Egypt. J. Soil Sci., **Vol. 57,** No.1, pp. 31 - 45 (2017)

Assessment of Soil Erosion Risk in The Basin of Wadi Maged in Northern West Coast of Egypt Using Corine Model and Gis Techniques

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SOIL erosion is one of the major threats to the conservation of soil and water resources. The main aim of this research is to determine potential and actual soil erosion risk of Wadi Maged basin using GIS techniques and COo Rdination of IN formation on the Environment (CORINE) model. The main factors of soil erosion including soil erodibility, erosivity, topography and vegetation cover were determined. Initially soil texture, soil depth, and surface stoniness maps were created and intersected in GIS environment in order to generate erodibility map. The Fournier precipitation and Bagnouls–Gaussen drought indices were determined based on meteorological data and erosivity was calculated. Potential erosion risk map was generated by composed soil erodibility, erosivity and slope layers. Results revealed that about 570.1 ha. of the study area was classified as no erosion risk. Areas under low and moderate potential soil erosion risk were about 8279.3 ha. and 10.0 ha. of the study area, respectively. The areas classified as high potential soil erosion risk was a small area (0.2 ha.) in the north. Results of actual erosion risk revealed that actual erosion risk areas were less than the potential one (7044.2 ha.). These results confirm the role of land cover in protecting the soil surface from erosion. The assessment of soil erosion risk helps to prioritize critical areas for adopting suitable soil erosion prevention measures.

Keywords: CORINE model, Soil erosion risk, GIS, Wadi Maged basin, Egypt.

Introduction

Soil erosion is a serious problem throughout the world due to its adverse economic and eco-environmental impacts such as losses in land resources and decreases in land productivity, especially through nutrient rich sediment delivery that leads to eutrophication and reduces the overall storage capacity of reservoirs as well as life span (Eroglu et al., 2010). Reservoir siltation has direct negative economic and environmental consequences, since less water volume is available for water supply, irrigation and flood control. Managerial practices that minimize conditions of soil erosion can be effectively implemented if the intensity and spatial distribution of soil erosion are known. However, for a long time, it is difficult to assess soil erosion in a precise manner for the complex processes of soil erosion determined by multi-factor, natural and anthropogenic interactions (Lu et al., 2004 and Ananda & Herath, 2003). Conventional erosion research methods, such as regular field experimentation or long-term monitoring, require substantial funding, time and manpower inputs. Thus accurate and timely assessment of soil erosion rate and spatial distribution for conservation planning is urgent in need. The Coordination of Information on the Environment (CORINE) model is an empirical model can predict soil erosion risk (SER) with spatial explicit (CORINE 1992). CORINE is a semi-qualitative cartographic method that involves designing and overlaying of several layers-thematic maps, and it can present the spatial heterogeneity of soil erosion risk (SER) within a GIS environment. It has a great advantage of simple structure and it is also easy to apply using GIS. The CORINE model correctly identified the areas of the Mediterranean, which have the highest

DOI : DOI: 10.21608/EJSS.2017.3587

risk of erosion (Gobin et al., 2003). CORINE model was widely applied by the European and Mediterranean countries for soil erosion risk assessment (Husnjak et al., 2008; Parlak et al., 2007; Yuksel et al., 2008 and Aydın & Tecimen, 2010). GIS technology is a powerful tool in environmental assessment through its advance features for collecting, storing, manipulating, and displaying spatial data (Wang et al., 2003). RS technologies have been used to provide land cover information by using digital image processing techniques (Yuksel et al., 2008). Therefore, a combination of RS, GIS, and CORINE model provides the potential to assess soil erosion risk and its spatial distribution with reasonable costs and better accuracy in large areas. Objective of this study is to characterize the spatial distribution of soil erosion risk in Wadi Maged basin.

Materials and Methods

Study area

The study was conducted at Wadi Maged basin in the Northern Western part of Marsa Matrouh city and south of Zawyat Umm El-Rakham area as shown in Fig. 1. The study area covers an area of 88.6 km2 (about 8859.5 ha.) and located between longitudes 26° 56' 58.4" to 27° 07' 19.7" East and latitudes 31° 11' 10.1" to 31° 22' 33.5" North. The International Coastal road passes in the middle of the study area from east side to west side and Al-Dabha Al-Sallum road pass through the south part of the study area. The northern part of the studied area contains number of close valleys started from the North West costal road to the south up to the International Coastal road. The climate of the study area is rainy in the winter, dry hot in the summer, where the minimum annual rain is 87.10 mm/year and the maximum annual rain is 274.50 mm/year with an average rainfall of 145.06 mm/year of climatic period from 2002 up to 2014 (E.M.A., 2014).

Materials and softwares

- Four topographic Maps, named; Wadi Maged, Kariat Ragwah, El Ramsa, and Abar Emaira with 1: 25,000 scale, produced by Department of Military Survey, MSA (1986),
- LANDSAT-8 ETM+ of scene P179 R038 in 2015, projection: Universal Transverse Mercator (UTM), with Datum: WGS 1984, Ellipsoid parameters: a=6378137.00 and 1/f=298.257, Northern Hemisphere, and Zone 35.
- Remote sensing and GIS softwares (ERDAS imagine 2014, ArcGIS desktop V.10.3).

Field Work

Ten soil profiles were selected to define the soil types of these areas. Soil samples were collected based on the morphological description, and air-dried, gently crushed, and then sieved through a 2-mm sieve. Fractions below 2 mm were subjected to soil analyses.

Fig. 1. Location map of the study area

Laboratory analyses

Laboratory analyses were carried out for particle size distribution, organic matter, calcium carbonate content, soil pH in the soil paste and electrical conductivity (EC) in the soil paste extract according to Klute, (1986) and Page et al., (1982).

Soil map creation

Using field work, laboratory analysis combined with thematic map which created by visual interpretation of the satellite images, soil map of the studied area was generated to present soil properties (Zinck, 1988). In addition, to be as base map for the application of CORINE model.

