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Study of soil erosion risk in the basin of Northern Al-Kabeer river at Lattakia-Syria using remote sensing and GIS techniques

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Abstract - Soil erosion is the most important challenge for agriculture presently on the Syrian coast, especially in areas close to rivers and lakes. This study is to produce a soil erosion risk map based on the COoRdination of Information on the Environment (CORINE) model for the Northern Al-Kabeer River, Lattakia Province. To achieve this objective, the first phase of the study evaluated the soil erosion potential, by estimating soil texture, soil depth and granulometry. Soil was classified according to its erosion potential. A soil erosion potential map was obtained from data on soil erodibility, erosivity and slope. A land cover map of the study area was produced and classified into two classes according to soil protection. A risk map of soil erosion was prepared from information on land cover and potential risk erosion classes obtained previously. The results showed that 2.47% of the study area is in high risk soil erosion areas, 22.18% in moderate risk areas, and 75.35% in low risk areas. The high risk erosion areas were mainly located in the center and northern location within the study area. This study also confirms that land cover is the highest determinant of soil erosion. Land cover accounted for 60.93% of the erosion risk.

Keywords: Risk Water Erosion, Geographic Information System, Al-Kabeer Northeren River, CORINE Methodology.

Introduction

Soil erosion is due to an interplay between soil erodability and erosivity (Kertesz and Gergely, 2011). Erosion is one of the most important environmental problems in agriculture because it causes the loss soil nutrients (N, P, K), lowering agricultural production (Tingting *et al.*, 2008). Also works on the pollution of water bodies as the outputs of soil erosion up to aquariums closed and caused the phenomenon of eutrophication (Eutrophication) deprives so it's vital importance and economic (Schiettecatte *et al.*, 2008).

As a result, leading to the loss of the most important exporters two water and soil which are essential for the continuation of human and, due to soil erosion processes which are fast, unlike soil formation processes which are very slowly.

There are many factors affecting the water erosion of the soil in Syria in general and the Syrian coast in particular (UNEP, 2004). That most notably are the rain, the decline of soil and vegetation, so locating dangerous drift and evaluation is important and necessary. In order to develop appropriate strategies for soil and water conservation.

The identification of areas of the seriousness of water erosion methods throughout traditional estimating quantities of soil lost is difficult and is not possible in areas with large spaces and differentiated terrain, and it needs to make a lot of efforts and exchange huge amounts (Zhang *et al*., 2010; Ren *et al*., 2011), which requires alternative methods and fast help identify threatened areas drift in order to accelerate the adoption of appropriate measures to reduce degradation processes, such as the use of some experimental models that rely on measuring factors drift locally as an erosion rain, worker susceptibility of soil to erosion, factor terrain factor vegetation, which gave good results faster and less expensive when used with remote sensing techniques and geographic information systems (Prasanna *et al*., 2013), remote sensing and GIS techniques is one of the tools actors in the process of studying the vegetation and monitor the changes that defects during different periods of time (Ahmad and Verma, 2013).

They were help access to spatial database and wide to identify areas at risk of water erosion, and were able to determine the rate of deterioration and the development of strategies and plans necessary for the maintenance of those areas soils (Sakthivel *et al*., 2011).

Using a lot of models in determining the seriousness of the drift depending on the techniques of remote sensing and geographic information systems, which will be predication the risk of soil erosion and determine the spatial distribution has (Aydin and Tecimen, 2010). So in this work will adopt in our study on one of these models, a model coordinate information environment (CORINE: COoRdination of Information Environment), according to the studied area.

Importance at this study and its objectives:

Leading factors causing erosion in the Great Northern river basin (human activity, and precipitation, high terrain corrugated and steep) to loss the agricultural soils and the soil process degradation characteristics (Al-khasobeh, low production capacity, and that the arrival of the outputs of the drift to the river) leads to the contamination of water basin and lowered the value of bio and agricultural.

There is difficulty of identifying areas of dangerous drift by estimating the amount of soil lost in this area because of the large area of the hand, and Oaourtha hand, Requires the use of modern technologies Kniz geographic information (GIS) to identify and assess the seriousness of the drift so that the foundation stone at the development of the necessary procedures for soil conservation and the reduction of erosion, where the aim of this study to:

1-Determine the risk of soil erosion.

2-Spatially distributed in the pelvic area.

3-the Near East to the Grand river in the north of Latakia, by applying the on the COREIN model.

