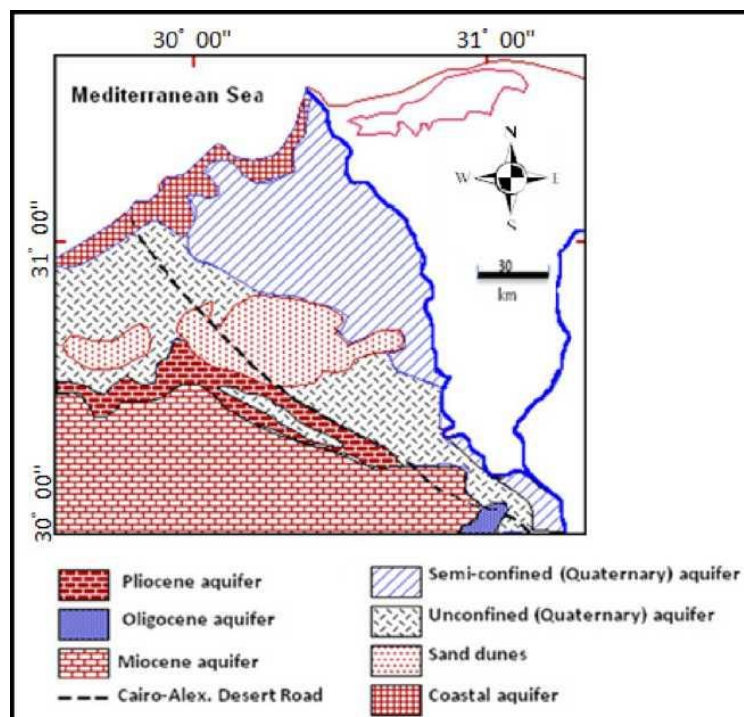
1- Post-Miocene aquifers, which include:

- An unconsolidated coastal dunes (Holocene) aquifer.
- A consolidated detrial oolitic limestone (Pleistocene) aquifers.

2- Miocene aquifers, which include:

- A consolidated cavernous sandy limestone (Middle-Miocene) aquifer.
- A consolidated sandstone and sandy shale (Lower Early-Miocene) aquifer.

These aquifers have direct contact with the Mediterranean Sea at different levels and over different thicknesses. The post-Miocene aquifers are connected hydraulically to each other and have large intake areas of well-defined character, with adequate gradient for the groundwater movements.



**Fig. (3): The groundwater aquifers in the western Nile Delta of Egypt (Sharaky et al., 2007)**

## Materials and methods:-

The following data were used for the study:

- (i) Remotely sensed data: Landsat-8 ETM multispectral image dated (Jan, 2015) with resolution of 30 m (Fig.4). This image is orthorectified Landsat imagery provided by the Global Land Cover Facility (GLCF; <http://glcf.umd.edu/>).
- (ii) Topographic map (1:50,000) (EGACS, 1989).
- (iii) Geological map of the study area (Fig. 2)
- (iv) Digital elevation model (DEM) that covered the area of interest (Fig.5) has been cut and separated from ASTER GDEM (<http://www.gdem.aster.ersdac.or.jp>, Access date: Oct. 2010).

**Landcover map:**

One Landsat-8 ETM image (path 178, row 39) dated 17 Jan 2015 with almost cloud-free conditions was selected in this study. Six bands (from 1 to 5 plus 7) of ETM data were used. Production of recent landcover map of the study area was extracted using firstly unsupervised classification by Erdas Imagine (2014) software, then field observations and lastly visual interpretation by Arc GIS (10.1) software.

**Geomorphological Units:-**

The geomorphological units of the study area were identified aided by topographic maps (1: 50000), DEM, geological map, Landsat ETM<sup>+</sup> image and field observation.

**Field and lab work:-**

- Twenty soil profiles representing the main geomorphological units were allocated by GPS, exposed and the soil samples were collected from the different profile horizons for laboratory analyses,
- The soil samples were analyzed for particle size distribution, pH (in the soil paste) ECe (in the soil paste extract), CaCO<sub>3</sub>, Ca SO<sub>4</sub> .2H<sub>2</sub>O and cation exchange capacity (CEC) according to USDA (2004).

**Soil suitability:-**

For the evaluation of land suitability for surface and drip irrigation, the parametric evaluation system was used (SYS et al. 1991). This method is based on morphology, physical and chemical properties of soil and the land is evaluated according to numerical indexes. In this classification system, firstly a degree, whose rate is from 0 to 100, is given to any land characteristic through comparing them with the tables of soil requirements. The specified degrees are used in order to measure the land index that is a multiplicative index that combines ratings assigned to soil map units and other physical conditions that affect the land use (Olsen 1981).

Six parameters (including slope, drainage properties, electrical conductivity of soil solution, calcium carbonates status, soil texture and soil depth) were considered and rates were assigned to each parameter, thus, the capability index for irrigation (Ci) was developed as shown in the equation below:

$$Ci = A \times B/100 \times C/100 \times D/100 \times E/100 \times F/100 \times G/100$$

where A, B, C, D, E, F and G are the rating of soil texture, soil depth, calcium carbonate content, gypsum content, electrical conductivity, drainage and slope, respectively.

