

GIS based soil erosion assessment using the USLE model for efficient land management: A case study in an area with diverse pedo-geomorphological and bioclimatic characteristics

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Abstract

The complex environmental process of soil erosion is crucial to sustainable land management and conservation. This study uses the Universal Soil Loss Equation (USLE) model to understand the intricate interactions that cause soil erosion in Cluj County, Romania, a region susceptible to complex erosion and landslide phenomenon. The established analysis depicts erosion patterns from localised hotspots to regions of relative stability, providing valuable insights into this critical issue. Spatial distribution maps with color-coded gradients show soil erosion risk and identify vulnerable regions, with temporal investigations depicting how environmental changes affect soil erosion, making it relevant to soil conservation and land management. A careful analysis of the USLE model's parameters (Ls, Cs, C, S, K) shows their soil erosion contributions. The erosion rates were graded in five classes in accordance to general practices of USLE modelling, which range from very-low, low, moderate, high and very-high susceptibility to soil erosion. While a significant majority of the county's surface is represented by very-low and low erosion risk, several hotspots were identified with intense erosion processes that highlights the critical need to implement soil conservation measures in the area.

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Identifying erosion hotspots and conservation solutions encourages stakeholders to protect soils, and can provide policymakers with useful information for developing improved guidelines for soil and water conservation.

Keywords: database; GIS analysis; land management; soil erosion; USLE

Introduction

Soil erosion poses a significant environmental concern on a global scale, since it leads to the depletion of fertile topsoil and consequent reduction in agricultural productivity (Spalevic *et al.*, 2020). Due to the increasing focus on advancing soil erosion models for more accurate estimation of soil loss at watershed and basin scales, the issues of soil loss and sediment supply have emerged as significant global difficulties in contemporary times. Direct measures of erosion in a watershed can be obtained by quantifying the mobility of solid particles within the downstream portion over an extended period of time (Gocić *et al.*, 2020; Mohammadi *et al.*, 2021). In cases where hydrometric and discharge data for a certain watershed are insufficient, the utilisation of modelling techniques emerges as a viable and established method for assessing the extent of erosion and discharge within said watershed. Mathematical erosion models were developed to predict the extent of erosion and the quantity of silt generated, owing to these causes. A multitude of soil erosion models have been developed globally with the aim of assessing the extent of soil erosion and the maximum discharge capacity at the regional or basin scale (Greiner *et al.*, 2017; Sestras *et al.*, 2023). The Universal Soil Loss Equation (USLE) developed by the United States Department of Agriculture (USDA) has played a significant role in the realm of soil erosion research and land management for an extended period of time (Roşca *et al.*, 2014). Since its establishment in the late 1960s, this empirical model has offered significant insights into the intricate mechanisms that regulate soil erosion. It has proven to be a pragmatic instrument for evaluating the hazards associated with soil loss and directing conservation endeavours in various geographical settings (Devatha *et al.*, 2015; Girmay *et al.*, 2020; Mazigh *et al.*, 2022). Given the escalating complexities associated with alterations in land use, fluctuations in climatic patterns, and growing global environmental apprehensions, the USLE model has acquired heightened importance in the realm of current soil conservation and land management.

Erosion is an intrinsic natural phenomenon that can provide significant ramifications for the overall well-being of soil, the quality of water, and the integrity of ecosystems (Mancino *et al.*, 2016; Kruk *et al.*, 2020). The repercussions of this phenomenon have wide-ranging implications that transcend beyond the agriculture sector, exerting influence on the sustainability of urban developments, infrastructure, and the broader environment (Bagherzadeh, 2014; Alewell *et al.*, 2019; Youssef *et al.*, 2023). In light of the ongoing expansion of the world population, it has become increasingly crucial to comprehend and address the hazards associated with soil erosion. This urgency arises from the need to safeguard food security, preserve water resources, and effectively administer our landscapes in a sustainable manner (Ahmad and Verma, 2019).

This research study aims to comprehensively explore the USLE erosion model, encompassing its historical evolution, theoretical foundations, and practical implementations. The objective of this study is to provide a comprehensive analysis of the model's inherent advantages and drawbacks, examine current developments and alterations, and evaluate its applicability in light of changing environmental circumstances. In undertaking this endeavour, our aim is to offer a thorough examination of the present condition of the USLE model and its prospects for future advancements in the realm of soil erosion forecasting.

The primary objective of this article is to provide researchers, land managers, and policymakers with a comprehensive understanding of the USLE model. By doing so, it aims to enhance their ability to make well-informed decisions and implement targeted conservation initiatives. In the context of contemporary soil erosion prediction, the USLE model continues to serve as a helpful instrument, aiding us in the pursuit of

sustainable land management strategies and the promotion of environmental stewardship (Dragicevic *et al.*, 2018; Ghosh *et al.*, 2022). The objective of acquiring a comprehensive map encompassing all areas of degraded terrain is to emphasise their spatial arrangement, particularly the regions exhibiting the highest concentration of soil erosion. This facilitates the consideration of both structural and non-structural approaches to mitigate erosion-induced deterioration (Costea *et al.*, 2022).