CORINE model

The CORINE model is based on USLE (Universal Soil Loss Equation; Wischmeier, 1978) and developed by EC (European Communities). Geographical information systems (GIS) and CORINE model are used to detect soil erosion risk assessment and this play an important role in soil conservation planning.

An outline of the soil erosion model is shown in Fig. 2. As can be seen, assessments are carried out on a three point scale ranging from 1 (low) to 3 (high), with an additional class of 0 (no erosion) for areas (e.g. rock areas, settlement areas). As such, the model clearly represents a considerable simplification of the USLE. Results of using this technique provide sufficient discrimination to meet general policy needs. In particular, results allow the definition of areas of high erosion risk, where active measures to control soil erosion may be needed, and areas of low risk where agricultural practices probably present no threat.

Assessment of soil erosion risk is carried out in two steps. First, potential soil erosion risk is calculated by aggregating the indices of soil erodibility, rain erosivity and slope angle. This lead to indicate the inherent susceptibility of the land to erosion, irrespective of existing land use. Second, actual soil erosion risk refers to the estimated present risk, taking into consideration of current land use practice. This is calculated by including the vegetation cover index, to modify the estimated potential erosion risk.

The model thus involves the computation of four separate indices, which are then combined to get an assessment of erosion risk as follows :

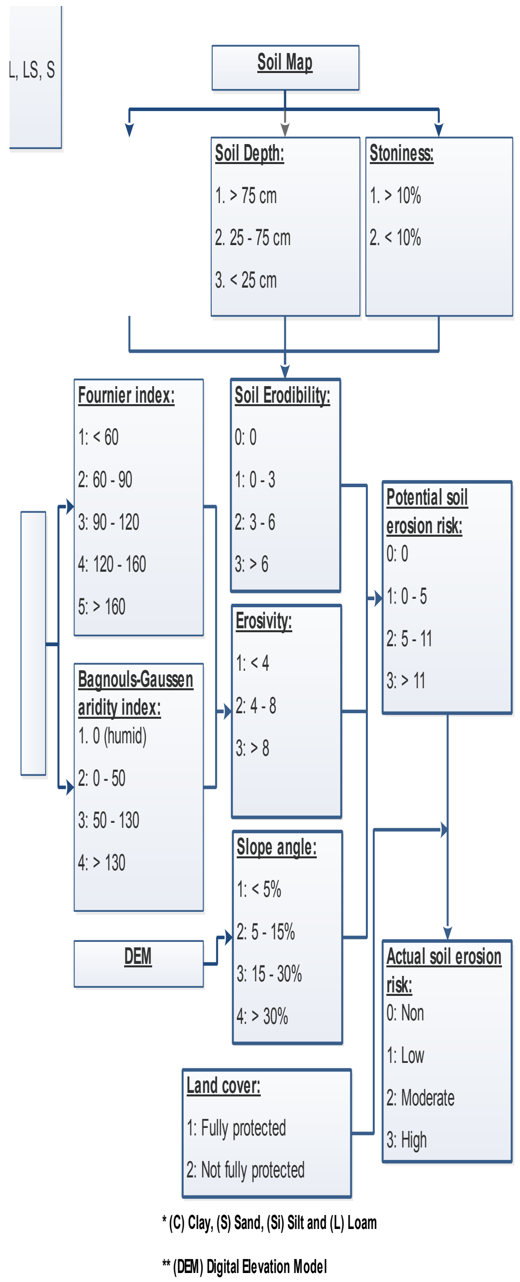

Fig. 2. Methodology for CORINE soil erosion assessment (CORINE, 1992)

Soil erodibility index

Soil erodibility refers to the susceptibility of the soil to erosion. Available data concerned the soil erodibility are texture, depth and the percentage of stones (Fig. 2 andTable 1). Table 1 showed that the texture data and soil depth were classified into three classes, while the soil stoniness refers to the percentage surface cover of stones was classified as two classes.

TABLE 1. Classes and assigned weighing indices for the various parameters used for assessment of soil erodibility (CORINE model)

Parameter	Classes	Index	Description
Soil texture	C, SC, SiC	1	Slightly erodible
	SCL, CL, SiCL, LS, S	2	Moderately erodible
	L, SiL, Si, SL	3	Highly erodible
Soil Depth (cm)	> 75	1	Slightly erodible
	25 to 75	2	Moderately erodible
	< 25	3	Highly erodible
Stoniness (%)	> 10	1	Fully protected
	< 25	2	Not fully protected

Soil erodibility is calculated as the product of these three attributes, as follows (CORINE, 1992):

Soil erodibility index = Soil Texture Index X Soil Depth Index X Stones Index.

The soil erodibility index is then scaled as follows (Table 2):

TABLE 2. Erodibility classes of CORINe model

Class	Description	Range
1	Low	> 0 to 3
2	Moderate	> 3 to 6
3	High	> 6

A soil erodibility index of 0 (no erosion) is assigned to areas (*e.g.* bare rock, settlement areas, water).

Rainfall erosion index (Erosivity Index)

The erosivity quantifies the effect of rainfall impact and also reflects the amount and rate of runoff likely to be associated with precipitation events. The rainfall and air temperature data were collected from 2008 -2014 from Meteorological station of Marsa Matrouh as shown in Table 3:

Erosivity is calculated by integrating two climatic indices including the modified Fournier index (FI) and Bagnouls-Gaussen aridity index (BGI) in CORINE model. Fournier index (FI) is computed according to the following equation, (Yuksel et al., 2008) :

$$FI = \sum_{i=1}^{12} \frac{Pi}{P}$$

where: (Pi) is the total precipitation in month (i) in (mm), and (P) is the total annual precipitation in (mm).

