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"RAINFALL EROSIVITY MAPPING AT DIFFERENT ALTITUDE SITES IN DUHOK GOVERNORATE"

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ABSTRACT

Rainfall erosivity (R) was determined by computation of rain erosivity factor that based on the recorded and analyzed rainfall data which was collected from the rain gauge stations (Duhok, Zawita, Ghlbuk, Swaratoka, Mangesh, Bamarney, Sarsink, Amadia, Batifa and Kani-Masi). Modified Fournier index (MFI) was calculated depending upon the monthly and annual rainfall for each of the ten stations, and then a map for annual rainfall erosivity was interpolated based on the multivariate pattern following the ordinary kriging method. The main purpose of this study is to estimate the erosivity factor and then to correlate the R values with the elevation of study sited (rain gauge stations), then drawing the rain erosivity map by use GIS tool. Results showed that the relationships between R and Altitude was weak as correlated in linear equation with (r^2=0.168). The highest R value was at Sarsink stations (436MJ mm/ha. h. yr) although its elevation was (1019m), While the highest elevation was at Kani-Masi stations (1281m) but its R value was only (293.4MJ mm/ha. h. yr). r^2 between rainfall and R was 0.821 which shows a moderately strong relationship.

KEYWORDS: Erosivity factor, Rainfall, Fournier index. GIS Map, Altitude

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1. -INTRODUCTION

Rainfall erosivity was defined by the computation of rain erosivity factors based on recorded and analysis rainfall data from rain gauges stations over a given period. Elwell (1981) uses rainfall energy to determine the erosivity factor for estimating soil loss in southern Africa. Hudson (1971) regarded that kinetic energy for rain falling at intensities of more than 25 mm/hr to be more appropriate for estimating kinetic energy. Lal (1975) in Nigeria reported a better correlation with the product of total rainfall and the maximum 30-minute intensity. The erosivity index was used in the Universal Soil Loss Equation and then in the Revised Universal Soil Loss Equation to compute the annual average erosivity for the entire USA (Wischmeier & Smith, 1978). There is some degree of correlation between erosivity power and amount of rainfall. A number of correlations have been established in localized conditions, for example in Malaysia, Morgan (1974) established the correlation between erosivity and the ten-year daily rainfall amounts. In Zimbabwe Elwell and Stocking (1975) obtained a reasonable agreement between erosivity and rainfall amount based on the idea of selecting only rainfalls within defined results of limited local application. Lo et al., (1985) found a correlation between mean annual rainfall and erosivity factor. In USA, Renard and Freimund (1994) used both mean annual precipitation and the modified Fournier index to estimate the (R) factor. A modified version of Fournier index was introduced for the FAO to study soil degradation (Arnoldus, 1980), and the first approximation of a worldwide map of erosivity factor applied modified Fournier index (Kingu, 1980). Bulgarian experts (Nikolov, 1983) estimated the erosivity factor and draw an iso-erosion map of Northern of Iraq. Sheridan

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and Rosewell (2003) obtain a new (R) value contour map for Victoria which developed from empirical relationships between rainfall intensity, frequency and duration. From the basic nature of the input, such models can only give a first approximation of erosivity factor and more accurate estimations must depend on more detailed input.

Spatial distribution maps were found for natural and management erosion factors and to be the best value in the early stages of land management plans, allowing selection preferential areas where action against soil erosion is more urgent or where the remediation effort will have the highest revenue (Mart´ınez et al., 2009). With the advent of GIS packages and the generalization of spatial interpolation techniques, maps of environmental parameters such as those relevant for soil erosion have become frequent. For example, several authors have used GIS‘techniques to map the factors of the RUSLE equation by means of interpolation methods (Lim, 2005: L´opez-Vicente et al., 2008). Interpolation methods are tools for the determination of unknown values from data observed at known regions. Due to spare synoptic stations, it is necessary to indicate the erosivity index for locations to prepare maps (Khorsandi et al., 2012).

The main purposes of this study are to estimate erosivity factor values and correlated them with altitude and rainfall then create a rainfall erosivity maps by using GIS for the study locations include Duhok, Zawita, Ghlbuk, Swaratoka, Mangesh, Bamarney, Sarsink, Amadia, Batifa and Kani-Masi sites.