The phenomenon of soil erosion is a multifaceted environmental concern that has wide-ranging implications, underscoring the necessity of employing rigorous approaches for both forecasting and mitigating its effects (Verheijen *et al.*, 2009; Sabzevari and Talebi, 2009). This section provides a description of the materials and methods employed in our research, whereby it was employed the Universal Soil Loss Equation (USLE) model to evaluate the potential for soil erosion in the selected study region.

Materials and Methods

Study area

The study region, which plays a crucial role in providing context for our findings, was meticulously delineated. The geographical locations, dimensions, and significant environmental factors, including historical context related to soil erosion in the region, were taken into consideration. Cluj County, encompassing an area of 6674 square kilometres, is situated in the northwestern region of Romania, positioned between the latitudinal parallels of 46°24'47" and 47°28'44" north, and the longitudinal meridians of 23°39'22" and 24°13'46" east. This county has a total of 81 Territorial Administrative Units (TAUs). Cluj County is situated in the central region of Transylvania, where it intersects with three significant physical-geographical regions: the Transylvania Plain, the Someşan Plateau (including the Cluj and Dej Hills), and the Apuseni mountain area (Figure 1). The presence of diverse geomorphological, lithological, bioclimatic, and pedological characteristics contributes to a significant range of vegetation components within this particular region (Bilasco *et al.*, 2009).

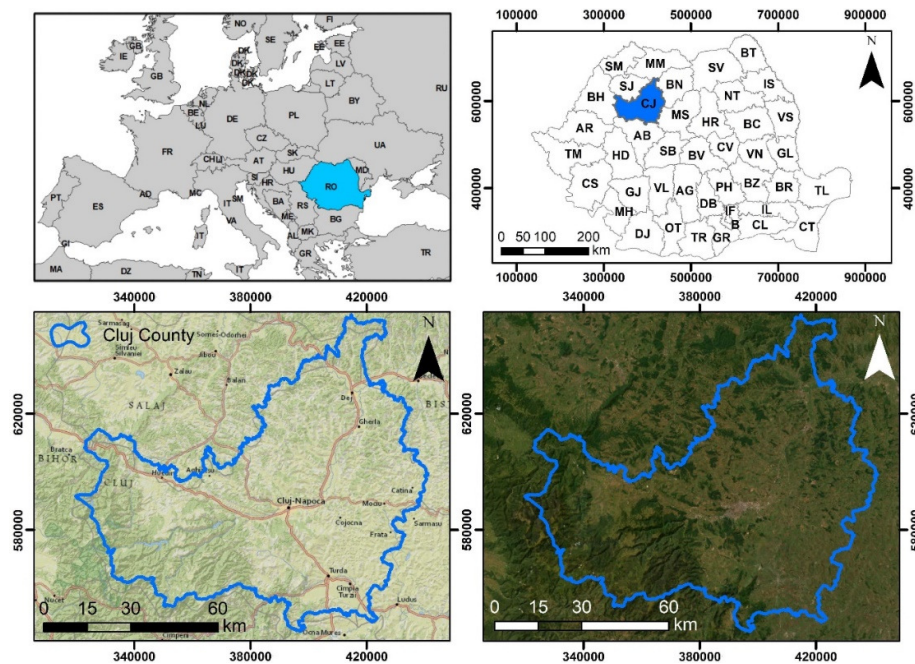


Figure 1. The geographical location of the study area

A breakdown of the county's land usage reveals that agricultural land accounts for 63.8% of the total area, while forest land occupies 25.1%. Constructions occupy 2.9% of the land, roads cover 1.8%, and degraded and unproductive land make up 5% of the county's territory. The topographically elevated region inside Cluj County is considered a constituent component of the broader Transylvanian Depression from a geographical standpoint. This region is characterised as the most extensive negative morphological area within the Carpathian Mountain range. It was formed as a result of alpine tectonic activity, exhibiting a predominantly hilly and plateau-like topography. The area is divided into distinct sequences of geomorphological zones, which are arranged in a nearly concentric manner. These zones progressively decrease in elevation from the outermost to the innermost regions. Notably, there are significant variations in both structural composition and relief characteristics observed across different areas within this region (Sestras *et al.*, 2023).

Methodological approach and database

The present study utilised an extensive dataset including soil characteristics, precipitation patterns, and land utilisation information to foster a full comprehension of the dynamics of soil erosion. The USLE model is dependent on a number of crucial characteristics, all of which are necessary in order to provide precise soil erosion prediction. The methodologies employed for determining these characteristics were delineated. The process of soil erosion is governed by several geomorphological elements, such as slope length and steepness, as well as climatic and soil properties (Desmet and Govers, 1996; Jiang *et al.*, 2023). Additionally, land cover management practises also play a role in this process. This work presents a geographic information system (GIS) based model that aims to calculate and visualise the regions that are susceptible to soil erosion in Cluj County. During the implementation phase of the USLE model, a vector and raster GIS database were developed to encompass the geographic unit under research (Figure 2). This was achieved by the utilisation of spatial analysis methodologies and database queries, which facilitated the quantitative assessment of the soil volume eroded within the designated study region.

