Mesopot. J. Mar. Sci., 2020, 35(1): 1 - 12

Spatial distribution of soil water erosion at Al-Hawiz Dam in Western Syria using CORINE model

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(Received: 18 December 2019 - Accepted: 16 February 2020)

Abstract - Water erosion is one of the most important environmental problems that cause soil degradation in the areas of water basins in the Syrian coast. The present study aims at determining the spatial distribution of the risk of water erosion of the lands of Al-Hawiz Basin (Jableh region) using the CORINE model. The CORINE model is based on calculating all factors that affect water erosion: soil erosion factor, erosion factor, inclination factor, ground cover fac tor. The soil susceptibility factor for erosion was calculated by estimating both the soil texture, soil depth and gravity percentage for preparing a potential risk map. The feasibility of both the soil susceptibility factor map and the slope map prepared from the use of DEM and the value of the erosion factor were calculated using system technology Geographical information. Then the ground cover map was prepared and classified into two rows according to the degree of protection. The actual risk map was prepared from the seriousness of the potential danger map and the land cover map. The study showed that 12.79% of the studied area is under the control of severe erosion while 32.10% of which had an average risk of erosion, and the risk of erosion was low in the largest part of the area (55.11%). The areas of severe erosion have been concentrated in the central western region of Lake Al-Sadd. It has been shown that vegetation is the most influencing factor in erosion, as it worked to reduce the high risk of possible soil erosion by 50.83%.

Key words: Risk Water Erosion, Geographic information System, Al-Hawiz Dam basin and CORINE Methodology.

Introduction

Water erosion is one of the most important environmental and agricultural problems in many parts of the world. Water erosion can cause Problems of ecosystems and disturb their balance and environmental functions. It reduces the diversity of Algae and fauna as a result of negative impact in appropriate environments; also it reduces nutrient production and contributes to the destruction of food chains of different types (Lasanta *et al*., 2001).

Many models were designed to determine the risk of Erosion after integrating it with GIS technology by predicting the risk of soil erosion and determining its spatial distribution (Aydin and Tecimen, 2010). In the present study, we will rely on one of these models, (CORINE: COoRdination of Information Environment). This model is an empirical model based on maps developed through the design and creation of several slides, as well as a number of digital maps illustrating the spatial distribution of data on factors affecting Erosion. It is one of the simplest models to implement and was designed to be used especially in the European and Mediterranean regions which are highly at risk of erosion (Estouea and Murayama, 2011).

Another study using the CORINE model to assess the risk of water erosion in the Samsun basin in Turkey showed that 36.7% of the study area was under the control of a low of actual Erosion risk and 58.7% of it was under the control of an average real Erosion risk, while 4.6% was under the control of high driest risk (Kwyes, 2014).

A similar study using the CORINE model for the Elmali basin in Istanbul showed that the risk areas of Erosion that were classified in 1984 in terms of actual risk was 29.67% of the studied area, the risk of actual erosion was low, 52.49% had an average Erosion risk and 17.84% had a high risk of Erosion (Aydin and Tecimen, 2010).

The results of the CORINE model of the upper and lower basin of the northern great river showed that 2.47% of the studied area faces the risk of extreme Erosion, while the risk of Erosion was averaged at 22.18% and low in 75.35% of the studied area, where, the extreme risk of erosion was concentrated in the center and north of the study area (Kwyes, 2014).

The basin of Al-Hawiz Dam is one of the most important watersheds in the Syrian coast. It is of agricultural importance and is located under threats of water erosion because of the favorable conditions for soil erosion such as high precipitation; steep slopes and dense agricultural activities. Thus, it is necessary to determine their spatial distribution using rapid and low-cost methods to develop and propose appropriate strategies for soil conservation. The objective of this study is to determine the spatial distribution of the risk of erosion of the Al-Hawiz Dam basin using the CORINE model.

