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Estimation of soil losses using RUSLE model and GIS tools: Case study of the Mellah catchment, Northeast of Algeria

Estimarea pierderilor de sol folosind modelul RUSLE și instrumentele GIS: Studiu de caz al bazinului Mellah, nord-estul Algeriei

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Abstract

Land and water are two most vital natural resources of the world and hence these resources must be conserved carefully to protect environment and maintain ecological balance. Estimation of soil erosion is one of the prerequisites for conservation and management of water resources and watersheds. The present study was carried out to predict soil erosion in the Mellah catchment, northeastern Algeria. Due to the importance of the water resources of this watershed and the lack of sedimentation data in this valley, a comprehensive methodology integrates Revised Universal Soil Loss Equation (RUSLE) model, remote sensing and GIS techniques to determine the catchment soil erosion vulnerability. The elaborations of RUSLE factors in this study were based on multi-source data for the improvement of soil erosion estimation. The results indicated that the average soil loss is 10.21 t. $ha^{-1}.yr^{-1}$, with a total annual soil loss in the basin area of 5648.58 t. Around 90% of area was under very low erosion risk, and5% of area was considered as moderate erosion risk while 3% of area was considered as high to very high erosion risk. The climate change and rainfall fluctuations witnessed influenced the soil loss in this region. Thus, the high erosivity registered has consequent in the detachment of particles due to the soil texture types in this region. The conjunction of high erosivity, soil texture and high steep slopes in this region resulted in high potential soil erosion which could lead to the deterioration of water resources if not a mitigation measures and an immediate intervention are taken in the Mellah catchment.

Keywords

GIS, Catchment, USLE, Erosion, Estimation, Mellah, Algeria

1. INTRODUCTION

One of the most serious land degradation problems is the soil erosion by water (Aiello *et al.,*2015). It is defined as the detaching, transporting and depositing soil particles (Meyer and Wischmeier, 1969; Parveenand Kumar, 2012). Many hydrological factors: such as climate, topography, soil, vegetation and anthropogenic activities such as soil practice, soil conservation measures, overgrazing and deforestation, were involved under the effect of a complex interaction process for the triggering of this phenomenon (Foster and Meye, 1972; Kuznetsov *et al.*, 1998). For example, in the semiarid countries**,** erosion is considered as a complex and largely widespread phenomenon because of the torrential nature of its precipitation (Guesri *et al.,* 2018), their spatial heterogeneity of soils as well as the impact of the human activities (Mosbahi *et al.*, 2015). In recent years, approximately of 6 million hectares are exposed to an active erosion and average sediment of 120 million tons is transported annually by the water in Algerian water sheds (Anteur *et al.,*2014). During the last years, several models of erosion phenomenon were developed. Therefore, the identification of erosive factors and areas prone to water erosion can be very useful for identifying the degree of sensitivity and for the establishment of mitigation measures and watershed management plans (Belasri and Lakhouili, 2016; Bouguerra *et al.*, 2017).

Using conventional methods to assess soil erosion risk is expensive and time consuming. The integration of existing soil erosion models, field data and data provided by remote sensing techniques through the use of geographic information systems (GIS) appears to be an asset for further studies (Fernandez *et al.*, 2003; Gitas *et al.*, 2009 ; Xu *et al.*, 2009 ; Ganasri and Ramesh, 2015; Bouhadeb *et al.*2018). Researchers have developed many predictive models that estimate soil loss and identify areas where conservation measures will have the greatest impact on reducing soil loss for soil erosion assessments (Angima *et al*. 2003). These models can be classified into three main categories as empirical, conceptual and physical based models (Merritt *et al*. 2003). Despite the development of a range of physical, conceptual based models, Universal Soil Loss Equation (USLE) and Modified Universal Soil Loss Equation (MUSLE) or Revised Universal Soil Loss Equation (RUSLE) are the most popular empirically based models used globally for erosion prediction and control and tested in many agricultural watersheds in the world. The main reason why empirical regression equations are still widely used for soil erosion and sediment yield predictions is their simplicity, which makes them applicable even if only a limited amount of input data is available. Due to the lack of data and the needs of assessing erosion on large scales, it is essential to integrate remotely sensed information and GIS techniques which became of great interest to the researchers in the management of watersheds (Kaci *et al*. 2017). The use of remote sensing and GIS techniques has been widely adopted. These techniques have become valuable tools, especially (for the assessment of erosion on large scales of ungauged watersheds. Currently, there are several studies that show the potential of GIS tools in water erosion mapping. (Pilesjo, 1992**;** Metternicht and Fermont 1998**;** Parveen and Kumar 2012; Hussein El Hage Hassan *et al*. 2013;Meghraoui*et al*. 2017; Bouguerra Hamza. 2018).

In the current study, an effort to predict potential annual soil losses in the Mellah catchmenthas been conducted using the Revised Universal Soil Loss Equation (RUSLE) adopted in a GIS software. The RUSLE is the dominant model applied worldwide to soil loss prediction, because of its convenience in application and compatibility with GIS (Millward *et al.*1999; Jain *et al.*2001; Jasrotia and Singh 2006; Dabral *et al.*2008; Kouli *et al.* 2009; Pandey *et al.*2009; Bonilla *et al.*2010). Although this is an empirical model, it not only predicts erosion rates in ungauged watersheds using watershed characteristics and local hydro climatic conditions, but it also describes the spatial heterogeneity of the soil erosion with better precision in spread areas at reasonable costs (Angima *et al.* 2003). The RUSLE has been widely used for both agricultural and forest watersheds to predict the average annual soil loss by introducing improved means for computing soil erosion factors (Wischmeier and Smith1978; Renard *et al.* 1997). This equation is the product of six input factors namely the rainfall erosivity; soil erodibility; slope length; slope steepness; cover management; and support practice.

This study aims to extract the different maps of erosivity, erodibility, topography, vegetation cover and support practice conservation factors, in order to apply the RUSLE model in the Mellah catchment. The objective of this effort is to identify potential erosion and soil loss distribution, in order to identify sensitive areas to the water erosion phenomenon and the influence of each factor.

2. PRESENTATION OF STUDY AREA

The Mellah catchment, which occupies an area of 551 km², is geographically located in the Seybouse basin, in the extreme northeast of Algeria. It is located from north with latitudes 36°12'58" to 36°30'26" and east with longitudes 7°28'34" to 7°58'36". The basin altitudes vary between 94 m and 1320 m. The studied area is subjected to Mediterranean climate characterized by two distinct seasons: a slightly fresh winter and a hot dry summer from June to October. The Mellah catchment is controlled by ten (10) pluviometric stations, which are spatially covering the area, and the Wadi is controlled by the Bouchegouf hydrometric station. Seventy percent (70%) of the total area is considered as an agricultural land, twenty-three (23%) as dense forestland, while the rest 4% represents barren lands and urbanisation.

The studied area is considered as a mountainous catchment, with a 27% of area located in the southern part of the watershed presenting a relatively rugged terrain with slopes higher than 30% and a high-density hydrographic networks. This mountainous landscape is a powerful stimulant to erosion. The catchment subjected to a Mediterranean climate characterized by two distinct seasons: a slightly fresh winter and a hot dry summer from June to October. The characteristic values of annual precipitation recorded in this region over a 42-year period are shown in Table 1. It should be noted that the rainfall stations of Machroha, Ain Seynour and Chaffia are the wettest with respectively 1143 mm, 1034 mm and 809 mm. The other stations (Bouchegouf, Ain Makhlouf and Khmissa) are dry recording only 541 mm, 517 mm and 478 mm respectively.