Materials and Methods

Study area:

The study was conducted in the basin river near and middle river great Northern in the province of Latakia (Syria), which is one of the largest coastal rivers. Which it stems from the northern end of the Western mountains of Latakia, specifically from high located at the Turkish border and which known mountains Ansari northern province of Latakia. The study covers an area of 430.43 km^2, where is the vegetation with the following components (agriculture field-forests-groves of citrus and olive trees and other fruits), as shown in Figure (1)

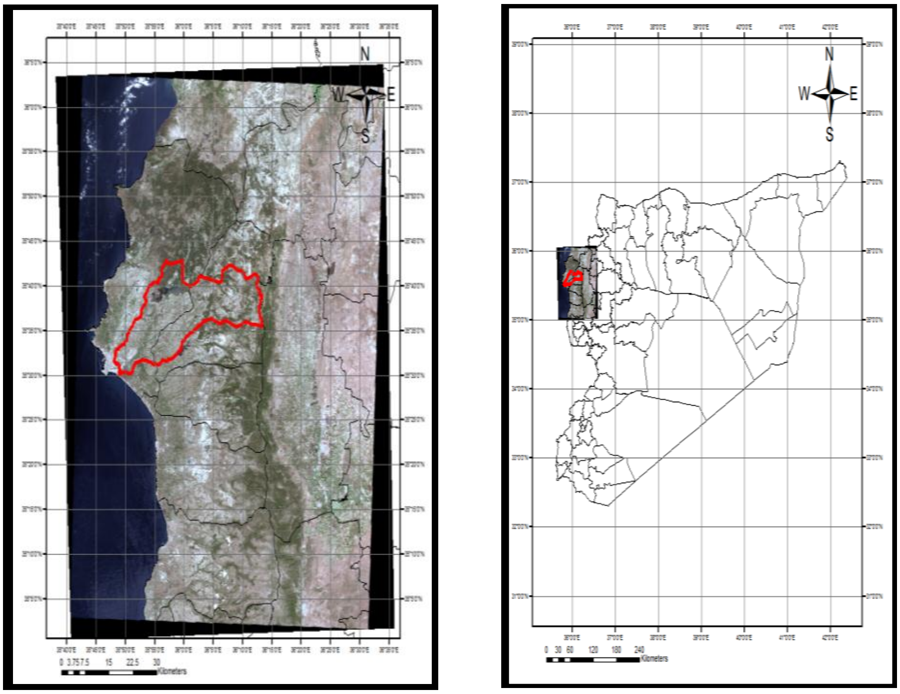

Figure 1. (a) Location of the study area on the map of Syria (b) province of Latakia

Soil sampling:

One hundred soil samples from sites were collected randomly from the study area form (2), as it took which have been taken samples at each of the 5 points form with each other an envelope mailed equilateral along the diameter of 22:00 at a depths of 0-10 cm, formed including soil sample vehicle, transported to the laboratory, and removed the roots and plant residues and dried an aerobically and Sieved diameter of 2 mm sieve to get the soft soil and then conducted some tests of physical and chemical laboratories in the College of Agriculture at the University of October.

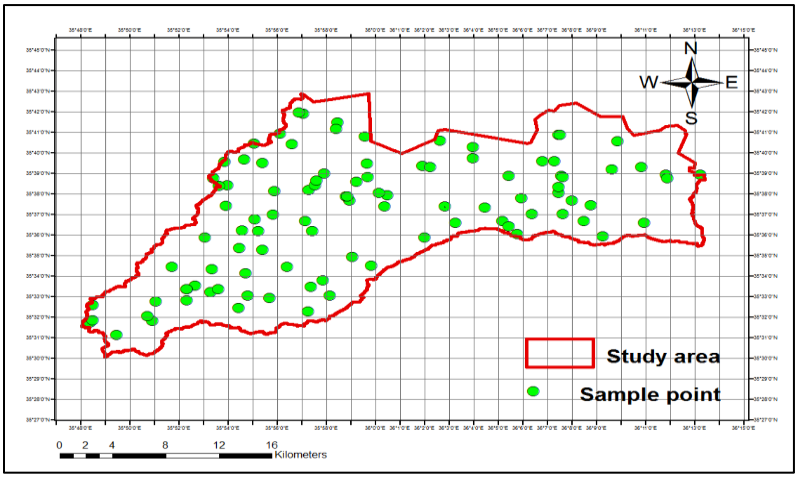

Figure 2. Map showing points of collection of soil samples in the study area.

Was performed mechanical analysis of the soil using at hydrometers method, and determine the Texture of the soil using the triangle textures by American classification (USDA), were identified as the percentage of coverage of the surface with gravel by taking an area of 13:00 2 from the sample and then measuring the coverage ratio with gravel, and measured the depth of the soil through using a metal rod runway was planted in the soil at the center of the sample, the sampling sites were identified using a global Positioning system (GPS: Global Position System).