2. MATERIALS & METHODS

2.1. Study area

The study area is illustrated ten sites were selected and coordinate as shown in Fig. (1). The lowest site was in Duhok (569 m) and highest one at Kani_ Masi site (1281m) the area has shown different above sea level (msl). Distribution of annual precipitation in each site during the past ten years from 2008-2018 that ranged from 548.2 mm to 1038.8 mm in Duhok and Sarsink respectively at table (2).

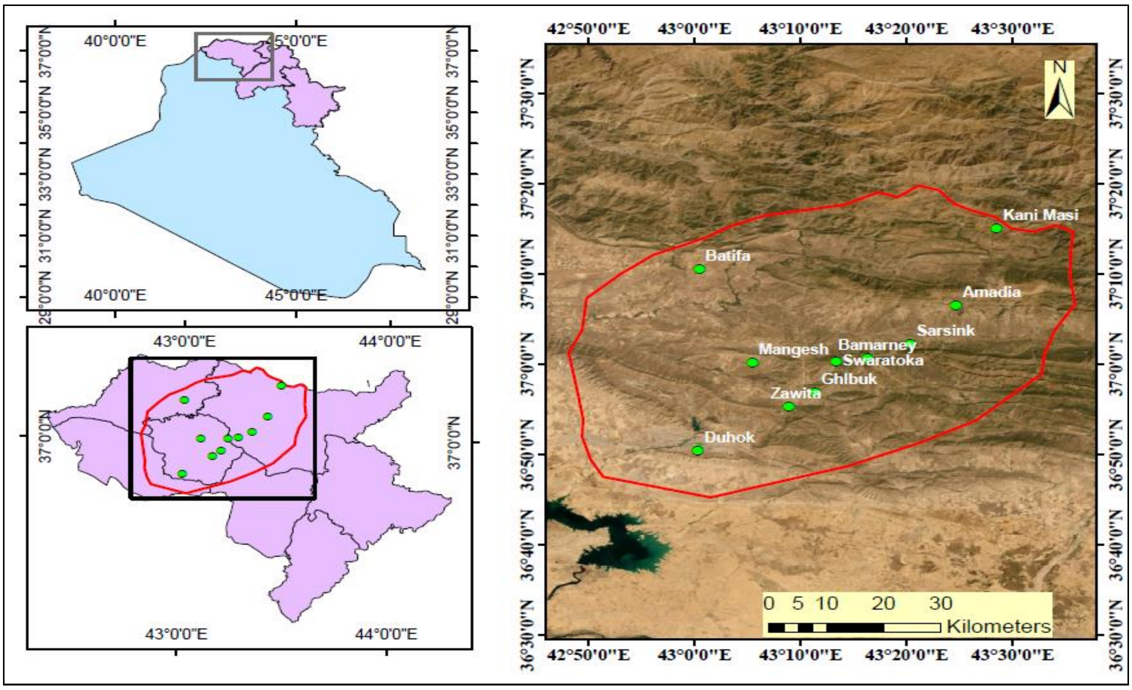

Fig. (1): Maps show the study sites

2.2. R factor

]The monthly precipitation data collected from each of the ten sites mentioned in table -1 for the years 2008-2018. These data used in modified Fournier index equation, (Amoldus, 1980): ($MFI = \sum_{i=1}^{12} p^2/P$) Where p_i is the monthly rainfall (mm) and **P** is the annual rainfall in mm. The obtained Results of all sites used to calculate R factor (Yu and Rosewell, 1996): ($R= 3.82\ MFI^{1.41}$ MJ mm/ha h yr). The researcher used a kriging method of interpolation to draw the rainfall erosivity maps (Governs, 1999).