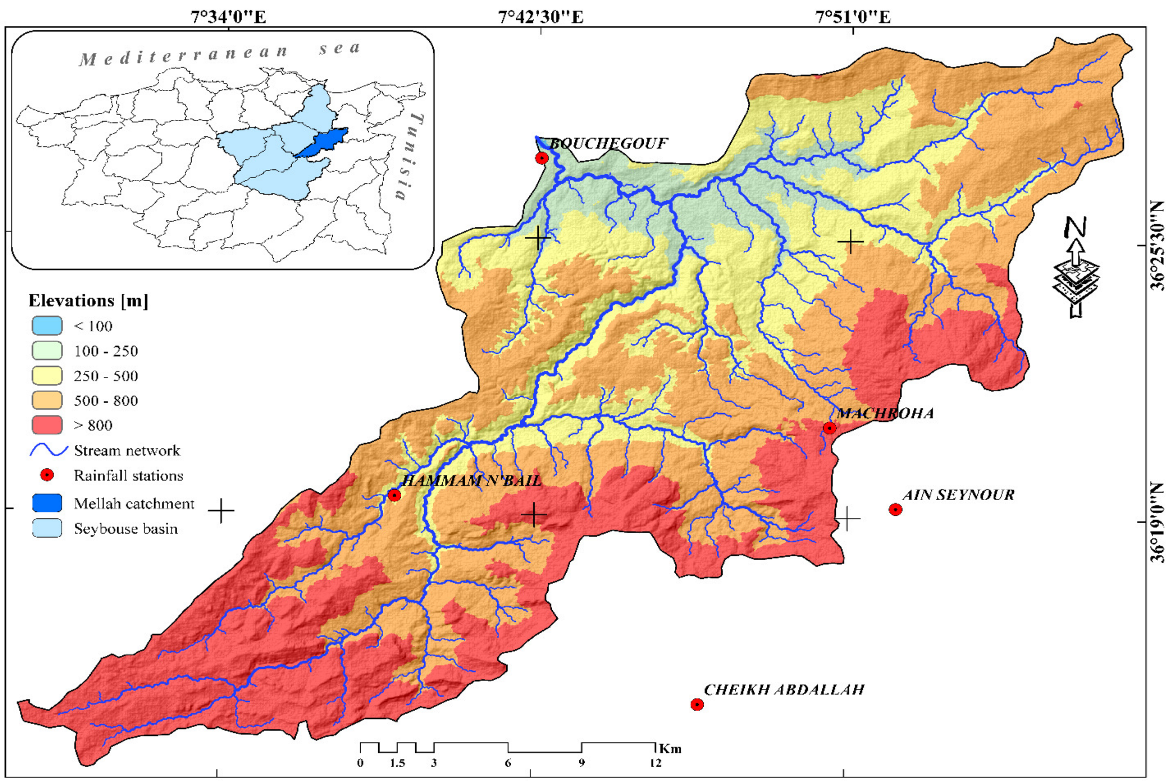

Fig 1. Location map of the Mellah catchment.

3. MATERIAL AND METHODS

Many techniques and studies realized worldwide were done for the evaluation of soil loss. Most of them are using the Universal Soil Loss Equation (USLE) (Benkaci*et al*. 2018) and its revised version (RUSLE) (Renard *et al.* 1997; Boufala*et al*. 2019; Panditharathne *et al*. 2019). Others had modified part of the equation to adapt in every country's situation. In this study, we tried to promote the process using the potentials of GIS.

Several data were used for application of RUSLE, the most widely used model including rainfall data, soil data, land use, and Digital Elevation Model (DEM). Rainfall data for a period of 42 years (from 1970/1971 to 2012/2013) relating to 10 climatic stations were collected from the National Water Resources Agency. The land use was extracted from Landsat 8 OLI/TIRS images recently acquired with a spatial resolution of 30 m and projected in Universal Transverse Mercator. The pedology map (1/500 000) are used to extract soil types. The digital elevation model was extracted for the study area from SRTM 1 Arc-second.

The RUSLE equation consists of five factors [Fig 2] in raster data format: soil erodibility (K); rainfall erosivity I; slope length and steepness(LS); cover management I; and support practice (P). The RUSLE equation is described as:

$$A = R * K * LS * C * P \qquad \ldots (1)$$

where: A is the soil loss **(t.ha^{-1}.yr^{-1})**. R is the rainfall erosivity factor **(MJ·mm·ha^{-1}·h^{-1}·yr^{-1})**. K is the soil erodibility factor **(t·h·MJ^{-1}·mm^{-1})**. LS is the slope steepness and slope length factor **(dimensionless)**. C is the vegetation cover factor **(dimensionless)**. P is the conservation practice factor **(dimensionless)**.

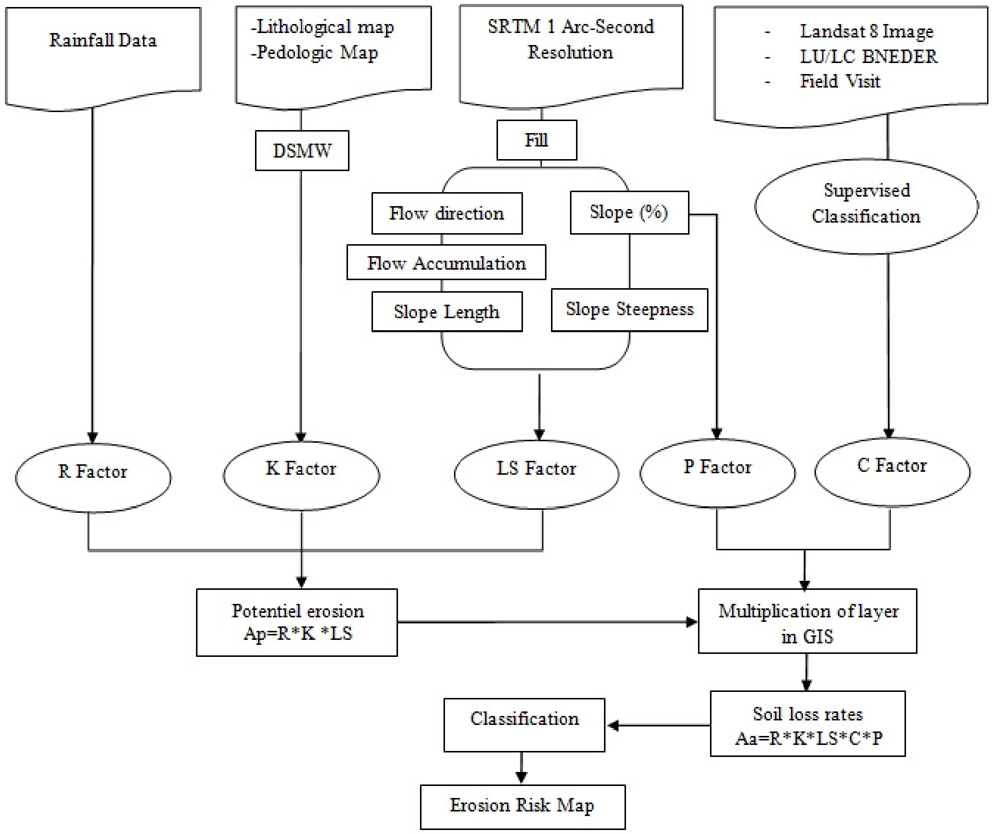

Fig 2. Flow chart of methodology.