The index of Bagnouls-Gaussen (BGI) is calculated according to the following equation, (Yuksel et al., 2008) :

$$BGI = \sum_{i=1}^{12} (2ti - Pi)Ki$$

where : (ti) is the mean temperature for the month, (Pi) is the total precipitation for month, and (Ki) represents the proportion of the month during which (2ti – Pi) > 0.

Fournier index (FI) and index of Bagnouls-Gaussen (BGI) are classified as shown in (Table 4):

TABLE 3. Annual precipitation and average air temperature from 2008-2014

Year	2008	2009	2010	2011	2012	2013	2014
Precipitation	192.9	121.6	131.1	209.0	167.8	130.4	137.4
Temperature	22.13	21.81	22.92	21.84	22.26	20.62	20.94

TABLE 4. The ranks of Fournier and Bagnouls-Gaussen indices

Class	FI Range	FI Description	BGI Range	BGI Description
1	< 60	Very low	0	Humid
2	60 to 90	Low	> 0 to 50	Moist
3	> 90 to 120	Moderate	> 50 to 130	Dry
4	>120 to 160	High	>130	Very dry
5	>160	Very high		

Finally, erosivity index is determined by combining these two climatic indices as follows :
Erosivity index = FI X BGI

Erosivity index is classified as shown in (Table 5):

TABLE 5. Erosivity classes of Corine model

Class	Description	Range
1	Low	< 4
2	Moderate	4 to 8
3	High	> 8

Slop index

Slope layer was derived from the digital elevation model (DEM), and classified according to CORINE model to four classes depending on slope angle percentage as in the Table 6.

TABLE 6. Classes of slope percentage by CORINE model

Class	Slope Angle (%)	Classification
1	< 5	Gentle to flat
2	5 to15	Gentle
3	>15 to 30	Step
4	>30	Very steep

Land cover index

Land cover classes were obtained by classification process on satellite images of the studied area, and represented the different types of ground cover. According to CORINE model, land cover index was classified by the degree of protection of the soil into two classes: (1) fully protected, which includes forests, bodies of water, construction, roads and rocky Land. (2) Not fully protected which includes land crops and fruit trees.

Potential soil erosion risk (PSER):

As indicated in Fig. 1, the potential soil erosion index (PSER) is calculated as :

PSER = soil erodibility index X Erosivity index *X slope index*

This is classified into an erosion scale, ranging from 0 (no potential soil erosion risk – bare rock) to 3 (high erosion risk). This index influences by soil properties and climate and does not take into consideration the potential protective role of vegetation; it thus represents a 'worst possible case' scenario and can be interpreted as the erosion risk assuming the absence of any protective measures.

Actual soil erosion risk (ASER)

Actual soil erosion risk index is derived by modifying the estimated potential soil erosion risk index according to the vegetation cover as follows

Potential soil erosion risk index		Non 0	Low 1	Moderate 2	High 3
Land cover index	1	0	1	1	2
	2	0	1	2	3

Results and Discussion

Visual interpretation

Visual interpretation was done on false color composite of bands 5, 4, 3 of Landsat-8 imagery scale 1:50,000 to produce a base map for the field work activities and other purposes related to the present study. The visual analysis was based on the physiographic analysis methods according to Zinck (1988).

Digital elevation model (DEM)

DEM was created using geostatistical analysis. Geostatistical analysis was carried out at a two-steps procedure: (a) Calculations of the experimental semi-variogram and fitting a model. (b) Interpolation through ordinary Kriging, which uses the semi-variogram parameters (Stein, 1998). From the semi-variogram operation, it could be possible to define which model fit the experimental semi-variogram values. By calculating the goodness of fit and select of most fitted model, the model parameters of Kriging method could be applied

The estimated or predicted values are thus a linear combination of the input values, (Stein, 1998). Kriging can be seen as an interpolation point, which requires a map point as input, and it was used as the main technique for geostatistical analysis. The geomorphic mapping units were created based on the result of digital terrain model (DEM) as shown in Fig. 3.

Defining the soil classes of the studied area

Based on the classes of digital elevation model of the studies area, soil samples were collected from 10 soil profiles based on the morphological description. Results in Table 7 showed that, the gravels percentage ranged from 15 to 55%. The dominant soil textures are sandy loam and loamy sand in coarse valley and sandy out the coarse valley.

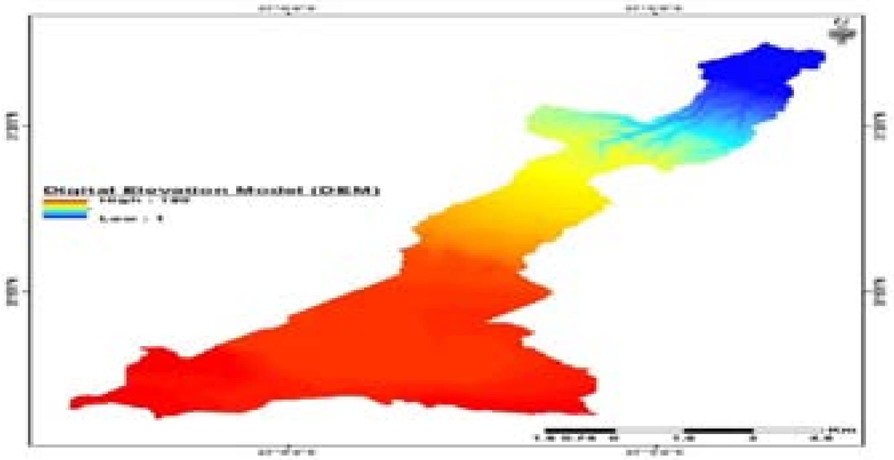

Fig. 3. Digital Elevation Model (DEM) map of the studied area.

