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Research Article

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Estimating of Soil Erosion Sensitivity Factor (K) with Open Sources Quantum GIS (QGIS) Software

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Abstract Soil degradation is one of the most important issues impacting agricultural production. The Revised Universal Soil Loss Equation (RUSLE) is the most popular empirical-based model used globally for erosion estimation and control. Remote sensing techniques have become significant instruments for analyzing erosion in greater scales because the requisite volume of data and broader field coverage is requisite. The GIS techniques for remote sensing have been developed. In this study, the Soil Erosion Sensitivity factor (K), which is one of the important elements of the RUSLE equation with the soil map obtained from the Tekirdag province, was determined by using GIS techniques. Using the open source QGIS 3.14 software in the RUSLE, topography in the region can be determined as a function of soil texture, land use, land cover, precipitation, erosion, crop management and their application. Soil Erosion Sensitivity factor (K) factor of RUSLE varied from 0.00 – 0.40 under Tekirdag conditions.

Keywords Soil erosion, RUSLE, K Factor, QGIS, Tekirdag

Introduction

Mountainous lands cover 56% of Turkey [1]. Turkey's topography and climatic dynamics of this aspect, it is quite susceptible to erosion formation. In order to take control measures, which have an important place in combating erosion, areas where erosion is effective should be determined quickly. Erosion studies carried out on large lands with methods based on traditional land surveys are labor-intensive and costly and take a long time [2].

The revised universal soil loss equation RUSLE is A=R*K*LS*C*P where A = average annual soil loss from sheet and rill erosion caused by rainfall and its associated overland flow (tons ac' yr'), R = the factor for climatic erosivity, K = the factor for soil erodibility measured under a standard condition, L = the factor for slope length, S = the factor for slope steepness, C = the factor for cover-management, and P = the factor for support practices. A value for soil loss A is computed by selecting values for each factor and multiplying them. These factors represent the effect of climate, soil, topography, and land use on sheet and rill erosion. By assigning values to these factors based on site-specific conditions, RUSLE computes soil loss for specific sites, and it can be used to guide conservation planning tailored to individual field sites [3].

RUSLE is to be used as a guide rather than as a precise estimator of soil loss. It represents the main trends demonstrated in field data, but the accuracy of RUSLE estimates varies depending on the magnitude of the soil loss, land use, and other factors.

In the light of the developments in technology, mostly Remote Sensing (RS) and Geographic Information System (GIS) techniques have been used in agriculture. Determining the amount and distribution of available agricultural land in agricultural activities plays an important role in better planning of the country's agriculture [4].

Soil erosion has negative economic and environmental effects [5]. The economic impacts are due to the loss of farm income due to the decrease in on-site and off-site incomes and other damages affecting the plant / animal production negatively. Soil erosion has both on-site and off-site effects on productivity. In situ efficiency loss of soil erosion is due to three reasons. The first of these is short-term productivity losses and these are factors such as loss of crop yield, loss of seeding, loss of input (seed, fertilizer), loss of water, additional tillage, time loss due to delayed planting. The second is long-term productivity losses and these are losses such as top soil loss, decrease in soil structure, decrease in soil organic matter content, soil cultivation erosion. The third factor is the reduction in land / soil quality, and these are factors such as temporary decrease in land / soil quality, temporary pollution of surface water by chemicals from sediment. The non-situational economic impact of soil erosion also depends on three reasons. The first of these is seedling deaths due to short-term effects, flooding of the low floor area, chemical effects on seedlings, delayed planting. Its long-term effects are the burying of top soil by infertile soils, change in drainage conditions and changing the slope with tillage erosion. The third and last effect are the reduction in land / soil quality, including temporary decrease in land / soil quality due to floodplains, changes in the soil-water regime and water layer, and additional water management (irrigation, drainage, etc.).

Obtaining agricultural land, excessive and irregular grazing, destruction of forests, etc. anthropogenic impact and erosion is accelerated by the increasing violence in Turkey Besides the natural factors [6].

Erosion is one of the important environmental problems that our country has to tackle. While erosion is observed in an area of approximately 25 million hectares per country in the European Union countries, 57 million hectares are seen in our country. Although erosion is considered as an ecological problem alone, it occasionally causes hunger and migration. Approximately 500 million tons of fertile soil is lost every year. It reveals how great a threat erosion is for our country, that 99% of our soils are affected by water erosion and 1% by wind erosion [7].