3.1. Erosivity Factor I

The erosivity factor I in the USLE equation is derived from the rainfall-run off relationship. It is considered as a driver of soil erosion processes (Guesri *et al* 2020). The R factor represents the effect of raindrops impact. It also reflects the amount and the rate of run off associated with precipitation events. It is defined as the product of kinetic energy and the maximum intensity in 30 minute estimating the erosivity of rainfall events (Wischmeier and Smith 1960). This direct method can only be applied in areas equipped with autographic recorders (Lahlaoi *et al.*2015).

$$R = K * E_C * I_{30} \qquad ...(2)$$

For our study, the equation (3), below developed by (Wischmeier and Smith 1978) and modified by (Arnoldus1980), was used in the computation involves only annual and monthly precipitation to determine the R factor:

$$R = \sum_{i=1}^{12} 1.735 * 10^{\left(1.5*\log_{10}\left(\frac{P_i^2}{P}\right)-0.08188\right)} \qquad ...(3)$$

Where R is the rainfall erosivity factor ($MJ{\cdot}mm{\cdot}ha^{-1}{\cdot}h^{-1}{\cdot}y^{-1}$), Pi is the monthly rainfall (mm), and P is the annual rainfall (mm).

Rainfall data was recovered from 10 weather stations for 42 years (1970-2012). They were obtained from the National Agency of Hydraulic Resources and imported into GIS since all the weather stations are geographically referenced [Fig3]. The rainfall erosivity values for the different stations were used to determine the areas at different erosivity rates using the Inverse Distance Weighted (IDW) interpolation method in GIS software to generate a raster map for R factor. The IDW interpolation method was selected because rainfall erosivity sample points are weighted during interpolation such that the influence of rainfall erosivity is most significant at the measured point and decreases as distance increases away from the point. The IDW interpolation method is based on the assumption that the estimated value of a point is influenced more by nearby known points than those farther away (Weber and Englund 1992-1994).

Table1. Mean annual, max, min and standard deviation rainfall data.

Station name	Mean annual (mm)	Min(mm)	Max(mm)	Standard deviation
Chaffia	809.5	439.2	1261.4	204.29
Bouhadjar	617	125.9	1165.6	230.30
Ain Seynour	1034.2	617.7	1524.2	238.02
Machroha	1142.7	298.6	2105.4	494.75
Bouchegouf	541.1	279.3	884	150.38
Boukhamousa	648.8	380.5	978.7	169.79
Khmissa	494.7	244.9	844	142.23
Cheikh Abdallah	653.5	280.3	1443.9	276.23
Hammam N'bail	664.4	246.7	1144.9	213.61
Ain Makhlouf	517	102.9	1071.2	176.17

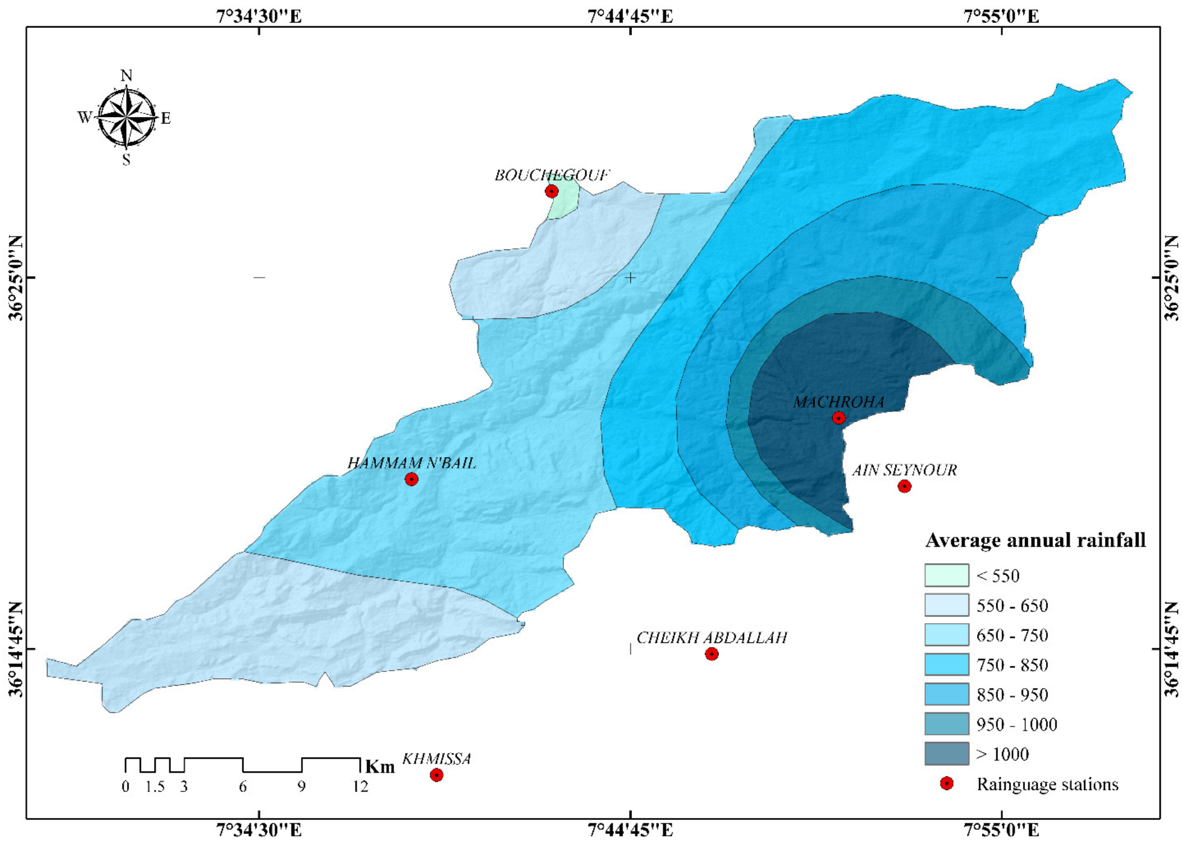

Fig3. Annual average rainfall map.

3.2. Soil Erodibility Factor(K)

Soil resistance to detachment and transport are depending on the soil texture, drainage potential, structural integrity, organic content and cohesiveness. The soil texture plays an important role in affecting the capability of soil erodibility and its estimation. However, the other characteristics affecting K factor are soil structure, permeability and the organic matter content. Soil erodibility factor map was prepared from soil texture classes of the study area based on different soil textures and the DSMW (Digital Soil Map of the World). Details such as the fraction of sand, silt, clay, organic matter and any other information on the parameters for the various mapping units were taken from the same report. The soil erodibility (K factor) of the studied area can be calculated using the relationships between soil texture classes and organic matter content (Anache *et al.* 2015).

$$K = 0.1317 * A * B * C * D \quad \ldots (4)$$

Where:

$$A = \left[0.2 + 0.3\exp(-0.0256\,\text{Sand}\left(1 - \frac{\text{Silt}}{100}\right)\right] \quad \dots(5)$$

$$B = \left(\frac{\text{Silt}}{\text{Clay} + \text{Silt}}\right)^{0.3} \quad \dots(6)$$

$$C = \left[1 - \frac{0.25 * OC}{OC + \exp(3.72 - 2.95 * OC)}\right] \quad \dots(7)$$

$$D = \left[1 - \frac{0.7\left(1 - \frac{\text{Sand}}{100}\right)}{\left(1 - \frac{\text{Sand}}{100}\right) + \exp\left[-5.41 + 22.9(1 - \frac{\text{Sand}}{100})\right]}\right] \quad \dots(8)$$

Where:

Sand, Silt, Clay and OC are the percentages of sand, silt, clay and organic carbon respectively.

