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Estimating the Soil Erosion Crop Factor (C) With Open Sources Geographical Information System (GIS) Software

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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 Crop factor (C), which is one of the important elements of RUSLE equation with CORINE 2018 database in Tekirdag province, was determined by using 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. Crop (C) factor of RUSLE varies between %0.27-%64.69 under Tekirdag conditions.

Key words: Corona, Architecture, building, HVAC

INTRODUCTION

Mountainous land consists of 56 percent of Turkey [1]. With this aspect, the topography and climate dynamics of Turkey are fairly susceptible to erosion. Areas where erosion is successful should be defined quickly in order to take control measures which have an important position in the battle against erosion. At the same time, erosion works that are labor intensive and expensive, carried out using methods based on conventional surveys of large areas, take a very long time [2].

In the light of advances in technology, Remote Sensing (RS) and Geographical Information System (GIS) techniques have begun to be used, in particular in agricultural land. Determining the quantity and distribution of existing agricultural land in agricultural activities plays an important role in better agricultural planning for the region [3].

The Rusle method was used in a small tank, using GIS and UA techniques, in the analysis conducted in southern China. On the slopes where the slope is increased, the areas where the average annual soil loss is 52 tons / ha, i.e. high, while the flat plains where the degree of slope decreases are the areas where the soil loss is 26 tons / ha, i.e. low [4].

Following a correlation analysis between the NDVI obtained from the images between the 250 m resolution and the C-factor data obtained from the existing 100 m resolution raster data with the study carried out in the South Lazio region of Italy, a European scale map was presented.

A European scale map was presented as a result of the correlation analysis between the NDVI obtained from the images between the 250 m resolution and the C-factor data obtained from the existing 100 m resolution raster data with the study conducted in the South Lazio region of Italy. The aim here was to find a regression model that helps to easily estimate RUSLE's land cover method factor using as a determinant the remote sensing and vegetation index. This study showed that the estimation of the C factor in the annual and seasonal time scales at different intervals is versatile and that updated maps can be easily drawn based on NDVI data availability [5-8].

MATERIALS

Study area is in the province of Tekirdag. Degradations of human-induced land, such as industrialization and provincial urbanization, continue to increase day by day due to multifaceted socio-economic and environmental factors. For these purposes, research area was chosen on the ground that it will serve as an example model to evaluate the current soil erosion danger situation and soil erosion caused by water and wind. Tekirdag province, northwest of Turkey, situated on the European continent in the Marmara region of Turkey and situated in section Tekirdag (Fig.1).

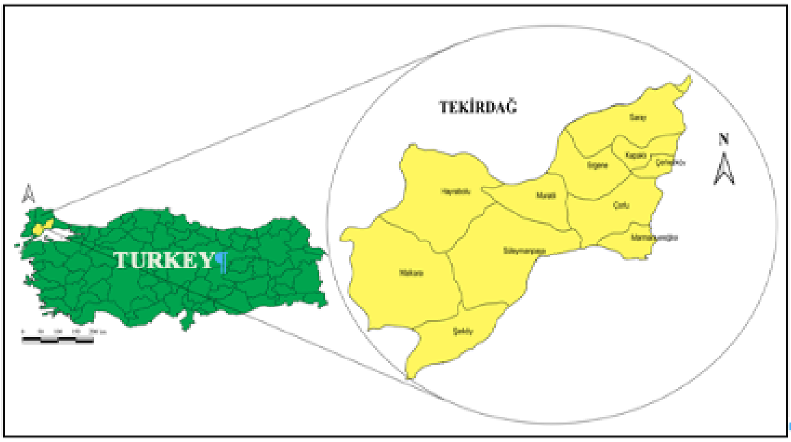

Fig. 1 Research area

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 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 [9], [10].

CORINE Land Cover Data

The pan-European component is coordinated by the European Environment Agency (EEA) and produces land cover / land use (LC/LU) information in the CORINE Land Cover data, High Resolution Layers, Biophysical parameters and European Ground Motion Service [11]. The CORINE Land Cover is provided for 1990, 2000, 2006, 2012, and 2018. This vector-based dataset includes 44 land cover and land use classes. The time-series also includes a land-change layer, highlighting changes in land cover and land-use. The high-resolution layers (HRL) are raster-based datasets which provides information about different land cover characteristics and is complementary to land-cover mapping (e.g. CORINE) dataset (Table-1) [11].

