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CREATING SOIL LOST MAPPING OF THE KARABURUN PENINSULA BY GEOGRAPHICAL INFORMATION SYSTEM AND REMOTE SENSING TECHNIQUE

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Abstract: With this study, it is aimed to draw a potential erosion risk map needed to be used for planning the precautions against erosion, which is one of the biggest problems of our country, by using advanced techniques. An area of 1126 km^2 including Çeşme Karaburun peninsula, which is located on the west coast of Turkey, has been selected as study area. RUSLE soil loss factors have been used in the study. Each factor used for detecting the soil loss has been determined geographically from different sources and recorded as layer in database according to Geographic information system. In the study, for determining C factor 15-m spatial resolution ASTER image, for determining "L" and "S" factors numerical counter lines, for determining "R" factor weather observation results, for determining "K" factor soil order maps have been used. Afterwards, layers are united by using spatial intersection and new polygons containing all attributes have been created. After the database was created, Rusle model has been applied and as a result soil loss has been determined for each polygon. At the end of the study, it has been determined that Çeşme Karaburun peninsula, selected as study area, has 1.279.548 ton/ha/year.
Key Words: Erosion, RUSLE, GIS, Remote sensing

1. INTRODUCTION

In our country, when population growth is considered, making use of soil and water resources in an efficient and sustainable way gains much importance. The biggest problem threatening the soil and water resources in our country is erosion. As the balance between the amount of worn out soil and that formed in its place is not established, many soil fauna die off. Turkey has appropriate conditions for soil erosion due to its climate and topographic structure. When the dispersion of problem areas is analyzed, it is found that in 1.7% of them aridity, in 3.1% drainage defect, in 31.5% rockiness, in 89.77% water erosion and in 0.65% wind erosion are effective (Figure 1) (KHGM, 1987). When the force and spread of water erosion in our country is considered, it is seen that necessary water and soil protection measures must be taken urgently. Water erosion is the result of topsoil water detaching, transporting and depositing soil particles from their location. In such erosions, runoff as erosive power is an important element. Due to variety of reasons, rain on soil cannot be percolated so it runs off; at this time it causes erosion both in where raindrop falls and in flow direction. Thus, particles eroded make fertile ground land, where they collect, infertile. Human activities accelerate the water and wind erosion. Wind erosion is defined as the removal, the transport and deposition of soil particles through winds blowing fast. It is seen in areas especially where the climate is arid and land is rough. Erosion (water and wind) is one of the most important environmental problems and when it is uncontrolled, it both reduces soil fertility agriculturally in large fertile lands and turns them into infertile areas.

Irregular rainfall in the lands with steep slopes increases the intensity of erosion and causes falling short in developing precautions and observing the damages related to it._With using remote sensing and geographical information systems together, in wide areas, factors causing erosion can be geographically analyzed and the risk map can be created in detail and rapidly. The combined use of GIS and erosion models, such as USLE/RUSLE, has been shown to be an effective approach for estimating the magnitude and spatial distribution of erosion (Mitasova et al., 1996, Molnar and Julien, 1998, Millward and Mersey, 1999, and Yitayew et al., 1999).

By the help of remote sensing and the application of soil erosion models with GIS, effective results can be achieved. These are generally defined as annual soil loss for large areas. However, these maps are built with geodetic processes related to sustainability of land ranges, various scale predictions etc. Actual soil loss was determined by these geodetic models generally not in physical but in sloped areas using trace radioactives or by measuring sediment accumulation in reservoir lakes. Before geodetic soil loss models, it is necessary that soil degradation indicators are defined qualitatively and quantitatively.

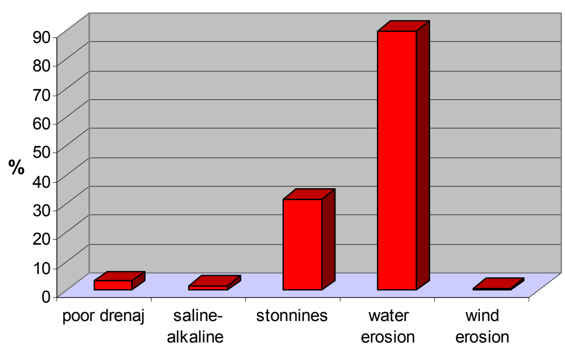

Figure 1. Soil problems of Turkey

Hill et al., in their research, which they used satellite images for mapping and displaying of land degradation in Mediterranean ecosystems in 1995, displayed the vegetation and soil properties and mapped them. Ritchie et al. (1996), in their study, spotted the changes on land surface due to erosion and ravine formation by analyzing topography, morphology and vegetation properties with a laser altimeter used in plane. Hussein, M. H., in 1998, used USLE (Universal Soil Loss Equation) and remote sensing method in his study in order to determine that the lands in North Iraq are affected by water erosion due to misuse and overgrazing and as a result, he set the scales of erosion in the maps he created.