Climate data has been collected monthly of precipitation and temperature from the meteorological station at (Mouthpiece) for ten years (2001-2011), where values ranged between average annual rainfall (550-1006) mm, while the values ranged between monthly average temperature (12 -28) °C.

Corinne model. (CORINE: COoRdination of information on the Environment) was applied to assess the risk of water erosion of the soil using a Corinne model, some of the factors are affecting the drift such as: the portability factor of soil erosion, rainfall erosion factor, factor inclination and vegetation factor, which calculated from previous indicators as follows :

1-Soil Erodibility Index:

Affected index susceptibility of soil to erosion each of the (soil texture, depth and percentage of coverage of the surface with gravel), as classified by the strength of the soil to four rows deep in three rows, while the percentage of coverage of the surface with gravel are classified in two rows (Table 1), and calculates the index susceptibility soil erosion, according to the following equation:

Index susceptibility to soil erosion, = Soil Texture * Soil Depth * Percentage of Stones Covered.

Table 1. The ranks of each type of textures, depth and vulnerability index for soil erosion by CORINE (Aydin and Tecimen, 2010).

Class	Soil Texture	Stones Class	(cm)	Erodibility
0	Rock Land.	-	-	0
1	Low Erodibility Soil (Clay-Sandy Clay-Silty Clay).	<10%	75>	0-3
2	Moderatly Erodibility Soil (Sandy Clay Lome-Clay Lome-Silty Clay Lome-Lome Sand-Sandy).	>10%	25-75	3-6
3	High Erodibility Soil (Lome-Silty Lome-Silty-Sandy Lome).	-	25<	>6

2-Rainfall erosion index (Erosivity Index):

Index was calculated based on the rainfall erosion of all Station Fournier Index (FI) and (BGI: Bagnouls-Gaussen Index) is calculated as rainfall erosion index using the following relationship:

Rainfall erosion index = index Fournier row * row index Bagnold-Gawsn

The index is calculated Fournier (FI) according to the following equation:

$$FI = \sum_{i=1}^{12} \frac{P_i^2}{P} \qquad \text{(Yuksel \textit{et al.}, 2008)}$$

Where:

pi: the amount of monthly precipitation in (mm).

P: Total annual rainfall in (mm).

The index of Bagnold-Gawsn (BGI) is calculated according to the following equation.

$$BGI = \sum_{i=1}^{12}(2t_i - P_i)K_i \qquad \text{(Yuksel \textit{et al.}, 2008)}$$

Where:

ti: Average monthly temperature (degrees Celsius).

Ki: calculated value when 2ti-pi> 0, Where (Ki) factor was calculated by the relationship (Ki = 2ti-pi), which is calculated when 2ti-pi> 0 and neglect If this ratio is less zero.

Index has been divided into five rows FI index and BGI to four rows, while the erosion index was divided into three rows as in the following table.

Table 2. Values and the ranks of both index and index Fournier Bagnold-Gawsn, and rainfall erosion index by model CORINE (Aydin and Tecimen, 2010).

Class	FI	Classification	BGI	Classification	Erosivity	Classification
1	< 60	Very low	0	Humid	<4	Low
2	60- 90	Low	0- 50	Moist	4 -8	Moderate
3	90-120	Moderate	50 -130	Dry	>8	High
4	120-160	High	>130	Very Dry		
5	>160	Very High				

3-Slop Index:

Determines the degree inclination using digital elevation model (DEM): Which been obtained from the Public Authority for Remote Sensing (GORS) in the patient, has been manufacturing DEM in 2011 from the image accurately ester 30 m. Were divided depending on the degree of inclination model CORINE to four rows in the table as (5).

Table 3. values and the Classes of Slope degree by CORINE model.

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

4-Potential Soil Erosion Risk:

The Potential Soil Erosion Risk was determined by applying the follow equation:

The potential Soil Erosion Risk index = Soil Erodibility map * Erosivity index * Slope Map

Was divided potential risk of erosion into four types, there is no danger (0), low (0-5), average (5-11) and high (> 11).

5-Land Cover:

It obtained on the map represent the different types of ground cover in the study area and using a satellite image of the type (Landsat TM) taken on 08/28/2011, was rated among the coverage of ground in this map represented by the degree of protection of the soil and in accordance with the model Corinne to two rows: (1) full protection (Fully Protected) It includes forests, bodies of water, construction, roads and rocky Land. (2) Protection of incomplete (Not Fully Protected) which includes land crops and fruit trees in addition to the land of olive and citrus.