The soils of this area have deep effective soil depth (100 -120 cm) in the coarse valley and shallow to moderate deep effective soil depth (50-90 cm) out the coarse valley. The EC values ranged from 4.3dS/m up to 7.6 dS/m with an average of 5.3 dS/m, therefore, this soil is moderately saline soils and the dominant salt is sodium chloride. The pH values ranged from 7.6 to 8.7 with an average of 8.3. The total content of calcium carbonate percentage ranged from 24.8 up to 37.1% with an average of 33.6%. These soils are moderately to strongly calcareous soils. The gypsum content percentage was low and ranged from 0.14 to 1.3% with an average of 0.35%. These soils classified as non-gypsiric soils. The organic matter percentage was very low and ranged from 0.06 to 0.24% with an average of 0.12%. The ground water depth is more than 150 cm, therefore, these soils were classified as very deep ground water.

According to the results of physical and chemical properties of the soil samples, soils of Wadi Maged basin was classified as shown in Fig. 4. and Table 8.

According to the results shown in Fig. 4 and Table 7, it was found that Typic Torripsamments was the dominant class in Wadi Maged basin where occupied an area of about 6309.7 ha. (71.2% of total area) and was represented by soil profiles 8, 9 and 10, while the minimum class of the basin was Lithic Torripsamments where occupied an area of about 492.7 ha. (5.5% of total area) and was represented by soil profile No. 7. Also present rock areas occupied an area of about 570 ha. (6.4% of total area) (Table 8).

TABLE 7. Physical and chemical properties of the studied soil profiles of Wadi Maged basin

Profile	Depth (cm)	pH	Gravels %	EC (dS/m)	Total Sand (%)	Silt (%)	Clay (%)	Texture	OM (%)	$CaCO_3$ (%)
P1	0-20	8.5	35	7.3	63.3	21.4	15.3	Sandy Loam	0.24	35.9
	20-45	8.4	30	7.6	65.0	22.9	12.1	Sandy Loam	0.21	37.1
	45-70	8.6	30	6.5	70.4	23.7	5.9	Sandy Loam	0.13	33.5
	70-120	8.5	55	5.5	75.7	19.9	4.4	Loamy Sand	0.10	33.8
P2	0-35	8.5	35	5.3	68.6	17.9	13.5	Sandy Loam	0.22	35.9
	35-65	8.4	45	5.5	68.9	19.3	11.8	Sandy Loam	0.13	35.7
	65-80	8.6	45	4.8	76.9	18.5	9.6	Sandy Loam	0.11	33.1
	80-120	8.1	45	5.4	77.7	18.7	3.6	Loamy Sand	0.09	34.0
P3	0-25	8.4	40	5.1	68.4	18.5	13.1	Sandy Loam	0.23	36.1
	25-50	8.6	45	5.7	69.5	18.8	11.7	Sandy Loam	0.20	35.3
	50-80	8.5	35	5.8	76.3	19.1	4.6	Loamy Sand	0.11	33.4
	80-120	8.4	25	5.5	77.4	18.6	4.0	Loamy Sand	0.08	34.9
P4	0-30	8.5	25	6.1	72.1	16.4	11.5	Sandy Loam	0.17	36.3
	30-65	8.7	30	5.9	72.6	16.7	10.7	Sandy Loam	0.11	30.5
	65-120	8.3	20	5.6	78.4	18.3	3.3	Loamy Sand	0.10	34.7
P5	0-35	8.2	15	5.3	75.9	15.5	8.6	Sandy Loam	0.13	35.5
	35-65	8.3	15	5.9	77.9	14.8	7.3	Loamy Sand	0.11	33.3
	65-100	8.1	10	5.0	79.6	17.3	3.5	Loamy Sand	0.10	34.9
P6	0-40	8.1	33	4.8	80.1	13.8	6.1	Loamy Sand	0.13	34.7
	40-70	8.3	41	4.5	80.9	15.6	3.5	Loamy Sand	0.09	33.5
	70-100	8	30	4.9	79.3	17.0	3.7	Loamy Sand	0.10	35.0
P7	0-15	7.6	35	4.3	92.0	6.3	1.7	Sandy	0.09	24.9
	15-45	7.9	40	4.5	91.0	7.5	1.5	Sandy	0.06	36.0
P8	0-40	7.8	20	4.3	83.0	11.1	5.9	Loamy Sand	0.11	35.6
	40-100	7.9	15	4.9	83.1	13.4	3.5	Loamy Sand	0.08	33.5
P9	0-20	8.4	33	4.6	89.1	8.0	3.5	Sandy	0.10	24.8
	20-50	8.5	35	4.3	90.2	7.3	2.5	Sandy	0.10	28.5
	50-90	8.5	25	4.9	89.7	7.5	2.8	Sandy	0.08	32.7
P10	0-25	8.7	30	5.0	88.3	7.9	3.8	Sandy	0.11	35.8
	25-55	8.6	25	4.3	88.7	8.3	3.0	Sandy	0.08	31.0
	55-90	8.3	15	4.4	90.6	7.1	2.3	Sandy	0.06	30.7

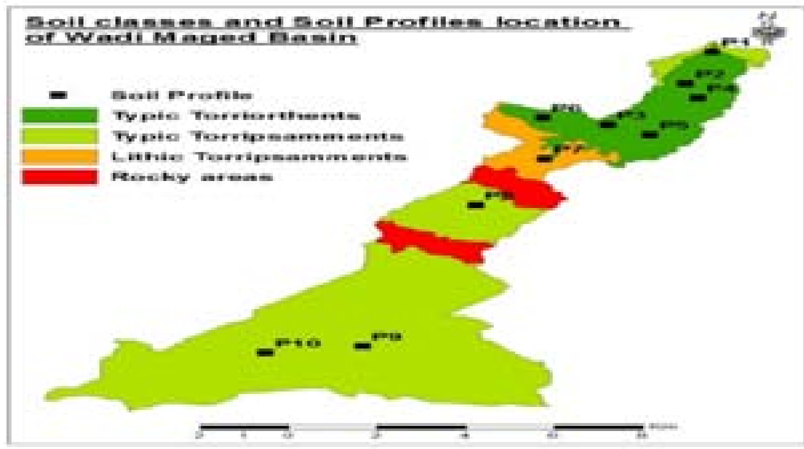

Fig. 4. Soils classes and soil profiles location of Wadi Maged basin

TABLE 8. Soil classifications units of Wadi Maged basin

Taxonomy units	Representative soil profiles No.	Area		
		Fed.	ha.	%
Typic Torriorthents	1, 2, 3, 4, 5, 6	3540	1486.8	16.8
Typic Torripsamments	8, 9, 10	15023	6309.7	71.2
Lithic Torripsamments	7	1173	492.7	5.6
Rocky areas	--	1358	570.4	6.4
Total		21094	8859.5	100.0

