Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 2458-9403
Vol. 7 Issue 8, August - 2020

Determination of R Factor in Revised Universal Soil Loss Equation (RUSLE) With Open Sources Geographical Information System (GIS) Software

Selcuk Albut
Dept. of Biosystem Eng., Faculty Of Agriculture
Tekirdag Namik Kemal University
Tekirdag, TURKEY
salbut@gmail.com

***Abstract*— Soil erosion is one of the most important problems affecting agricultural productivity. The Revised Universal Soil Loss Equation (RUSLE) is the most popular empirical-based model used globally for erosion estimation and control. Remote Sensing (RS) and Geographic Information System (GIS) techniques have become important tools as they evaluate erosion at larger scales due to the required amount of data and wider area coverage. In this study, the R factor, which is one of the important elements of RUSLE equation with long years average precipitation data in Tekirdağ province, was determined by using RS and GIS techniques. Using the open source QGIS 3.14 software in the Regulated Universal Soil Loss Equation, topography in the region can be determined as a function of soil texture, land use, land cover, precipitation erosion, crop management and their application. Rainfall erosion R factor of RUSLE varies between 32,975-275,929 ha^{-1} $year^{-1}$×mm h^{-1} under Tekirdağ conditions.**

***Keywords*— Soil erosion, RUSLE, R factor, QGIS, Open Source, Tekirdag**

I. INTRODUCTION

Mountainous terrain is composed of 56% of Turkey [1]. With this aspect, Turkey's topography and climatic dynamics are quite susceptible to erosion formation. For taking control measures that have an important place in combating erosion, areas where erosion is effective should be determined quickly. Erosion works, at the same time that are labor-intensive and costly, carried out with methods based on traditional land surveys in large areas take a rather long time [2].

Especially in agricultural land, Remote Sensing (RS) and Geographical Information System (GIS) techniques have been started to use in the light of the developments in technology. Determining the amount and distribution of existing agricultural land in agricultural activities plays an important role in better planning of the country's agriculture [3].

In this study, Rainfall Erosion Creation Factor (R) value, which is one of the important criteria of RUSLE equation in Tekirdağ province will be calculated using the open source coded Geographical Information System software QGIS [4], [5], [6], [7], [8], [9].

What is QGIS & Why QGIS?

From the QGIS website, "QGIS is a user friendly Open Source Geographic Information System (GIS) licensed under the GNU General Public License. QGIS is an official project of the Open Source Geospatial Foundation (OSGeo). It runs on Linux, Unix, Mac OSX, Windows and Android and supports numerous vector, raster, and database formats and functionalities." QGIS is open source. That means the code is available for you to read or modify, should you choose to, but you don't have to.

QGIS is an open source, community-driven desktop GIS software that allows users to visualize and analyze spatial data in a variety of ways. There are many reasons to use QGIS, but here are a few:

- It's a robust, powerful desktop GIS
- Runs on all major platorms: Mac, Linux, & Windows
- Free of charge, all access (no paid add-ons or extensions)
- Frequent updates & bug fixes
- Responsive, enthusiastic community
- Integration with other geospatial tools & programming languages like R, Python, & PostGIS
- Access to analysis tools from other established software like GRASS and SAGA
- Native access to open data formats like geoJSON & GeoPackage
- Comes in a more than 40 languages, making it easier to work with a larger variety of colaborators [10], [11].

II. MATERIALS

Research area is Tekirdağ province. Human-induced land degradations such as industrialization and urbanization in provincial continues to increase day by day due to multifaceted socio-economic and environmental reasons. For these reasons, research area has been selected on the ground that it will serve as an example model for determining the current situation of soil erosion risk and soil erosion caused by water and wind. Tekirdağ province, in the northwest of Turkey, located in the Marmara Region of Turkey to the European continent and is located in Tekirdağ section (Fig.1).

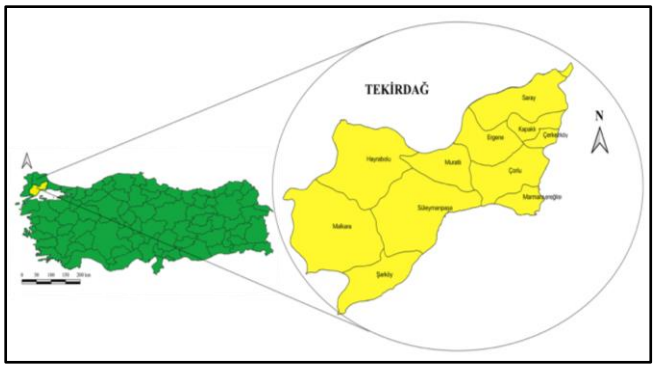


Fig. 1. *Research area*

There are 13 meteorology stations covering the research area (Table 1). Coordinate values of the meteorology stations were taken from the General Directorate of Meteorology and combined with precipitation data in MS Excel file.