The tendency of the soil to erosion illustrates the resilience of the soil to abrasive forces and the tendency to erosion induced by different properties in its own structure. The erodibility of soils is largely due to the physical and chemical properties of the soil which form its internal structure. In other words, the hydraulic permeability of the soil depends on the properties, texture and structure of the organic material. Although some soils are resistant to the same erosive forces, some other soils are easily dissolved and eroded [8, 9].

K Factor is the expression of soil lost from hectare in tons with unit erosion index on a land with a slope of 9% and a slope length of 22.1 m.

In this study, databases of erosion caused by precipitation and wind in Tekirdag province will be created. All data will be processed using Remote Sensing and Geographical Information System software (QGIS) and the results obtained will be accessed on the internet.

Materials and Methods

Tekirdag is one of the three cities where is in the northwest of the Sea of Marmara, is located in the European continent, less hilly, is situated on land enriched with alluvium. Tekirdağ province is located on the coordinates of 26˚43 ’- 28˚08’ east longitudes and 40˚36 ’- 41˚31’ northern latitudes. It is surrounded by Istanbul to the east, Edirne and Çanakkale to the west, Marmara Sea to the south and Kırklareli to the north and the Black Sea with a short coast.

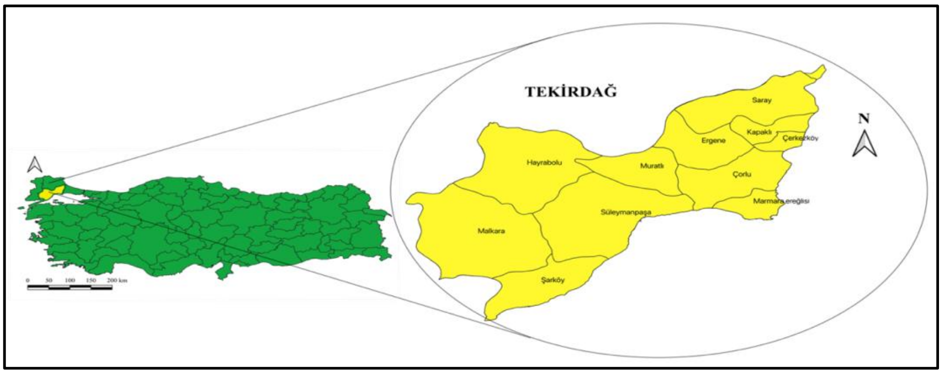

Figure 1: Research area

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 supporting various vector, raster, and database formats and functionalities.". 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 platforms: 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 geo JSON & Geo Package Comes in a more than 40 languages, making it easier to work with a larger variety of collaborators [10, 11].

Preparation of Data Elevation Model (DEM) Map

The Tekirdag province DEM maps were created using NASA-ALOS satellite images. The plugin "SRTM Downloader" in QGIS was used to prepare DEM maps for Tekirdag province. The resolution of the ALOS satellite images, consisting of 5 sections that cover the entire Tekirdag province, is 16.5x16.5 m. With the aid of the "Raster / Miscellaneous / Merge" command, DEM images, each consisting of 5 pieces, were combined as one object. In the next step, with the aid of the vector-based layer map showing the provincial borders of Tekirdag, the DEM map was determined with the command "Raster / Extraction / Clip Raster By Mask Layer" according to the provincial borders (Fig. 2).

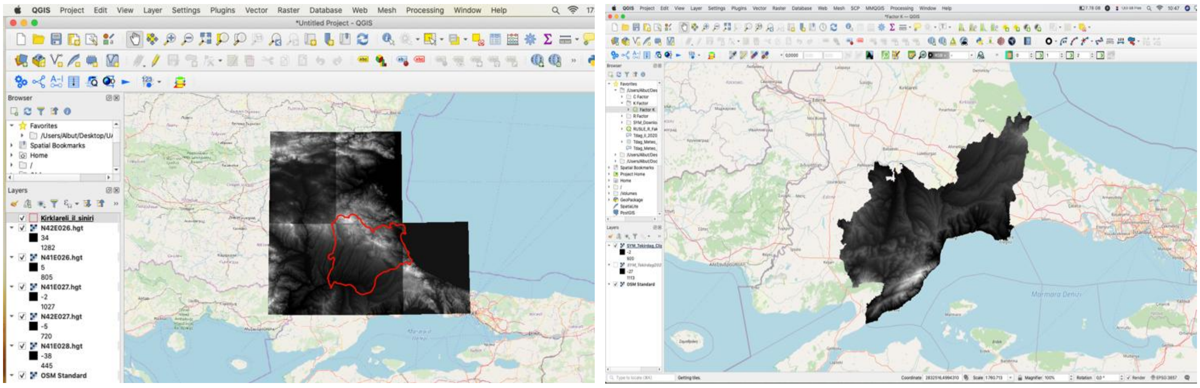

Figure 2: Preparation of Tekirdag DEM map

Calculating Soil Erosion Sensitivity Factor (K)