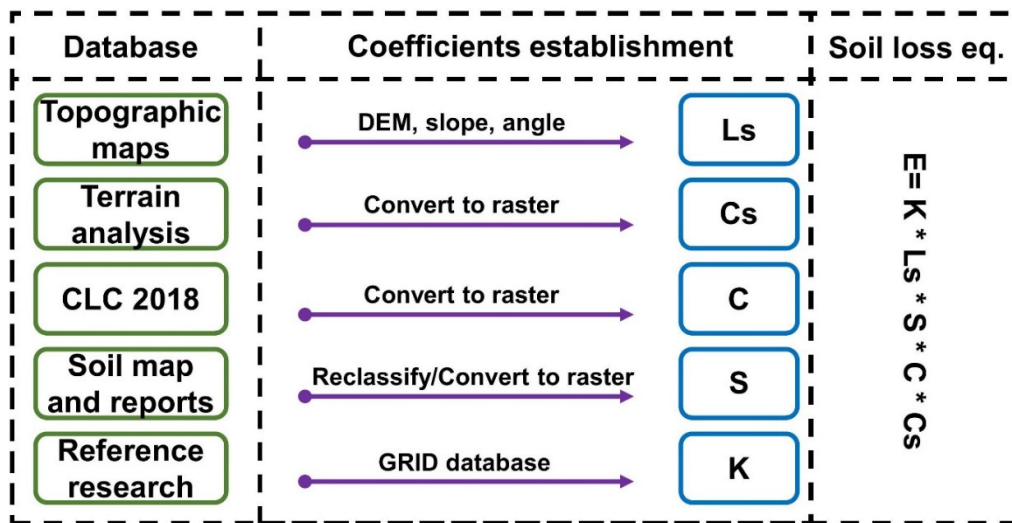


Figure 2. Methods for calculating soil erosion using the USLE model

The calculation of the erosion rate was determined using the widely recognised Universal Soil Loss Equation (USLE), as modified by Moțoc *et al.* in 1975 based on the work of Wischmeier and Smith in 1965. The computational framework of the model incorporates five primary components in the estimation of soil

erosion within a certain geographical region. Each element represents a quantitative evaluation of a distinct situation that has an impact on the severity of soil erosion within a certain geographical area. The erosion values exhibit a concurrent relationship with climatic fluctuations, so rendering the values derived from the Universal Soil Loss Equation (USLE) more accurate by employing long-term average values (Costea *et al.*, 2022). The formula can be expressed as follows:

$$E = K * Ls * S * C * Cs \quad (1)$$

The variable **E** represents the mean annual rate of surface erosion, measured in tonnes per hectare per year. The correction coefficient, denoted as **K**, is a measure of climatic aggressivity, specifically in relation to rainfall. It serves as an indicator of the erodibility index associated with precipitation. In its initial form, the USLE was the cumulative annual product of the erosive rainfalls' energy (**E**) and their greatest intensities during a 30-minute period (**I₃₀**). Indirect estimation approaches have been developed to address the challenge of directly calculating rainfall erodibility, given meteorological stations do not currently record rainfall intensity. These methods rely on statistical relationships between erodibility and other quantifiable factors. The slope length coefficient **Ls** and slope degree are topographic factors that serve as coefficients in the analysis of a researched region. These factors are determined by considering both the slope and length of the area under investigation (Kinnell, 2005). As the length of the slope increases, there is a corresponding increase in the quantity of cumulative runoff. Moreover, it should be noted that there exists a positive correlation between the steepness of a terrain's slope and the velocity of the runoff, which in turn leads to an increased contribution to the process of erosion. The correction coefficient for soil erodibility **S** denotes the capacity of soil or rock to withstand the erosive forces exerted by rainfall and the micro currents induced by the movement of meteorologically derived water. The correction coefficient, denoted as **C**, pertains to the cover-management factor and plant features. It quantifies the ratio between soil loss from land with a certain vegetation type and the soil loss from an equivalent area of continuous barren land. The values of erosion are contingent upon factors such as vegetation cover, management practises, as well as the growth stage and degree of cover during periods of high rainfall-induced erosion. The correction coefficient, denoted as **Cs**, is utilised to account for the impact of erosion control measures. The aforementioned factor pertains to the practise of conservation. Values are derived from empirical observations in the field pertaining to tables on soil conservation practises. These tables provide information on the ratio of soil loss in areas where contouring and contour strip-cropping techniques are implemented compared to areas where these techniques are not employed. The final erosion map encompasses the five previously established coefficients, as depicted in Figure 3.