Table 1. *Tekirdağ meteorology stations*

Station ID	Station name	Altitude (m)	Latitude	Longitude	Average Precipitation
17056	Tekirdag	2,00	541753,63	4534259,26	585,03
17640	Cerkezkoy	137,00	577034,67	4568105,61	567,65
17634	Malkara	202,00	492249,49	4526250,49	694,57
18107	Sarkoy	6,00	506344,94	4495123,42	484,11
18108	Hayrabolu	103,00	507150,25	4562872,28	593,20
17054	Corlu	147,00	568440,33	4559037,78	616,81
18422	Muratli	112,00	541513,47	4555926,41	591,08
18423	Saray	153,00	578035,01	4588790,25	665,38
19122	Kapakli	207,00	583972,58	4576731,84	522,40
18804	Banarli	137,00	528535,82	4547415,93	681,20
18806	Ganos Dagi	736,00	518407,46	4512726,54	1011,60
18805	Dogankoy	243,00	486608,97	4546850,84	598,07
19121	Vakiflar	127,00	559904,23	4565099,13	556,60

III. METHODS

The primary method of this study is to visually calculate the R factor value of modeling the soil erosion process based on the RUSLE equation integrated with the Open Source GIS technique (using the QGIS software and plugins).

In the calculation of the R coefficient in the RUSLE model, taken from 13 meteorology stations in Tekirdağ province and its surroundings, which is a research area from the General Directorate of Meteorology, meteorological data of many years were used.

The Modified Fournier Index (MFI) formula of Arnoldous (1980), one of the formulas developed to find the "Erosion Index" value, was used in the calculation of the R value [12], [13], [14].

$$MFI = \sum_{1=1}^{12} \frac{\square\square^2}{\square}$$

Equality; Pi monthly precipitation (mm) is expressed as the average of P annual precipitation (mm). Equation used in the precipitation Erosive Factor (R) calculation;

$$R = (4{,}17\ MFI) - 152$$

The steps followed in the calculation of the R factor with QGIS in the study area are given in the flow chart in Figure 2.

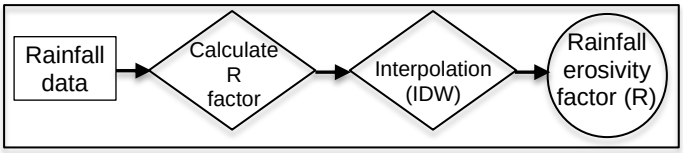
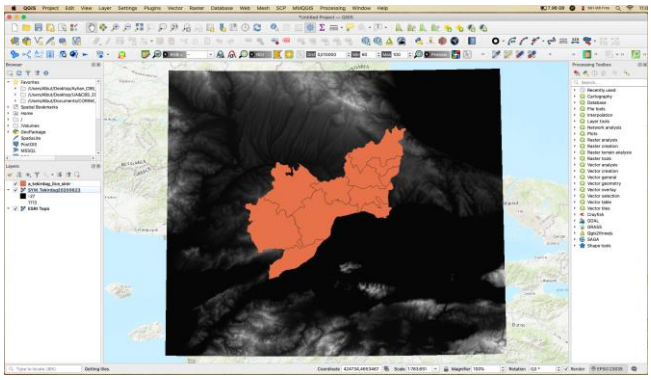


Fig.2. *Used R factor schematic approach*

Coordinate values of the meteorological stations were taken from the General Directorate of Meteorology and merged with precipitation data in MS Excel file.

In the QGIS application, firstly correction process was applied and the Data Elevation Model (DEM) map was added as a layer.

Tekirdag provincial borders and location of meteorology stations were added as separate layers as vector data (Fig.3).



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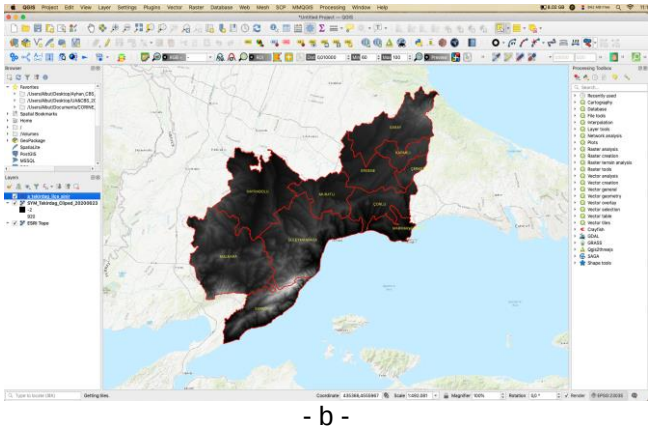

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Fig.3. *Creating raster and vector maps of the research area*

In adding table data prepared in MS Excel to QGIS application as a layer, "*Layer/Add layer/Add Spreadshet layer*" plugin is used in the add layer command (Fig. 3).