Çullu and Dinç (1994), mapped the lands affected by current erosion and its severity by the help of Landsat satellite data and GIS. In this study, land use and plant density, which are highly effective in soil erosion, were determined with Land TM 3 (0.63-0.69 nm), 4 (0.76-0.90 nm) and 5 (1.55-1.75 nm) band components. In order to detect the soil erosion severity, along with plant density in different climate areas; land use, slope steepness, geological structure and soil depth parameters were used. According to study, it was found that climate, slope, plant density, types of soil and geological structure had important effects on erosion.

Dwivedi (1997), in the study, he made optical interpretations for Landsat MMS, TM and India Remote Sensing Satellite (IRS-1A) linear mapping and identification receiver) (LISS-2) in order to present the qualitative data in agricultural and erosion lands.In the study, erosion-worn areas were detected by using LISS-2 data as optical image.

Millward and Mersey (1999); in the study, which they did for the purpose of customizing the soil erosion potential model in mountainous tropical basin to Revised Universal Soil Erosion Equation (RUSLE), used rain data chart, digitized soil and topographic maps, Landsat TM digital satellite imagery and detected important potential erosion differences between rainy and dry seasons.

Daba et al, in 2003, in the research which they did for detecting ravine formations; they used aerial photos belonging to 1966 and 1996 and digitized them at a pixel size of 20 µm and created digitizing model in net of squares ranging from 20m to 2m. After the observations they made, they found that soil loss was 1.7 ton/m2/30 year.

Navas and Machin (1997), in the gypsiferous steppe of Litigio in Northeast Spain, broken with ravines, having arid climate and fragile vegetation, over cultivation, overgrazing, created digital rocks cover Paleozoic old basement (Figure 3). The geological structure of the Peninsula composes of limestones, basalts, andesites, conglomerates, graywackes, arkoses, sandstones, schists, quartzites, marls and brownstones (Kalafatçıoğlu, 1961). A tectonic belt, in which is found mesozoic mass, circles Karaburun Peninsula. The oldest unit of this evaluation model by means of SUFFER Access System (3.0) (Golden Software Inc.). Soil erodibility was determined by organic matter, structure, soil depth and soil profile development. Soil erodibility (low, medium, high), slope (0-50,5-80,8-170 and above 170), vegetation (low, medium, high), rainfall factor (<75, 75-100, 100-125, and above 125), aridity degree (>0.75, 0.75-0.50, 0.50-0.33 and below 0.33) were classified and maps were designated as Litigio steppe no risk of erosion (20%), low-medium (26%) and high erosion (54%).

Engel (1999), stated that ArcView GIS tool could be used for estimating erosion by RUSLE method. Here he explained that while the K and C factors were estimated from USLE, The LS factor were estimated from the DEM (Digital Elevation Map) and according to RUSLE method, soil loss could be calculated (tons/acre/year).

Raghunath (2002), carried out a research, in which the P factor was evaluated as 1.0 so that in circumstances where total erosion signified basin potential erosion rate, by using RUSLE and GIS together. In Bagmati basin, which is a river basin in Nepal, the potential erosion amount was estimated for each fundamental land use and erosion risk map was drawn. This map was used for detecting the primary areas in integrated basin management actions.

In this study, it is aimed to develop a new model for creating current and potential erosion risk maps in a short time by analyzing the parameters created for estimating the areas affected by current and potential erosion in Karaburun peninsula in geographic information system.

2. STUDY AREA

2.1. Geographical Position

Karaburun Peninsula forms the northern part of the Urla headland in West-Anatolia. It is bordered by Gerence Gulf in southwest, by the Aegean Sea in northwest, north and northeast, and by Gülbahçe Gulf in southeast. The Peninsula, of which from east to west the longest coast is 21 km and has 30 km of length from north to south, covers an area of approximately 436 km^2 (Figure 2). Karaburun Peninsula lies in the north-south direction and consists of largely mountainous areas. The area's highest peak of the area Akdağ mountain, which has the height of 1218m (Kalafatçıoğlu, 1961).