As a first step, a typology of the watershed soils was carried out. Then the percentages of sand, silt, clay and organic matter were then entered in based on the soil samples map. Having only one sample for each type of soil, the values have been attributed and generalized to classes of the same type, without taking into account the spatial and temporal variability of K (type of vegetation, slope). These values are given in tones/acres (US System), and need to be converted into the international system, for this, a factor of 0.1317 is multiplied for each value of K [Table 2]. This methodology provides an approximation in the calculation of the factor K.

Table2. Variation of Kfactor depending on the type of soil

Soil type	K factor [$t.ha.h.ha^{-1}.MJ^{-1}.mm^{-1}$]
Limestone	0.0338
Limestone and Solonchak	0.0313
Limestone and Solonetz	0.0410
Calcic	0.0339
Podzolic	0.0360
Alluvial	0.0366
Unsaturated soils	0.0339

3.3. Topographic Factor (LS)

For the topographic factor, the digital elevations model SRTM 1 arc-secondwas used to extract the slope length and slope steepness using GIS tools. This factor reflects the effect of topography on erosion. It has been demonstrated that increases in slope length and slope steepness can produce higher overland flow which leads to higher erosion (Haan *et al.*1994). There are many relationships available for estimation of LS factor. Among these, the best suited relation for integration with GIS is the theoretical relationship proposed by (Moore and Burch, 1986; Moore and Wilson, 1992), based on unit stream power theory given below.

$$LS = \left(\frac{a * p}{22.13}\right)^{0.4} \times \left(\frac{\sin(d)}{0.0896}\right)^{1.3} \qquad \ldots (9)$$

Where LS: represents the topographic factor; a: refers to the flow accumulation model obtained from the digital elevation model; p: to the cell size (1 arc-second for this study) and d: to the slope model in degrees.

3.4. Cover and management Factor (C)

Vegetation cover plays a very important role in soil protection by damping raindrops, reducing the rate of runoff and infiltration. Thus, soil losses decrease with the increase of vegetation cover. Vegetation cover indices such as the NDVI (Normalized Difference Vegetation Index) are quantitative measures, based on vegetation spectral properties that attempt to measure biomass or vegetative vigor (Agapiou and Hadjimitsis 2011). As an indirect estimate of vegetative density, a Normalised Difference Vegetation Index (NDVI), which approximates chlorophyll density, was calculated for the studied area using Landsat 8 OLI/TIRS images with a spatial resolution of 30 meters. Acquired during the rainy season, these images are very adapted for this application since during this season, soil erosion is most active and plant cover is at its peak.

$$\mathrm{NDVI} = \frac{\mathrm{NIR} - \mathrm{RED}}{\mathrm{NIR} + \mathrm{RED}} \qquad \ldots (10)$$

Where NIR is light intensity in the near infrared, and RED is light intensity in the red band (Bands 4 and 5).

This index is an indicator of the energy reflected by the Earth related to various cover type conditions. When the measured spectral response of the earth surface is very similar to both bands, the NDVI values will approach zero. A large difference between the two bands results in NDVI values at the extremes of the data range.

The following formula based on NDVI was used to generate the C factor value for the present study area (Van *et al.* 2000; Van Leeuwen *et al.* 2004; Zhou *et al.* 2008).

$$C = \exp\left[-a * \frac{NDVI}{b - NDVI}\right] \qquad ...(11)$$

Where a = 2 and b = 1.

3.5. Support practice conservation Factor (P)

The P factor explains human intervention in creating erosion control practices that conserve soil and reduce surface runoff (Herron1994). These practices include contouring, strip-cropping, terracing, strips, etc. (Haan *et al.*1994). The P factor is the soil loss ratio with a specific support practice to the corresponding soil loss with up and down slope tillage (Renard *et al.*1997). Usually, this factor corrects the USLE estimation for management and tillage practices that protect the soil from erosion.

In the present study, the P factor map was derived according to the cultivating methods and slope (Shin 1999) [table 3]. The values of P factor ranges from 0to 1, in which the high value is assigned to areas with no conservation practices. Table 03 presents the P factor values in combination of each slope class.

Table 3. Support practice factor according to the type of cultivating methods and slope

Slope [%]	Contouring	Strip Cropping	Terracing
<7.0	0.55	0.27	0.10
7.0-11.3	0.60	0.30	0.12
11.3-17.6	0.80	0.40	0.16
17.6-26.8	0.90	0.45	0.18
> 26.8	1.00	0.50	0.20

4. RESULTS AND DISCUSSION

R FACTOR

In the study area, the average annual rainfall data of 10 rainfall stations was used to get the rainfall distribution map of the entire catchment. It varies between 541 mm.yr^{-1} and 1143 mm.yr^{-1}. The rainfall erosivity factor map [Fig4] was generated in GIS based on average annual rainfall map. It varies from 216 to 749 MJ.mm. $ha^{-1}.h^{-1}.yr^{-1}$ [table 4].