6-Actual Soil Erosion Risk:

Actual risk was calculated for each point of the soil samples by selecting a row the potential erosion risk, and then determine the type of ground cover and the actual risk is calculated for each point of law the following:

Actual Soil erosion Risk = Potential Soil Erosion Risk map x Vegetation map

The class of the actual risk of erosion into three ranks of low, medium and high.

Mapping:

ArcGIS10 program was used to get the maps required for each of the indicators except for the previous rainfall erosion index. Where to get maps of soil properties (soil texture, soil depth, percentage of gravel cover) by applying the logarithm of Kriging on samples collected Haklaa. Expresses this logarithm process statistical geography allows estimating a surface depending on the values of a set of points distributed (samples) on this surface and actress for a particular phenomenon, and supports its core principle on the theory of variable-site The Regionalized Variable Theory which assumes that the change phenomenon represented by a set of samples. Raster distributed on a surface according to the place shall be homogeneous from a statistical standpoint across the surface, as was the distribution of traits of the soil of the strength and depth of the coverage in areas with gravel samples over the entire study area. In a later step maps has been used three representing characteristics of the soil to get on the map of soil susceptibility to erosion. As this map that represents the product of the maps of the three above-mentioned among them.

Was then preparing a map of the tendency that has been obtained using a digital elevation model (DEM) 30 m pixel accuracy. We subsequently prepare a map of the inherent risk of erosion by multiplying the process to my map susceptibility to soil erosion and tilt with the value of the index factor rainfall according to the above equation.

At a later stage, it have been prepared Coverage Map Land cover for ground study site basing on the satellite image of the moon Landsat TM taken on August 28, 2011, through the application of technology Category observer Supervised Classification mentioned on image using the program ERDASI magine 8.4. Been dropping 75 sample field on the satellite image in order to identify areas of training (Training Zones), which used to collect spectral information representing various types of ground cover the study area, After the completion of the configuration file spectroscopy has been performed classification process observer using the logarithm of the probability-Azam (Maximum Likelihood). Coverage was ground in the resulting image classification process through the ranks 5: (1) Forests, (2) Bodies of Water, (3) Construction-Methods-land rocky, (4) crops-fruit trees, (5) Citrus-Olive, are then testing the accuracy of the classification process by using a matrix error (Error Matrix). We eventually reclassified coverage map land resulting from the classification process according to the model Corinne into two rows:(1) full protection (Fully Protected) It includes forests and water bodies, construction, roads, Altkchwet rock, and (2) the protection of non-full (Not Fully Protected), which includes land crops and fruit trees (Kaltvahiat and almonds ... etc.) in addition to the land of olive and citrus.

In the final stage, it have been prepared map of the actual risk of water erosion of the soil in the study area in accordance with the model Corinne through the process of multiplying the map to the inherent risk of erosion with map coverage of land reclassified into two rows by the degree of protection of the soil.

Results and Discussion

Soil Erodibility Index:

Soil Texture:

The soils Celtic textures and fine sandy loam and more resistant to erosion of sandy soils and sandy Allomah and Allomah (Corbane *et al*.,.2008). It has been observed that 37.52% of the studied soils with the strength of (C, SC, SiC), which is characterized as resistant severe erosion, while 35.81% of the soils strength (SCL, CL, SiCL, LS), a soil medium resistance to erosion, and 26.67% of the strength of soils (L, SiL, SL), a light soils resistance to erosion. Figure (3) varieties strength of soils and their distribution within the study area.

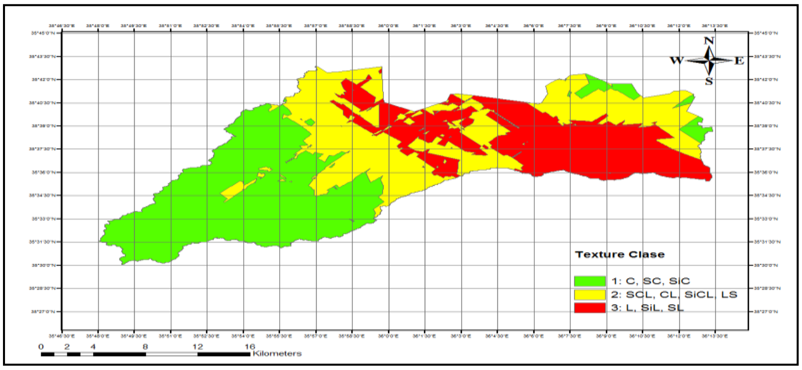

Figure 3. Soil texture map of the study area.