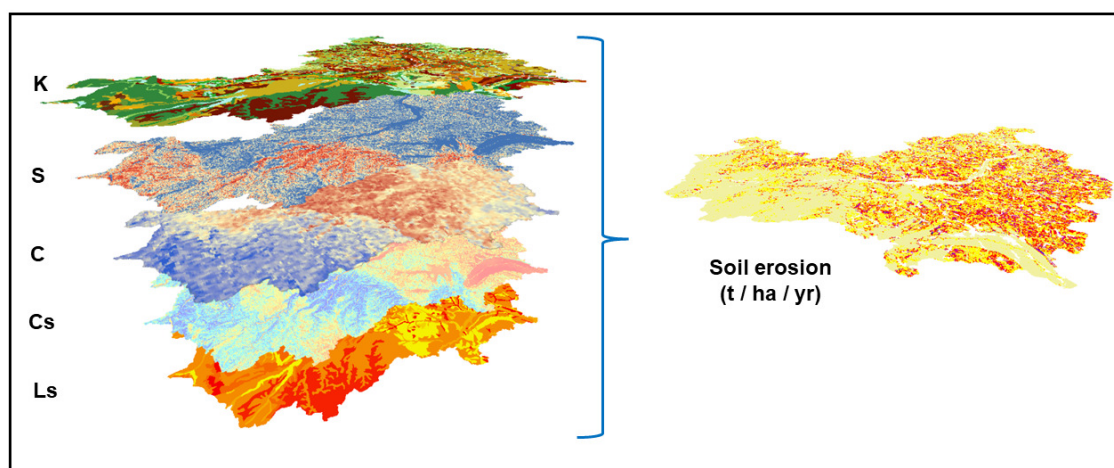


Figure 3. The five coefficients used in the USLE model

The calibration and validation of the Universal Soil Loss Equation (USLE) model were important stages in the research endeavour. The calibration method was explicated, providing a comprehensive account of the criteria employed for evaluating the performance of the model, by comparing the areas highlighted by high erosion with field and Google Earth investigations. Additionally, we provided a thorough explanation of our validation process, which encompasses the datasets and statistical methodologies utilised to assess the accuracy of our model (Rizeei *et al.*, 2016; Serbaji *et al.*, 2023). In order to provide a thorough viewpoint, a comparative study was undertaken, when appropriate, to compare the results of the USLE model with those of other soil erosion models or historical data, such as the Intensity of Erosion and Outflow (IntErO) model. This analysis aimed to evaluate the effectiveness of the USLE model in predicting soil erosion (Sestras *et al.*, 2023).

Regarding software and tools, we have delineated the specific software and Geographic Information System (GIS) tools employed for the purpose of data processing, model implementation, and statistical analysis (Hysa *et al.*, 2021; Hyka *et al.*, 2022). Thus, the software ArcMap 10.8 was employed for the USLE modelling, along with open source data such as the Shuttle Radar Topography Mission Digital Elevation Model (SRTM DEM), Corine Land Cover 2018 (CLC 2018) dataset that provided information on land cover and land use, average annual precipitation datasets regarding the rainfall were used from meteorological stations inside of Cluj County, and the soil database constructed by digitizing 1:200,000 scale maps with the SRCS ICPA-1980 (Romanian Soil Classification System). This meticulous approach has been adopted to guarantee transparency and repeatability in our research methodology. The utilisation of specific materials and methodologies in our study established the groundwork for a thorough evaluation of the potential hazards associated with soil erosion, hence facilitating a more profound comprehension of this significant ecological concern.

Results and Discussion

Our study focuses on soil erosion, an environmental issue of great significance that has far-reaching implications for land management and sustainability. Using the Universal Soil Loss Equation (USLE) model, our objective was to analyse the complex soil erosion patterns within our selected research area. The investigation was initiated by taking a comprehensive perspective on the patterns of soil erosion. The USLE model facilitated the identification of a diverse array of erosion risks distributed throughout the landscape. The complex interaction among variables such as topography, land cover, and soil properties resulted in diverse levels of susceptibility to soil erosion. The aforementioned viewpoint provided the fundamental basis from which we proceeded to explore the intricacies in greater detail.

Spatial distribution maps played a prominent role in depicting the spatial patterns of soil erosion risk. The maps shown in this study utilise color-coded gradients to visually depict the vulnerability of the study area to erosion, so providing a narrative representation. The model's ability to reflect localised dynamics was demonstrated by the emergence of several variants, ranging from low-risk zones to erosion hotspots. When applicable, temporal analysis sheds light on the temporal evolution of soil erosion risk. Graphs and charts provide a visual representation of temporal patterns, illustrating trends, variations, and the influence of altering environmental factors on the dynamics of soil erosion. The inclusion of the temporal dimension has contributed to a more comprehensive display of the erosion process. By examining the inner workings of the model, it was conducted an analysis on the impact of its individual components (Ls, Cs, C, S, K) on the process of soil erosion, thus shedding light on the relative significance of each parameter in influencing erosion patterns.

Focusing on the practical ramifications of our research outcomes, we have identified specific areas of erosion concentration known as hotspots, as well as determined the priority for conservation efforts. These regions with a high-risk factor necessitate concentrated attention and well-informed methods for conservation. The research conducted in this context provided practical insights that can be utilised by land managers, policymakers, and conservationists.

