ACTA UNIVERSITATIS SAPIENTIAE
AGRICULTURE AND ENVIRONMENT, **10** (2018) 31–38

DOI: 10.2478/ausae-2018-0003

Soil loss susceptibility model of the Baraolt Depression

Levente CSISZÉR,[1] Ştefan BILAŞCO[2]

[1] Department of Horticulture, Faculty of Technical and Human Sciences,
Sapientia Hungarian University of Transylvania, Cluj-Napoca,
e-mail: csiszer.levente@ms.sapientia.ro

[2] Faculty of Geography, Babeș–Bolyai University, Cluj-Napoca, Romanian Academy,
Cluj-Napoca Subsidiary, Geography Section, e-mail: stefan.bilasco@ubbcluj.ro

Manuscript received January 12, 2018; revised February 10, 2018; accepted February 24, 2018

Abstract. The soil loss susceptibility model, made for the Baraolt Depression, offers useful information for the farmers regarding the areas that should be used in a certain way and for a certain purpose, with farming methods which aim at the protection of their most important means of production – soil.

Keywords: R.U.S.L.E., rainfall-runoff, slope length, erodibility factor, land use, quantitative analyses

1. Introduction

Soil erosion can be defined both as a natural process and as a process induced by the activity of the human society, which interfere and have a negative impact on the current evolution of the pedosphere. The factors of this process can be grouped into dynamic factors, such as the kinetic energy of the water, both dropping and flowing down the slope, and static factors such as the properties of the soils or land use.

In Romania, concerns regarding the quantity of the eroded and transported soil started in the 1960s, and the most used model was the one developed by Moţoc M. in 1963. This model was continuously improved up to 2002 [2].

At the global level, the interest in soil erosion loss started around the 1930s – the great dust bowl in the States. This event triggered a real race in soil loss research. A research network was established for collecting the necessary data. In 1940, R. W. Zingg [17] was the first researcher who suggested a mathematic model which made possible the calculation of the quantity of soil loss based on the length and declivity of the slopes. Similar models were made by Dwight Smith in 1947, G. H. Browning and collaborators in 1947, and Lloyd Eley in 1952 [8] – quoted by Bilaşco Şt. and collab. (2009) [2]. Up to 1960, more models were made, some including in the equation, besides the length and degree of the slopes, other soil loss factors such as the type of the soil, the quantity of the organic matter in it, the consistency of the vegetation, and used farming methods.

In 1965, Wischeimer and Smith published in the *Agriculture Handbook of the United States Department of Agriculture (U.S.D.A.)* no 282 a model, an equation to calculate the quantity of soil loss, which was used from 1960 by the Department and proved to be the most comprehensive ever made up to that time [16].

This equation entered into the science under the name of U.S.L.E (Universal Soil-Loss Equation).

Following the accumulated experience and the development of the mathematical modelling, the equation was revised and upgraded, and so R.U.S.L.E. (Revised Universal Soil-Loss Equation) was published. A remarkable contribution to it was done by K. G. Renard, who published the new equation in 1985 [15]. The R.U.S.L.E. equation analyses each soil-loss contributing factor [1], but, as the calibration was done in Anglo-Saxon measurement units, it was hardly usable in European countries. The adaptation to the metric system was done in 1992, and thus EUROSEM (European Soil-Erosion Model) appeared [19].

2. Materials and methods

To realize the soil loss model of the Baraolt Depression, the first thing we did was to mark the limits of the depression as many geographers, geologists, and geomorphologists consider this area an extent appendix of the Brașov Depression. We did not use just one criterion for delimitation but several ones such as: petrological (Mesozoic rocks on the surface), tectonic (faults), geomorphological (upper glacis on the slopes), vegetation (beech tree forests), land-use (plough land vs grazing land) [4].