Table (1): coordinates of the sites

Stations	Longitude (X)	Latitude (Y)	Altitude (m)
Duhok	43˚ 02¯ 00˭	36˚ 50¯ 00˭	569
Zawita	43˚ 08¯ 28˭	36˚ 54¯ 16˭	890
Glbuk	43˚ 11¯ 34˭	36˚ 56¯ 88˭	996
Swaratoka	43˚ 13¯ 36˭	37˚ 00¯ 34˭	1211
Mangesh	43˚ ¯05 45˭	37˚ 02¯ 05˭	957
Sarsink	43˚ 20¯ 35˭	37˚ 02¯ 30˭	1019
Bamarney	43˚ 16¯ 30˭	37˚ 06¯ 51 ˭	1164
Amadia	43˚ 29¯ 13˭	37˚ 05¯ 22˭	1202
Batifa	43˚ 00¯ 27˭	37˚ 10¯ 32˭	879
Kani_ Masi	43˚ 08¯ 28˭	37˚ 13¯ 43˭	1281

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Table (2): Monthly precipitations in the studied stations

Stations	Month												Total Precipitations (mm)
	Jan.	**Feb.**	**Mar.**	**Apr.**	**May**	**Jun.**	**Jul.**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	
Duhok	111.6	69.2	67.2	50.4	24.9	2.2	1.0	0.3	4.6	29.7	77.3	109.8	548.2
Zawita	189.7	101.8	97.2	65.6	37.6	1.2	1.4	0.0	7.5	43.0	100.8	175.1	820.8
Glbuk	116.3	152.4	138.1	104.6	50.35	0.7	0.2	0.2	1.2	23.2	78.4	118.5	784.2
Swaratoka	161.4	123.2	93.6	74.9	39.8	4.0	0.0	3.0	16.2	51.4	93.2	130.5	791.2
Mangesh	118.2	144.5	133.8	107.1	51.4	2.2	0.6	0.6	1.6	27.9	82.0	117.8	787.7
Sarsink	211.2	137.4	149.7	101.3	52.7	4.2	0.0	0.2	7.8	67.8	117.4	189.1	1038.8
Bamarney	117.0	158.1	143.1	119.8	59.1	1.9	0.6	0.5	1.5	33.5	92.1	118.8	845.9
Amadia	148.0	108.4	137.4	97.1	45.2	3.3	0.9	0.0	9.7	66.7	93.2	147.9	857.8
Batifa	120.9	135.3	127.4	107.0	50.2	2.9	0.7	0.7	1.8	30.9	82.3	115.4	775.5
Kani_ Masi	144.1	106.1	145.9	96.0	52.4	5.6	0.3	1.3	10.8	69.2	94.7	156.4	882.8

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3. RESULTS & DISCUSSIONS

Evidently, study rainfall-runoff erosivity factor have a prominent role in soil management and erosion purposes, especially in case mutations of rainfall distribution. Conspicuously erosivity factor (R) in conjunction with rainfall intensity and distribution of rainfall of any region. In line with this, the current research was a focus on the study the real coincident of (R) with geographical feature factor especially altitude at all study sites. Fig (2) shows the slope map that was interpolated from DEM. It is obvious that the study area is mountainous and ground elevation is increased from southwest to northeast, it was between 545m- 1282m.