Materials and Methods

The study was conducted in the lands around Al-Hawiz, located 9 km southeast of Jiblah city in 2015. The dam collected the Water from the area of the basin is 95 hectares and is intended to irrigate an area of 400 hectares of agricultural land. The study covers an area of 18.164 km^2. The land cover consists of the following components: olives; citrus; field crops and vegetables; fruit trees; meadows and forests. Figure (1) shows the location of the study area within the province of Latakia and on the map of Syria.

Thirty-one soil samples from a depth of 0-10 cm (Fig. 2) were collected from 5 points, forming a 10-m post envelope consisting of a compound sample, which was transferred to the laboratory. The roots and plant residues were removed and the antennae were dried and sanded with a 2 mm sieve for soft soil.

Soil mechanical analysis was performed using the hydrometer method and the type of tissue was determined using the triangle tissue by the American classification USDA.

The gravel coverage was estimated by taking 1 m^2 of land and drawing the gravel (diameter greater than 2 mm), which is shown in the form of circles and calculated the area covered by the gravel and distributed on the unit area (hectare).

The depth of the soil was determined by the use of an inserted metal rod implanted in the soil at the center of the sample. Sample sites were identified using the Global Positioning System.

Climate data (monthly precipitation and temperature) were collected from the meteorological station at Basel Airport for ten years 2005-2014. The annual rainfall rate ranged from 250 to 1756 mm. Monthly temperature values ranged between 11 and 29 Celsius.

CORINE Model Methodology: CORINE: COoRdination of Information on the Environment is the methodology of the work to assess the risk of water erosion of the soil at the expense of some factors affecting the Erosion: soil Erodibility Index; Erosivity Index; slope factor and vegetation factor.

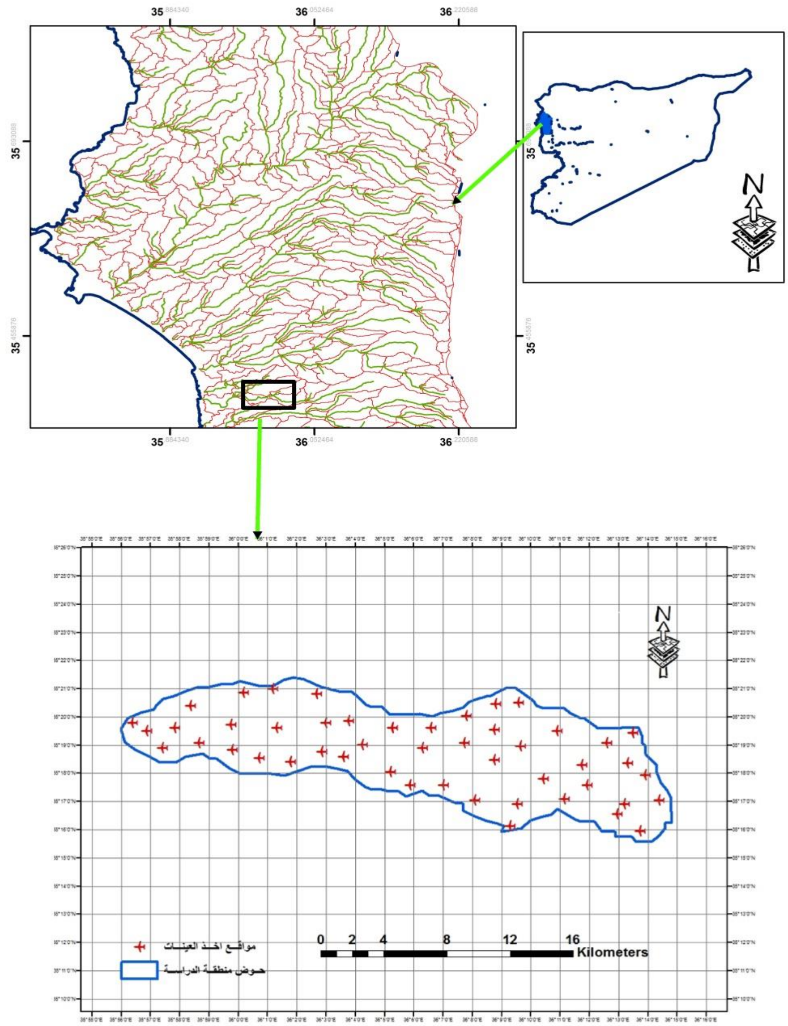

Figure 1. Location of the study area within the province of Latakia and on the map of Syria.