In calculating the quantity of soil loss under different terrain conditions, the R.U.S.L.E. [18, 20, 21] equation uses five factors which represent the quantification of a specific condition that influences the gravity, seriousness of soil erosion on that terrain. The form of the equation is:

$$A = K \times Ls \times S \times C \times Cs,$$

where:

A – quantity of the soil loss in t/ha/year,
K – rainfall-runoff erodibility factor,
Ls – slope length and steepness factor,
S – soil erodibility factor,
C – land-use factor, and

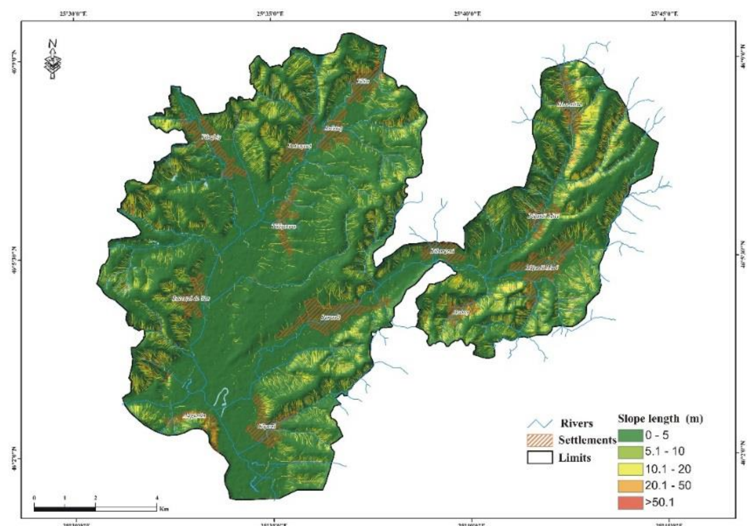
Cs – correction factor.

To elaborate the soil loss model for the Baraolt Depression using G.I.S. technics, we followed the model used before by Moore I. D., Wilson J. P. (1992), Mitasova H. et al. (1998), Mitasova H., Mitas L. (1999), Patriche C. V. et al. (2006), and Filip S. (2008) [11, 9, 10, 14, 7]. Accordingly, we needed a database for each factor of the equation.

Regarding the K factor, there are studies to calculate its value using the rainfall quantities or annual average values or monthly high values. The value of the factor can be precisely calculated just experimentally, on specially arranged parcels and applied to extended areas which are homogeneous from a climatic point of view.

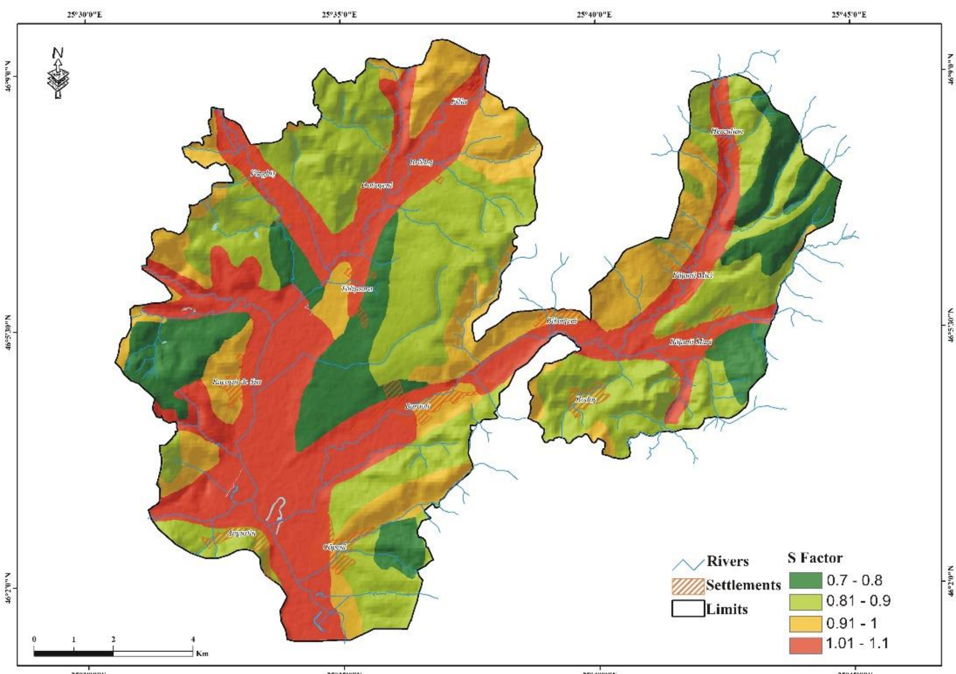
For Romania, the values were calculated by Moţoc M. et al. (1975) [12], who extended from 33 MJ mm/ha/h/year for the Western Plains to 102 MJ mm/ha/h/year for The Southern Carpathians and The Curvature Carpathians. We used the latter value in the equation.

