



## Temporal Variations of Rainfall Erosivity Factor in Mazandaran Province, Iran

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### Abstract

The rainfall erosivity factor indicated as R in Universal Soil Loss Equation (USLE) is one of the best quantitative indices for the evaluation of potential erosion risk in an area. The erosivity factor describes the ability of rainfall to erode the soil. Studying the magnitude of erosivity factor in different times and spaces is an important task which can be used for managerial purposes of soil erosion control. In order to study the temporal variation of R-factor, the Mazandaran Province located in the northern part of Iran was selected. The entire 25 years data of 4 stations in the Mazandaran province and one station in the Golestan province were collected for the study. The R values were then calculated with the help of equation applied in USLE. The average annual rainfall erosivity of the study area was found to be 46.62 ton.m/ha.h with the maximum and the minimum values of 14.77 and 0.40 ton.m/ha.h respectively belonging to months October and May. The highest and the lowest values of R factor also occur in autumn and winter, respectively. The crop management treatments can therefore be easily suggested to protect the land against the rain drops based on the results obtained from the study.

**Key words:** Erosivity, Iran, Mazandaran Province, Temporal variation, USLE

### Introduction

Annually on protection against natural dangers, it is spent about 2% of the gross world product. At growth rate of the gross world product of 3.5% in year, growth of damage from natural hazards is about 10% one year (Blagovechshenskiy *et al.*, 2004). Iran also has no exception and thus losses lots of resources owing to different causes. On the basis of 1991 statistics, 300m<sup>2</sup> of forests and 400m<sup>2</sup> of rangelands are being continuously depleted per each second (Rahmani and Jalaliyan, 1993). Among miscellaneous destructive factors, erosion stands in top priority and needs to be considered well. Water, wind, glacier and gravity are the main causes of soil erosion. The extension of water erosion is more and its consequent results is also much complicated than other types of erosion in Iran. In water erosion, detachment of soil grains seriously is controlled by rainfall splash. The magnitude of kinetic energy of rain drops is described by an index known as rainfall erosivity factor and shown as R factor in Universal Soil Loss Equation (Wischmeier and Smith, 1958). Duration, intensity, rain drop diameter, elevation, and spatial and temporal variability of rainfall influence the rain erosivity. Wischmeier and Smith (1958) studied 183 storms in Zanzoil region in USA and showed that soil loss has strong relation with rainfall intensity ( $I_{30}$ ) which itself varies with time. Atre (1997) estimated rainfall erosivity in Rahuri, India, in three periods of pre-monsoon, monsoon and post-monsoon and highlighted the differences among the studied periods. Posch and Seppo (2003) computed rainfall erosivity factor for Finland. They pointed the noticeable monthly and seasonally difference of erosivity. Till date no study has been conducted in Iran to emphasize the temporal variation of erosivity. Therefore, in the present paper, the temporal variability of rain erosivity has been considered for one of the northern

provinces in Iran facing with serious rate of land degradation and having high potential for agricultural utilization.

### Materials and Methods

The Mazandaran province with an area of 23756.4 km<sup>2</sup> laid in 50°34' to 54°10' E-longitude and 35°37' to 37° N-latitude. Mean rainfall of the province is 750mm and classified as semi-humid climatic. Figure 1 shows the location of the study area in Iran (Management and Planning Organization of Mazandaran Province, 2001).

In order to conduct the study, at first, the climatological stations equipped with rain gage recorders and located in the study area were selected. The location of the selected stations i.e. Ramsar, Nowshahr, Babolsar and Kasiliyan has also been shown in Fig. 1 and their coordinates have been summarized in Table 1. Because of lack of station in eastern part of the study area, another station was then selected in neighboring province of Gorgan.

The collected rainfall hytographs of 25 common years were precisely analyzed for daily, monthly, seasonal and annual basis. The rainfall kinetic energy for each storm in the aforesaid periods was calculated using the following equation:

$$E = 210.3 + 89.7 \text{Log}I_i \quad (1)$$

where E is kinetic energy of rainfall in j/m<sup>2</sup>/cm rain and I<sub>i</sub> is rainfall intensity in cm/h for any time step.