Soil Erodibility Index:

The Soil Erodibility Index is affected by soil texture; soil depth and percentage of surface cover. The soil tissue is classified into four rows and depth in three rows. The percentage of surface coverage in gravel is classified in two rows according to the following equation (Kwyes, 2014):

Soil Erodibility Index = Soil Texture row X Soil depth row X Stones percentage row

ArcGIS10 was used to obtain the required maps for the soil characteristics (soil texture; soil depth and percentage of gravel coverage) by applying Kriging logarithms to the samples collected in the field. The studied soil characteristics were distributed from tissue; depth and gravel coverage in the sampling areas on the entire study area. In a later step, the three maps representing the soil characteristics were used to obtain a map of soil Erodibility to Erosion. This map represents the result of the above three maps.

Erosivity Index:

Erosivity Index was calculated using Fournier Index (FI) and Bagnouls-Gaussen Index (BGI). The metric is calculated by using the following relationship:

(Metric indicator= Row of the Fornier index X A row of the Bagnold-Gaussen index)

The Fournier Index (FI) is calculated according to the following equation (Aydin and Tecimen, 2010):

$$\mathrm{FI} = \sum_{i=1}^{12} \frac{P_i^2}{P}$$

Where;

P_i: the amount of monthly precipitation expressed in millimeters (mm).

P: The annual total of precipitation expressed in millimeters (mm).

The Bagnold-Gaussen (BGI) index is calculated according to the following equation (Aydin and Tecimen, 2010):

$$\mathrm{BGI} = \sum_{i=1}^{12} (2t_i - P_i)K_i$$

Where;

t_i: average monthly temperature expressed in centimeter.

K_i: The value is calculated when $2ti\text{-}P_i > 0$.

Where K_i is calculated by the relationship ($K_i = 2t_i\text{-}P_i$), which is calculated when $2t_i\text{-}P_i > 0$ and it is negligible if this ratio is less than zero.

Slope Index:

DEM: Digital Elevation Model was obtained from the GORS in Saboura, and DEM was manufactured in 2011 from a 30 m diameter ester image. The slope degree was classified into four rows.

Potential Soil Erosion Risk:

The Potential Soil Erosion Risk was calculated using the following equation (Kwyes, 2014):

(Potential Soil Erosion Risk = Map of Soil Erodibility index X Map of Erosivity Index X Map of Slope Index).

The potential risk of Erosion was divided into four rows, no risk (0), low (0-5), average (5-11) and high (>11).

Land Cover:

A map of different types of terrestrial coverage in the study area was obtained using a Landsat (TM5) satellite image taken in 2014. The ground coverage lines represented by this map were classified according to their degree of soil protection and according to the CORINE model to two classes: (1) fully protected. It includes forests; water bodies; construction; roads and rocky terrain. (2) not fully protected. This includes crops; fruit trees (apples, almonds, etc.) as well as olive and citrus fields. Field visits were adopted for recording the prevailing land coverage type.

Actual Soil Erosion Risk:

The actual risk for each of the soil sampling points is calculated by determining the potential risk class, and then determining the type of ground cover. The actual risk of each point is calculated by the following expresion (Imamoglu *et al.*, 2014):

(Actual Soil Erosion Risk = Map of Potential Erosion Risk X Vegetation Cover Map)

The actual risk of Erosion was classified into three rows: low, medium and high.