2.2. Geology of Study Area

Karaburun Peninsula has a geological structure, which consists of Devonian old limestones, is situated on detrial unit, has fossiliferous early carboniferous old limestones and where carbonate mass is called lower-middle carboniferaus Alandere formation dominantly consisted of fossiliferous limestones. Lower triassic formations appear directly over this formation. In lower trias, Karareis and Gerence formations were detected and collected under Denizgiren group. Karareis formation consists of limestones, laminated black chert, pelagic limestones and basalts. Balıklıova formation fits directly on the units of Karaburun mass from lower trias to lower crates and is seen a distinctive angular unconformity at the bottom. This formation consists of carbonate rocks and flysch facies browmstones (Erdoğan et al., 1990).

Figure 2. Location map of study area

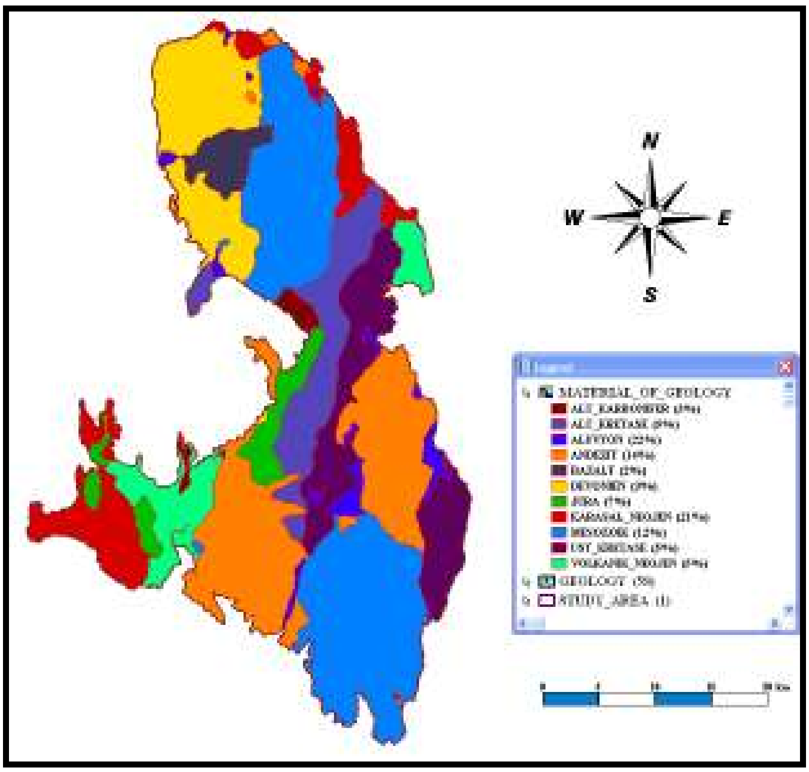

Figure 3. Geology map of study area

2.3. Study Area Vegetation

In areas included the study area, where Mediterranean climate is seen, the plant communities consisted of evergreen sclerophyll bushes and shrubs are called maqui. Maquis generally develop in consequence of destroying old forest lands by overgrazing, cutting trees for firewood or with fires.

Phryganas are vegetation formations dominated by low, soft-leaved plant species. Natural or human related fires have an important role in shaping the ecological characteristics of the area. The vulnerability of vegetation to fires increases in hot and arid summer months.

Natural vegetation dominates the majority of Karaburun Peninsula. The areas engaged in agriculture are situated on the foot slope. Bekat and Seçmen (1984), in a research carried out in Karaburun Peninsula, determined that maquis and phryganas dominate the vegetation and that it has been destroyed by fire and overgrazing. The researchers indicate that there are 384 species from 255 genius and 70 families. Natural forests, in form of small patches are mainly dominated by *Pinus bruita* Ten. and P. *halepensis* L., up to altitudes of 800m. Maqui and phrygana formations spread over nearly the whole natural vegetation area. Among the maqui species, the most common ones are Kermes oak (*Quercus coccifera* L.), Mastic Tree (*Pistacia lentiscus* L.), Turpentin Tree)*Pistacia terebinthus* L.), Rowboat Tree (*Arbutus andrachne* L.), Strawberry Tree (*Arbutus unedo* L.) and woodwaxen (*Spartium junceum* L.).

More than half of Karaburun General Directorate of Forestry (56,3%) is seen as forest land. However, 16,7% of forest lands are seen as fertile areas. Most of the areas seen as corrupted forest are the areas turning into maquis and phryganas. Here, there are 3,898,5 ha. calabrian pine forests in total were created as a result of afforestation.