Using the layer where the meteorology station coordinates are, spreading from MFI values to the surface of the work area, in other words, precipitation values for the whole of Tekirdağ were created with the spatial interpolation process.

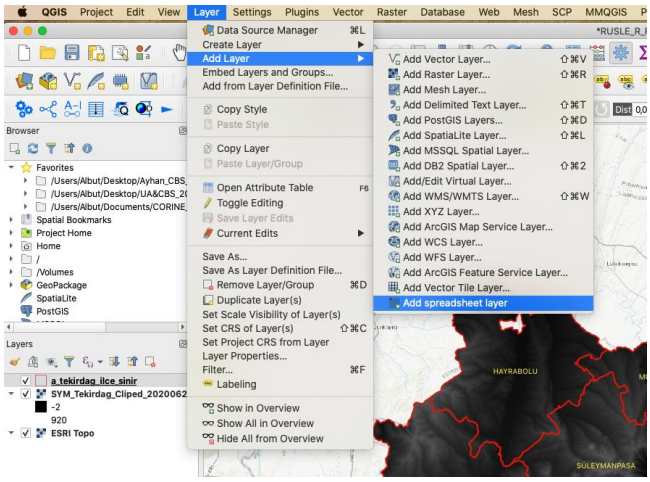

Fig.4. *Add spreadsheet layer plugin*

The calculated MFI values differ according to 13 stations. The MFI values belonging to stations mentioned are only the point values of those stations. Generates an Inverse Distance Weighted (IDW) interpolation of a point vector layer. From the calculated MFI factor values, rainfall values for the entire province of Tekirdağ were formed by interpolation.

As the last process in calculating the R factor, "Raster/Raster calculator" command in the Raster command to the QGIS application has been used. In the opened transaction window, the command was run by typing the equation R = (4,17 * MFI) -152, which we used to calculate the R factor, and the R factor was calculated visually in raster data format.

IV. RESULTS & DISCUSSION

In this study, for the calculation of R factor with QGIS application, Tekirdağ Meteorology station numbers, station names and annual average precipitation in mm, with the formula of Arnoldous (1980), all MFI values and R factor values are given in Table 2.

Table 2. *MFI values and R factor values Tekirdağ meteorology stations*

Station ID	Station name	Average Precipitation	MFI (mm)	R factor
17056	Tekirdag	585,03	56,62	84,133
17640	Cerkezkoy	567,65	47,80	47,331
17634	Malkara	694,57	65,74	122,169
18107	Sarkoy	484,11	44,36	32,975
18108	Hayrabolu	593,20	54,18	73,918
17054	Corlu	616,81	56,52	83,678
18422	Muratli	591,08	64,49	116,934
18423	Saray	665,38	76,91	168,705
19122	Kapakli	522,40	51,79	63,965
18804	Banarli	681,20	67,86	130,979
18806	Ganos Dagi	1011,60	102,62	275,929
18805	Dogankoy	598,07	59,53	96,241
19121	Vakiflar	556,60	58,80	93,188

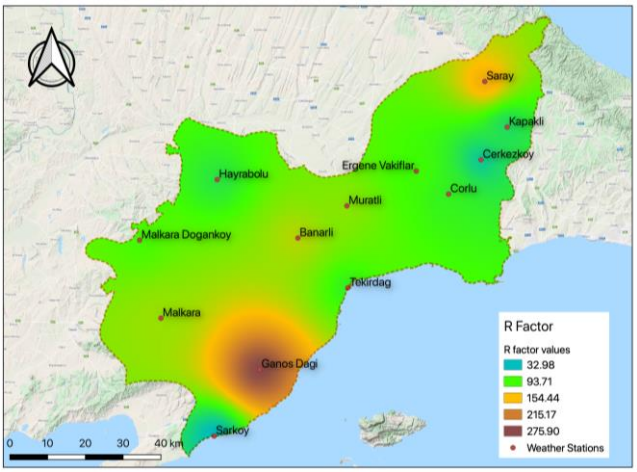

Fig.5. *Add spreadsheet layer plugin*

According to this; the values range from 32,975 to 275,929 MJ ha-1 year-1 × mm h-1 in the R factor map belonging to Tekirdağ province area. It has been observed that as the altitude increases, the amount of rainfall increases, in spite of observing that the R map is similar to the precipitation map of the research area, the R factor of the research area has emerged to confirm the relationship between precipitation and altitude. As it can be understood from Table 2, as the annual average precipitation increases, the MFI values and R factor values also increase3.