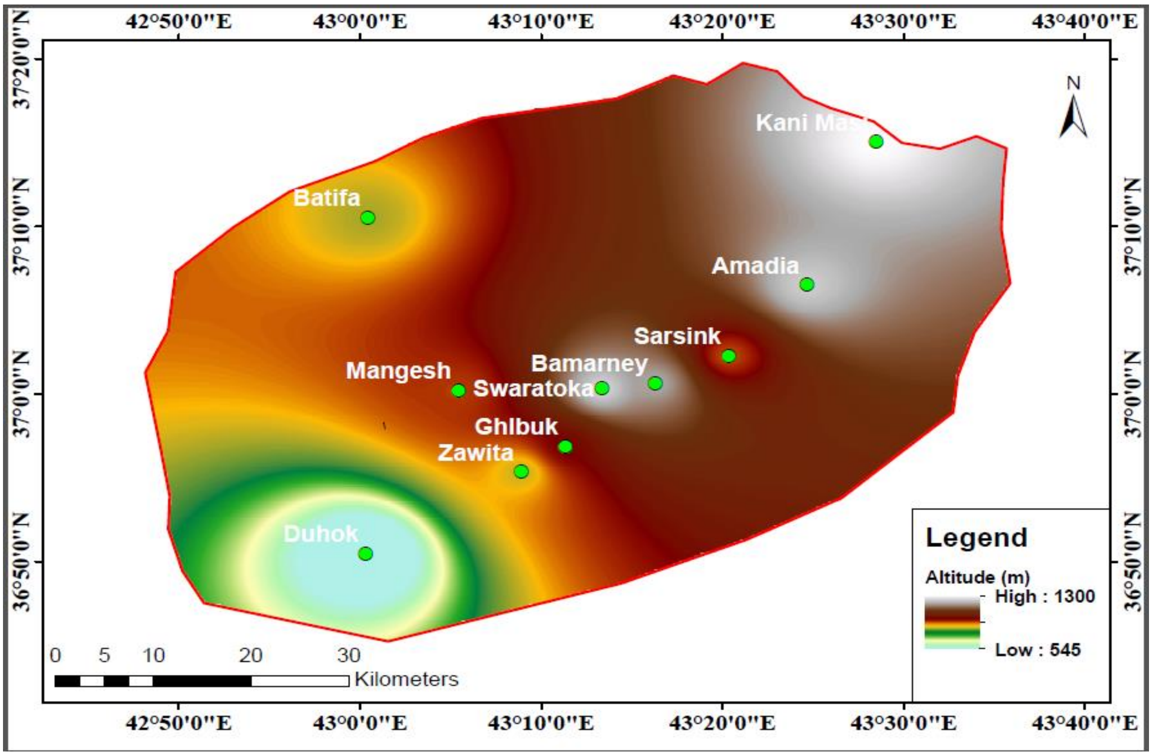

Fig. (2): altitudes in the study stations

In table (3) depicted the P value, MFI and R values in all the ten sites, the total precipitations were ranged from (548.2mm to 1038.8mm) Duhok and Sarsink station respectively, while the MFI from (80.01mm to 147.37mm) in both Duhok and Sarsink, finally the R factor in Duhok lowest value (184.28 MJ.cm/ha. hr. Year) compare to Sarsink gave the highest value (436.04 MJ.cm/ha. hr. Year).

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Table (3): Rainfall and Erosivity factors with MFI at different altitude sites.

No.	Stations	P (mm)	MFI (mm)	R (MJ.cm/ha. hr. year)	Altitude (m)
1	Duhok	548.2	80.01	184.28	569
2	Zawita	820.8	126.00	353.26	890
3	Glbuk	784.2	97.75	244.42	996
4	Swaratoka	791.2	108.15	281.86	1211
5	Mangesh	787.7	112.06	296.34	957
6	Sarsink	1038.8	147.37	436.04	1019
7	Bamarney	845.9	119.04	322.69	1164
8	Amadia	857.8	115.57	309.51	1202
9	Batifa	775.5	108.54	283.30	879
10	Kani_ Masi	882.8	111.27	293.40	1281

The R-factor maps reveal high spatial variability with elevated values in the study sites as shown (Panagos et at., 2016).

Highly relationship was illustrated between mean annual rainfall and MFI with r^2 value equal (0.82) Fig (3) (Amoldus, 1980),