3. MATERIAL AND METHODS

In the study, 1/ 25.000 scale soil and topographic maps were used as basic materials. Road, residential area, river and drainage patterns were digitalized from 1/25.000 scale topographic maps by using Geomedia software and digital base map was designated to be used in this project. In order to determine the vegetation of the study area, ASTER satellite image of 15m x 15m resolution taken in March 2004. Soil map was digitalized and the data about soil features were input for each polygon and in conclusion a GIS featured database was created.

Total 69 topsoil samples were taken from 23 spots where shattered in study area and where natural soil erosion was observed in summit, shoulder, back slope and foot slope along with gentle sloppy geomorphologic parts (Figure 7). Back parts of mountains and hills are generally prone to erosion. In the soil samples; structure, organic matter, suspension percentage, dispersion percentage, dispersion rate percentage, skeleton percentage, sand, silt, clay rates, aggregate stability, pH, water-soluble total salt, $CaCO_3$, cation-exchange capacity (CEC) were analyzed. The K factor was estimated by evaluating the results indicated in chart 4 and the data obtained from digitalized soil map and it was input into soil polygons in GIS featured database (Figure 8).

In sampling phase, some soil properties; such as color, texture (structure), viscosity, plasticity, structure, organic matter content, plant roots distribution, insect activity traces, concretions, pores, clay pads, lime concretions and sliding surfaces, were observed in soil horizons. And also coordinates of sampling locations, the sea level, terrain type, relief, land form, the main substance, erosion, stoniness, rocky type, drainage status, the current land use type, natural vegetation pattern and density, land use capability classes were determined. Additionally, after the data related to all samples taken from the area and laboratory analysis results concerning the soil samples were evaluated, they were transferred into the database.

The digital contour lines were used to generate digital elevation model (DEM), which was used for determining the length of slope degree. 1/25.000 scale digital topographic contour maps including Karaburun Peninsula were bought from General Command of Mapping and the Digital Elevation Model (DEM) of the land was created. Besides, digital soil maps belonging to the study area were purchased and the most appropriate multi-year rainfall data were provided from rainfall meteorology stations.

One of the still most widely used empirical models is the Revised Universal Soil Loss Equation (Renard et al., 1997). It is frequently applied to assess erosion risk (Fernandez et al., 2003, Lu et al., 2004, Shi et al., 2004 and Fu et al., 2006).

In this study, RUSLE, which is one of the most empirical models used widely for determining soil erosion quantitatively and geodetically, was used in Karaburun Peninsula. Therefore, evaluating of field surveys and the data obtained were carried out for the factors developing the RUSLE equation defined below:

A=RxKxLSxCxP (Renard et al., 1997)

In the equation;

A: *soil loss;* indicates the average annual soil loss caused by surface and finger erosion as ton / ha / year. It is calculated by multiplying the factors.

R: *rainfall erosivity factor;* is the measure of the erosive force of certain rains and is indicated as (MJmm) / (ha h year). The rainfall erosivity factor was calculated by using records of annual rainfall data belonging to the rainfall stations in Karaburun, Çeşme and Seferihisar situated in research basin.

The rainfall erosivity factor was calculated by using the equation below:

$R = 4.17\ (Pi^2 / P_{ave}) - 152$ (Renard and Freimund, 1994)

R: rainfall erosivity factor
P: the average annual rainfall (mm)
Pi: the average monthly rainfall (mm)
K: *soil erodibility factor;* indicates the rate of erosion per unit erosion index from a standard area (22.1 m length and 9% slope continuously in fallow).

Soil samples taken from the specified spots in the study area were analyzed so that the data basic for estimating soil erodibility were obtained. Soil erodibility (K) rates were determined by using the equation developed by Wischmeier and Smith (1978).

In estimating the K factor with this method, silt and very fine sand (0,002-0,1 mm), clay (<0,002 mm), organic matter ratio (%), soil structure and permeability classes are used. Soil structure is determined by using soil profile definitions while the other rates are determined by laboratory analysis.

The following equation was used to determine the K factor.

$100xK=((2.1x10^{-4}) \times (M) \times (12-a) + 3.25 \times (b-2) + 2.5 \times (c-3))x\ d$ (Wischmeier and Smith, 1978)

M = (very fine sand + silt) x (100-clay)

In the equation;
K: soil erodibility factor,
M: soil particle size parameter,
a: organic matter content (%),
b: structure type code,
c: permeability class code,

K factor rates obtained for each soil type were added to soil polygons as attribute in order to create the soil erodibility map of the study area.