The calculation of the modelled erosion rate was determined using the USLE model as modified by Moțoc *et al.* in 1975. The soil erosion map for Cluj County is displayed in Figure 4. The computational framework of the model incorporates five primary factors to estimate soil loss within a certain geographical region. Thus, the modelled erosion based on five classes incorporates the following: very-low (tolerable) rate of below 3 tonnes per hectare per year ($t\ ha^{-1}\ yr^{-1}$); low rate which is between the interval of 3.1 to 10 $t\ ha^{-1}\ yr^{-1}$; moderate rate which is between the interval of 10.1 to 20 $t\ ha^{-1}\ yr^{-1}$; high rate which is between the interval of 20.1 to 40 $t\ ha^{-1}\ yr^{-1}$; very-high rate of over 40.1 $t\ ha^{-1}\ yr^{-1}$. Highlighted inside of Figure 4 is the percentage chart of each of the five erosion susceptibility classes, in regards to the occupied surface from Cluj County total area. Thus, it was established that almost half of the surface of Cluj County, namely 49.63%, belongs to the low class of soil erosion. The highlighted regions belonging to the very-low class of erosion are predominantly situated in the West and South-West part of Cluj County, which belong to the Apuseni Mountain area, a geographical unit well constituted in terms of forests and appropriate land use. The low and moderate rates represent 32.40%, respectively 14.16% of the total area, and are distributed across all the county's surface. The high and very-high rates of soil erosion represent 3.56%, respectively 0.24% of the total area, and are considered hotspots of significant land degradation. The aforementioned discovery denote that the highlighted hotspots are undergoing substantial degradation, underscoring the imperative requirement for the implementation of soil conservation measures in those regions. The main regions subjected to high and very-high rates of soil erosion belong to the Transylvanian Plain, located in the Eastern part of Cluj County, a geographical region with significant agricultural use. Moțoc *et al.* (1975) established that the acceptable limit for soil erosion in the Romanian region varies between 2 and 8 tonnes per hectare annually, thus more than three quarters of Cluj County fall in an expected and manageable threshold (Moțoc, 1983; Moțoc and Mircea, 2002).

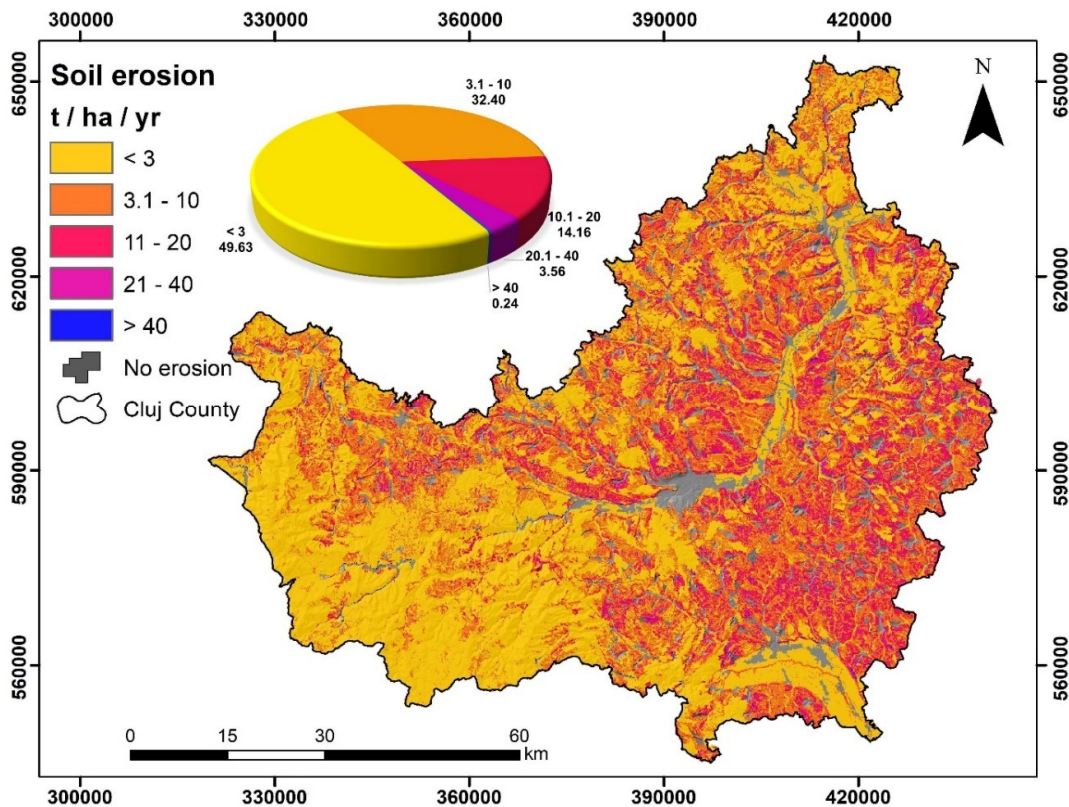


Figure 4. Soil erosion map for Cluj County

The utilisation of GIS technology and geospatial databases enables the modelling and querying of soil erosion classes, which we find highly advantageous. In order to provide landowners with an initial assessment of the susceptibility to soil erosion in plots used for agricultural and non-agricultural purposes, it is necessary to ensure that they have a comprehensive understanding of the situation. Consequently, determinations can be formulated pertaining to the strategies aimed at mitigating the hazards associated with soil erosion, encompassing both the broader context of the TAU and the specific scope of individual plots. The examination focused on the plots exhibiting the most significant erosion rates, with particular attention given to the geographical locations in which they are situated. Figure 5 illustrates the average annual erosion rate for agricultural and non-agricultural plots, based on the parcels obtained from *Agenția de Plăți și Intervenție pentru Agricultură* APIA (Payments and Intervention Agency for Agriculture).