Results and Discussion

Soil Erodibility:

Soil Erodibility is more resistant to Erosion than soils with coarse texture. It was observed that 36.76% of the studied soils were (C, SiC), which had a strong resistance to erosion, while 39.57% were (SCL, CL, LS), which had a medium erosion-resistant, and 23.67% were (SiL, S), which had a weak erosion-resistant, because fine textured soils have the potential to drift more than coarse-textured soils (Corbane *et al.*, 2008). Figure (2) shows soil cultivars and their distribution within the study area.

Soil Depth:

The depth of the soil affects the rate of water permeability, as the rate of runoff and thus the water Erosion in the soils are low in the deep soils (Marina and Febles, 2008). The study showed that 46.75% of the soils with a depth of more than 75 cm are low to erosion and 15.08% of the studied soils with a depth of 25-70 cm are medium to erosion, while the ratio of soils with a depth of less than 25 cm is very high (Fig. 3).

Stoness Index:

The presence of gravel above the soil surface can be a protective factor for soil from the negative effect of rain drops (Yuksel *et al.*, 2008). It was found that 59.69% of the treated soils with a surface coverage of more than 10 %, provide full soil protection, while the soil with surface coverage of less than 10% provides incomplete protection (40.31%) of the study area (Fig. 4).

Soil Erodibility:

The soil Erodibility map for soil erosion was determined by the ratio of the soil texture; depth and percentage of surface cover with gravel as previously mentioned. Figure (5) illustrates the soil permeability index for erosion in the study area. It is clear from the previous Figure that 59.32% of the studied land area had an Erosion index located within the first row, where the value of soil erodibility index ranged between 0 and 3 which has a low Erosion potential, while the value of the index ranged between 3 and 6 in about 22.79% of the studied area, and hence, it is located with the second row, as it has an average driest potential. However, the rest of the study area of about 17.89% was located in the third row and were highly erodible. Their Erosion index was greater than 6.

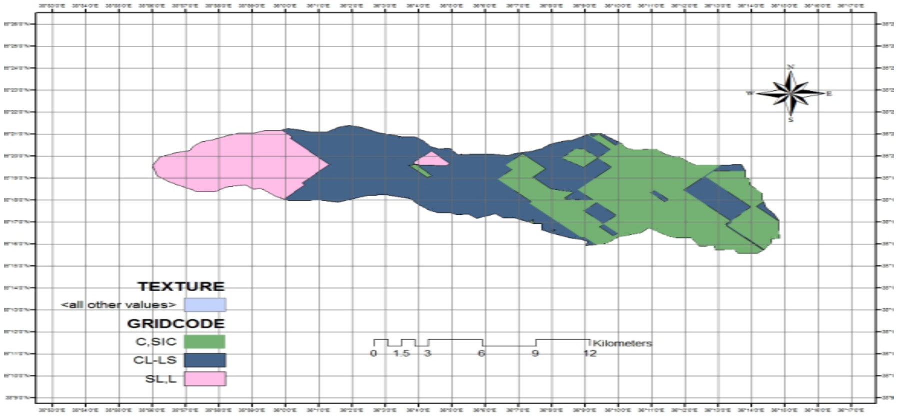

Figure 2. Soil tissue distribution in the study area.

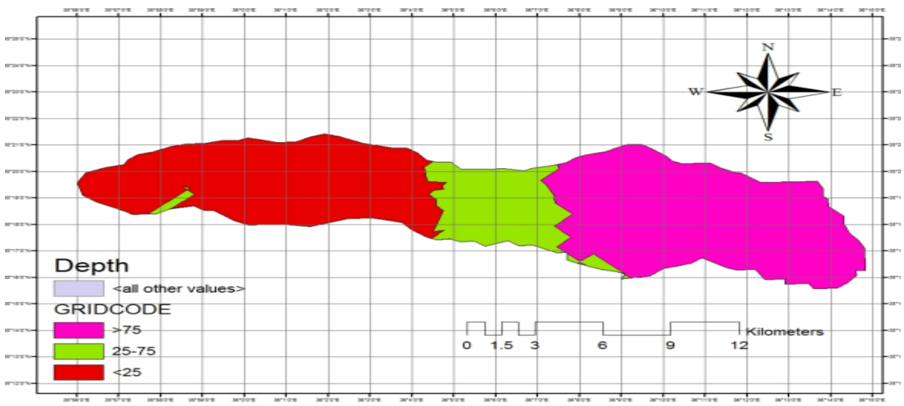

Figure 3. Distribution of the soil depth in the study area.