Table -1 CORINE land cover and land use classes [11]

Level 1	Level 2	Level 3
1. Artificial surfaces	1.1. Urban fabric	1.1.1. Continuous urban fabric 1.1.2. Discontinuous urban fabric
	1.2. Industrial, commercial and transport units	1.2.1. Industrial or commercial units 1.2.2. Road and rail networks and associated land 1.2.3. Port areas 1.2.4. Airports
	1.3. Mine, dump and construction sites	1.3.1. Mineral extraction sites 1.3.2. Dump sites 1.3.3. Construction sites
	1.4. Artificial non-agricultural vegetated areas	1.4.1. Green urban areas 1.4.2. Sport and leisure facilities

2. Agricultural areas	2.1. Arable land	2.1.1. Non-irrigated arable land 2.1.2. Permanently irrigated land 2.1.3. Rice fields
	2.2. Permanent crops	2.2.1. Vineyards 2.2.2. Fruit trees and berry plantations 2.2.3. Olive groves
	2.3. Pastures	2.3.1. Pastures
	2.4. Heterogeneous agricultural areas	2.4.1. Annual crops associated with permanent crops 2.4.2. Complex cultivation 2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation 2.4.4. Agro-forestry areas
3. Forests and semi-natural areas	3.1. Forests	3.1.1. Broad-leaved forest 3.1.2. Coniferous forest 3.1.3. Mixed forest
	3.2. Shrub and/or herbaceous vegetation association	3.2.1. Natural grassland 3.2.2. Moors and heathland 3.2.3. Sclerophyllous vegetation 3.2.4. Transitional woodland shrub
	3.3. Open spaces with little or no vegetation	3.3.1. Beaches, dunes, and sand plains 3.3.2. Bare rock 3.3.3. Sparsely vegetated areas 3.3.4. Burnt areas 3.3.5. Glaciers and perpetual snow
4. Wetlands	4.1. inland wetlands	4.1.1. Inland marshes 4.1.2. Peatbogs
	4.2. Coastal wetlands	4.2.1. Salt marshes 4.2.2. Salines 4.2.3. Intertidal flats
5. Water bodies	5.1. Inland waters	5.1.1. Water courses 5.1.2. Water bodies
	5.2. Marine waters	5.2.1. Coastal lagoons 5.2.2. Estuaries 5.2.3. Sea and ocean

In this study, the value of the cover-management factor (C), which is one of the important RUSLE equation criteria in Tekirdag province, will be calculated using the QGIS software of the CORINE 2018 datasets and open source coded Geographical Information System [12-17].

METHODS

The steps followed in the crop factor (C) calculation with QGIS 3.14 in the region of analysis are shown in the flow chart in Fig 2.

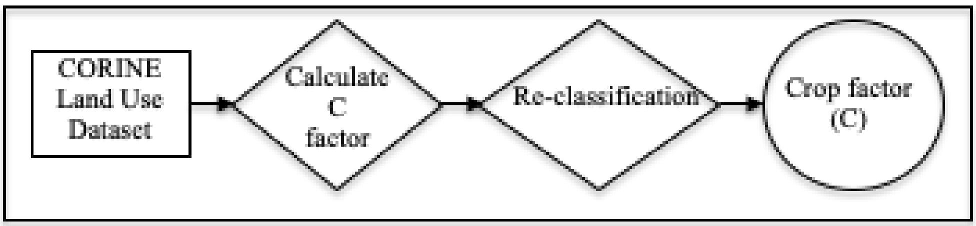

Fig. 2 Using flowchart with factor C

Data from CORINE 2018 were used for calculating the factor C. These data have been downloaded from the web address as database containing CORINE data [18]. CORINE 2018 The digital map was cut using the "Vector / Geoprocessing Tools / Clip" command in the QGIS 3.14 framework according to Tekirdag provincial borders.

Assistance was obtained from the values used by the EU Research Institute in the assessment of C factors belonging to the land use areas of the map created for the Land Vegetation C factor value to be determined [18].