CORINE model and Remote sensing and GIS integration

The CORINE model was used in integration with remote sensing and Geographic information system (GIS) techniques to produce soil erodibility, erosivity, slope angle and surface cover maps as essential database for evaluating actual and potential erosion risk.

Soil erodibility

a. Soil texture:

In terms of soil texture, silty, very fine sand, and clay soils tend to be less erodible than sand, sandy loam, and loamy soils (CORINE, 1992). The less erodible soils are regarded as being of inherently low erodibility due to their high cohesiveness. In contrast, the highly erodible soils are typically lack cohesiveness and have low structural stability whilst still permitting significant overland flow. Texture of Wadi Maged basin was classified as shown in Fig. 5 and Table 9.

Results in Fig. 5. and Table 9. recorded that, About 6630.9 ha (about 74.8% of the studied area) are moderate erodible (texture index = 2) which characterized as a soil medium resistance to erosion (Corbane et al.,2008), where texture classes are sandy and loamy sand. While about 1658.3 ha (about 18.7% of the studied area) are high erodible (texture index = 3) which characterized as a high soils resistance to erosion, where texture class is sandy loam.

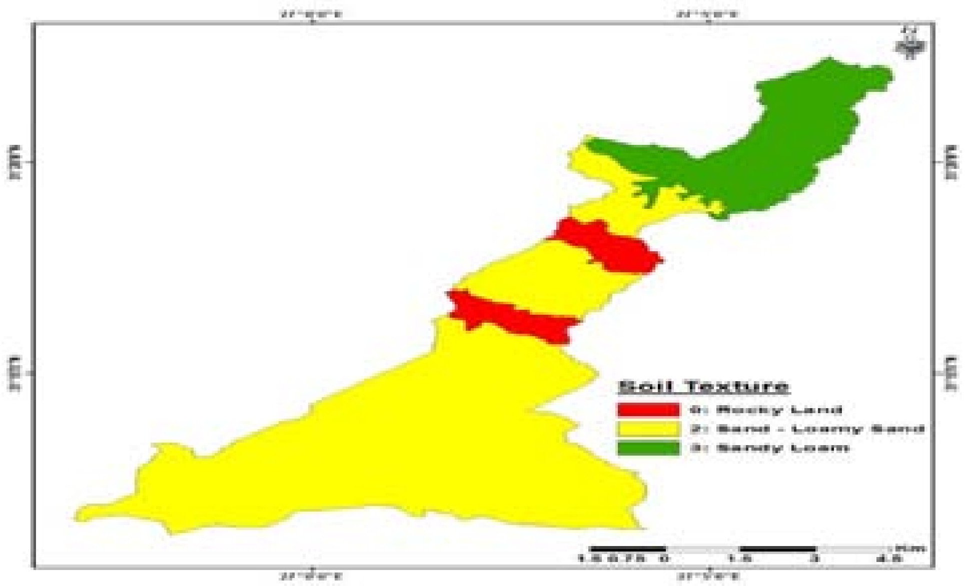

Fig. 5. Soil texture map of the study area

TABLE 9. Soil texture classes of the study area

Texture Class	Area (ha)	Area (fed)	%
0 (No erodible)	570.3	1357.9	6.4
2 (Moderate erodible)	6630.9	15787.8	74.8
3 (Highly erodible)	1658.3	3948.3	18.7
Total Area	**8859.5**	**21094.0**	**100.0**

b. Soil depth:

Soil depth is assumed an important factor in soil erodibility for two reasons. Firstly, deep soils typically absorb and hold larger volumes of water than shallow soils, and thereby generate overland flow less readily. Secondly, soil loss tends to be less damaging in deep soils because of their greater tolerance to erosion. Results in Fig. 6 and Table 10 recorded that, about 7796.3 ha (about 88.0% of the studied area) have depth >75 cm (low susceptibility to erosion). This area has higher water holding capacity, and thus is able to absorb larger rainfall amounts before overland flow is generated. About 496.1 ha (5.6% of the studied area) have depth 25-75 cm (medium susceptibility to erosion) and 567.0 ha (about 6.4% of the studied area) have depth <5 cm (severe soil erosion susceptibility). Erosion of deep soils is considered less problematic because of their greater tolerance to erosion (CORINE, 1992).

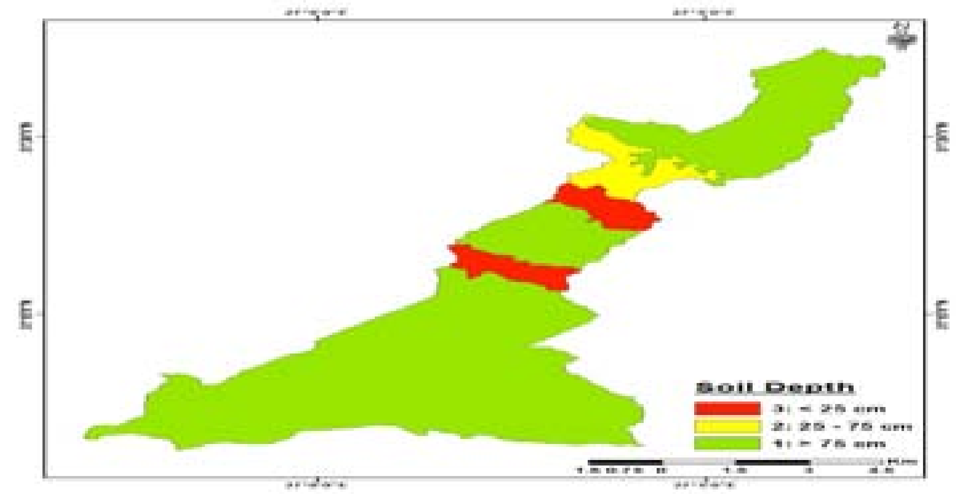

Fig. 6. Soil depth map of the study area

TABLE 10. Depth classes of the study area

Depth Class	Area (ha)	Area (fed)	%
1	7796.3	18562.7	88.0
2	496.1	1181.3	5.6
3	567.0	1350.0	6.4
Total Area	**8859.5**	**21094.0**	**100.0**