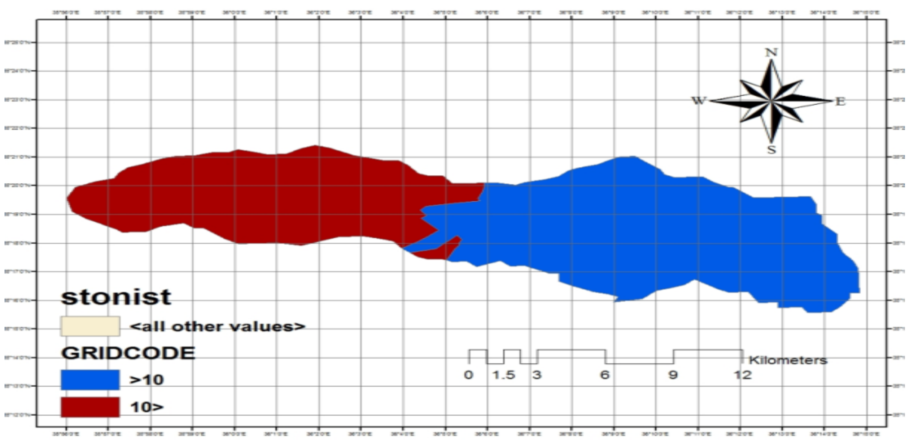

Figure 4. Map of the distribution of gravel surface coverage in the study area.

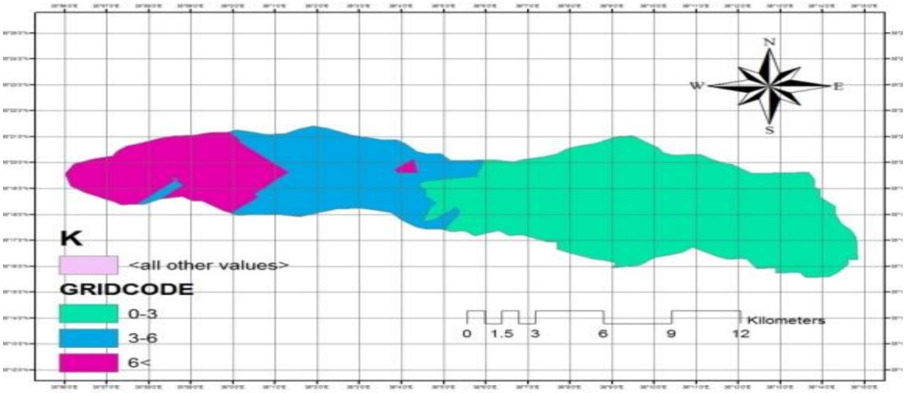

Figure 5. Soil Erodibility Map of the Study Area.

Slope Index:

The Slope degree significantly affects the severity of the water Erosion as it increased, the speed of surface runoff increased, thus increasing its ability to sweep the soil (Dragut *et al.*, 2012). The slope map was obtained using the digital elevation model and was classified into four rows according to CORINE. The low slope in the first row was 40.14% and occupied an area of 20.7 km^2, while the average slope in the second row was 34.82% and occupied an area of 15.65 km^2. The high slope was 14.31% and occupied an area of 12.33 km^2. The very steep slope was 10.31 % and occupied an area of 3.15 km^2 (Fig. 6).