The vegetation cover in the Tekirdag province was calculated taking into account the main and subgroup levels of the CORINE Project Land Cover Classification. The CORINE 2018 digital map was reclassified according to the CORINE classification numbers in the vector data attribute table, prepared according to the provincial borders of Tekirdag.

C Factor values of classifications in the province of Tekirdag were calculated from the literature according to the CORINE classification values (Table 2) [19-21]. The reclassification method applied to CORINE classification values is shown in Figure 3.

Table -2 C Factor values in Tekirdag for the classification values CORINE

CORINE classification ID	Land cover / Land use classes	C - Factor
311	Broad-leaved forest	0.001
312	Coniferous forest	0.010
313	Mixed forest	0.050
322-324	Moors and heathland / Transitional woodland shrub	0.038
231-321	Pastures Natural grassland	0.090
221-222	Vineyards / Fruit trees and berry plantations	0.180
211-212-213	Non-irrigated arable land / Permanently irrigated land / Rice fields	0.280
242-243	Complex cultivation / Land principally occupied by agriculture, with significant areas of natural vegetation	0.500
511-512	Water courses / Water bodies	0.001
331-333	Beaches, dunes, and sand plains / Sparsely vegetated areas	1.000

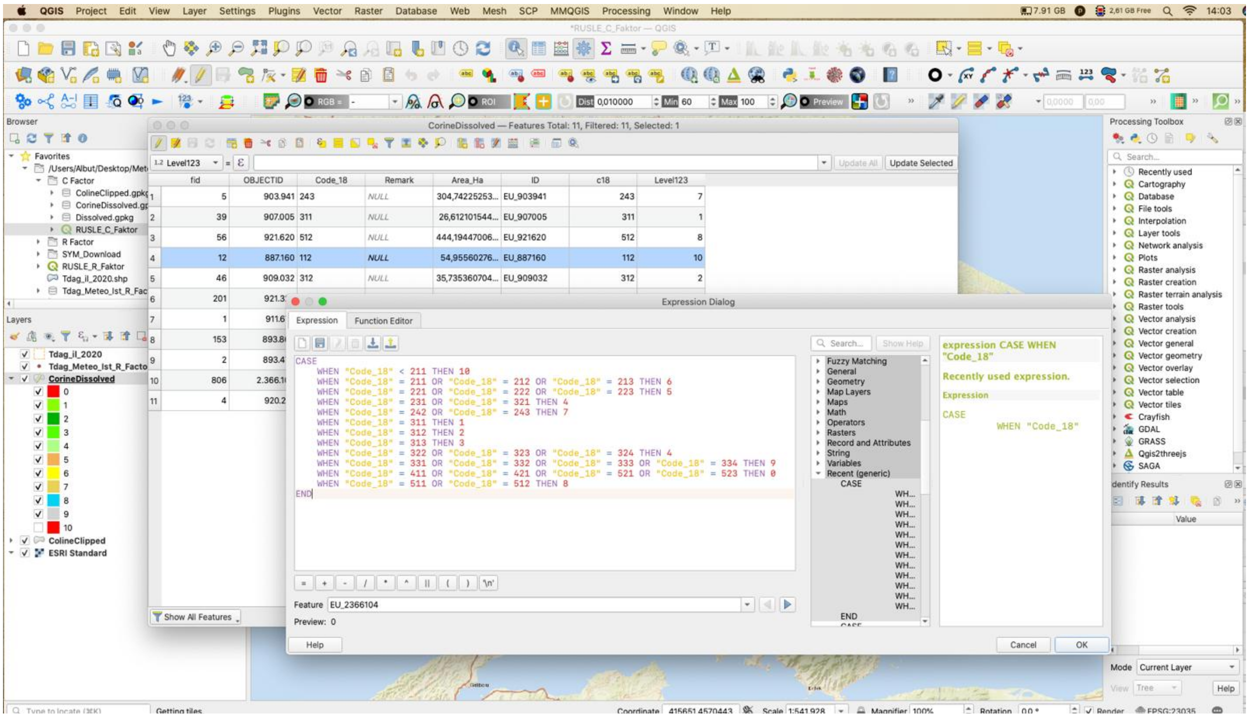

Fig. 3 Reclassifications C factor values

After completing the classification process of Tekirdag 's Land Use over the CORINE 2018 digital map with the aid of the attribute table, the command "Vector / Geoprocessing Tools / Dissolve" was used to combine values belonging to the same class group.