c. Stoniness:

Data of soil stoniness as shown in Table 6 revealed that a percentage of stones of soil profiles were more than 10%. These soils with coverage of more than 10% are providing full protection of the soil. However, Yuksel et al. (2008) reported that surface cover of stones may protect the soil from rain splash but after surface runoff is initiated, existence of stones might cause adverse effects by encouraging rill erosion through water turbulences.

d. Soil erodibility index:

Soil erodibility refers to the susceptibility of the soil to erosion. General level, this depends primarily on its resistance to particle detachment by rain splash or runoff and on its ability to absorb rainfall. The erodibility index was calculated and classified as shown in Fig. 7. Soil erodibility classified into no erosion, low and moderate erosion. The distribution of the areas with soil erodibility classes is given in Table 11.

Results indicated that 7796.3 ha (about 88.0% of the studied area) have low erodibility and 496.1 ha (about 5.6% of the studied area) have moderate erodibility. It is noticed that the moderate erodibilty is associated with soil depth of 25-75 cm. Results also showed that 6.4% of the studied area is located within the first class, where the value of the index indicated susceptibility of soil to no erosion.

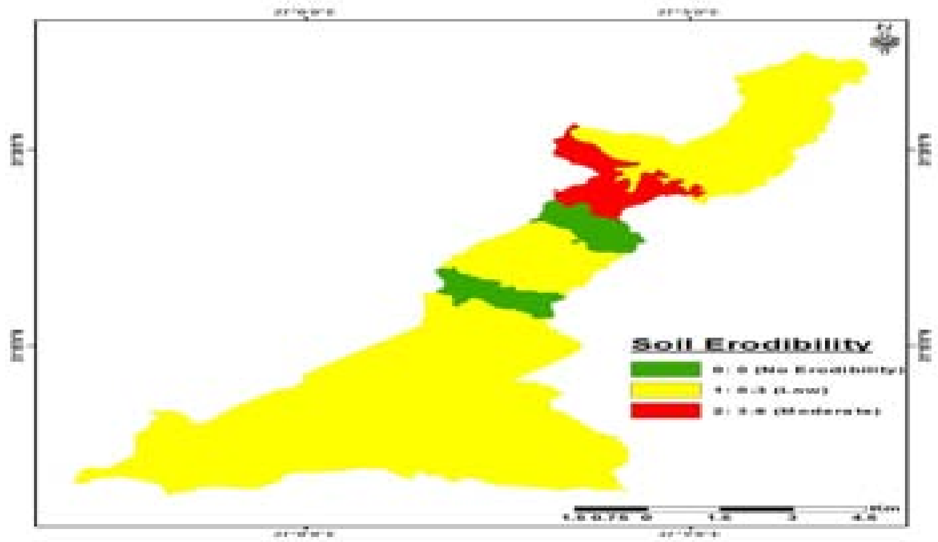

Fig. 7. Soil erodibility map of the study area

TABLE 11. Soil erodibility classes of the study area

Soil erodibility class	Area (ha)	Area (fed)	%
0	567.0	1350.0	6.4
1	7796.3	18562.7	88.0
2	496.1	1181.3	5.6
Total Area	**8859.5**	**21094.0**	**100.0**

Erosivity index (EI)

The erosivity quantifies the effect of rainfall impact and also reflects the amount and rate of runoff likely to be associated with precipitation events. Meteorological data were used to calculate the erosivity index for the study area as shown in Table 12.

Results showed that Fournier index values ranged from 18.10 to 50.11 with a mean value of 31.62 which located within the first class. Values of the Bagnouls-Gaussen index ranged between 41.08 to 112.51 with a mean value of 66.27 located within the three class according to CORINE model. The erosivity index value of the whole studied area is equal to 3 which is within

the class one that indicates low rainfall erosion index. This study indicated that environmental system is generally influenced by small changes in climate.

TABLE 12. Rainfall erosivity index, Forner and Bagnouls-Gaussen indices for the years 2008-2014

Year	Index	
	(FI)	(BGI)
2008	50.11	112.51
2009	18.10	43.57
2010	30.36	53.78
2011	35.85	74.40
2012	32.25	73.87
2013	32.51	64.71
2014	22.19	41.08
average	**31.62**	**66.27**
Class	**1**	**3**

Slope degree

Slope is an important factor influencing overland flow generation and has an important influence on controlling erosion rates due to its effect on the rate of runoff and the amount of water infiltration in the soil (Dragut and Eisank, 2012). Erosion only occurs when slope exceeds a critical angle and it increases with the absence of vegetation cover. Moreover, it has also significant effect on the net rain excess, the flow velocity, and shear stress (Liu et al., 2001). According to CORINE (1992), slope degrees were categorized into four sub-slope groups, these slope groups are presented in Fig. 7. and Table 13.