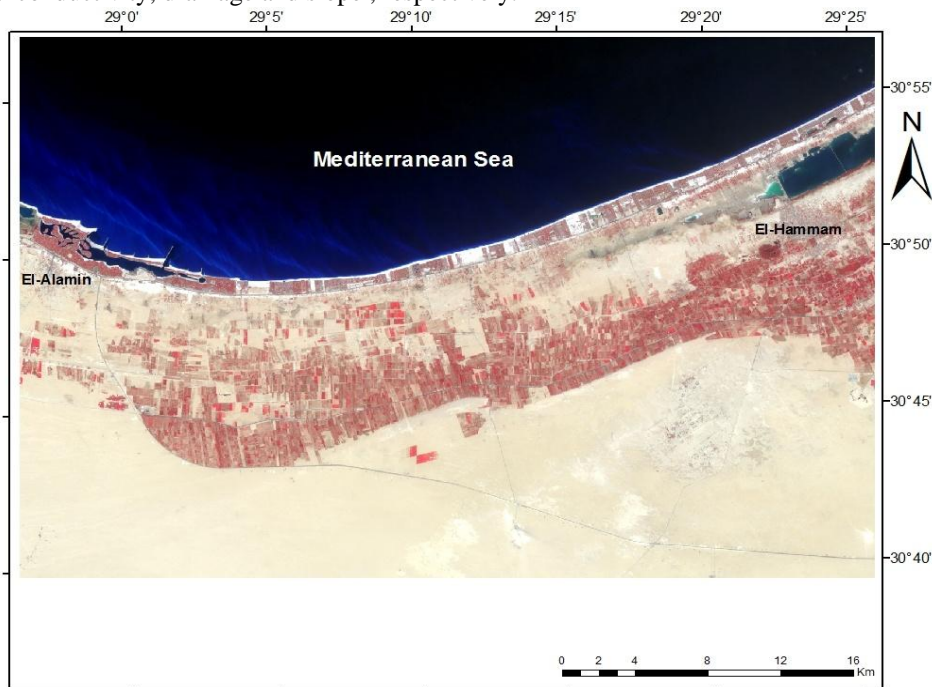
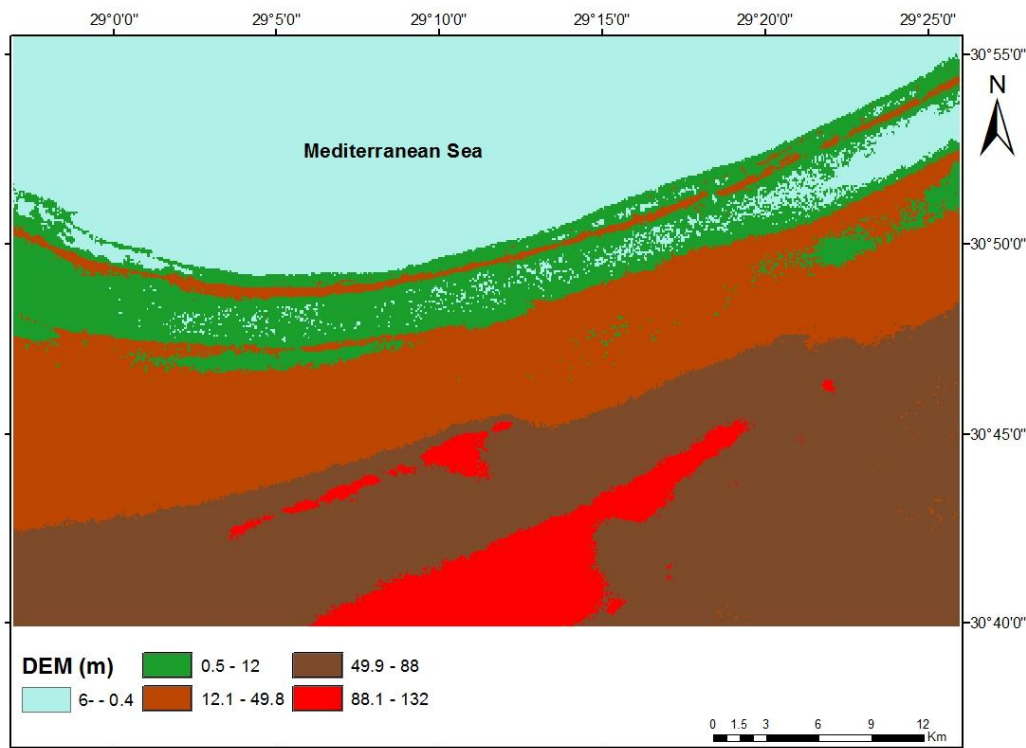


Fig. (4): Subset of Landsat-8 ETM image (path 178, row 39); bands 4, 3, 2 of the study area



**Fig.(5): Digital Elevation Model (DEM) of the study area**

The main objective of this research is to produce the landcover and geomorphological maps as well as to evaluate land suitability for irrigation system in an area of the northwestern coastal zone, Egypt.