Soil Depth:

As the depth of the soil increased the ability to absorb rain water and the amount of water runoff and therefore less soil loss (Marina and Febles, 2008) Results showed that 44.40% of the soil with a depth of more than 75 cm low susceptibility to erosion, 39% of the studied soils with a depth of between 25-70 cm were classified as medium susceptibility to erosion, while the percentage of severe soil erosion susceptibility to 16.16% with a depth of less than 25 cm (Fig. 4).

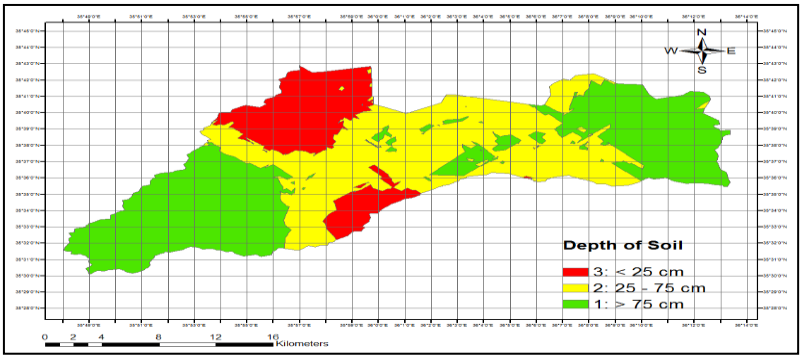

Figure 4. Map the ranks of the depth of the soil in the study area

Soil Surface Coverage with Stoness:

The presence of gravel over the surface of the soil can be a factor to protect the soil from rain drops act (Yuksel *et al*., 2008). It has been found that 41.31% of the studied soils with superficial coverage of more than 10%, providing full protection of the soil while the percentage of soil surface coverage of less than 10%, which provides full protection is 58.69% of the study area (Fig. 5).

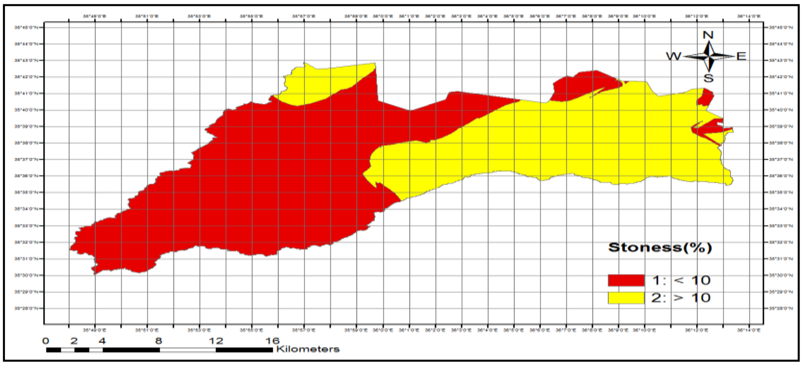

Figure 5. Map ranks the coverage of the surface of the soil with gravel in the study area.

Soil Erodibility:

It has been prepared map susceptibility of soils to erosion by multiplying the ranks of both the soil texture, depth and percentage of coverage of the surface with Stoness which as previously stated in the procedure, and is shown in Figure (6) index susceptibility of soil erosion at the study area.

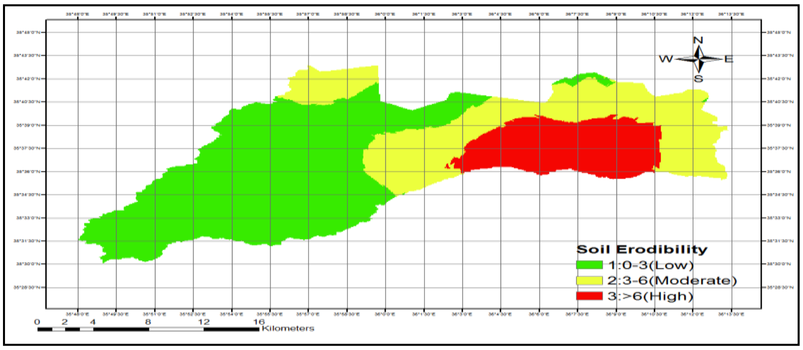

Figure 6. Erodibility map of the study area.

It has been shown from the previous figure that 53.41 % of the land area studied was the index usability of erosion is located within the first row , where the value of the index susceptibility of soil to erosion ranged between (0-3) any high scalability little drift, while the value of the index ranged between (3-6) at about 30.45 % of the area studied and therefore it located within the second row, a high susceptibility medium to drift, while the remaining percentage of the area of the study area 16.14% fall within the third grade and were of a high affinity for the drift where the Erodibility index is >6.