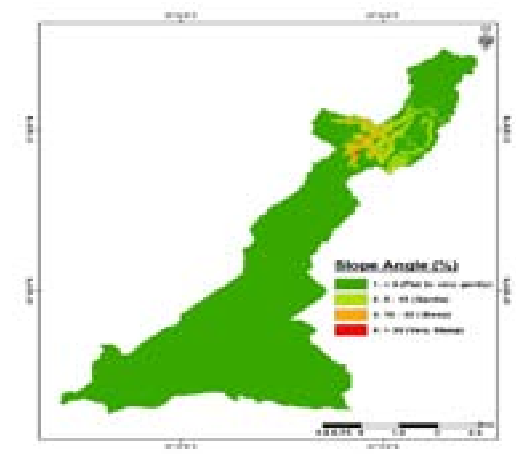

Fig. 8. Slope degrees map of the study area

TABLE 13. Slope classes and its distribution of the study area

Slope Class	Area (ha)	Area (fed)	%
1	8345.6	19870.5	94.2
2	389.8	928.1	4.4
3	115.2	274.2	1.3
4	8.9	21.1	0.1
Total Area	**8859.5**	**21094.0**	**100.0**

It can be seen that about 8345.6 ha (about 94.2% of the studied area) have less than 5 % slope angle (class 1) and 389.8 hectare (about 4.4% of the studied area) have 5-15% slope angle (class 2) whereas, 115.2 ha. and 8.9 ha. are varying from steep to very steep which is subjected to high erosion rate.

Land cover index

Land cover is one of the most important factors in the soil erosion risk assessment. Soil erosion accelerates due to inappropriate land uses. The vegetative cover and land use conventions of the study site have been detected by visual Interpretation and field work and digitized of LANDSAT-8 satellite images within GIS environment. Figure 9. and Table 14. show land cover distribution of the studied area as follows:

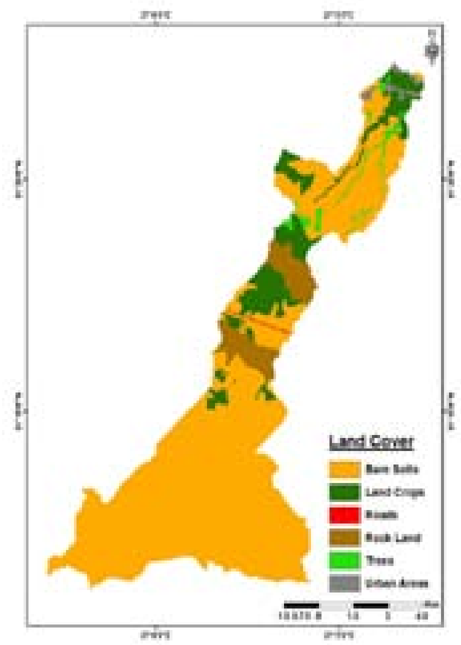

Fig. 9. Land cover map of the study area

TABLE 14. Land covers distribution of the study area

Land Cover Class	Area (ha)	Area (fed)	%
Land Crops	996.8	2373.2	11.3
Trees	154.4	367.7	1.7
Settlement areas	81.4	193.9	0.9
Roads	12.6	30.0	0.1
Bare Soils	7044.2	16771.8	79.5
Rock Land	570.1	1357.3	6.4
Total Area	**8859.5**	**21094.0**	**100.0**

From the previous results most of the study area is bare soils with a distribution of 79.5 % of the study area. Land crops and trees occupy 1151.2 ha., about 13.0% of the study area. The settlement areas and roads are covered a small areas (0.9% and 0.1%, respectively). The settlement areas and roads together occupy 94 ha. of the study area (1.06%).

Results showed that the areas that classified as non protected areas covered by 8195.4 ha (about 92.5% of the studied area), whereas, the full protected areas covered 664.1 ha (about 7.5% of the studied area)

Potential soil erosion risk

The potential soil erosion risk (PSER) represents the possible situation of soil erosion risk. It shows the inherent risk of soil erosion on the basis of the physical environmental conditions, independently of current land use. The data of potential soil erosion risk PSER, Fig.10 and Table 15 showed that the area exposed to potential erosion risk occupied the largest area found in the map, whereas, the areas with little danger erosion risk occupy a small areas.

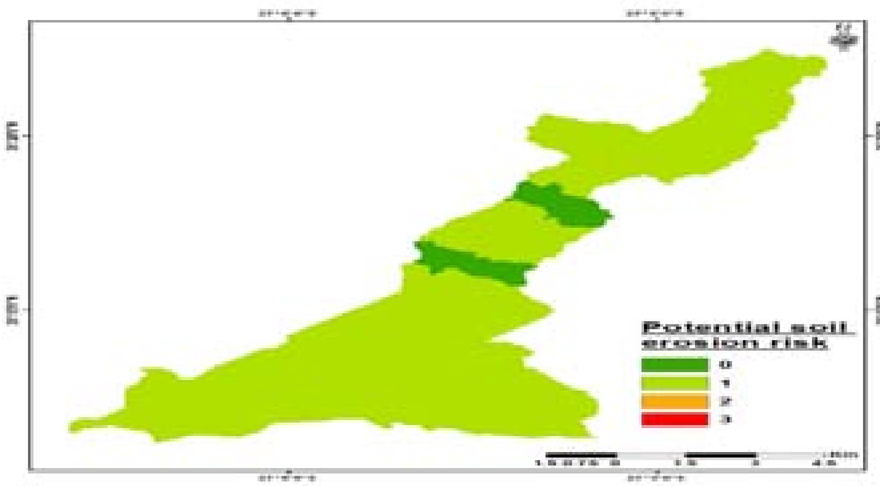

Fig. 10. Potential soil erosion risk of the study area

TABLE 15. Potential soil erosion risk classes of the study area

Potential soil erosion risk class	Area (ha)	Area (fed)	%
0	570.1	1357.4	6.4
1	8279.3	19712.5	93.5
2	9.9	23.6	0.1
3	0.2	0.4	0.0
Total Area	**8859.5**	**21094.0**	**100.0**

Actual soil erosion risk

Actual soil erosion risk is more related to the current risk of erosion under current vegetation and land use conditions. Results of ASER, Fig. 11 showed that 7044.2 ha. of the studied area are exposed to actual erosion risk and classified as moderate erosion risk. The area that has no actual erosion risk covers about 1815.3 ha (around 20.49% of the studied area). The areas exposed to ASER are less than the PSER areas. Land use changes influenced actual erosion risks. This is due to the role of land cover in increasing soil protection of the studied area. When the land cover was taken into account, soil erosion risk decreased. Soil erosion may be a slow process that continues relatively unnoticed, or it may occur at an alarming rate causing serious loss of top soil. Therefore, it is important to predict actual and potential soil erosion risk in order to adopt suitable soil erosion prevention measures. These results also indicated that it is possible and practical to quantitatively assess and predict soil erosion risk at the regional scale for efficient planning of conservation programs.