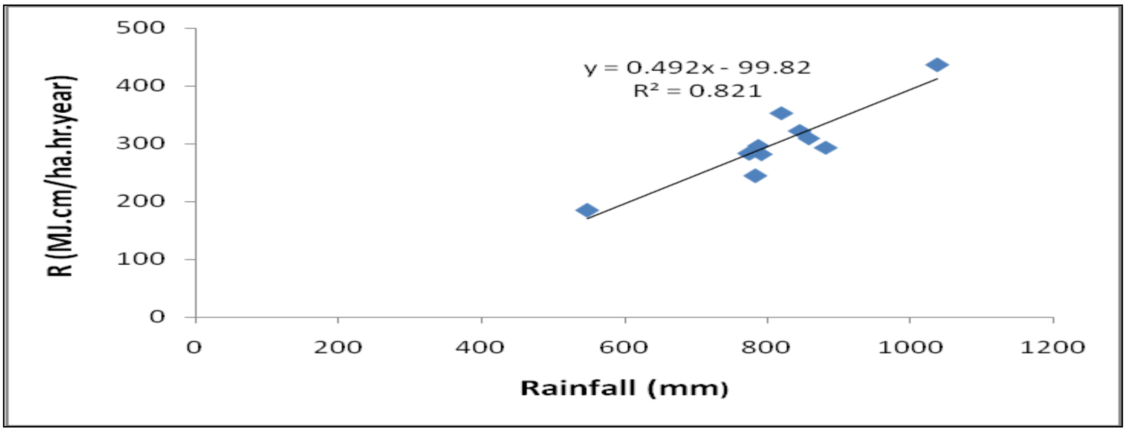


Fig. (3): Relationship between Rainfall and Erosivity factor

Where as strong relation was obtain between MFI values and erosivity factor (r^2 = 0.98) as show in Fig (4). Highly intense has close links of rainfall that reflect the high value of MFI which compatible with erosivity of study locations as shown that in table (3) this helps conveniently and virtually possibility of rainfall erosivity map in Fig (6).

Conspicuously, the relationship between (R) and altitude was weak linear relation as showing in (r^2=0.168) Fig (5), but this result is computable with that show by (Brychta and Janeček 2017).