As can be seen from the R factor map (Fig. 5), the elevation has an important role on the R values. When we compare the elevation map and R factor map of the region, it is seen that the parts with high R values correspond to the high places in the province, that is, it decreases as we go from north to south. The areas with the highest R value appear in the high parts of the Ganos Mountain of the province. Also, if it is assumed that precipitation increases due to the increase of the altitude, this relationship will be seen to be normal. Again, in the central part of the province, R values show a slight increase around the village Cerkezkoy. The drop in Sarkoy district values is remarkable. Values fall on the slopes of the mountains.

V. CONCLUSION

Soil erosion involves complex, heterogeneous hydrological processes, and models can only simulate these processes. The RUSLE model is simple to use and easy to understand conceptually, however, the biggest criticism of this model has been its ineffectiveness in applications except the conditions in which it was developed.

Potential erosion is a process in which the erosion process is not seen as the effect of human, application factors and cultural practices. RUSLE method has been used, with this study, used with the purpose of obtain quantitative data about soil erosion and preferred frequently in recent years. The R value, one of the important elements of the RUSLE model, was calculated visually with the Open Source coded Software QGIS, with the help of precipitation data.

R values calculated with the help of rainfall data obtained from 13 points in Tekirdağ province were found between 32,975 to 275,929 MJ ha-1 year-1 × mm h-1. With the R factor during the application of Rusle method and the production of soil loss maps; soil erosion factor (K), slope length factor (L), slope steepness factor (S), vegetation factor (C) and protection factor (P) data are also used. Free and open source coded software can be used in similar studies, updating, renewaling and sharing informations are easier, and there is no need for any financial resources for this.

REFERENCES

[1] Görcelioğlu, E. (1997). Ormanların Erozyon ve Sedimentasyona Etkileri. İÜ Orman Fakültesi Dergisi, Seri B, Cilt: 47, Sayı:1-2-3-4, 1-12.

[2] Pan, J.H. and Wen, Y. (2014). Estimation of soil erosion using RUSLE in Caijiamiao watershed China. Natural Hazards, 71(3), 2187-2205.

[3] Albut, S. ve Sağlam, M. (2004). Determination of land distribution and spectral characteristics of the wineyard crop grown in Tekirdağ region by using digital satellite data. Agro-environ 2004, Role of Multi-purpose Agriculture in Sustaining Global Environment, 63–70, Udine, Italy.

[4] Alexandridis, T. K., Sotiropoulou, A. M., Bilas, G., Karapetsas, N. and Silleos, N. G. (2014). The effcets of seasonlity in estimating the C-factor of soil erosion studies. Land Degradation and Development, 1-16.

[5] Wischmeier, W. H. and Smith, D. D. (1978). *Predicting rainfall erosion losses.* A Guide to conservation planning. United States Department of Agriculture, Agricultural Research Service (USDA-ARS) Handbook, No.537. United States Government Printing Office, Washington, DC.

[6] Wischmeier WH, Smith DD (1978) Predicting rainfall erosion losses - a guide to conservation planning, Agriculture Handbook, No 537. US Department of Agriculture Science and Education Administration, Washington, p 163

[7] Ege, İ. (2019). Kula-Manisa Peribacaları'nın jeomorfolojik özellikleri ve oluşumlarında erozyon etkisinin RUSLE yöntemi ile belirlenmesi. The Journal of Academic Social Science Studies, Number: 74, p. 455-479.

[8] Mongkolsawat, C., Thurangoon, P. and Sriwongsa, A. (1994). *Soil erosion mapping with USLE and GIS.* Proc. Asian Conf. Rem. Sens., C-1-1 to C-1-6.

[9] Van, B.L., Phuoc, M.T., Thi, A.T. and Raghavan, V. (2014). An Open Source GIS Approach for Soil Erosion Modeling in Danang city, Vietnam.

[10] https://github.com/MicheleTobias/Intro-to-Desktop-GIS-with-QGIS

[11] https://docs.qgis.org/3.10/en/docs/user_manual/

[12] Desmet, P. J. J. and Govers, G. (1996). A GIS Procedure for Automatically Calculating the USLE LS Factor on Topographically Complex Landscape Units. Journal of Soil and Water Conservation, 51(5).

[13] Nearing, M.A., Yin, S.G., Borelli, P. and Polyakov, O.V. (2017). Rainfall Erosivity: An Historical Rewiew. Catena, Issue 157, p. 357-362.

[14] Arnoldous, H. M. J. (1980). An Approximation of the Rainfall Factor in the USLE. In Assessment of Erosion. Chichester: Wiley, p. 127-132.