A method has been developed for determining the K value using silt and very fine sand (%), sand (%), organic matter (%), soil parameters for structure and permeability [12, 13].

The soil map obtained from the Kırklareli Atatürk Research Institute for Soil, Water, and Agricultural Meteorology was used in the K factor calculation. The map is opened numerically in the QGIS software and simplified from the options in the “Attributes Table” according to the Turkish Great Soil Groups function.

The values of soil erodibility were determined according to the K factor values as a result of literature research and are given in Table 1 [14, 15].

Table 1: Soil erodibility values according to K factor values

No	Soil Erosion Class	Soil erodibility values
1	Slight	0.00 – 0.05
2	Moderate	0.05 – 0.10
3	High	0.10 – 0.20
4	Very High	0.20 – 0.40
5	Severe	0.40 – 0.80
6	Very Severe	More than 0.80

Turkish Great Soil Groups (TGSG) classification of Tekirdağ province and the K Factor values obtained from different literature are provided below Table 2 [16, 17, 18].

Table 2: The TGSG classification of Tekirdağ province and the K Factor values

TGSG	Description	K Factor	Area (km^2)	Percentage (%)
V	Vertisols	0,10	112,33	1,77
U	Non-calcareous Brown Soil	0,21	4.207,97	66,34
X (diğer)	Settlements and Water Surfaces	-	145,70	2,30
N	Non-calcareous Brown Forest Soil	0,29	1.129,45	17,81
M	Brown Forest Soil	0,20	679,45	10,71
A	Alluvial Soil	0,15	67,60	1,07
TOPLAM			**6.342,5**	**100,00**

This was changed to the Tekirdag soil database, in other words. This process is achieved by combining the values of the same class category with the aid of the QGIS software plugin "Vector/Geoprocessing Tools/Dissolve". Classification process for Tekirdag province is conducted according to soil erodibility values (K factor). Finally, the values of the K factor were calculated for the province of Tekirdag, the areas covered by them and the proportional distributions.

Data obtained from Kırklareli Atatürk Soil, Water and Agricultural Meteorology Research Institute Directorate were used to obtain the K value in Tekirdag. In order to spread the obtained point K values over the surface of the study area, interpolation method was used as the geostatistical method and the K factor map (layer) of the site was obtained.

A single point is represented by K factor values obtained in the GIS environment. The method of interpolation, one of the geostatistical methods, was used to spread the value to the entire area representing a single point. In QGIS 3.14 software, this technique was implemented using Tools > Interpolation > IDW Interpolation.

For Tekirdag province, this layer was created according to the degree of erosion of the soils, and the areal and proportional distributions of K factor classes were calculated by classifying them according to K factor classes.

Results & Discussion

For the province of Tekirdağ, the areal and proportional distributions of the K factor classes obtained were calculated. The results are given in the following table (Table 3).

Table 3: Soil erodibility values according to K factor calculations

No	Soil Erosion Class	Soil erodibility values	Area (km^2)	Area (%)
1	Slight	0,00 – 0,05	145,71	2,30
2	Moderate	0,05 – 0,10	112,33	1,77
3	High	0,10 – 0,20	747,04	11,78
4	Very High	0,20 – 0,40	5.337,42	84,15
	Total		6.342,50	100,00

The K factor, highly erodible, has been identified as the majority of the research area (Grade 4). There is little erosion in terms of erosion (Class 2), moderately erosive (Class 3) balls, very little soil erosion (Class 1), very little and very high soil erosion (5th class).

It can be said that lithology (main rock) and the soils formed accordingly are the most important factor in the fact that the K Factor values are very close to each other and the value obtained is highly erodable (Grade 4) in Tekirdağ province. In almost all of Tekirdağ, rocks originating from the same origin sprout.