Slope length and steepness factor *Ls* was produced by elaborating the slope map of the Baraolt Depression using ESRI ARCINFO platform. First, we created the slope steepness map using a resolution of 5 m. It was impossible to make a better resolution as we used a 1:25,000 scale map as topographic database. According to this, we started to make a classification of the steepness and of the length of the slopes [4]. The best classification that reflects also the reality on the field was: 0–1.99°, 2–5.99°, 6–9.99°, 10–14.99°, 15–24.99°, and over 25° for steepness, while for slope length: under 5 m, 5.1–10 m, 10.1–20 m, 20.1–50 m, and over 50 m. We applied these classifications to the slope maps and made the soil loss susceptibility map according to the slope steepness and length (*Map no. 1*).



Map 1. Susceptibility to soil loss according to the slope length and steepness factors

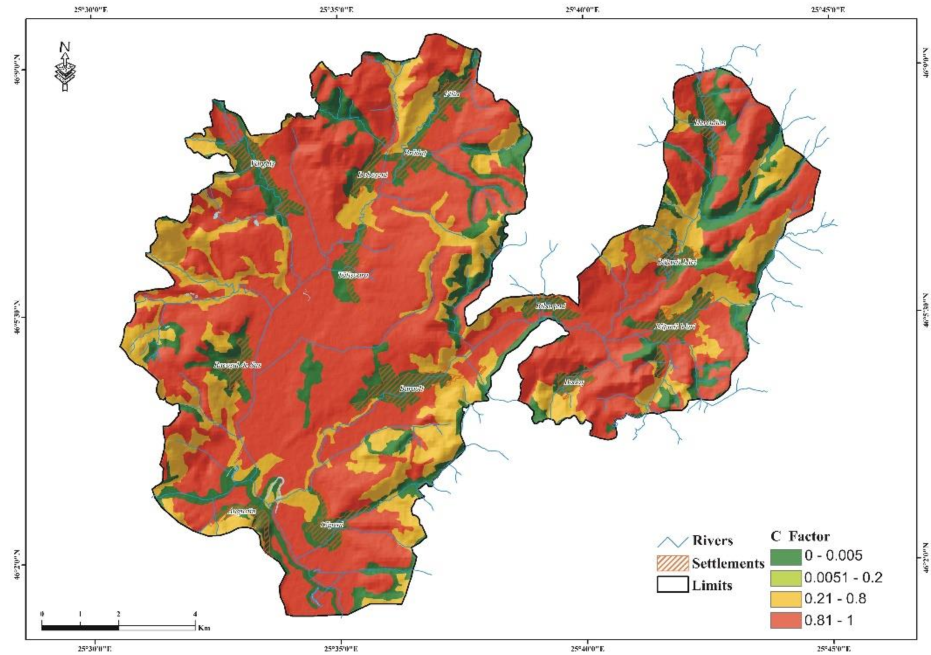
Soil erodibility factor *S* represents the tolerance of the soil or of the rock to rainfall or to wash-off done by the water run-off down the slope. The estimation of its value was based on *Indicator 186* used in *Soil study methodology* published by the Romanian Soil and Agrochemical Institute (ICPA) in 1987. To be able to use the values, we made the soil map of the Depression using the studies made by the Soil and Agrochemical Office Braşov. Using the Romanian System of Soil Taxonomy, we have seven soil classes (protisoil, cernisoil, luvisoil, cambisoil, andisoil, hidrisoil, antrisoil) and 16 soil types [4]. Taking into account all of these, we determined four erodability ranges: 0.7–0.8, 0.81–0.9, 0.91–1, and 1.01–1.1. The aluvosoils and technosoils have the highest coefficient, 1.01–1.1, from the meadows of the rivulets and of the River Olt and in the open pits. The lowest coefficient is for the faeoziom from the fluvial-lake terrace. The other soil types could be included in the range from 0.81 to 1 (*Map no. 2*).