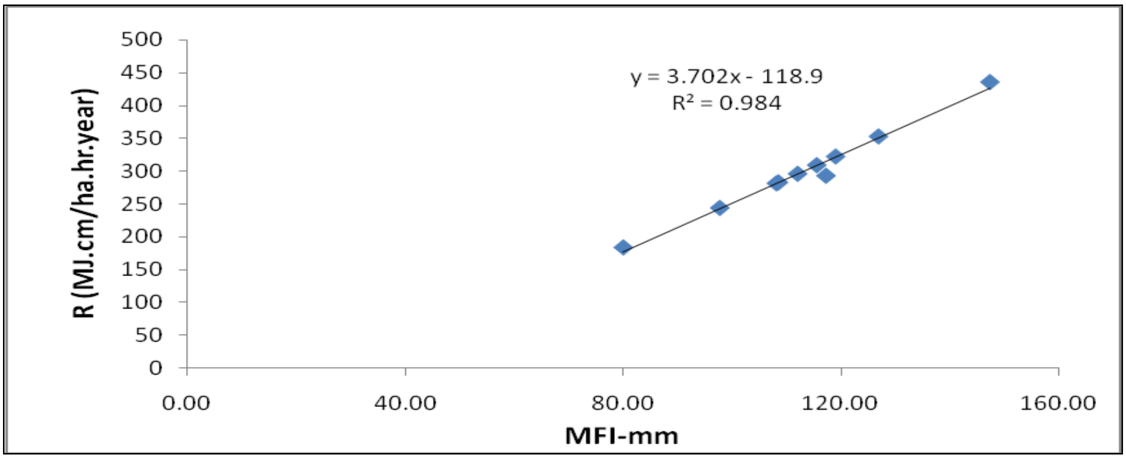


Fig. (4): Relationship between Erosivity and Modify Fournier index

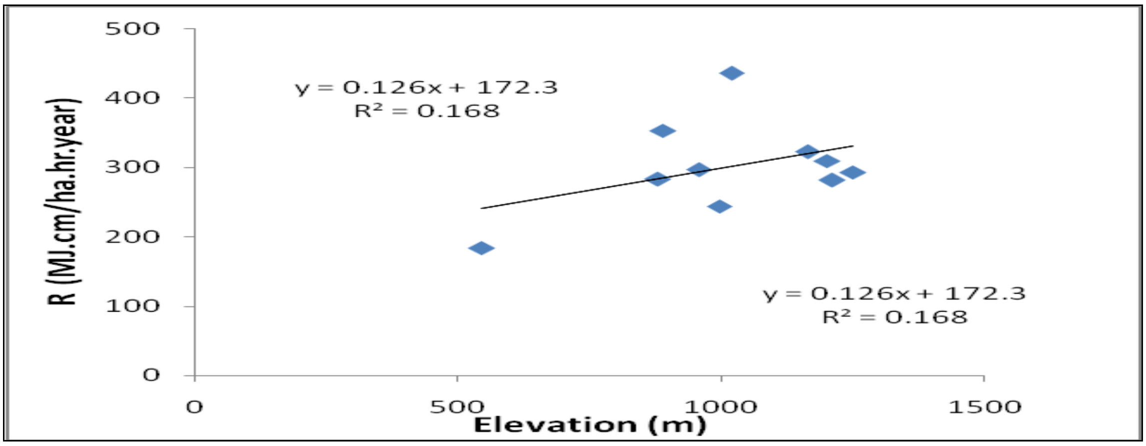
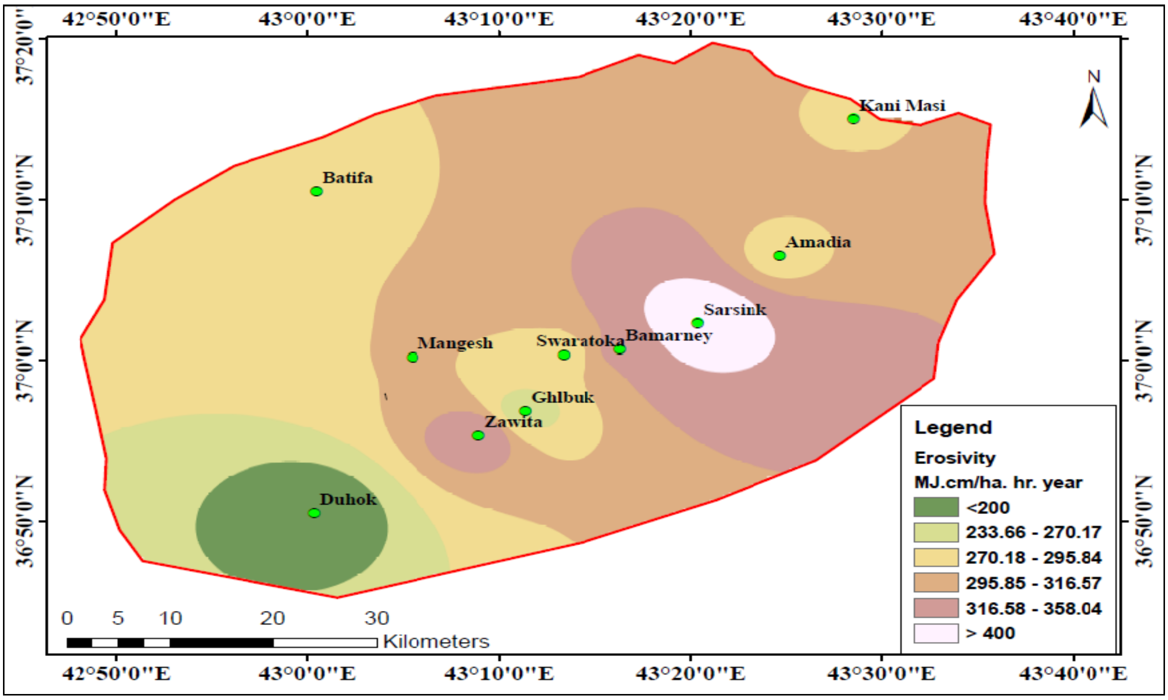


Fig. (5): Relationship between Erosivity and altitude

The elevation of sea level of both stations Kani_ Masi and Sarsink showed contradictory results, the lower value of sea level at Sarsink gave high value of R. Whereas the high level of Kani_ Masi gave low R-value, this is due to two different factors reasons, the first one refers to the technical reasons which related to the accuracy of the rainfall gauge devices, where the second one, Sarsink has a direct relation with the natural of topography and the precipitation distribution.

Fig (6A) Indicates the six rainfall erosivity classes the lowest value was less than (200 MJ.cm/ha. hr. year) and the highest value was more than (400 MJ.cm/ha. hr. year) .While in the Fig (6B) that related to the spacial pattern map ranged (184.28 MJ.cm/ha. hr. year) to (436.04 MJ.cm/ha. hr. year) (Sadeghi et al., 2017). Lastly the Fig (6C) indicates to three classes low erosivity show in (Duhok), moderate erosivity show (Glbuk, Swaratoka, Mangesh, Bamarney, Amadia and Kani-Masi) while the high erosivity show in (Zawita and Sarsink) (Foster et al., 1981).