The rainfall erosivity factor (R) was then computed with the help of the following equation (Wischmeier and Smith, 1958):

$$R = \frac{\sum_{i=1}^n EI_{30}}{100} \quad (2)$$

where R is rainfall erosivity factor in ton.m/ha.h; E= storm energy from step i=1 to i=n and I<sub>30</sub> is maximum rainfall intensity in 30 minutes of an individual storm in cm/h.

After computing the storm-wise rainfall erosivity, the monthly, seasonal and annual erosivity values were then respectively computed by sum of daily, monthly and seasonal values. The concept of Thiessen method was also used to obtain an average values for the study area. The temporal variation of rainfall erosivity was ultimately investigated throughout the study province.

### Results and Discussions

The monthly and seasonal values of rainfall erosivity in selected stations calculated as per the procedure explained above have been summarized in Tables 2 and 3 and their graphical variations have been depicted in Figs. 2 and 3. The annual rainfall erosivity for the Mazandaran province was also found to be 46.62 ton.m/ha.h.

As it is seen in Tables 2 and 3 as well as Figs. 2 and 3, the variation of rainfall erosivity in different time scales is high and necessary attention is therefore seriously required. The prioritization of different months in seasonal and annual rainfall erosivity contribution in the study area has been sorted in Fig. 4 and shows that October, and April and May have the maximum and the minimum rainfall erosivity, respectively.

To analyze the reasons behind such results, the storm characteristics were scrutinized. The frequency of storm occurrence has been demonstrated in Fig. 5.

Fig. 6 shows that the maximum numbers of storms occurred in months February and October while their erosivity is quite different. Comparing Figs. 5 and 6 shows that number of storms can not describe the potential rainfall erosivity of the associated month. The mean maximum 30 minutes intensity of storms occurred in October is 0.6 cm/h which is much higher than 0.24 cm/h belonging to February. This result which has also been incorporated by



Wischmeier and Smith (1958) may be supposed as one of the main reasons. In addition, the maximum mean rainfall occurs in October with the amount of 9.83mm.

Prioritization of the seasons, demonstrated in Fig. 6, showed that autumn and winter have the highest and the lowest rainfall erosivity, respectively. Analyzing the storm characteristics in different seasons showed that storms occurred in autumn have high maximum 30 minutes rainfall intensity equal to 0.5 cm/h, the highest rainfall duration as well as mean rainfall of 7.96mm.

**Conclusion**

The results of the study verified the significant variation of rainfall erosivity during different months as well as seasons in the Mazandaran Province in southern part of Caspian Sea. The average annual rainfall erosivity of the study area was found to be 46.62 ton.m/ha.h with the maximum and the minimum values of 14.77 and 0.40 ton.m/ha.h respectively belonging to months October and May. The highest and the lowest values of R factor also occur in autumn and winter, respectively. The crop management treatments can therefore be easily suggested to protect the land against the rain drops based on the results obtained from the study. Study on the main sources and reasons of temporal variations in the study area and extension of such type of studies in different parts of the country and providing necessary agricultural issues are strictly advised.

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Table 1. Some characteristics of the stations

No.	Station	Long.(E)	Lat.(N)	Elevation(m, ams)
1	Ramsar	50° 40'	34° 54'	-20
2	Nowshahr	51° 30'	36° 39'	-20.9
3	Babolsar	52° 39'	52° 39'	-21
4	Kasiliyan	53° 11'	36° 6'	1100
5	Gorgan	54° 16'	36° 51'	13.3

Table 2 Monthly variation of rainfall erosivity factor (ton.m/ha.h)

station \ Month	Ramsar	Nowshahr	Babolsar	Kasiliyan	Gorgan	Weighted mean
April	0.75	0.22	0.44	0.30	0.47	0.40
May	0.36	0.46	0.38	0.13	0.52	0.40



June	1.70	6.63	0.96	0.97	6.21	3.57
July	5.73	1.78	2.49	4.03	1.84	2.62
August	0.94	2.78	2.71	1.31	2.35	2.33
September	3.89	18.29	6.90	0.55	2.79	7.65
October	6.42	37.28	11.10	0.39	7.30	14.77
November	4.74	4.93	11.90	0.29	12.26	8.30
December	2.23	6.42	3.57	0.66	12.26	5.76
January	1.41	1.24	1.79	0.72	3.52	1.89
February	0.71	1.63	1.87	0.05	0.91	1.28
March	0.86	0.55	1.31	0.31	2.21	1.17