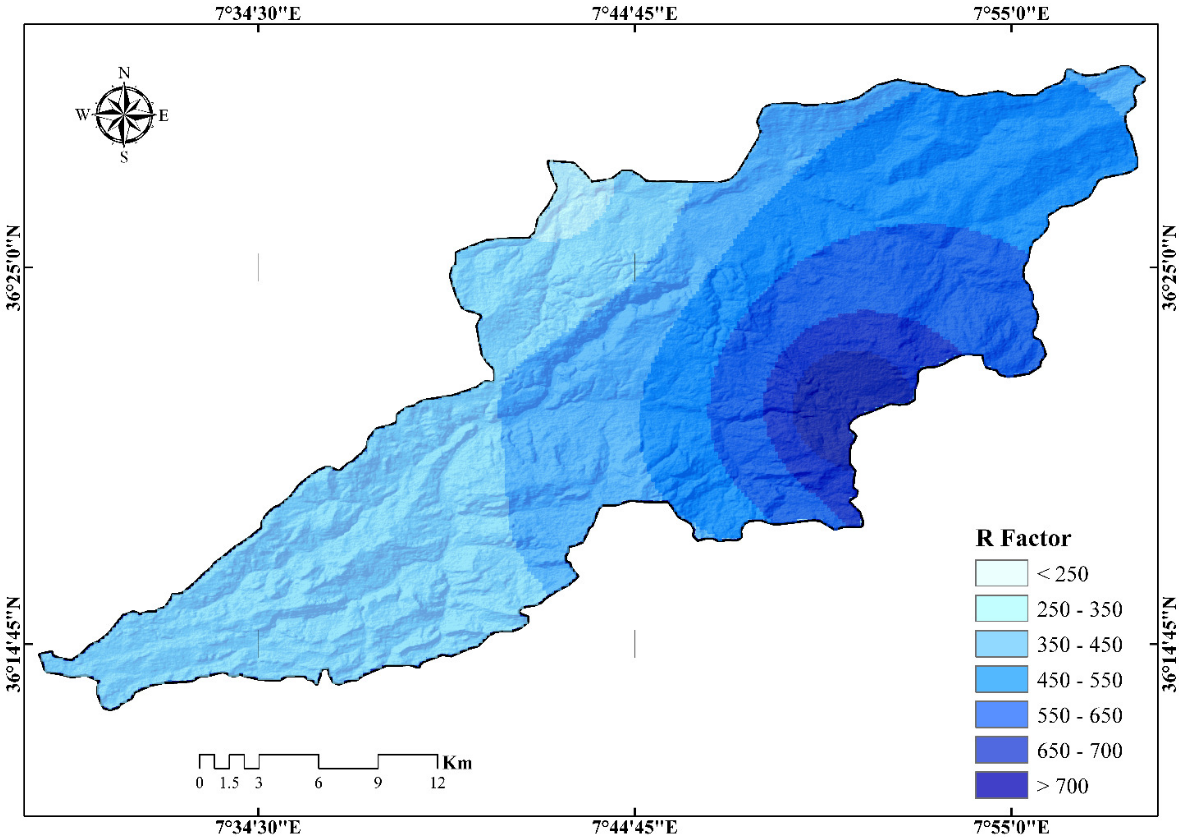

Fig4. Erosivity factor map ($MJ.mm.ha^{-1}.h^{-1}.yr^{-1}$).

Table 4. Rainfall erosivity factor of 10 rainfallstations of the Mellah catchment.

Station	X [Degree]	Y [Degree]	Z [m]	R Factor
Chaffia	8.037932	36.61213	170	456.86
Bouhadjar	8.109478	36.50467	300	313.73
Ain Seynour	7.872032	36.32054	830	716.00
Machroha	7.841738	36.35208	750	748.75
Bouchegouf	7.709768	36.45639	110	215.99
Boukhamousa	7.750115	36.57838	9	310.35
Khmissa	7.656759	36.18787	900	201.70
Cheikh Abdallah	7.783397	36.24352	700	326.91
Hammam N'bail	7.645225	36.32375	460	334.49
Ain Makhlouf	7.241511	36.23285	520	200.62

K FACTOR

The susceptibility of detached soil particles refers to the soil erodibility factor (K) which is related to the aggressively rainfall, the runoff kinetic energy and infiltration on soil loss, accounting for the impact of soil properties on soil loss during storm events in upland areas (Renard *et al*., 1997).

The soil map was reclassified with an assigned K factor value. The K factor is a numerical value varying from 0.0313 to 0.041t.ha.h.ha-1.MJ-1.mm-1in which soil erodibility values closer to 0 reflect low erodibility.

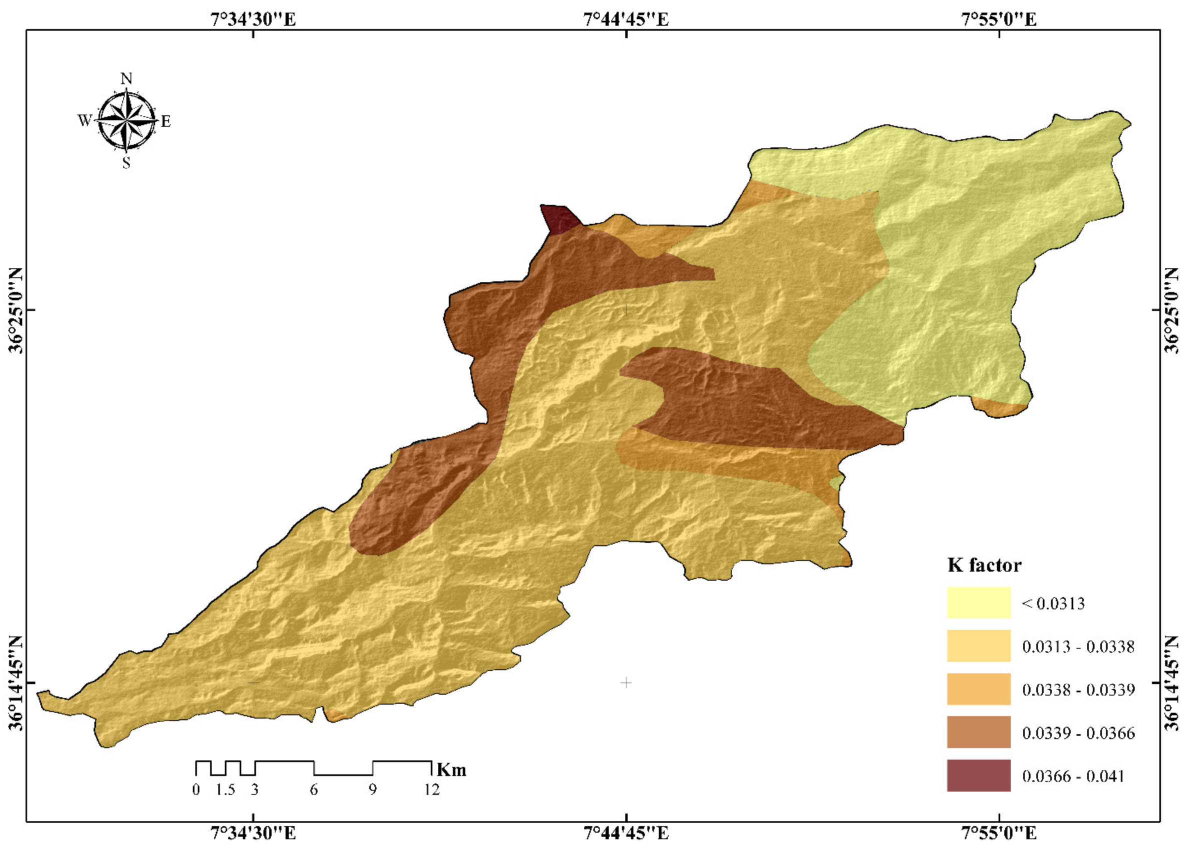

Fig5. Soil erodibility factor map(t.ha.h.ha^{-1}.MJ^{-1}.mm).

LS FACTOR

The length and steepness of a slope affect the total sediment yield from the site and is accounted by the LS factor in RUSLE model. In addition to steepness and length, the other factors such as compaction, consolidation and disturbance of the soil were also considered while generating the LS factor. Erosion increases with the slope steepness, and contrary with the length. The LS factor was computed for the catchment by means of raster calculator in ArcGIS Spatial analyst extension using the ASTER DEM following the proposed equation by Moore and Burch, (1986).

The LS factor values in the study area varied from 0 to 72, with mean and standard deviation of 8.62 and 9.95 respectively. In the studied area, the class (LS <5) is the most dominant. For some specific areas, values greater than 10 are recorded.