## Results and discussions:-

### Land cover of the study area:-

The study area was firstly classified by unsupervised classification of Landsat-8 ETM image (path 178, row 39; dated 17 Jan 2015) into seven classes (deep sea water, shallow sea water and salt marches, sabkha, agriculture land, grass land, urban and barren land; Fig 6). After field trip and observations, the study area was classified by visual interpretation into eleven main classes as follows: Mediterranean Sea, shoreline, backshore with tourism villages, consolidated ridges & sand dunes, Sabkhas, salt marches, urban, grass land, cultivated land, industrial area and barren land (Fig.7). The areas of these classes are presented in Table (2) and their description as follows:

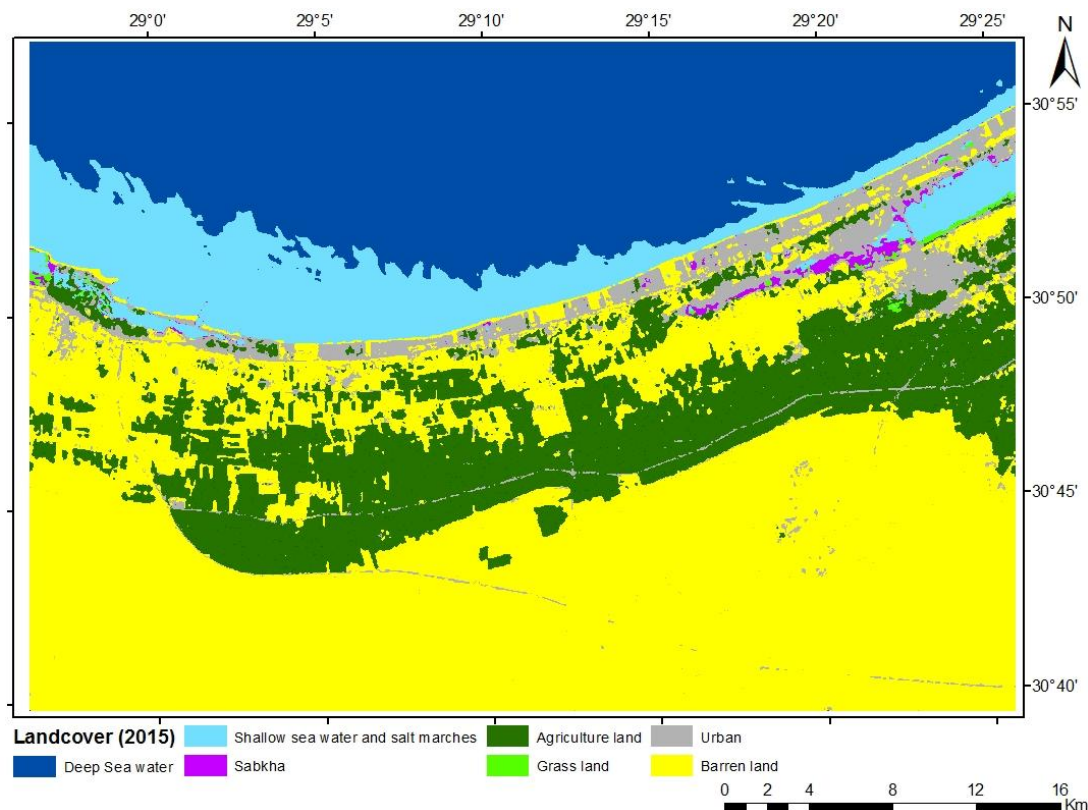
- **Shoreline:** Strip area of narrow few meters width followed the Mediterranean Sea water and consists mainly of friable sand.
- **Backshore with tourism villages:** area followed the shoreline and includes construction activities along the coastal dunes (summer resorts).
- **Consolidated ridges and sand dunes:** elevated aelio-marine ridges composed of limestone walls and in some places the sand dunes are present.
- **Salt marshes:** transitional areas between land and water, occurring along the intertidal shore of estuaries and sounds where salinity ranges from near ocean strength to near fresh in upriver marshes.
- **Sabkha:** is an Arabic name for a salt-flat ordinarily found nearby sand dunes. The low-lying sabkha is a landscape of sand cemented into a fragile crust by the alkaline minerals of a high water table. Due to the high water table, moisture is plentiful but most plants won't tolerate the harsh chemical environment
- **Cultivated land:** area cultivated with annual crops, vegetables, or fruit. These crops are irrigated mainly from the water of the river Nile and/or ground water. Most of the cultivated area is newly reclaimed.
- **Grassland:** the plants of the study area can be classified into nine life forms: annuals, perennial grasses, perennial herbs, evergreen succulent perennial sub-shrubs, evergreen non-succulent perennial sub-shrubs,

partially deciduous perennial sub-shrubs, evergreen succulent perennial shrubs, evergreen non-succulent perennial shrubs and deciduous perennial shrubs (Kasperek, 1993).