Table 3. Seasonal variation of rainfall erosivity factor (ton.m/ha.h)

station \ season	Ramsar	Nowshahr	Babolsar	Kasiliyan	Gorgan	Weighted mean
Spring	2.80	7.37	1.78	1.4	8.9	4.76
Summer	9.61	7.34	12.10	1.95	8.18	8.60
Autumn	14.71	48.62	26.57	1.34	31.82	28.93
Winter	2.98	3.42	4.97	1.08	6.64	4.33

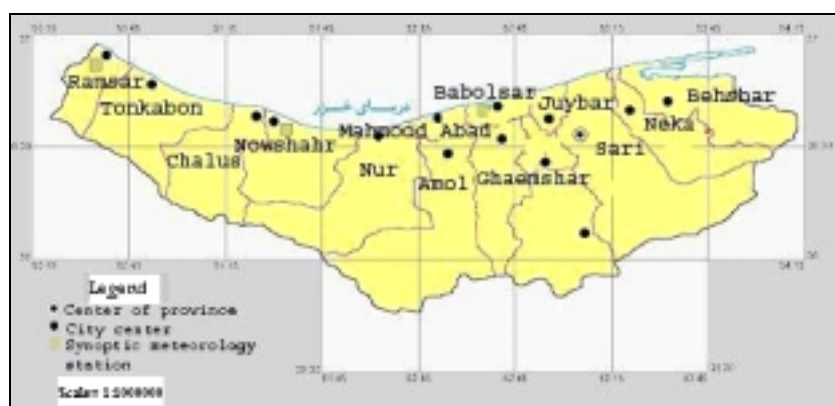


Fig. 1 The location of study area in Iran

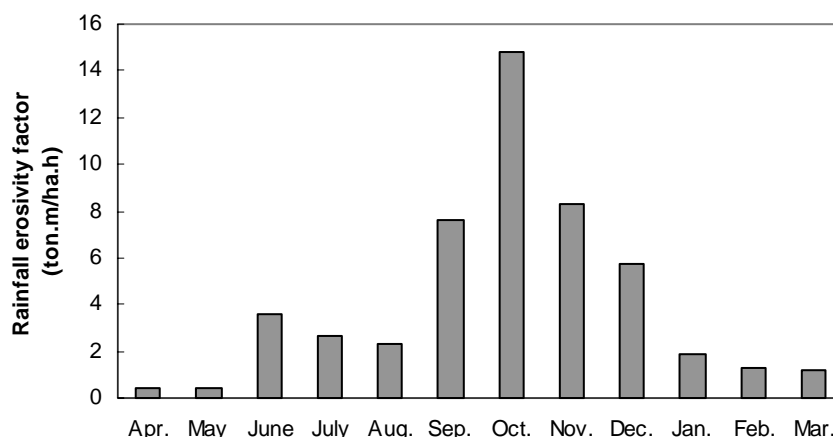


Fig. 2 Monthly variation of rainfall erosivity in Mazandaran Province