42°50'0"E
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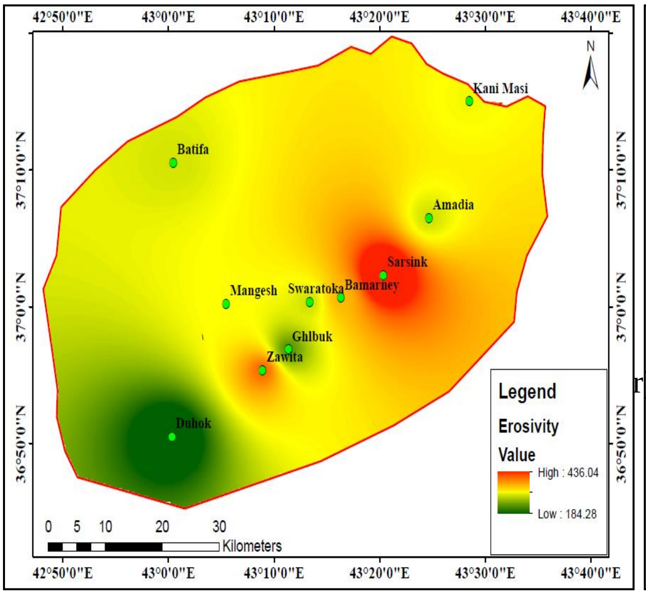
43°10'0"E
43°20'0"E
43°30'0"E
43°40'0"E
37°20'0"
37°10'0"N
37°0'0"N
36°50'0"N
Kani Masi
Batifa
Amadia
Sarsink
Mangesh
Swaratoka
Bamarney
Ghlbuk
Zawita
Duhok
N
Legend
Erosivity
MJ.cm/ha. hr. year
<200
233.66 - 270.17
270.18 - 295.84
295.85 - 316.57
316.58 - 358.04
> 400
0 5 10 20 30
Kilometers

A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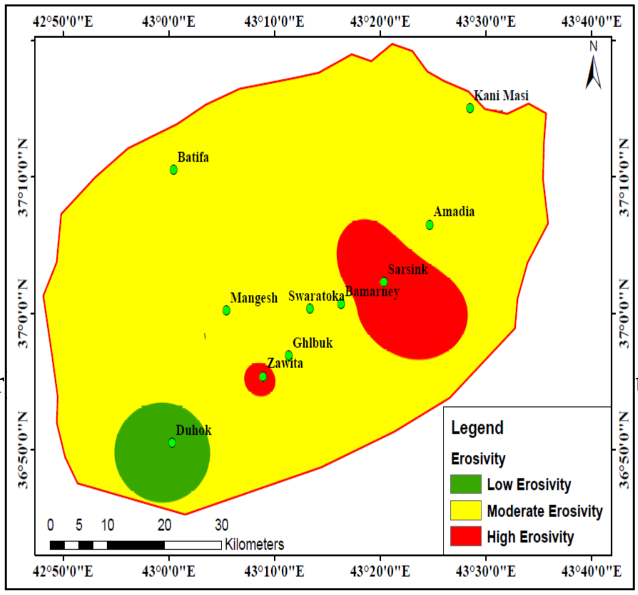
37°0'0"N
36°50'0"N
Kani Masi
Batifa
Amadia
Sarsink
Mangesh
Swaratoka
Bamarney
Ghlbuk
Zawita
Duhok
N
Legend
Erosivity
Value
High : 436.04
Low : 184.28
0 5 10 20 30
Kilometers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43°30'0"E
43°40'0"E
37°10'0"N
37°0'0"N
36°50'0"N
Kani Masi
Batifa
Amadia
Sarsink
Mangesh
Swaratoka
Bamarney
Ghlbuk
Zawita
Duhok
N
Legend
Erosivity
Low Erosivity
Moderate Erosivity
High Erosivity
0 5 10 20 30
Kilometers

CONCLUSION

Results show that the relationship between R-value and altitudes was very weak (0.168). The reason is related to many factors, rainfall distribution in the study region, while other factors are due to associated with technical reasons.