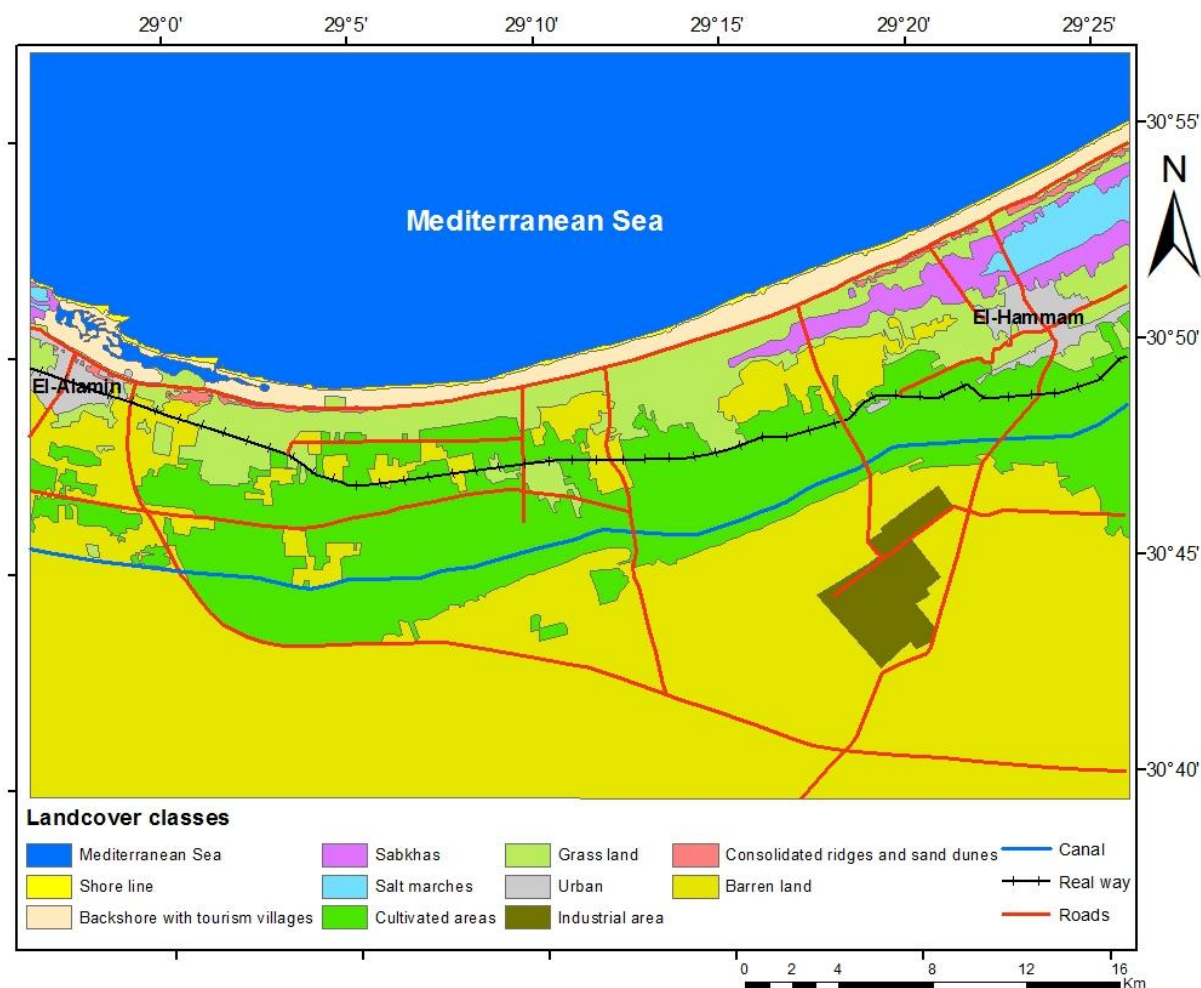
- **Barren land:** Bare soils are located in the southern part of study area. It is covered by sparse natural vegetation with very low plant cover value as a result of overgrazing, woodcutting, etc. and is promising for reclamation.
- **Urban:** include the main cities of El-Hammam and El Alamein as well as sporadic houses of the Bedouins within the local villages and some governmental buildings.
- **Industrial area:** area covered by factories buildings of different industries.

**Table (2) Landcover of the study area and their acreage**

Landcover	Area (Km <sup>2</sup> )	Area (Feddan)	Percentage
Shoreline	6.4	1530.2	0.65
Backshore with tourism villages	38.9	9251.1	3.93
consolidated ridges and sand dunes	4.1	986.4	0.41
Sabkhas	21.2	5055.5	2.14
Salt marches	11.9	2836.9	1.20
Urban	17.3	4110.8	1.74
Grass land	100.1	23837.7	10.1
Cultivated land	233.3	55554.1	23.53
Industrial area	19.6	4668.6	1.98
Barren land	538.5	128214	54.32
Total	991.3	236045.3	100



**Fig.( 6 ):Unsupervised classification of Landsat image of the study area**



**Fig.(7): Landcover map of the study area by visual interpretation**

#### **Geomorphologic Setting:-**

The Northwest Coast of Egypt forms a belt about 20 Km deep, which extends for about 500 km between Amria (20 Km west of El-Alexandria) and El-Salloum near the Libyan borders. The landscape is distinguished into a northern coastal plain and a southern tableland. The coastal plain stretches in general east-west direction, bounded by the sea to the north and tableland in the south. The land surface of the frontal plain is slope in a northward direction. However, the slope of the land surface in the study area is mostly range from 1 to 5% which is considered as gentle slope (Fig.7). This gentle slope does not accelerate surface runoff where the area has an indistinct drainage pattern. The surface runoff is captured by low lying depression where most of this surface storage evaporates (Fehlberg and Stahr, 1985).