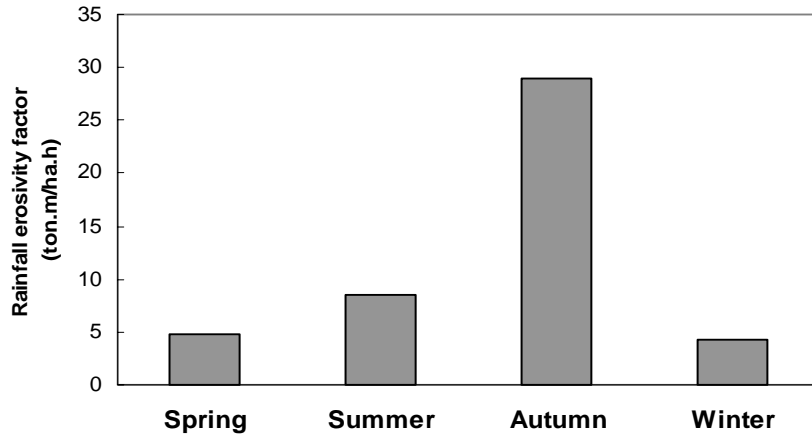


Fig. 3 Seasonal variation of rainfall erosivity in Mazandaran Province

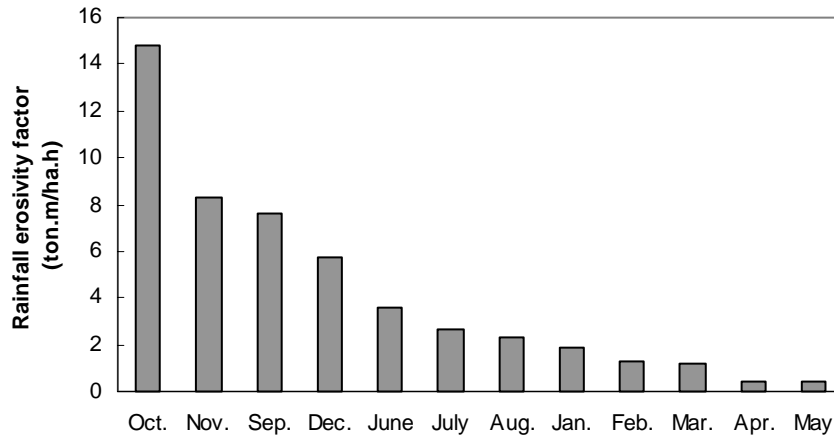


Fig. 4 Monthly prioritization of rainfall erosivity in Mazandaran Province

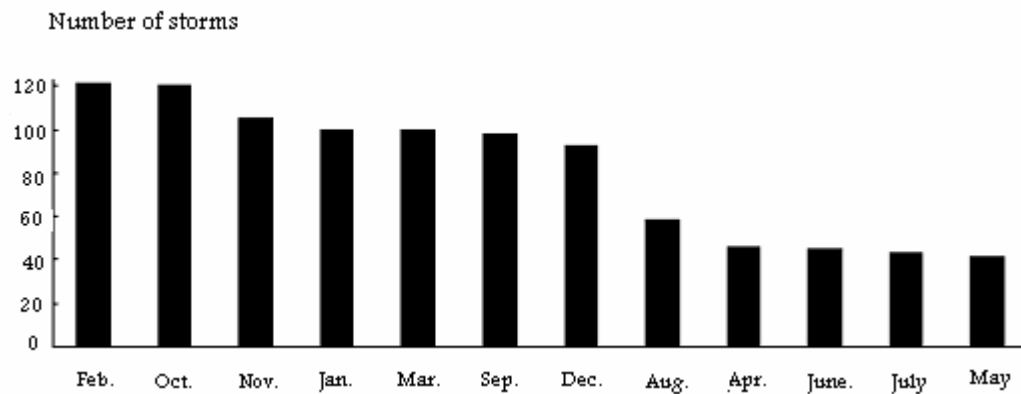


Fig. 5 Frequency of monthly storm occurrence in Mazandaran Province

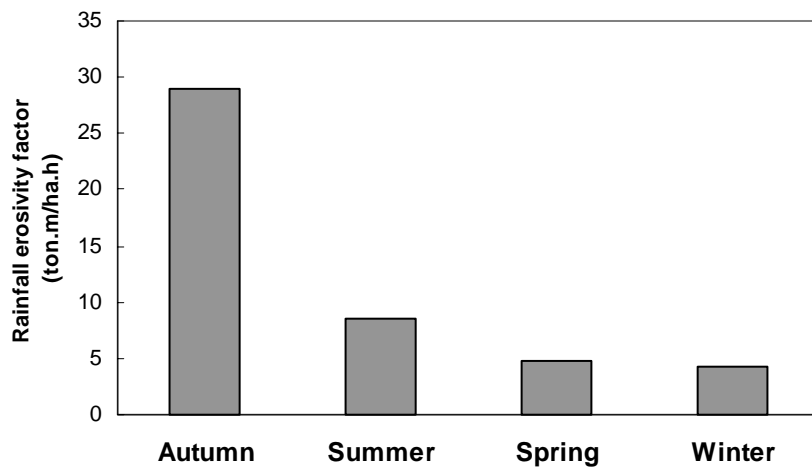


Fig.6 Seasonal prioritization of rainfall erosivity in Mazandaran Province