LS: *slope length and slope degree factor*; the effect of topography on erosion is described by the LS factor. Slope length (L) is the horizontal distance from the starting point of overland flow to the point where, the slope steepness decreases enough that deposition starts or the runoff water enters a certain channel. Slope gradient "S" indicates the effect of slope gradient on erosion. Even though the effects of these factors were evaluated separately by using uniform sloping lands, L and S factors are generally technologically evaluated together for estimating erosion.

The Digital Evaluation Model (DEM), composed of digital contour topographic maps, was used for obtaining the LS factor which indicated the combination of the measurements of slope gradient and slope length.

C: *vegetation and its management;* is the indication of the rate of soil loss in a land where a specific product is grown and has amenajman to the soil loss in a land in fallow. Aster satellite image dated May 2004 including the study area was used for obtaining the land data.

C rates criteria, determined as a result of land researches carried out in our country as well as in other countries, were used in the study area. Vegetation species and density obtained from satellite images set the basic parameters for determining the C factor.

P: *soil protection factor;* indicates the rate of soil loss of a land where contour cultivation, band seeding, terracing were done to the rate of soil loss in the land where down slope cultivation was done. As soil protection was not performed in the basin, the P factor was defined as 1.0 in RUSLE model.

The various data obtained from this study and those contained in RUSLE model were evaluated separately in GIS environment (Figure 4).

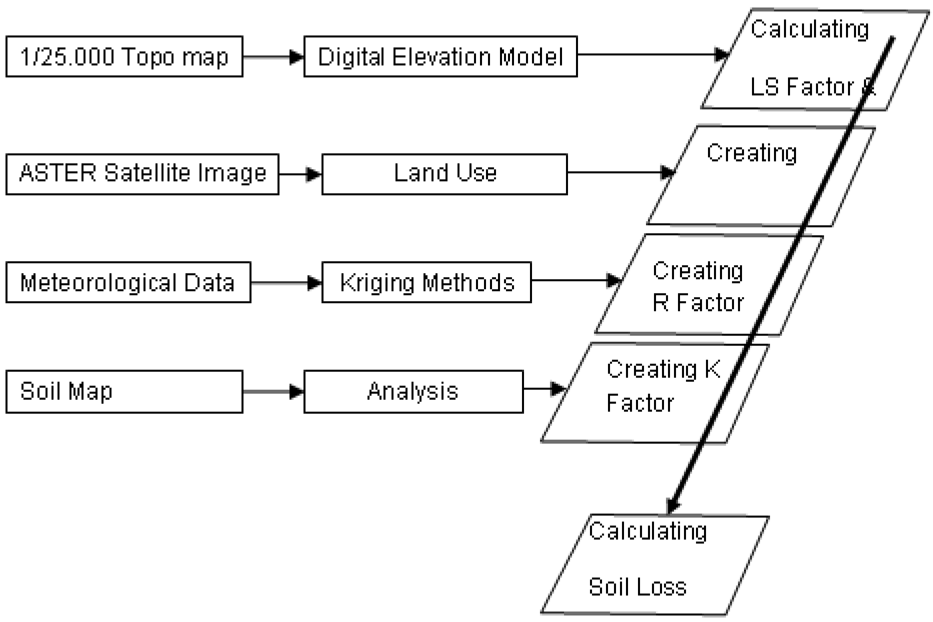

Figure 4. Methodolgy

4. RESULTS AND DISCUSSION

In the research area, cretaceous limestone or marl, Mollisols forming steep-center steep sloped topographic position on main matter, Entisols developing on medium-coarse textured alluvial deposits collected by the effect of gravitation and side rivers, Alfisols developing on cretaceous limestone and on schists on sloped lands, and soils appearing in Entisol provide the basis of this research. The physical corrosion of geological formations in the research area are intense while their chemical metamorphosis is slow. Along with calcite and dolomite containing less competent and soft featured calcium and magnesium, irregular rainfalls in seasons and especially those in spring and winter, and that the land is excessive slope intensify the natural and accelerated soil erosion in these areas.

Since geological parent materials forming the research area are rich with lime in basic, here their chemical decomposition is in medium level. Similarly, the intensity of calcium and magnesium ions keeps pH value of soil above than 7 by reacting with decomposition products; in other words, it keeps the reaction neuter, light or in mid-level amount of alkali and this decelerates the chemical decomposition.