The geomorphological units of the study area are shown in Fig. (8) and Table (3). The area includes a narrow and very low relief shore line and backshore with tourism villages in the north, followed at some areas to the south by consolidated aeolio-marine ridges and sand dunes. The low relief coastal plain unit with sabkhas and salt marches is present to the south. Southwards, there is medium relief coastal plain unit with deep soil profiles where most of the cultivable soils in the study area are located in this unit. However, the subsoil layers are formed locally from marine limestone (El-Bastwasy, 2008). The terraced coastal plain unit with relatively high elevation is present near the limestone plateaus area (Miscellaneous land unit).

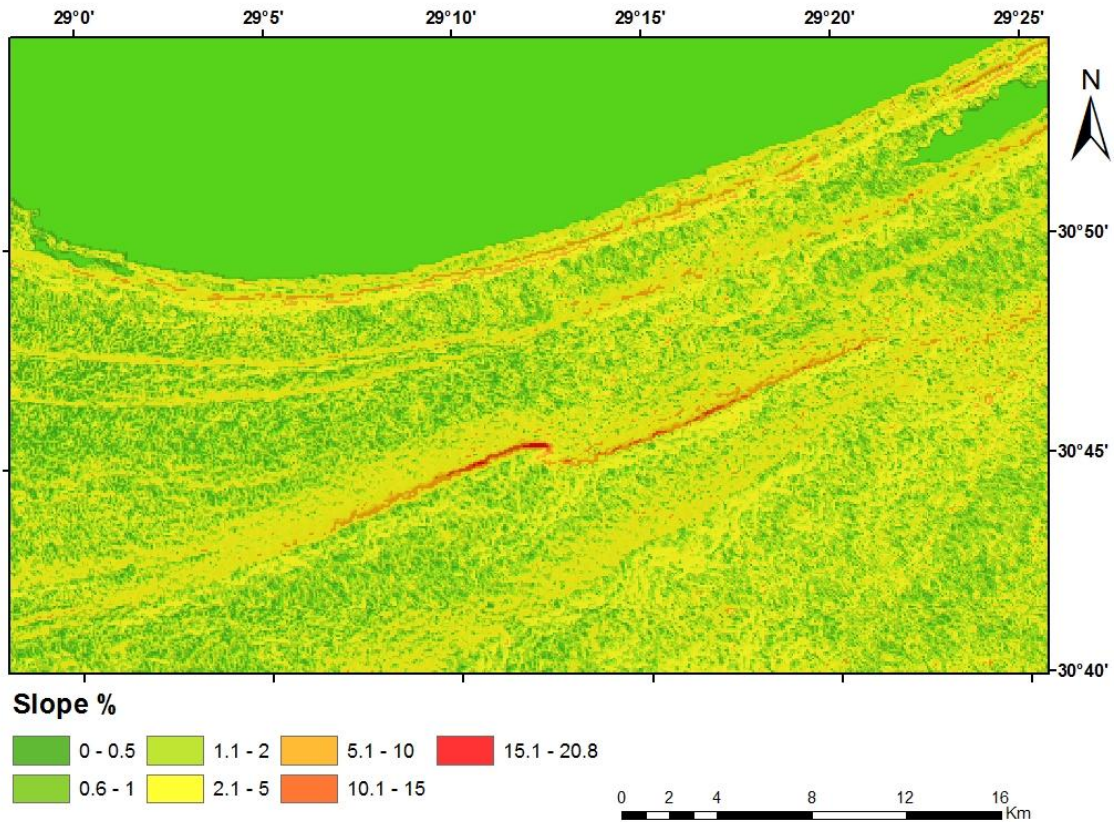


Fig (7): The slope map of the study area

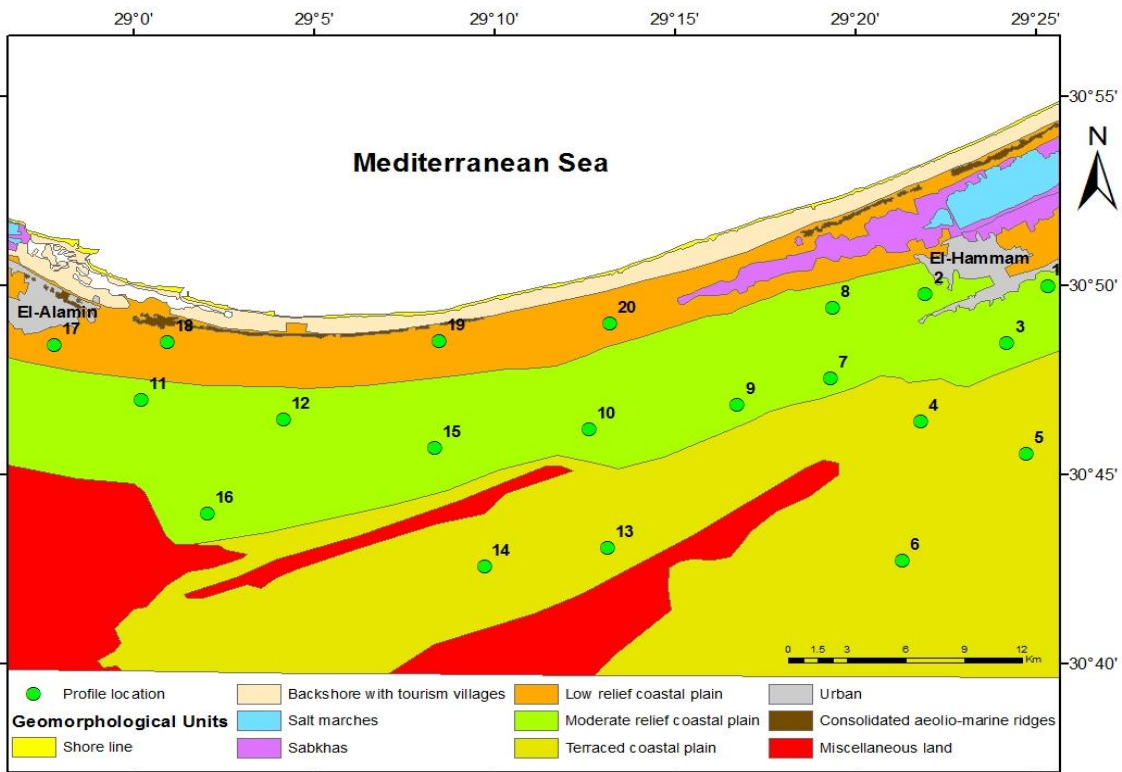


Fig.(8): Geomorphological map and soil profile location of the study area

**Table (3): Geomorphological unit and their acreage in the study area**

Geomorphological Units	Elevation (m)	Area (Feddan)	Area (Km <sup>2</sup> )
Shore line	0.5 - 12	1530.2	6.4
Backshore with tourism villages	0.5 - 12	9251.1	38.9
Urban	-	4110.8	17.3
Consolidated aeolio-marine ridges	12.1- 49.8	986.4	4.1
Sabkhas	<0.5	5055.5	21.2
Salt marches	<0.5	2836.9	11.9
Low relief coastal plain	0.5-12	27172.2	114.1
Moderate relief coastal plain	12.1- 48.9	65047.6	273.2
Terraced coastal plian	49.9 - 88	91098.9	382.6
Miscellaneous land	88.1-132	28953.9	121.6
Total	-	236043.9	991.0

**Soil suitability for irrigation systems (Sys et al., 1991):**

The main objective of this method is to evaluate the study soils for surface and drip irrigation systems based on the parametric evaluation system (Sys et al. 1991). This method was primarily based on physical and chemical soil properties (Table 4). In the proposed system, the factors which are affecting the soil suitability for irrigation purposes can be subdivided into four groups which are physical properties, chemical properties, drainage properties and environmental factors such as slope (Albaji et.al, 2010). These characteristics are used to calculate the capability index for irrigation (Ci). Suitability classes are defined by considering the value of the capability indices (Table 5).