Slope Degrees:

The tendency of the most important factors causing soil erosion, due to its effect on the rate of runoff and the amount of water infiltration on the soil (Dragut and Eisank, 2012). Has been getting on the map tendency using digital model of the rise has been classified into four classes according to CORINE, as the percentage of degree decreased low decreased in the first grade 46.17 and occupied an area of 198.79 km^2, while the degree of inclination average in the second row ratio of 38.9 % and occupied an area of 167.47 km^2 from the area of the study area, while the extreme degree inclination and 12.44 % occupied an area of 53.57 km^2 of the study area, either very severe regression rate reached 2.49% and filled an area of 10.7 km^2, as shown in Figure (7).

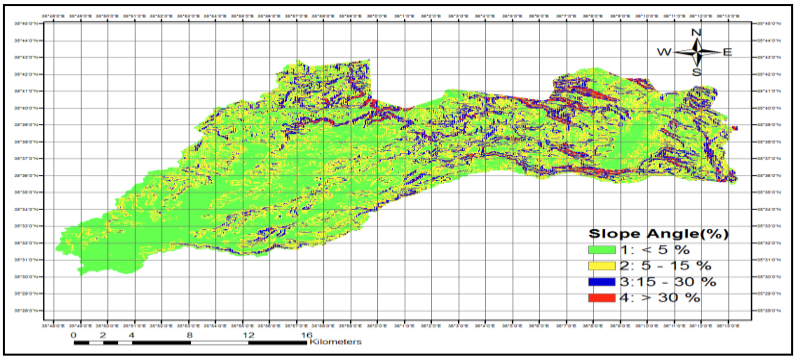

Figure 7. Slope degrees Map of the study area by CORINE methodology.

Erosivity Index:

Erosivity index values have been of the calculated rainfall and erosion in the Table (5), depending on climatic data and of both temperature and rainfall. Where is noted that the value of the index Fournier calculated from data terminal climate of the study area is equal to 135.456, located in the fourth grade, according to Corinne, while the value of the index Bagnold-Gawsn 244.77, located within the fourth grade according to Corinne, and therefore the value of the index erosion rainfall equals 16, which is within the grade 3 which indicates high rainfall erosion index.

Table 5. Forner index Bagnold-Gawsn index for the years 2000-2010.

Years	Index		
	MFI	BGI	EI
2000	110.47	270.83	
2001	236.38	213.78	
2002	111.34	255.40	
2003	151.42	229.6	
2004	187.28	302.7	
2005	75.17	198.1	
2006	85.07	201.3	
2007	122.9	250.8	
2008	137.47	235.18	
2009	156.15	1183.24	
2010	116.35	351.54	
Mean	135.46	244.77	16

Potential Soil Erosion Risk:

The map shows (8) that 6.40% of the studied area was the potential danger of soil erosion by severe, concentrated in the eastern regions where the gradient where very severe, while the potential danger was average in% 28.85 of the area of the study area is focused in central and eastern regions, while focusing little danger in the central and southern regions where, and hit rate of 64.74% of the area studied.

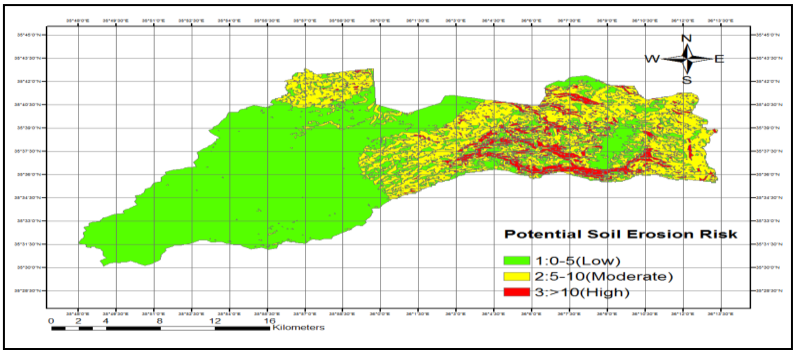

Figure 8. Map of the potential danger of soil erosion.

Land Cover Index:

Cover Ground Plays role in alleviating the collision between the raindrops and the soil surface, by reducing the rate of runoff over the soil , and reduce the severity and seriousness of soil erosion (Estoquea and Murayama, 2011), and therefore it has been relying on the lid Ground mainly to estimate the actual risk of erosion soil.

The figure shows (9) Ground cover map resulting from the classification process observer accuracy rating of (87.44), as shown in Table (6) which expresses the error matrix. Map shows the cover ground which the biggest part of the study area is used in the cultivation of citrus and olive trees, especially the west and center of the study area, while the forests spread over small areas in the northern part near the dam, October 16, as well as in the eastern part where there are with areas planted with fruit and apples trees, in addition to agricultural crops.