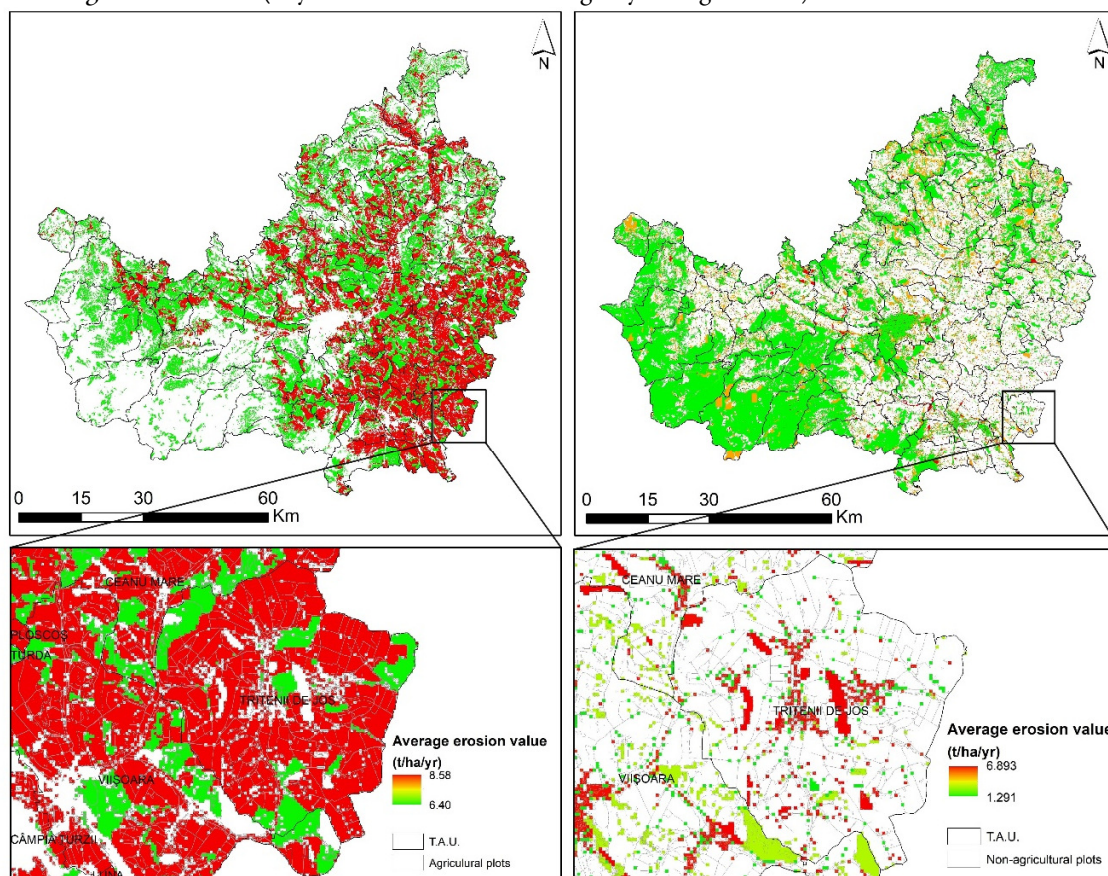


Figure 5. The average annual erosion rate for agricultural (left) and non-agricultural (right) plots

By utilising the modelled values of soil erosion acquired at the Cluj County level, it was derived the average soil erosion value for each parcel within the study region, considering both agricultural and non-agricultural land use. Based on the APIA obtained parcels, six large distinct classes were identified, respectively: 1. Permanent crops other than vineyards, orchards, hops; 2. Non-productive land; 3. Permanent pasture; 4. Arable land including greenhouses, solariums; 5. Gravel, sands, rocks, tailings ponds, rubbish pits; 6. Forest vegetation, shrubs, bushes. In the case of plots designated for non-agricultural purposes, the average rate of erosion ranges from $6.40 \text{ t ha}^{-1} \text{ yr}^{-1}$ to $8.58 \text{ t ha}^{-1} \text{ yr}^{-1}$. It is worth noting that the higher erosion values are typically observed in isolated plots that are utilised for non-agricultural activities, such as the class identified by gravel, sands, rocks, tailings ponds, rubbish pits. The individual analysis of agricultural plots focused on identifying

permanent crops, in addition to arable land that includes greenhouses and solariums. These land uses account for 28.26% and 36.43% respectively, falling within the categories of moderate erosion.

Regarding non-agricultural plots, it is identified that a significant majority, specifically 79.08% (449 plots), exhibit a low average erosion value ranging from 3 to 10 t ha⁻¹ yr⁻¹. Conversely, the remaining 21.91% (126 plots) demonstrate an even lower average erosion rate, thereby enhancing their economic worth. In 2022, there were a total of 281 parcels categorised for agricultural use. These parcels, on average, exhibit moderate erosion levels. However, it is important to note that there are localised instances of rapid erosion within these parcels. Figure 6 illustrates the five degrees of erosion intensity (very-low, low, moderate, high, very-high) based on the USLE modelling, together with the six APIA distinct classes of land use.