In the new map that was obtained, the area (km^2) and proportional (percent) values of the classification groups were calculated using the attribute table.

As a result the research area map (layer) was obtained for land use and vegetation purposes. The land use and vegetation classes are therefore broadleaf forests, coniferous forests, mixed forests, shrubbery, woodland areas, meadow pastures, vineyards, gardens, cultivated fields, vacant agricultural land , water bodies, and barren lands.

In the last point the land use and vegetation map obtained as a result of the classification was converted into factor C using the numerical values suggested for and land use and vegetation in the RUSLE method. Consequently the lowest value is 0.001, and the highest value is 1.00.

RESULTS AND DISCUSSION

It is known that, as it includes more up-to-date data, the base data map prepared with CORINE provides more reliable results. The rate of areas exposed to erosion was, however, very poor. It should not be ignored that the amount of erosion from sloping lands is higher than that of other fields. Areas of higher breakup and degradation in the northern portion of the study region are at higher risk of erosion. Just how significant the effect of land use and land cover on erosion should not be forgotten. It was found that the map with a low amount of erosion has higher areas of oak and forest which reduced the amount of soil loss.

The threat of erosion seen in agricultural areas has been found to be higher. Within the framework of combating erosion in agricultural property, farmers should be considered as the target audience and awareness and training should be carried out (Fig. 4).

Below are the ratios and isal results for the C values obtained in Tekirdag province (Table 3).