In the other the relationship between R and rainfall values shows a significant one, it was a moderately strong (R^2=0.821). This means that rainfall can be used to estimate R but we cannot use altitude to predict R.

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نەخشە كێشانا هوكارێ رامالينا ئاخێ برێكا باران ل بلنداهێن جياواز ل پارێزگەها دهوكێ

پوختە:

رامالینا ئاخێ (R)دشێن پێناسە بکەین ب ریکا هژمارتنا هوکارێن رامالینا ئاخێ و گرنگیێ د دەتە ل سەر بنەمایێ شلوڤەکرنا رێژا بارانا یا تومارکری ب هاریکاریا ئامیرێت جیاواز یێت پیڤانا بارانێ ل وێزگەهێت گەشناسی یێت (دهوك, زاویتە, غەلبوك , سوارەتوکا, مانگێش, بامەرنێ, سەرسنگ, ئامێدی, باتیفا و کانی ماسێ) نیشاندەرێ فورنر MFI و هاتە دیارکرن ب هاریکاریا بارانێن هەیفانە و سالانە یێن هەر دەە وێزگەهێت گەشناسی, و نەخشە هاتە کێشان بو هوکارێ (R) بو هەر جهەکێ خاندنێ ب رێکا Ordinary kriging map. ئارمانجا سەرەکی یا فێ خاندنێ دیاکرنا گرێدانا دنافبەرا بهایێ هوکارێ (R) و بلنداهیا یا جهێت جیاواز یێت خاندنێ و دانانا وان بهایا ل سەر نەخشەی ب هاریکاریا سیستەمێ پێزانینێن جوگرافی (GIS), و هاتە دیارکرن کو پێکڤە گرێدانەکا کێم هەیە دنافبەرا هوکارێ (R) و بەرزی دا (r2=0.168), بلنداهی ل سەر ئاستێ دەریا ل هەر ئێك ژ وێزگەهێن کانی ماسێ و سرسنکێ دەرئەنجامێ (R)یێ پێچەوانە یە کو بەرزیا سەرسنکێ (m1019) بهایەکێ زێدە دا MJ mm/ha. h. yr436)) بەراودی دگەل ئامێدیێ کو بلنترە و بهایەکێ کێم هە بو .(MJ mm/ha. h. yr293.4) هەوەسا پێگڤە گرێدانانەکا زێدەیە دناڤبەرا هوکارێ (R) و بارانێ دا=0.821) (r2.

خارطة عامل قابلية المطر علىَ التعرية للمواقع ذات الأرتفاعات مختلفة في محافظة دهوك

الخلاصة

يمكن تعريف عامل قابلية المطر على التعرية (R) من خلال حساب معامل تعرية التربة بواسطة المطرعن طريق تحليل قيم الأمطار المسجله بواسطه اجهزه قياس الأمطار للمحطات المختلفه للسنوات العشره الأخيره.اعتمادا على العلآقه القويه بين مؤشرفورنر MFI وعليه تم عمل خارطه لقيم العامل (R) لكل موقع من مواقع الدراسه بأستخدام طريقه الاستنباط الاعتيادي (ordinary kriging map) واستنادا على نموذج (regression-krigingtechnique). ان الهدف الأساسي لهذه الدراسه هي ايجاد مدى الأرتباط بين قيم العامل (R) والأرتفاع المختلفه لمواقع تحت الدراسه و تم اسقاط تلك القيم على خارطه المنطقة باستخدام GIS. اظهرت النتائج ان العلآقه بين قيم العامل (R) والأرتفاع كانت خطيه ضعيفه (r^2=0.168), حيث وجد عند قيم الأرتفاعات في كل من محطتي كاني ماسي وسرسنك ان قيم (R) كانت عكس التوقعات, حيث ان الأرتفاع في موقع سرسنك 1019m اعطىَ قيمة Rعاليه (R= 436 MJ mm/ha. h. yr) في حين موقع العماديه ذات قيمة (R) منخفضة (293.4MJ mm/ha. h. yr). بالاضافة الىَ ذلك اظهرت النتائج ان هناك علاقة قوية بين كل من (R) والامطارالسنويه وكانت (r^2=0.821).