**A-Current suitability under surface irrigation system:-**

The agriculture lands in the study area (which are mentioned in the landcover map; Fig 7) are mostly irrigated by surface irrigation system mainly from El-Hammam canal. The results of the processing of the parametric evaluation system for surface irrigation in all the study area are shown in Table (6). The obtained results reveal that the soils are suitable for surfaces irrigation at various rating levels for different geomorphological units. 45% of the studied soil profiles are moderately suitable (S2), 50% are marginally suitable and 5% are currently not suitable (N1). The mean of land capability index (Ci) for surface irrigation system is 48.6 and the limiting factor to this kind of land use is mainly soil texture and salinity (Table 6).

Under the prevailing conditions of water scarcity in Egypt, surface irrigation endures wasteful loss for deep percolation. Furthermore, it leaches fertilizer away from root zone and it requires extensive labors. Because it has low water application efficiency, it requires high energy level.

**B- Potential suitability under drip irrigation system:**

The potential suitability for the studied soils is to convert the surface irrigation system in the cultivated area into drip irrigation and use directly the last system to irrigate the uncultivated land (barren land).

Conversion from surface to drip irrigation can have multiple benefits; including increase yield, water savings, reduce fertilizer application, reduce erosion and less tillage. Drip irrigation improve irrigation uniformity and efficiency by applying water precisely where it is needed, thus limiting water losses via surface runoff and deep percolation. These benefits can only be realized with careful management and need to be evaluated with the cost associated with the infrastructure change, energy use, and maintenance (Hanson et al., 1997).

Apply the parametric method of Sys et al (1991) for drip irrigation system in the study area reveal that the soils are mostly moderately suitable (S2; 95% of the studied profiles) and only 5% are marginally suitable (S3) where the values of texture and slope parameters are high in this system than surface irrigation system. The mean of land capability index (Ci) for drip irrigation system is 59.1 and the limiting factor to this kind of land use is mainly soil texture and salinity (Table 7).

The comparison of the two types of irrigation revealed that it would be of more benefit to irrigate by drip irrigation than surface irrigation.