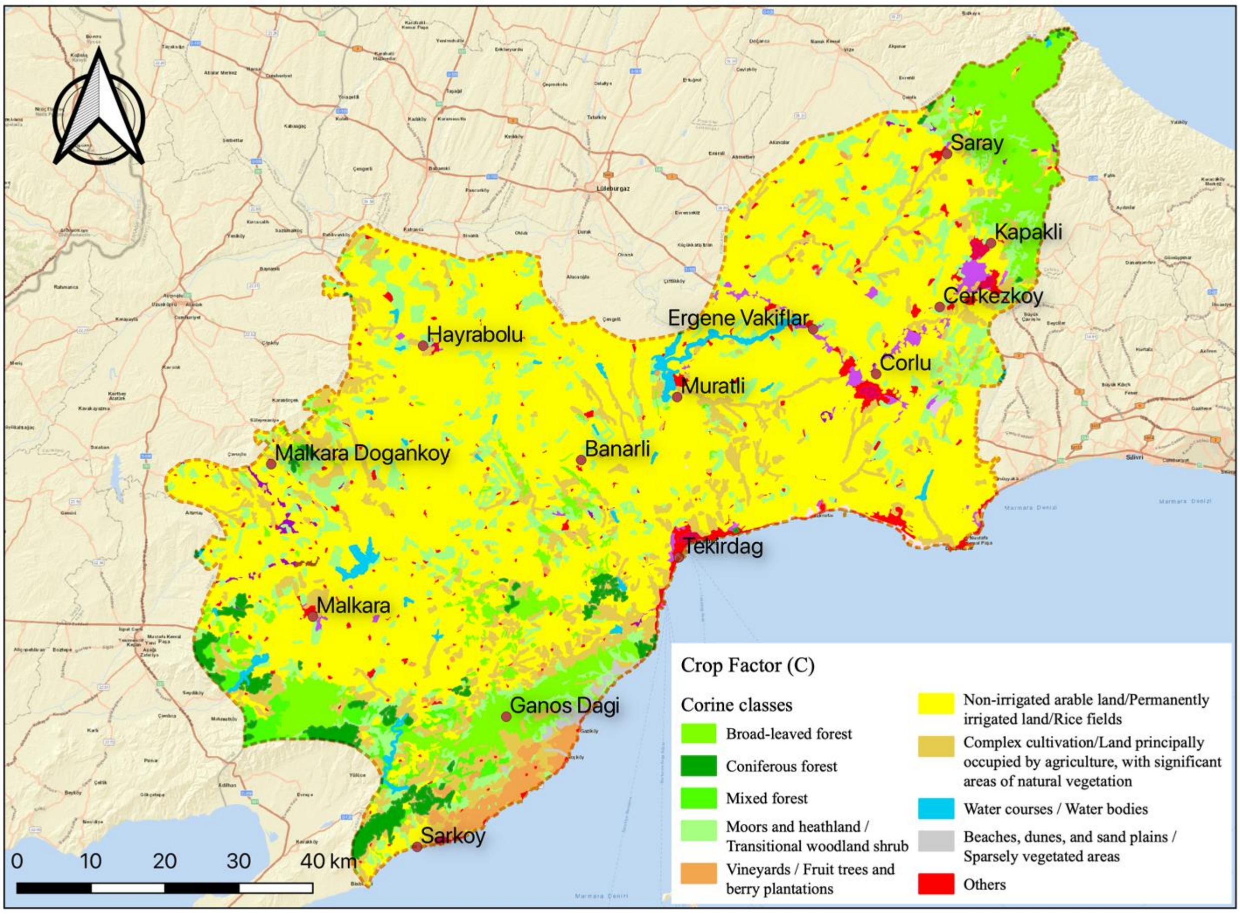

Fig. 4 Reclassifications C factor values

Table -3 The area and rates computed for Tekirdağ covered by the values of the C factor

CORINE classification ID	Land cover / Land use classes	C Factor	Area	
			(km^2)	(%)
311	Broad-leaved forest	0,001	551,928	8,71
312	Coniferous forest	0,010	105,705	1,67
313	Mixed forest	0,050	100,541	1,59
322-324	Moors and heathland / Transitional woodland shrub	0,038	241,318	3,81
231-321	Pastures Natural grassland	0,090	287,953	4,54
221-222	Vineyards / Fruit trees and berry plantations	0,180	61,603	0,97
211-212-213	Non-irrigated arable land / Permanently irrigated land / Rice fields	0,280	4100,714	64,69
242-243	Complex cultivation / Land principally occupied by agriculture, with significant areas of natural vegetation	0,500	489,286	7,72
511-512	Water courses / Water bodies	0,001	53,546	0,84
331-333	Beaches, dunes, and sand plains / Sparsely vegetated areas	1,000	16,924	0,27
-	Others (Artifical surveys/Wetlands/Marine waters etc.)	-	329,481	5,20
-	TOTAL		6339,000	100,00

C values can be divided into 10 groups in Tekirdag, which range from 0 to 1. Of these classes agriculture occupies the largest region with a ratio of 64.69 percent. With 8.71 percent, broad-leaved forests take up the most room and 7.72 percent vacant agricultural land.

Study region where the slope is low has found cultivated agricultural areas. It is worth noting that wide-leaved trees, heathlands, meadows and grazing areas are situated in the higher parts of the Ganos Mountains, where the altitude in the north of the region increases. These areas are places which can not be opened to agriculture for different purposes and are often used as grazing areas for animal husbandry activities.

CONCLUSION

Soil erosion involves complex, heterogeneous hydrological processes, and only those processes can be simulated by models. The RUSLE model is simple to use and conceptually easy to understand, but the main criticism of this model has been its inefficiency in implementations except for the conditions under which it was built.

Process models and physically based models offer advantages over simple statistical empirical models when defining simply and effectively individual processes and components affecting erosion. The drawbacks of these models, however, are that the mathematical representation of a natural operation can only be approximate, and parameter estimation difficulties exist.

Remote sensing and GIS techniques are very effective modelling tools for soil erosion and risk assessment for erosion. Remote sensing and open source GIS (QGIS) software is a method of soil erosion research in Tekirdag province. RUSLE, which is the most widely used model, was used in this study to determine the amount and spatial distribution of erosion and sediment load released as a result of it. This study also added methods for modeling soil erosion using the RUSLE equation using the data from CORINE 2018 for C-factor interpolation.

With this research, potential soil erosion situation map was created for the Tekirdag region with Remote sensing and GIS, which was clearly analyzed with regard to spatial distribution using RUSLE and QGIS technology.

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