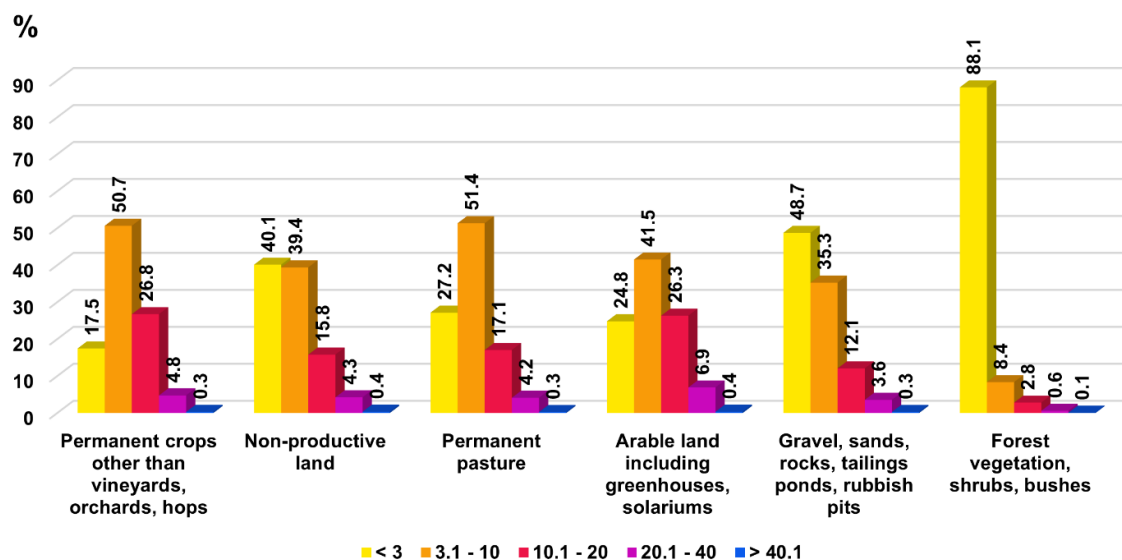


Figure 6. The distribution of soil erosion rates based on the APIA land parcel classes

Within regions characterised by forest vegetation, the soil erosion rate is seen to be at its minimum level, encompassing around 88.1% of the total area. This phenomenon can be attributed to the well-established understanding that forest vegetation plays a crucial role in water retention, particularly during periods of excessive precipitation, thereby effectively mitigating the occurrence of floods (Curovic *et al.*, 2020; Bilaşco *et al.*, 2022). The regions characterised by continuous agriculture exhibit a notable rate of soil erosion, ranging from 20 to 40 t ha⁻¹ yr⁻¹. This phenomenon can be attributed to the elevated erosivity resulting from the expansion of non-vegetated land areas. The present study aimed to analyse unproductive areas with the objective of accurately classifying them in future agricultural circuit classifications.

The regions designated as "Gravel, sands, rocks, tailings ponds, rubbish pits" are primarily situated alongside the primary watercourses, which do not possess agricultural significance. However, these regions were incorporated into the analysis to ensure comprehensive territorial representation at the county level. The statistical examination of agricultural and non-agricultural parcels in Cluj County reveals that a majority of these parcels (41.5%) are categorised as having low erosion. However, a small portion of the land (0.4% of the total area) falls into the high erosion class, with erosion rates reaching up to 40 t ha⁻¹ yr⁻¹. This necessitates the implementation of both structural and non-structural measures to mitigate erosion, such as agrotechnical implementations, afforestation, crop rotation, and the cultivation of crops with high soil coverage. In addition to the aforementioned, the implementation of the works is carried out in accordance with the overall alignment of the contour lines, while incorporating the establishment of strip crops designed to serve as a protective measure against erosion, with due consideration given to the permissible yearly erosion rate, which according

to Moțoc *et al.* 1975 the permissible threshold for soil erosion in the Romanian area ranges from 2 to 8 tonnes per hectare per year. The areas exhibiting soil erosion under the category of permanent pastures are primarily situated in the hilly and premontane regions of Cluj County. This circumstance contributes to the deterioration of the unique pasture ecosystem and the reduction in the diversity of plant and animal species.

The primary goal of obtaining a complete map that encompasses all degraded terrains is to highlight their spatial distribution, with a specific emphasis on places exhibiting the greatest concentration of soil erosion. This enables the examination of both structural and non-structural measures intended to alleviate the degradation caused by erosion. The research was augmented by incorporating a comparative analysis utilising several soil erosion models or datasets. The analysis indicated above not only accomplished the purpose of validating the USLE model, but also drew attention to its notable strengths and revealed areas that may require further improvement. Figure 7 illustrates the hotspots and coldspots identified in terms of soil erosion at the TAU level in Cluj County.