**Table (4) Weight average of some physic-chemical characteristics for soil profiles in the study area**

Geomorphic Unit	Profile No.	Landcover	Depth (cm)	Coarse fragments (% by volume)	Texture	EC (ds/m)	pH	CaCO <sub>3</sub> %	Gypsum %	CEC (meq/100g)
Moderate relief coastal plain	1	Cultivated land	150	-	SCL	1.7	7.6	25	0.2	8.6
	2		150	25	SCL	1.2	7.4	20	0.21	5.7
	3		150	-	SCL	0.8	7.5	18.5	0.18	7.6
	7		150	-	LS	0.8	7.6	19.2	0.22	4.1
	8		150	-	SCL	1.3	7.7	10.5	0.23	4.2
	9		150	-	SL	0.55	7.8	15.2	0.24	5.5
	10		150	-	LS	0.51	7.5	11.5	0.24	7
	11		150	-	SL	7.3	7.4	15.4	0.5	7.2
	12		150	-	CL	1.8	7.9	15.4	1.9	6.3
	15		150	-	SCL	12.1	7.8	19.1	1.5	8.9
16	150	-	SL	1.7	7.4	13.6	0.27	6.1		
Terraced coastal plain	4	Barren land	40	-	SL	4.2	7.5	9.2	0.12	9.4
	5		150	16	SL	4	7.4	16.5	0.16	8.5
	6		150	12	SL	0.7	7.5	15.4	0.16	7.5
	13		150	17	SCL	15.2	7.2	16.5	0.17	7.5
	14		150	-	LS	0.47	7.6	11.2	0.18	6.0
Low relief coastal plain	17	Grass land	150	-	SCL	20.5	7.5	15.5	1.6	6.4
	18		150	-	SCL	19.5	7.8	19.2	1.5	7.6
	19		150	-	CL	18.5	7.7	12.5	1.1	6.5
	20		150	-	CL	19.6	7.6	8.4	0.8	6.7

**Table (5): Suitability classes for the irrigation capability indices (Ci) classes**

Soil class	Definition	Capability index
S1	Highly suitable	> 75
S2	Moderately suitable	50 -75
S3	Marginally suitable	25-50
N1	Currently not suitable	12.5- 25
N2	Permanently not suitable	< 12.5

**Table (6) Suitability of soil profiles for surface irrigation in the study area**

Geomorph- hic Unit	Profile No.	Texture	Depth	CaCO <sub>3</sub>	Gypsum	Salinity	Drainage	Slope	CI	Suitability class
<b>Moderate relief coastal plain</b>	1	74	100	90	90	96	100	95	54.7	S2t
	2	73	100	90	90	96	100	95	53.7	S2t
	3	73	100	90	90	96	100	95	53.9	S2t
	7	63	100	90	90	96	100	95	46.5	S3t
	8	72	100	90	90	96	100	95	53.2	S2t
	9	68	100	90	90	96	100	95	50.2	S2t
	10	64	100	90	90	96	100	95	47.3	S3t
	11	68	100	90	90	90	100	95	47.1	S3t
	12	90	100	90	90	96	100	95	66.5	S2
	15	73	100	90	90	85	100	95	47.7	S3t
16	68	100	90	90	96	100	95	50.2	S2t	
<b>Terraced coastal plain</b>	4	68	60	90	90	90	80	90	21.4	N1td
	5	67	100	90	90	96	100	90	46.9	S3t
	6	67	100	90	90	96	100	90	46.9	S3t
	13	72	100	90	90	85	100	90	44.6	S3t
	14	63	100	90	90	96	100	90	44.1	S3t
<b>Low relief coastal plain</b>	17	73	100	90	90	80	100	90	42.6	S3tn
	18	74	100	90	90	80	100	90	43.2	S3tn
	19	90	100	90	90	80	100	90	52.5	S2n
	20	90	100	100	90	80	100	90	58.3	S2n
<b>Mean</b>									48.6	

CI: Capability index    t: texture    n: salinity    d: depth

The main recommendation:

- 1- It is better to irrigate the soil using the drip irrigation system since it proves suitability to the irrigation purposes and ensures the sustainable use of the land for irrigation agriculture. The quality of water used for irrigating the soils must be evaluated appropriately.
- 2- For the soils of Low relief coastal plain, it is better to use surface irrigation especially in area belongs to highly EC in the surface layer and highly content of CaCO<sub>3</sub>. In respect to the ECe value, it could expect helping in leaching salt out of the profile. Whereas, the soils with high salinity could irrigate by surface irrigation until leaching salt is completed then replaced by drip irrigation.

**Table (7) Suitability of soil profiles for drip irrigation in the study area**

Geomorphologic Unit	Profile No.	Texture	Depth	CaCO <sub>3</sub>	Gypsum	Salinity	Drainage	Slope	CI	Suitability class
Moderate relief coastal plain	1	84	100	90	90	96	100	100	65.3	S2t
	2	83	100	90	90	96	100	100	64.5	S2t
	3	83	100	90	90	96	100	100	64.5	S2t
	7	73	100	90	90	96	100	100	56.8	S2t
	8	82	100	90	90	96	100	100	63.8	S2t
	9	78	100	90	90	96	100	100	60.7	S2t
	10	74	100	90	90	96	100	100	57.5	S2t
	11	78	100	90	90	90	100	100	56.8	S2t
	12	95	100	90	90	96	100	100	73.9	S2
	15	83	100	90	90	85	100	100	57.1	S2t
Terraced coastal plain	4	78	70	90	90	90	80	100	35.8	S3td
	5	77	100	90	90	96	100	100	59.9	S2t
	6	77	100	90	90	96	100	100	59.9	S2t
	13	73	100	90	90	85	100	100	50.3	S2t
	14	73	100	90	90	96	100	100	56.8	S2t
Low relief coastal plain	17	83	100	90	90	80	100	100	53.8	S2tn
	18	84	100	90	90	80	100	100	54.4	S2tn
	19	95	100	90	90	80	100	100	61.6	S2n
	20	95	100	100	90	80	100	100	68.4	S2n
Mean								59.1		