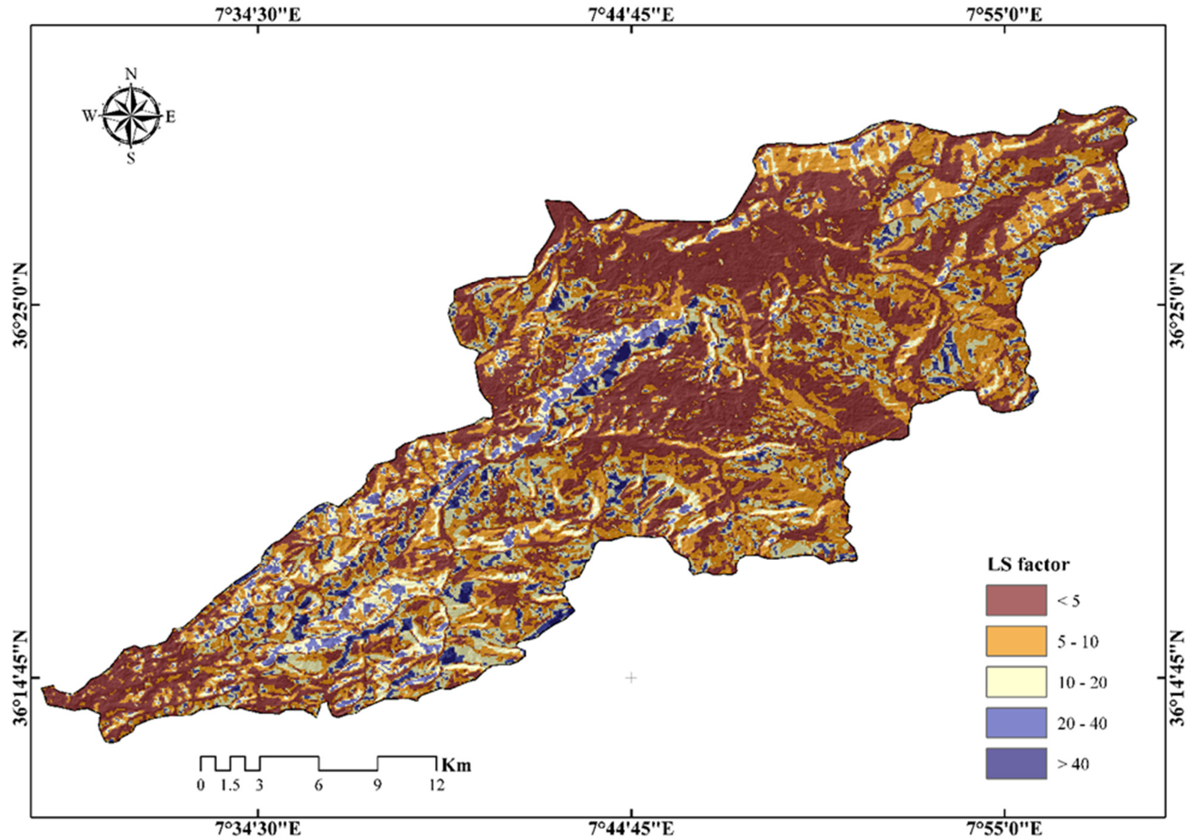

Fig6. Topographic factor map.

C FACTOR

The Normalized Difference Vegetation Index (NDVI), was derived from Landsat 8 satellite data. The NDVI was used in generating the C factor as shown in fig7. The C factor values in the studied area vary between 0 and 0.28. Forest areas show C values between 0.01and 0.036with bare lands showing values approaching 0.2. Agricultural areas in the catchment show C value from 0.2 to 0.28.

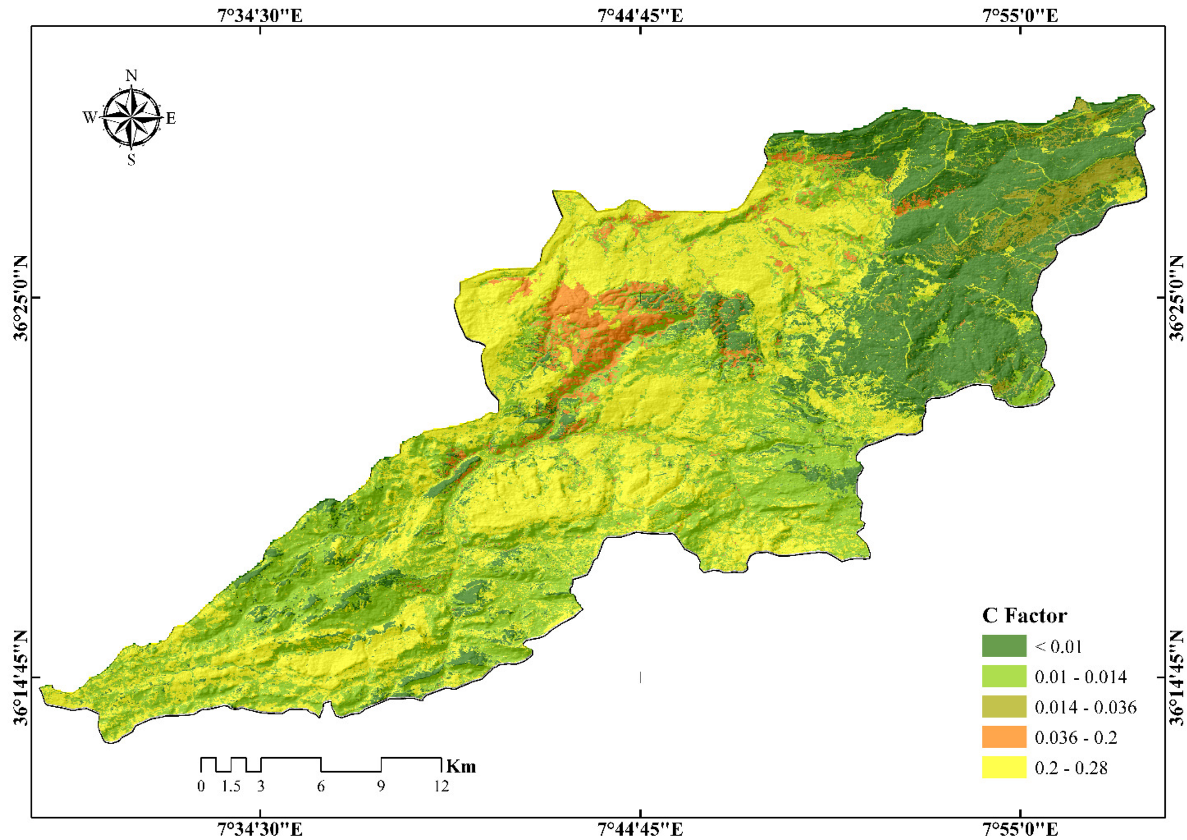

Fig7. Cover management factor map.

P FACTOR

In this study, the P factor map was derived from the slope class's percentage. The founded values range from 0.55 to 1, in which the highest value is assigned to areas with no conservation practices; while the minimum values correspond to built-up-land and plantation area with strip and contour cropping.