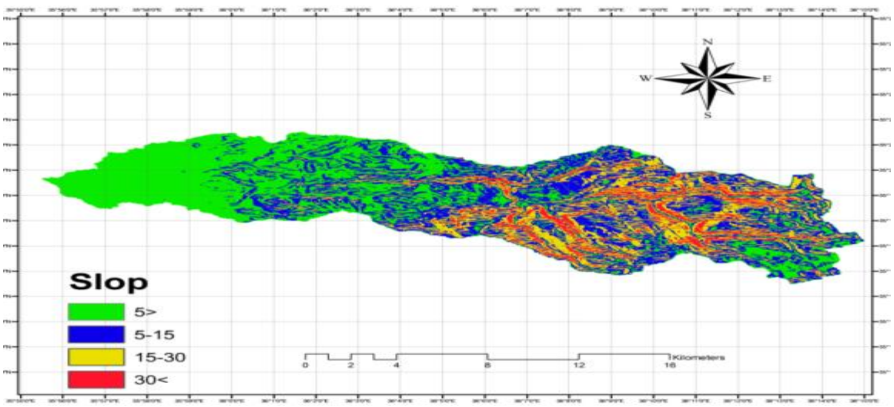

Figure 6. The degrees of slope of the studied sites according to CORINE.

Erosivity Index:

The values of the rainy index in Table (1) were calculated based on climatic data of both temperature and rainfall. It is noted that the value of the Fornier index calculated from the data of the climate station for the study area is 154.14, and located in the fourth row according to CORINE, while the value of the Bagnold-Gaussen is about 202.57, and located in the fourth row according to CORINE. Therefore the value of the index is equal to 16, and it is within the third row indicating to the increase in rainy index.

Table 1. Values of the Forner coefficient and the Bagnold-Gaussen coefficients for the years 2005-2014.

Mean	Years										Index
	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	
154.1	128.7	128.6	384.6	162.12	140.2	176.7	120.7	77.2	64.56	128.2	FI
202.5	141.1	236.2	242.2	105.2	281.4	212.2	208.7	209.6	193.2	193.6	BGI
16											EI

Potential Soil Erosion Risk:

Figure (7) shows that only 18.49% of the studied area had a potential risk of low soil erosion. It was concentrated in the northern and western regions, while the potential risk was averaging 55.15% of the study area and concentrated in the western; eastern; northeastern and southeastern regions. The extreme danger was concentrated in the central regions and some eastern parts accounting for 26.62% of the surveyed area.

Land Cover Index:

Vegetation plays a role in reducing the strength of the collision between rain drops and soil surface and reduces surface runoff, thus reducing the risk of soil erosion (Estouea and Murayama, 2011). The bulk of the study area is used for the cultivation of citrus and olives, while the forest covers a few areas area as well as fruit trees and other agricultural crops.

Figure (8) represents the land coverage map after reclassification according to the CORINE model to two rows fully protected and non-fully protected. The study indicates that 40.64% of the study area is fully protected (forests; meadows; water bodies; structures; buildings; roads and rocky surfaces). A 59.36% of the surveyed area is under-protected which includes land planted with citrus; olives; fruit trees and crops.

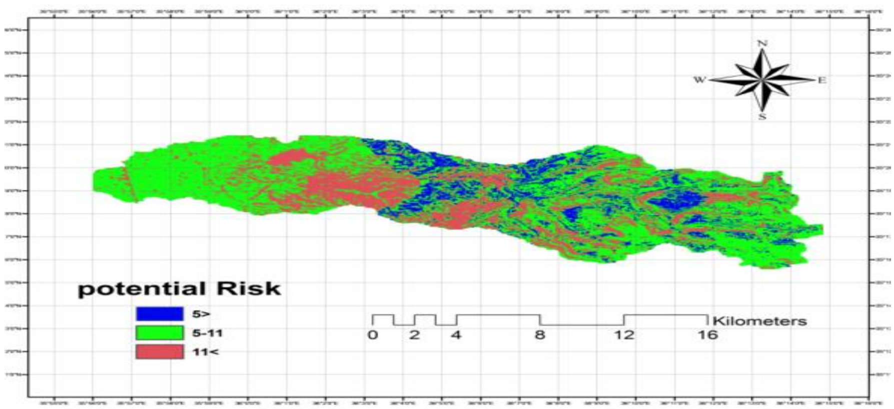

Figure 7. A map of the potential danger of soil erosion.