When natural water content of soils or field damp capacity excess the saturation line, such soils become fluid (viscous) and as a result, move towards to slope end points depending on the slope degree of the land. Many parent material with different geologic features are found in the basin affects the erosion velocity and scale. Over the mountainous lands bordering and circling the study area, depending on the such properties as physio-graphic location, slope gradient, main material, lower and upper vegetation species and their density and distribution, soil were formed in different depth and taxonomic units (Figure 5). As parent materials with sedimentary origin are resistless against erosion, main material type and erosion velocity change depending on the increase of slope. In this sense, lands of sample soils do not have a developed pedon structure because of excessive slope, lack or scarcity of vegetation and as a result, A horizon, epipedon of these soils, or the big part of surface layer is eroded. As there is not enough alteration and deposition towards the soil depth due to surface erosion, B horizon, required for in a pedon structure, is very weak or unformed.

As the parent materials with magmatic origin are considerably resistant against erosion, in areas, called autochthonous, soil formation is not observed. While steep or very steep sloped lands are seen on back slopes of mountainous terrains, soils on these lands classified as Orthent. Soil samples taken from the specified spots in the study area were analyzed so that the data basic for estimating soil erodibility were obtained. Soil erodibility (K) rates were determined by using the equation developed by Wischmeier and Smith (1978) (Figure 6). Road, settlement area, river and drainage patterns etc. from the 1/25.000 scale topographic maps are digitalized and used for creating digital base map. By using digital base map, the geometric correction of the ASTER satellite image (15m x 15 m), taken May 2004, was realized.

The land vegetation map of the study area was created on the satellite image by the method "screen digitize". C rates criteria, determined as a result of land researches carried out in our country as well as in other countries, were carried out in the study area and the data obtained were transferred to the database so that C factor thematic map was created (Figure 7, 8).

1/25.000 scale digital topographic contour maps including Karaburun Peninsula were purchased from General Command of Mapping and the Digital Elevation Model (DEM) of the land was created by using the software DIGEM. By using the data obtained from DEM, the slope length (L) and the slope gradient (S) were calculated so that LS layer was created in GIS environment (Figure 9).