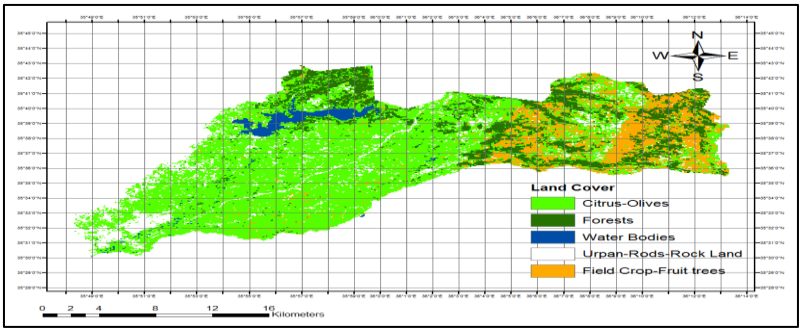

Figure 9. Land cover map of the study area.

Table 6. Matrix Error for the classification process observer.

Class Names	Reference Data						User's Accuracy %
	Forest	Water Bodies	Bulding Rods Rock Land	Field Crop-Fruit trees	Citrus trees-Olive	Total	
Forest	610	1	0	1	225	837	72.88
Water Bodies	0	1181	0	0	18	1199	98.49
Bulding-Rods-Rock Land	3	2	1033	10	232	1280	80.70
Field Crop-Fruit trees	0	0	2	827	123	952	86.87
Citrus trees-Olive	9	37	10	26	4636	4718	98.26
Total	622	1221	1045	864	5234	8986	87.44
Producer's Accuracy	72.88	98.49	80.70	86.87	98.26		

Represents (Fig. 10) Land Cover Map after the re-classified according to the model Corinne into two rows (full protection and the protection of non-full), where the study indicates that 27.10% of the study area with full protection (forests-Bodies of Water-constructors and Buildings-Methods-Tkchwet rocky (and that 72.9% of the studied area with incomplete protection which includes land planted with citrus, olive, fruit trees and crops.

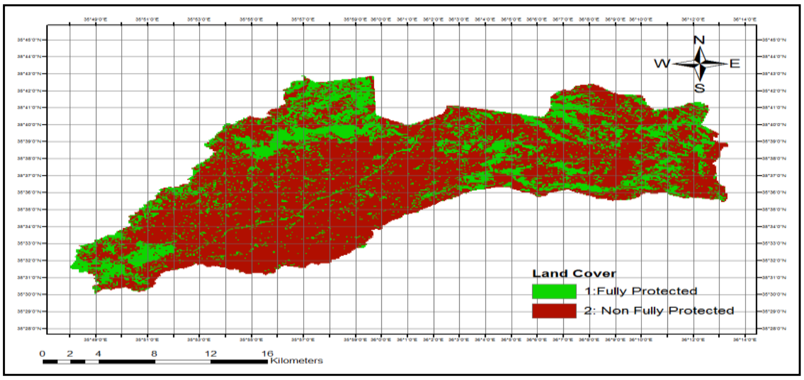

Figure 10. land Cover map classes at the study area.

Actual Soil Erosion Risk:

The Table (7) shows the difference between the areas of potential risk and areas of actual risk of soil erosion, due to the role of Cover Ground in reducing the risk of soil erosion, as the proportion of areas that were classified as having the degree of high risk in the map of the potential danger of erosion from 6.40 % to 2.47 % in the map of the actual risk, After taking the factor of land cover into account the rate of 60.93 %, this corresponds to what referred to (Ekpenyong, 2013) to confirm the role of vegetation in minimizing the potential risk of erosion due to the protection and coverage provided by the soil cover. On the other hand, the percentage of areas that were classified as falling under little threat in the map of the potential danger increased from 64.74 % to 75.35 %. And fell in the average risk of 28.85 % to 22.18 %, respectively, in the map of the actual risk of erosion.

The concentrated areas of the actual risk the eroded soil erosion in the central and eastern parts of the study area. As well as the case for the risk the actual average has also focused in the central parts of Eastern and Central North, while focusing the actual risk low in the central and western parts of them (Fig. 11).

Table 7. Values of the Potential and Actual Erosion Risk.