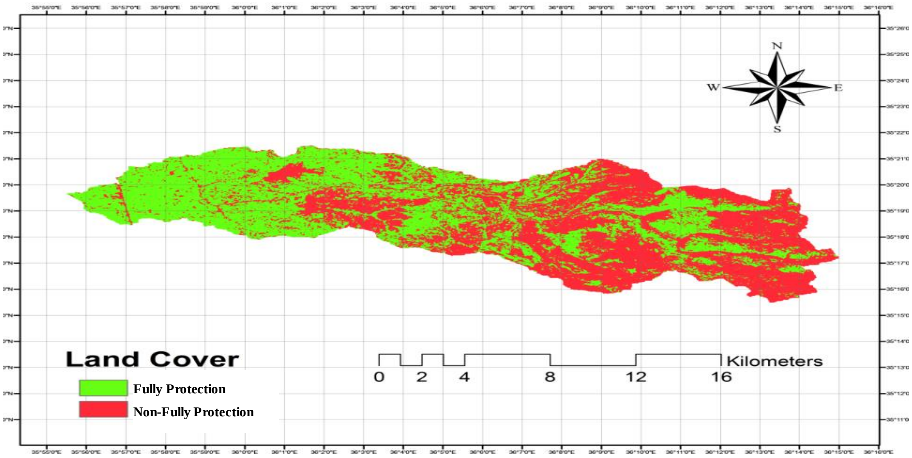

Figure 8. Map of the distribution of land coverage in the study area.

Actual Soil Erosion Risk:

Table (2) shows the difference between potential risk areas and the actual risk areas of soil erosion. This is due to the role of vegetation in reducing the risk of soil erosion.

The percentage of areas classified as high and moderate in the map of the potential risk of erosion has decreased from 16.39% to 7.61% and from 29.63% to 17.19%, respectively in the actual risk map after considering the vegetation factor in accordance with what of Ekpenyong (Ekpenyong, 2013). This is confirming the role of vegetation in minimizing the potential risk of erosion due to protection and coverage of soil.

On the other hand, the proportion of areas classified as under threat in the potential risk map is increased from 53.98% to 75.25% in the actual risk map of Erosion.

The actual high-risk areas of soil erosion were concentrated in the northern central; eastern and southeastern regions of the study area. The average actual risk was also concentrated in the northern central and eastern central, while the actual low risk was concentrated in the central; western and northern east (Fig. 9).

Table 2. Values of the potential and actual risk of Erosion.

Soil Actual Erosion Risk		Soil Potential Erosion Risk		Class
%	Area (Km^2)	%	Area (Km^2)	
55.11	90.47	18.49	29.91	(Low)1:
32.10	52.70	55.15	90.54	2: (Moderate)
12.79	21.01	26.36	43.73	3: (Sever)
100	164.18	100	164.18	Sum.