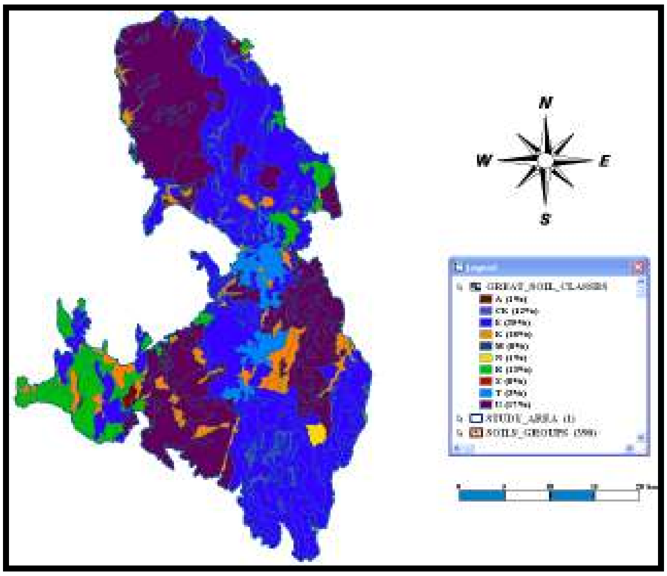

Figure 5. Soil taxonomy units of study area

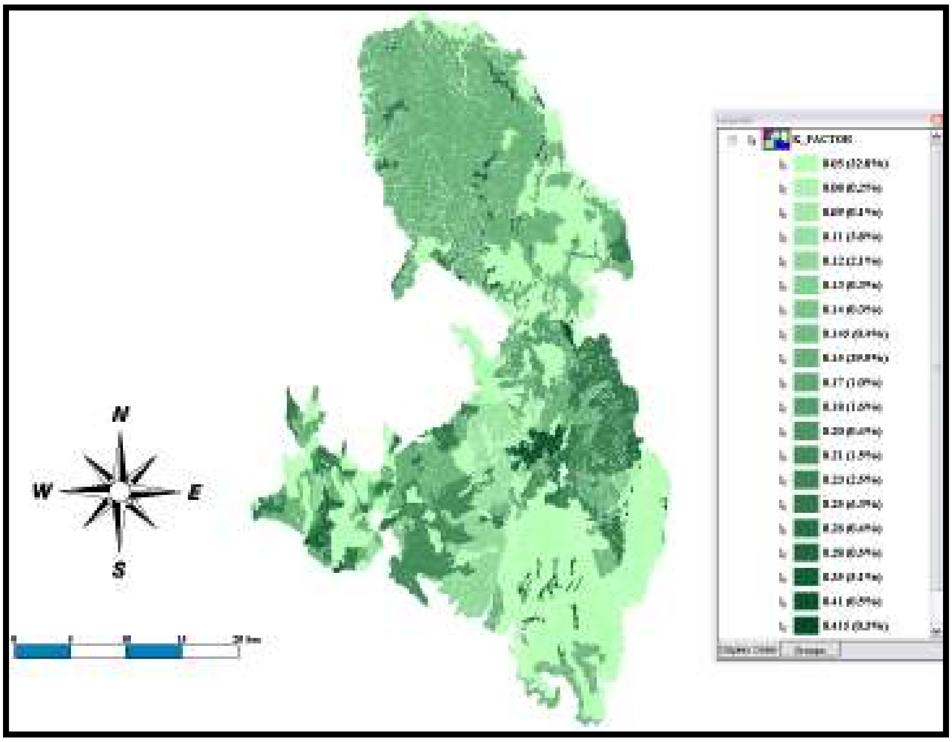

Figure 6. Thematic map of the Soil erodibility factor (K)

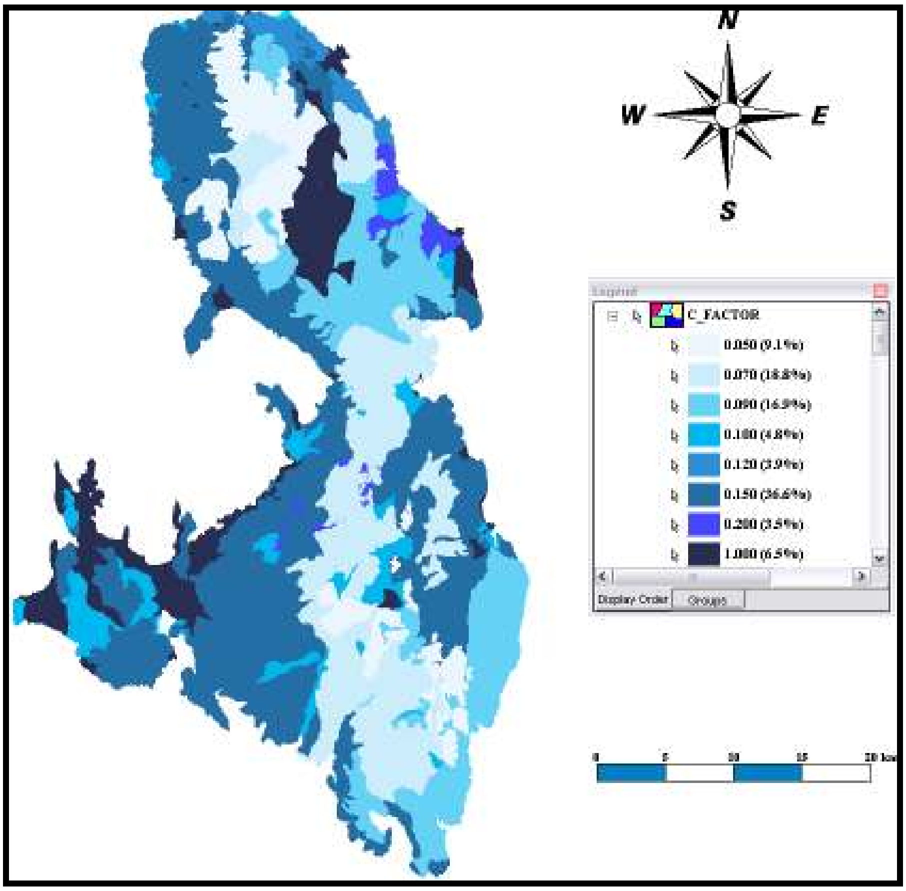

Figure 7. Thematic map of ground cover factor (C)