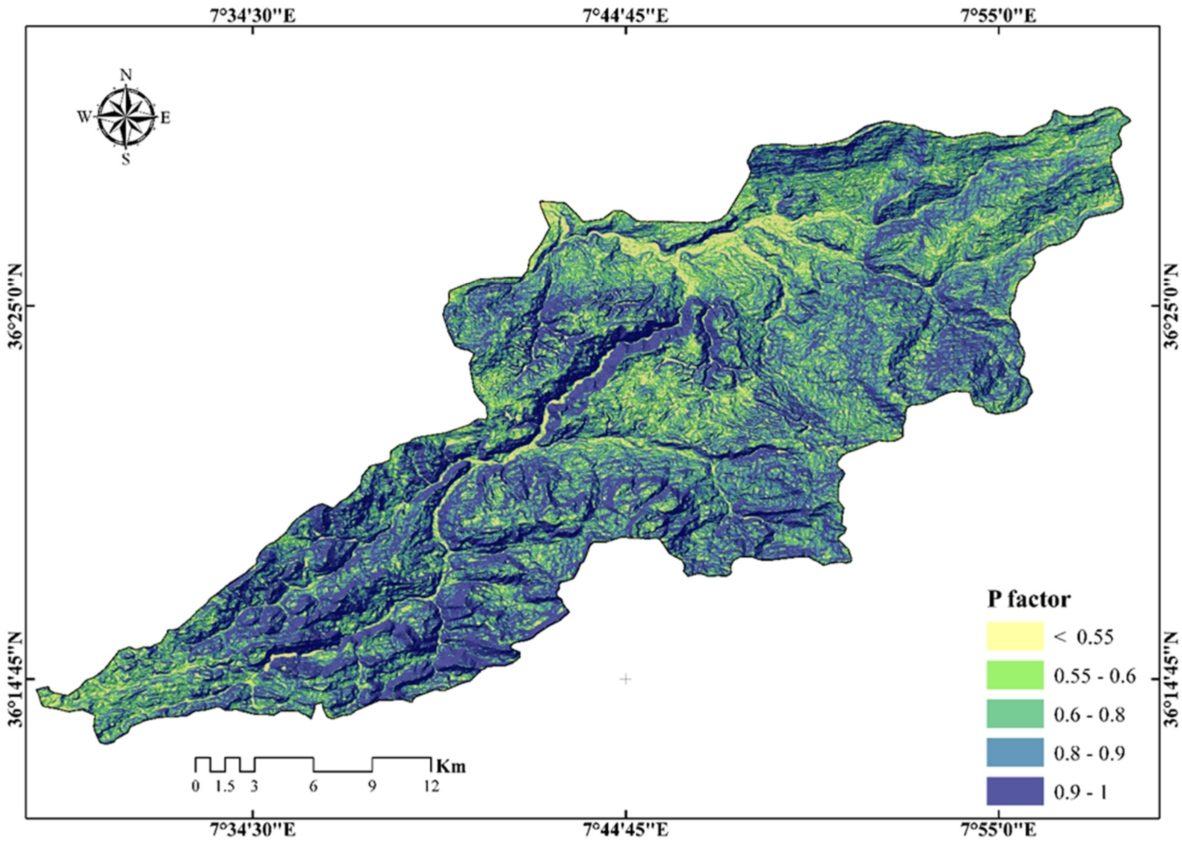

Fig8. Conservation practice factor map.

POTENTIAL EROSION AND SOIL LOSS RATES

The data layers extracted for K, LS, R, C, and P factors of the RUSLE model were integrated using equation (1) in order to quantify, evaluate, and generate the maps of soil erosion risk and severity for the studied catchment. Generally, a high value reflects a higher rate of sediment yield, and contrarily.

Fig 9 and fig 10 shows potential erosion and soil loss rates maps respectively, which reflect to the very important role that is played by the C and P factors for the protection of the soil against water erosion. The C factor is probably the most important factor in RUSLE since it represents conditions that can easily be managed to prevent or reduce soil loss (Bouhadeb *et al.*2018). Higher values of C factor correspond to very high soil losses. Significantly, poor vegetal cover have contributed in accelerating soil erosion and corroborates the results of (Bella *et al*. 2017) in the two semi-arid catchments of Wadi Soultez and Wadi Reboa; located in the North-East of Algeria.

The average soil loss in the Mellah catchmenthas been estimated at 121.80 t $.ha^{-1}.yr^{-1}$ for erosive potential and 10.20 t $.ha^{-1}.yr^{-1}$ for soil loss rates. About 63% of the total area of studied catchment presents a very low soil loss (less than 5 t $.ha^{-1}.yr^{-1}$), while 80% of the surface presents a very high erosive potential (greater than 40 t $.ha^{-1}.yr^{-1}$) [Fig 11].

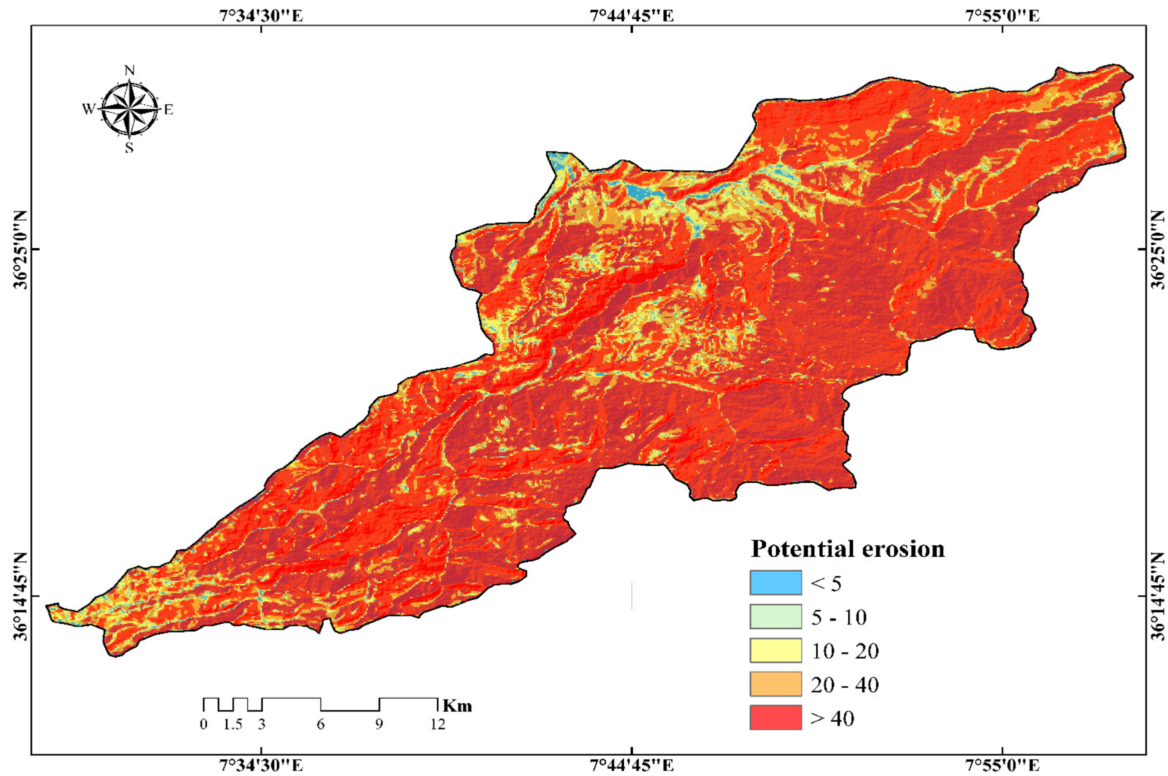

Fig 9. Potential erosion map in Mellah catchment.