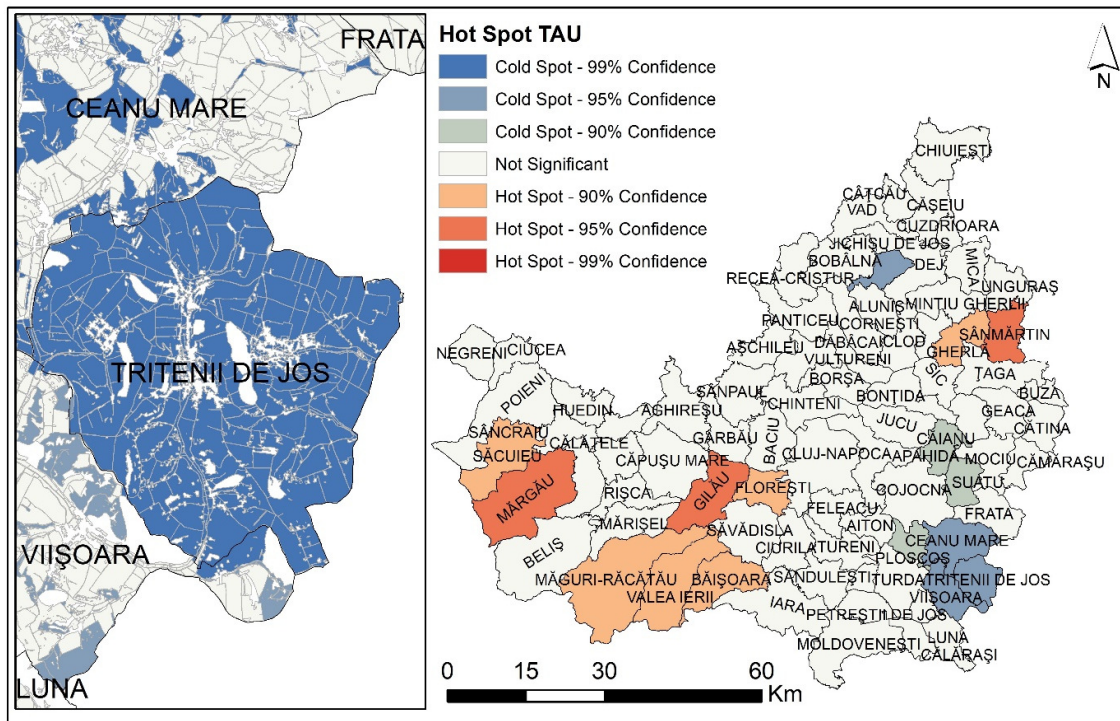


Figure 7. The identified erosion hotspots and coldspots at TAU level in Cluj County

To identify agricultural plots with a high susceptibility to soil erosion, we employed GIS statistical analysis tools. These tools facilitated the extraction of average erosion values for each individual agricultural plot and enabled the implementation of the HotSpot model within the studied area. The plots exhibiting a significant level of confidence in relation to soil erosion were consequently emphasised. A hotspot can be described as a geographic location characterised by a significantly higher concentration of events in relation to the expected number of events that would occur if they were randomly distributed. The concept of hotspot identification has undergone development through the examination of point distributions or spatial configurations of points inside a given location.

The territorial administrative units located in the mountainous region of the Apuseni mountains (Mărgău, Săcuieni, Măguri-Răcățau, Valea Ierii, and Băișoara) are susceptible to accelerated soil erosion. This vulnerability is primarily attributed to the topographical characteristics, including steep slopes and increased torrentiality. Additionally, the expansion of deforested areas (Hartel *et al.*, 2017; Dragan *et al.*, 2019) further

exacerbates the erosion process until new forest vegetation is established. In these regions, there is a noticeable rise in the density of access roads leading to the properties, indicating that the area is at the forefront in terms of constructing vacation residences.

The urban areas of Gherla, Sânmărtin, and Gilău are classified as hotspots due to the significant expansion of agricultural land, specifically permanent crop cultivation, which mostly caters to the nearby urban communities. An elevated rate of soil erosion was documented in both regional investigations, such as the one conducted by PATJ Cluj (Cluj County Territorial Development Plan), as well as in studies conducted at the level of hydrographic sub-basins.

Despite the increase of the built environment (Dolean *et al.*, 2020), TAU Florești remains a significant hotspot. The proliferation of concrete surfaces has resulted in a decrease in the rate of water infiltration into the soil inside urbanised areas, while simultaneously causing an excessive discharge of water in neighbouring regions. TAU Triteni, situated in the Transylvania Plain, is totally within the 99% confidence interval of the coldspot category, indicating a higher level of clustering of low values. In this particular scenario, the implementation of agrotechnical measures and the appropriate utilisation of agricultural plots have a beneficial impact on soil erosion. The recorded average soil erosion rates at the plot level range from 1.3 to 6.9 t ha⁻¹ yr⁻¹, which are within the acceptable threshold for the Romanian territory.

Conclusions

Soil erosion is significantly impacted by global climate change, including the intensity and magnitude of climatic risk events such as heavy rainfall, uneven precipitation patterns throughout the year, and the inadequate management of agricultural land, characterised by non-compliance with recommended agrotechnical practises. Additionally, human activities such as deforestation, alterations in land use, and the expansion of transportation networks also contribute to soil erosion. The implications of our findings extend beyond the scope of this study. These concepts resonate within the domains of land-use planning, erosion control strategies, and sustainable land management techniques. The practical implications of the research highlight the need for well-informed decision-making and the conservation of the existing valuable soil resources. The future presents prospects for the advancement of soil erosion modelling, with continuous progress in data gathering, technological advancements, and modelling methodologies, thus establishing an opportunity of enhancing the comprehension of this crucial environmental issue.

Authors' Contributions

All authors have contributed equally to the work. All authors have read and agreed to the published version of the manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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