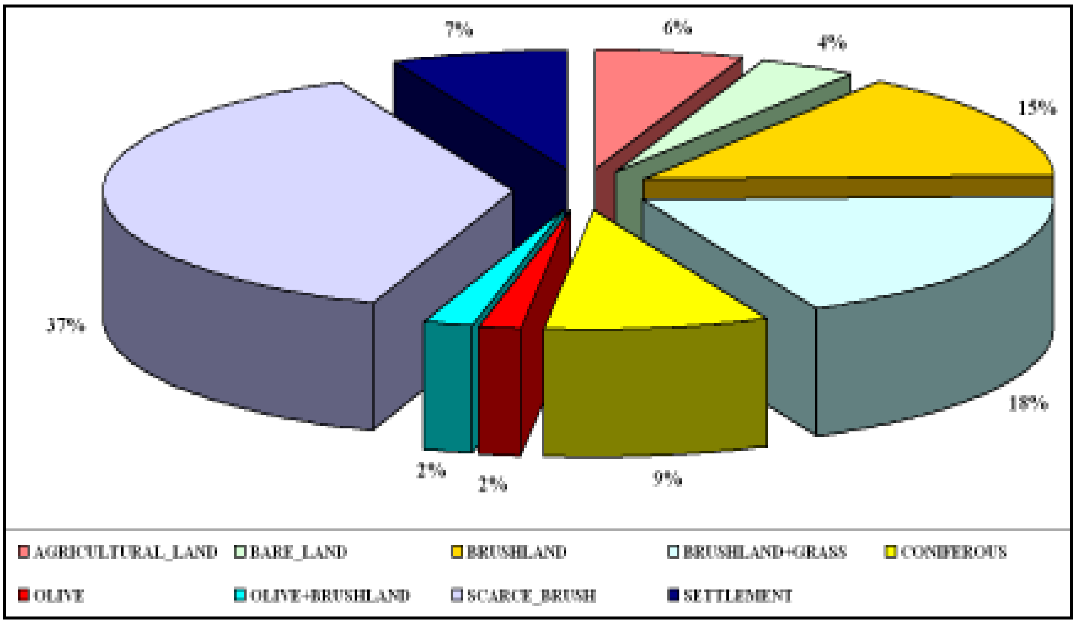

Figure 8. Land vegetation areas in study area

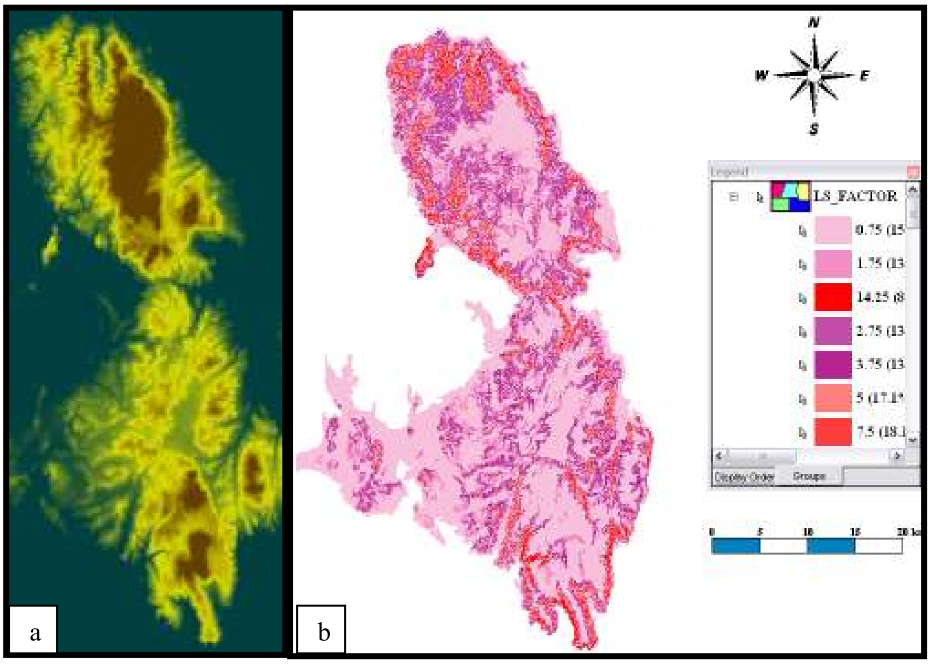

Figure 9. (a) DEM deriveted from digital contour line, (b) Slope Length & Steepness Factors (LS)

4. CONCLUSION

In this research, it is aimed to map potential erosion risk of lands, the most important natural source of Karaburun Peninsula, by using remote sensing and geographical information system. At the end of the research, after assessing all the data obtained, it was determined that there is annual 1.279.548 ton/ha soil loss in Çeşme-Karaburun Peninsula.

With this research, the scale of soil loss and erosion severity scale of the land under the influence of erosion were determined geographically. It was observed that remote sensing and geographical information system were very effective agents in determining each factor, which causes erosion, as layer and geographically.

5. ACKNOWLEDGEMENT

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