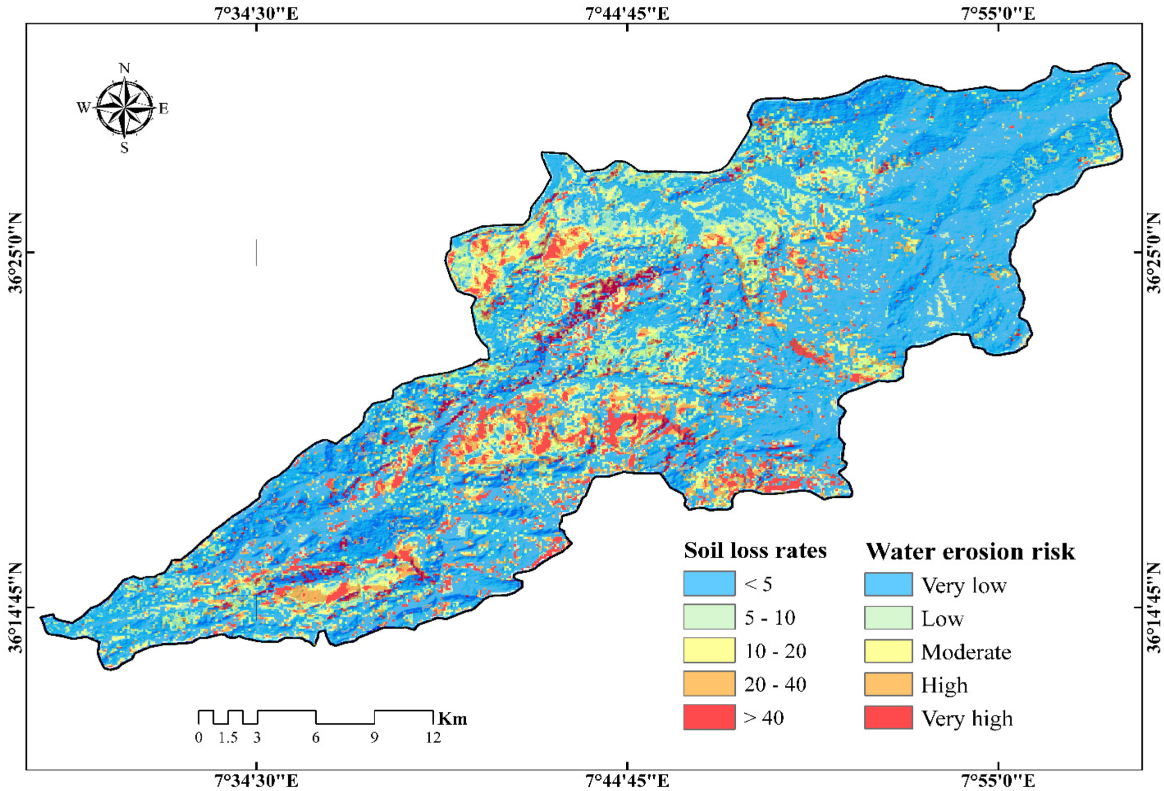

Fig10. Soil loss rates(t .ha^{-1}.yr^{-1})and water erosion map in Mellah catchment.

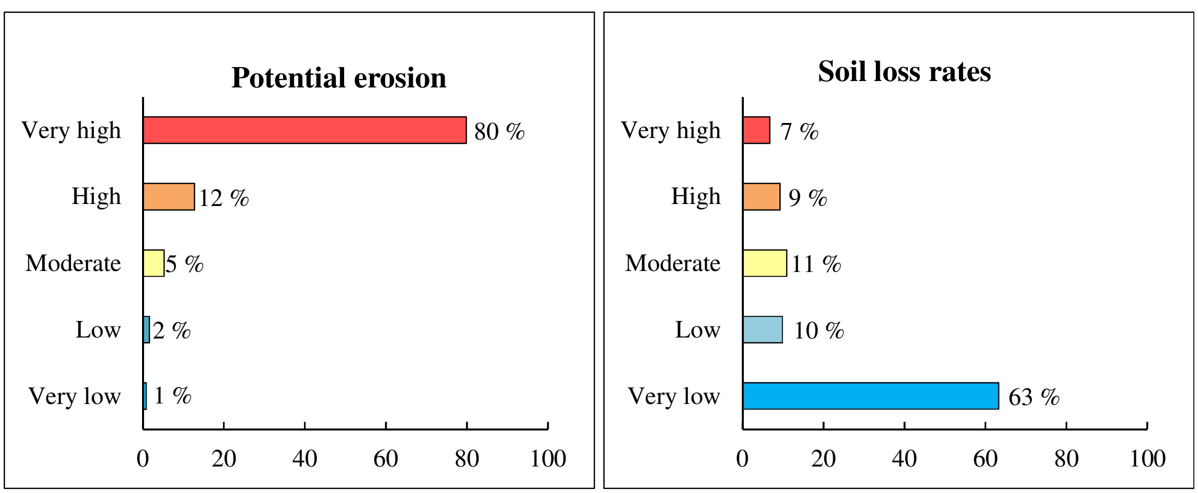

Fig11. Distribution of soil loss and potential erosion classes in the Mellah catchment.

5. CONCLUSION

The watershed erosion map produced by RUSLE model provides a great deal of information concerning the potential for sediment production by water erosion and the location of source areas expressed in t .ha^{-1} .yr^{-1}.The potential erosion rate values obtained at the studied catchment were then grouped into five classes, very low (<5t. ha^{-1}.yr^{-1}), low (5-10 t. ha^{-1}.yr^{-1}), moderate (10-20 t. ha^{-1}.yr^{-1}), high (20-40 t. ha^{-1}.yr^{-1}) and very high (>40 t. ha^{-1}.yr^{-1}) with percentages 63%, 10%, 11%, 9% and 7% respectively of total area. The assessment gave an average soil loss of 10.21 t. ha^{-1}.yr^{-1}. The observations revealed that water erosion is present and visible in all the studied catchment and most areas have suffered soil loss of less than5 t.ha^{-1}.yr^{-1}.

The climatic aggressiveness index ranges from 216 to 749 MJ.mm.ha-1.h-1.yr-1. Soil erodibility is determined synthetically based on the different soil textures and the Digital Soil Map of the World database, to assign each type of soil a K factor value. Limestone, podzolic and alluvial soils present a significant and visible loss on the north-south axis of the catchment, while the soils of the north eastern zone are occupied by limestone-solonshak and limestone-solonetz which shows good resistance to erosive phenomenon.

This loss is favoured by other factors that were combined to accelerate erosion, such as slopes and vegetation cover. Low values of C factor (0.01 - 0.036) confront also lower values in soil loss, which explains the cruel role of vegetation cover in protection against water erosion. Conversely, agricultural land and bare lands (0.036 - 0.28) are much easier to detach and exposed to erosion risk.

Statistical analysis shows that more than 73% of the total area of Mellah catchment is weakly sensitive to erosion, while 27 % has moderate to very high sensitivity. The USLE takes into account only sheet erosion but estimates the average losses caused by surface erosion. It is based on data from plots or watersheds with a very small surface.

Thus, remote sensing and GIS have an important role in the generation of maps for the USLE model. GIS analyses input information in a much faster way with better spatial distribution of map production. The use of GIS techniques to measure soil loss can be more authenticated and reliable with high-resolution spatial data. It makes it possible to manage in a rational way, a multitude of data, with spatial reference, relating to the various factors of soil degradation, which allowed us to conclude that these main factors influence water erosion.

The application of the RUSLE model gives relatively very reliable results, which can provide valuable assistance, at very low costs, to decision-makers and land planners in order to simulate evolution scenarios, and consequently target priority areas that require conservation and erosion control actions.

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