Ci: Capability index      t: texture      n: salinity      d: depth

### References:-

- Albaji, M., Shahnazari, A., Behzad, M., Naseri, A., BoroomandNasab, S., and Golabi, M. 2010. "Comparison of different irrigation methods based on the parametric evaluation approach in Dosalegh plain: Iran." *Agricultural Water Management*, 10.1016/j.agwat.2010.02.015,1093-1098.
- Ali R.R. 2008. Digital Soil Mapping for Optimum Land Uses in some Newly Reclaimed Areas West of the Nile Delta, Egypt. *Australian Journal of Basic and Applied Sciences*, 2008, 2, 165-173.
- Atta, A.S., Sharaky, A.M., El Hassanein, A.S. and Khallaf, K.M.A., 2005. Salinization of the Groundwater in the Coastal Shallow Aquifer, Northwestern Nile Delta, Egypt, *First International Conference on the Geology of Tethys*, Cairo University, pp. 151-166.
- Campagna M. 2005. GIS for sustainable development. Taylor & Francis Group.
- CONOCO. 1987. Geological map of Egypt 1:50000.NH 36 NW CAIRO, Egypt.
- Darwish Kh. M., Wahba M.M., Awad F., *Agricultural Soil Suitability of Haplo-soils for Some Crops in Newly Reclamid Areas of Egypt. Journal of Applied Sciences Research*, 2006, 2, 1235-1243.
- Di Gregorio, A. & Jansen, L.J.M. 1997. A new concept for a land cover classification system. *Proceedings of the Earth Observation and Environmental Information 1997 Conference*. Alexandria, Egypt, 13-16 October 1997.
- EGACS, 1989: Egyptian General Authority for Civil Survey. Topographic Sheets, Scales 1; 50.000.
- El-Bastwasy, M.A. 2008. The Use of Remote Sensing and GIS for Catchments Delineation in Northwestern Coast of Egypt: An Assessment of water Resources and Soil Potential., *Egypt J Remote Sensing Space Sci*, pp. 3-16.
- FAO. 1976. A framework for land evaluation. *FAO Soil Bulletin*, 32. Rome, Italy.
- Fehlberg, H. and Stahr, K., 1985. Development of sustained land use by understanding soil and landscape formation in the desert fringe area of nw-Egypt. *CATENA*, 12(1): 307-328.
- Guindy, K.H.A. 1989. Hydrogeology of the coastal zone between El- Ameriya and El-Hammam, Ain Shams University, Cairo, 151 pp.
- Hanson, B.R., Schwankl, L.J and Pettygrove, G.S. 1997. Acomparison of furrow, surface drip and subsurface drip irrigation lettuce yield and applied water. *Agric.Water Manage*.33: 139-157.
- Kasperek, M. 1993. Survey of the Mediterranean coast between Alexandria and El Salum, Egypt. *Marine Turtle Newsletter*, 63, 8–9.

15. Meinel, G. and Hennemersdorf, J. 2002. Classification Systems of land cover and land use and their challenges for picture processing of remote sensing data – Status of international discussion and programs In: Proceedings of the 3rd International Symposium Remote sensing of urban areas, Istanbul, S. 472-479
16. Meinel, G. Hennemersdorf, J. 2002. Classification Systems of land cover and land use and their challenges for picture processing of remote sensing data - Status of international discussion and programs. In: Proceedings of the 3rd International Symposium Remote sensing of urban areas, Istanbul, S. 472-479.
17. Ministry of Agriculture and Land Reclamation, 2007. Climatologically normal's at Alexandria station (1971-2000).
18. Mohamed A.G.M., 2002. Corporation of remote sensing and geographic information systems in water management and land use planning in El-Hammam area, Northern coast of Egypt, MSc Thesis, Mediterranean Agronomic Institute of Chania, Crete, Greece.
19. Olsen G.W., 1981. Soils and the Environment. Chapman & Hall, New York, pp. 37–39.
20. Said, R., 1990. The Geology of Egypt., Balkema , Rotterdam.
21. Sharaky, A.M., Atta, S.A., El Hassanein, A.S. and and Khallaf, K.M.A., 2007. Hydrogeochemistry of Groundwater in the Western Nile Delta Aquifers, Egypt, 2<sup>nd</sup> International Conference on the Geology of Tethys, Cairo University.
22. SYS C., Van Ranst E., Debaveye J. 1991. Land Evaluation, Part 1, Principles in land evaluation and crop production calculations. International Training Centre for Post-graduate Soil Scientists, University Ghent, pp. 19–98..
23. USDA. 2004. "Soil Survey Laboratory Methods Manual" Soil Survey Investigation Report No. 42 Version 4.0 November 2004.
24. Zahran, A.A., 2008. Geotechnical Study of Carbonate Rocks on the Area Between Alexandria and El Alamein Along The Mediterranean Sea Coast of Egypt. Ass. Univ. Bull. Environ. Res., 11(1): 12.