When the distribution map of the K Factor (Figure 3) is examined, although Tekirdağ soils are in the 4th class, there are differences in the distribution throughout the region within this class. In the central and northern parts of the region, high values with K values are found. On the other hand, low K values are seen in the area where the southern residential areas of the region where the slope and elevation are decreased.

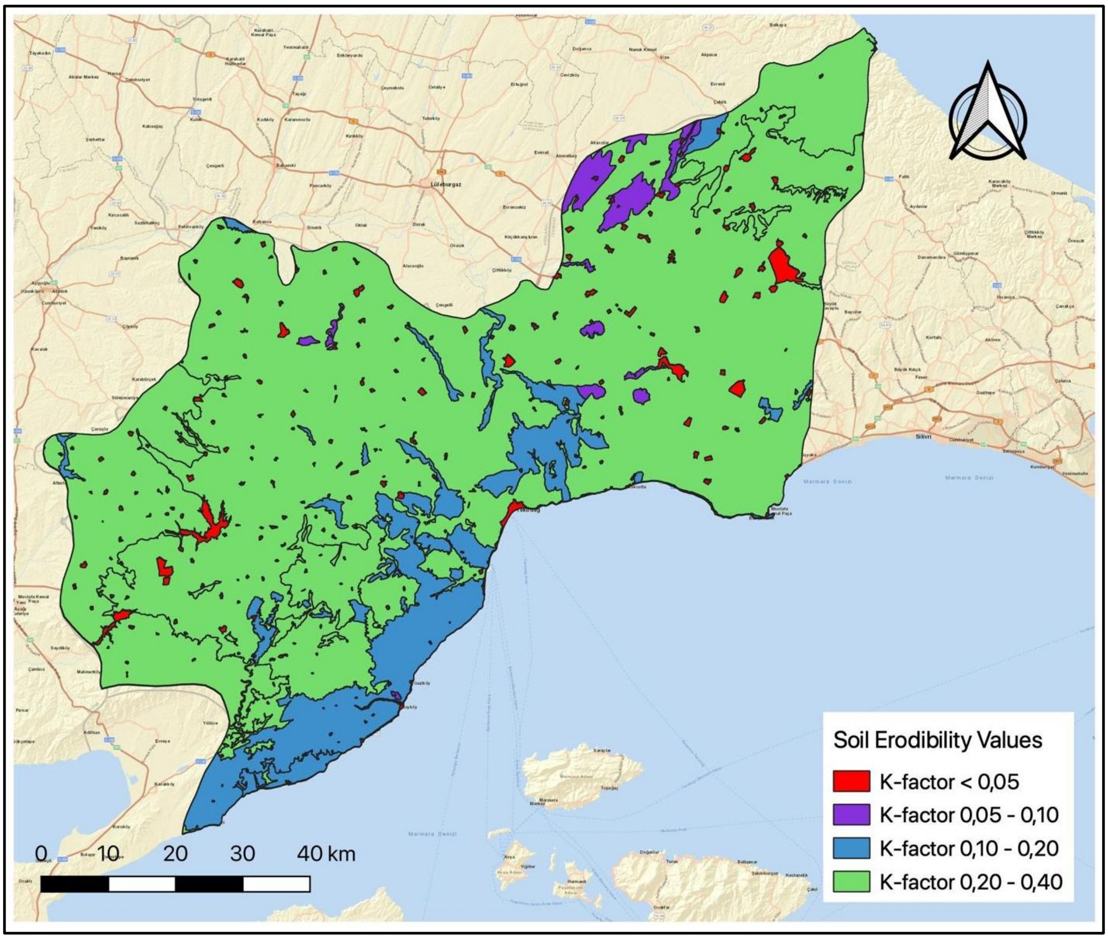

Figure 3: Soil erodibility values map of Tekirdag region

Conclusion

Process models and physically based models, when individual processes and components affecting erosion are described in a simple and effective way, offer advantages over simple statistical empirical models. The disadvantages of these models, however, are that the mathematical representation of a natural operation can only be approximated and parameter estimation difficulties exist. RS and GIS techniques are very efficient instruments for modeling soil erosion and evaluating the risk of erosion. The soil erosion research method in Kırklareli province is an approach to remote sensing and open source GIS software (QGIS). In this study, to determine the amount and spatial distribution of erosion and sediment load released due to it, RUSLE, which is the most widely used model, was used.

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