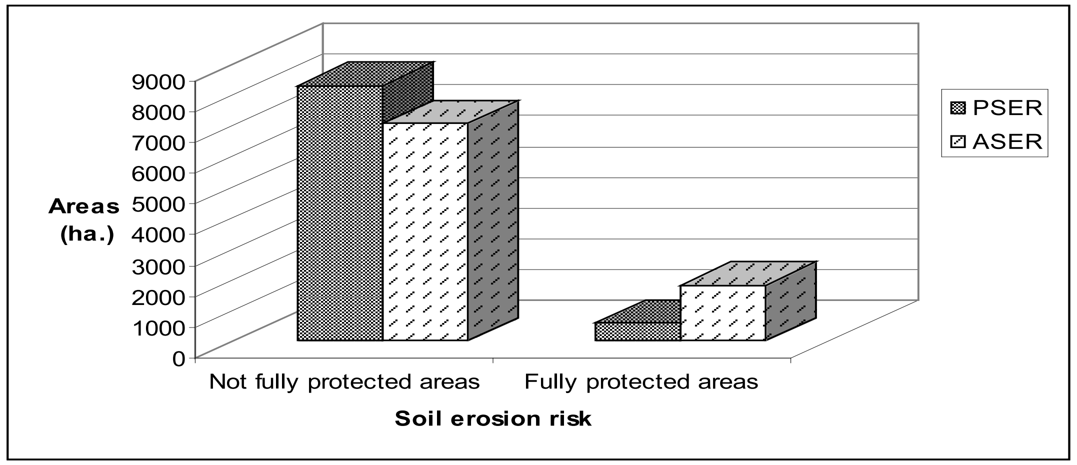

Fig. 11. Potential and actual soil erosion risk of the study area

Conclusions

1. This study demonstrated that the study area is under low-moderate erosion risk level. Therefore, these areas need good management practices for effective erosion control.

2. It is necessary to use the recent techniques of remote sensing, geographic information system and modeling in detecting and monitoring the qualitative and quantitative soil erosion process and its risk.

3. Following these recent techniques in this application in other regions differentiated in terms of soil, vegetation, and climatic conditions could help in avoiding land degradation process.

4. It should be having a data concerning soil erosion when it is planning to land use new areas in basin, wadies and valleys as it facilitate and accelerate the development of strategies and take actions necessary.

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(*Received:* 20/12/2015;
accepted : 10/1/2016)

تقييم مخاطر إنجراف التربة فى حوض وادى ماجد بالساحل الشمالى الغربى– مصر بإستخدام نموذج CORINE ونظم المعلومات الجغرافية

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إنجراف التربة من التهديدات الرئيسية في الحفاظ على التربة والموارد المائية لذلك فإن الهدف الرئيسي من هذه الدراسة هو تحديد المخاطر المحتملة لتآكل وانجراف التربة(PSER) والمخاطر الفعلية لأنجراف التربة (ASER) بحوض وادي ماجد. بإستخدام نظم المعلومات الجغرافية ونموذجCORINE . وقد تم تقديرالعوامل الرئيسية لأنجراف التربة وتشمل vegetation cover. ، topography ، erosivity ،erodibility فى البداية خرائط قوام التربة، وعمق التربة، حصوية السطح تم إنشائها حيث تتقاطع هذه الخرائط في بيئة نظم المعلومات الجغرافية من أجل انشاء خريطة للـ erodibility. مؤشرات Fournier لهطول الأمطار ومؤشرات الجفاف لـ Bagnouls- Gaussen يتم تحديدها استنادا إلى بيانات الأرصاد الجوية ومنها يتم حساب الـ erosivity . تم جمع كل من خريطة erodibility مع erosivity وخريطة الانحدار لإنشاء خريطة الاحتمالات لخطر التآكل (PSER). وكشفت النتائج أن حوالي ٥٧٠,١هكتار من المساحة المدروسة غير معرضة للنحر و٨٢٧٩,٠ هكتار و ١٠,٠ هكتار بمنطقة الدراسة معرضة لأنجراف قليل وإنجراف متوسط بينما مساحة ٠,٢ هكتار معرضة لأنجراف شديد وتوجد فى شمال المنطقة المدروسة. أظهرت نتائج الأنجراف الفعلى أن المساحات المعرضة لخطر فعلى لانجراف التربة كانت أقل من تلك المعرضة لخطر محتمل (٧٠٤٤,٢ هكتار) . بدرجة منخفضة ومتوسطة على التوالي. وان هناك جزء صغير من منطقة الدراسة (٠,٢ هكتار) في الشمال به خطر فعلى لانجراف التربة بدرجة عالية. أيضا كشفت النتائج ان مساحات اقسام الخطر الفعلى لانجراف التربة متطابقة مع مساحات اقسام الخطر المحتمل لانجراف التربة. وذلك يعزى الى ان الغطاء الارضى السائد بمنطقة الدراسة لا يغطى المنطقة تماما وبذلك فهو لا يلعب اى دور في زيادة الحماية للتربة من الانجراف بمنطقة الدراسة.