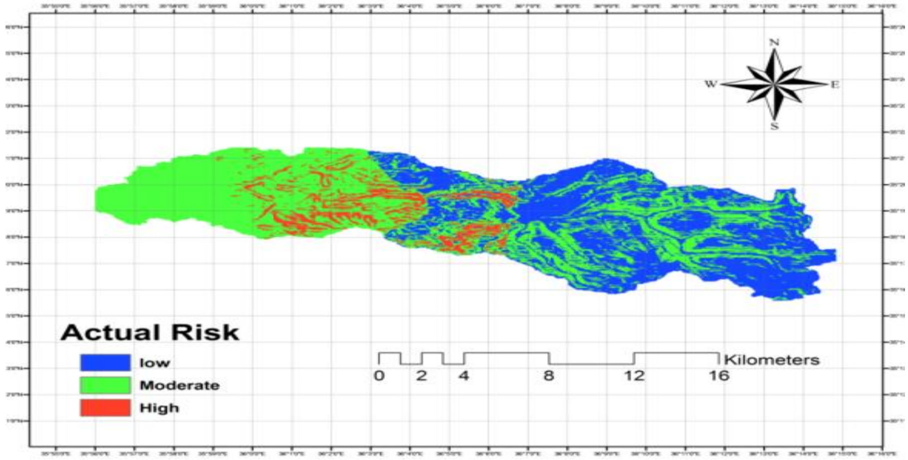

Figure 9. Map of the actual risk of soil erosion in the study area.

Conclusion

The present study, was conducted to determine the spatial distribution of the areas of water erosion in the basin of Al-Hawiz Dam and the following points could be raised:

1. Areas with high risk of erosion are concentrated in the western central region and occupied a small area of the total area of the study.
2. The study indicated the positive role played by land cover in soil protection from erosion. The actual risk of soil erosion decreased compared with the potential risk of erosion after the introduction of the land coverage factor, which reduced the actual risk value by 60.93%.
3. The use of geographic information systems (GIS) techniques to map the risk of erosion based on the CORINE model is an effective and rapid way to assess the risk of soil erosion at low cost and large area. This technique has proven to be effective in showing the impact of each CORINE model on the actual risk of Erosion and has helped to determine the spatial distribution of risk areas, facilitating and accelerating the development of strategies and actions necessary to protect these soils.

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التوزيع المكاني للانجراف المائي لحوض سد الحويز باستخدام انموذج كورين

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[1] مركز علوم البحار, جامعة البصرة, البصرة, العراق، [2] كلية الزراعة, جامعة تشرين, اللاذقية, سورية

المستخلص - تعد التعرية المائية أحد أهم المشاكل البيئية التي تسبب تدهور التربة في مناطق الأحواض المائية في الساحل السوري. تهدف هذه الدراسة إلى تحديد التوزيع المكاني لخطر الانجراف المائي لأراضي حوض الحويز (منطقة جبلة) وذلك باستخدام انموذج كورين. يعتمد انموذج كورين على حساب جميع العوامل التي تؤثر على الانجراف المائي: عامل قابلية التربة للانجراف، عامل التعرية المطرية، عامل الميل، عامل الغطاء الأرضي. تم حساب عامل قابلية التربة للانجراف من خلال تقدير كل من نسجة التربة وعمق التربة والنسبة المئوية للتغطية بالحصى من أجل إعداد خارطة الخطر المحتمل وتم حساب جداء كل من خارطة عامل قابلية التربة للانجراف وخارطة الميل التي أعدت من استخدام DEM وقيمة عامل الحت المطري وذلك باستخدام تقانة نظم المعلومات الجغرافية. وبعد ذلك أعدت خارطة الغطاء الأرضي وصنفت إلى صفين حسب درجة الحماية وقد أعدت خارطة الخطر الفعلي من جداء خارطة الخطر المحتمل وخارطة الغطاء الأرضي. أظهرت الدراسة التصنيفية لخطر أنجراف التربة أن 12.79% من المساحة المدروسة تقع تحت سيطرة خطر انجراف شديد في حين أن

32.10% من المساحة المدروسة كان خطر الانجراف فيها متوسط، وقد كان خطر الانجراف منخفض في القسم الأكبر من منطقة الدراسة (55.11%). تركزت مناطق خطر الانجراف الشديد في المنطقة الوسطى الغربية من بحيرة السد، وقد تبين إن الغطاء النباتي هو العامل الأكثر تأثيرا في الانجراف حيث عمل على تخفيض الخطر العالي لانجراف التربة المحتمل بنسبة (50.83%).

الكلمات المفتاحية: خطر الانجراف المائي للتربة, نظم المعلومات الجغرافية, حوض سد الحويز, نموذج كورين