Classes	Potential Erosion Risk		Actual Erosion Risk	
	Area (Km²)	%	Area (Km²)	%
1: (Low)	278.73	64.74	324.41	75.35
2: (Moderate)	124.21	28.85	95.53	22.18
3: High)	27.59	6.40	10.59	2.47
Total	430.53	100	430.53	100

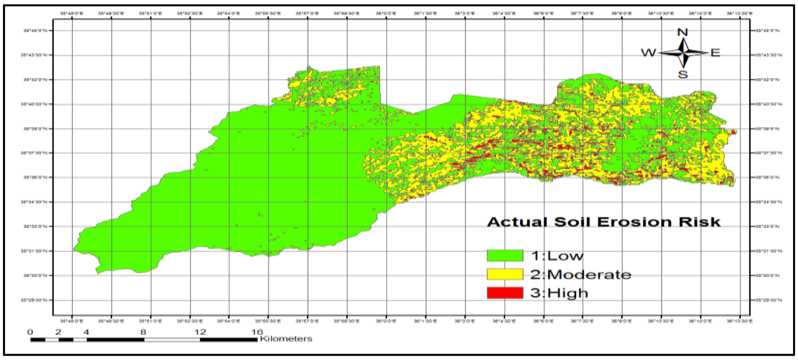

Figure 11. Actual Soil Erosion Risk of map in the study area.

Conclusions

1. Study data to the positive role of the ground cover to protect the soil from erosion, falling values of the actual risk of soil erosion compared to the potential threat of erosion after the introduction of worker land cover, which led to the devaluation of the real danger by 60.93 % of the value of the potential risk grade soils severe dangerous drift.
2. The use of GIS techniques to map the risk of erosion depending on the model CORINE is quick and effective way to assess the risk of soil erosion and the low cost and large area. This technique has proved effective in showing the impact of each indicator used in the model

Corinne on the actual risk of erosion, and helped in determining the spatial distribution of the areas of risk. Which leads to facilitate and accelerate the development of strategies and take actions necessary to protect those soils.

3. Recommend follow-up study to other regions differentiated in terms of soil and vegetation and climatic conditions and using the model Corinne.

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دراسة خطر انجراف التربة في حوض نهر الكبير الشمالي في اللاذقية- سورية باستخدام تقنيات الاستشعار عن بعد ونظم المعلومات الجغرافية

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المستخلص - إن خطر انجراف التربة من أهم المشاكل والتحديات التي تواجه العملية الزراعية في الساحل السوري في وقتنا الحالي, وخصوصا المناطق المحيطة بالأنهار والتجمعات المائية. تهدف هذه الدراسة إلى تصنيف خطر الانجراف المائي للتربة, وتوضيح توزعه في الحوض الأوسط والأدنى لنهر الكبير الشمالي (محافظة اللاذقية), وذلك بالاعتماد على نموذج كورين. تم في المرحلة الاولى حساب عامل قابلية التربة للانجراف من خلال تقدير كل من قوام التربة, عمق التربة والنسبة المئوية للتغطية السطحية بالحصى، حيث تم تصنيف هذه الخصائص حسب درجة تأثيرها في انجراف التربة ومن ثم اعداد الخرائط التي توضح ذلك, ومن جهة أخرى تم حساب معامل الحت المطري وإعداد خريطة الانحدار في منطقة الدراسة وتحديد صفوفها وفقا لدرجة تأثيرها في انجراف التربة. كما تم اعداد خريطة الخطر المحتمل للانجراف بالاعتماد على مقاطعة جميع المعلومات التي توصلنا إليها من قابلية التربة للانجراف، عامل الحت المطري ودرجة الميل لمنطقة الدراسة باستخدام تقنيات نظم المعلومات الجغرافية (GIS). تضمنت المرحلة الثانية من البحث دراسة نوع الغطاء الأرضي (Land Cover) لمواقع الدراسة وتصنيفها إلى صفين حسب درجة الحماية التي توفرها للتربة، ثم أعدّت خريطة الخطر الفعلي للانجراف بعد مقاطعة صفوف الغطاء الأرضي مع صفوف الخطر المحتمل للانجراف على

كامل موقع الدراسة. أظهرت النتائج أن 2.47% من المساحة المدروسة تواجه خطر الانجراف الشديد, في حين إن خطر الانجراف كان متوسطا في 22.18%, ومنخفضا في 75.35% من المساحة المدروسة. إذ تركزت مناطق خطر الانجراف الشديد في وسط منطقة الدراسة وشمالها. كما أكدت الدراسة أن الغطاء الأرضي هو العامل الاكثر تأثيرا في انجراف التربة، إذ أدى الى خفض الخطر المحتمل الشديد للانجراف بنسبة قدرها 60.93%.

كلمات مفتاحية :خطر الانجراف المائي للتربة- نظم المعلومات الجغرافية- نهر الكبير الشمالي- نموذج كورين