Map 2. Susceptibility to soil loss according to the soil erodibility factor

Land-use factor *C* is a correction factor, calculated as a relation between soil erosion from a surface with certain vegetation and one without vegetation [4]. In the studied area, the values from 0 to 1 were grouped as (*Map no. 3*): areas with values between 0 and 0.005 – forest areas, hydrophilic vegetation from the meadow of the

River Olt and of the rivulets; areas with values between 0.005 and 0.2 – have a very small extent; areas with values between 0.2 and 0.8 – especially the hay lands; areas with values between 0.8 and 1 for grazing land and plough land.



Map 3. Susceptibility to soil loss according to land-use factor

Support practice factor *P* reflects the impact of support practices. As there is no integrated soil loss management in the area and considering that land-use factor includes the necessary data, we did not introduce it in the equation.

Using the G.I.S. platform Esri ArcGis, we made grids for each factor – as the above maps can illustrate –, superposed them, and used the equation.

3. Results and discussions

The values of the soil loss in the Baraolt Depression are between 0 and 2 t/ha/year.

The G.I.S. platform used allowed us to make a quantitative analysis of this soil loss model (*Map no. 4*) and offered valuable information about the phenomenon, usable in possible soil loss management works.

In the whole Depression, having a total surface of 144.4 km^2, the areas with a soil loss between 0 and 0.1 t/ha/year dominate with 87.5 km^2, which are 60.74%

from it (*fig. 1*). Here we can mention the meadows of the River Olt and of the other rivulets, the forested front of the volcanic plateau, the flat or slightly bulging heights, and the valley-free portions of the fluvial-lake terrace. This big proportion of areas with little soil loss is also due to the great weight of short slopes – less than 5 m (*Map 4*).

The second category is that of the areas with a soil loss between 0.1 and 0.5t/ha/year. It covers a total surface of 35.82 km^2, representing almost a quarter (24.87%) from the total area of the Depression. This category of land is spread in spots all over the surface of the Depression on low steep slopes used as hay lands and orchards.

The third category is that of the areas with a soil loss of 0.5 to 1 t/ha/year, covering a total surface of 12.16 km^2, amounting to 8% of the total area of the Depression. These areas have also spotted array.

The rates of soil loss between 1 and 1.5 t/ha/year and between 1.5 and 2 t/ha/year amount to 4.61 km^2 and 1.79km^2 (3.2% and 1.24%) respectively from the total surface of the Depression.

These areas are spread on the front of the fluvial-lake terrace, on the deforested slopes of the volcanic plateau and on the slopes of the following hills: Hotarului (620.7 m), Doboşeni Nord (641.6 m), Vârghiş Vest (751.3 m), Boldi (676 m), Vârful cu Păr (627 m), Pustnicului (566.9 m), Cinodului (641 m), Scândurii (641.6 m), Mestecănişul Mic (626.3 m), and Gaura Mică (623 m).

The highest rates of soil loss of over 2 t/ha/year cover just 2.14 km^2, namely 1.5%. These areas can be found on the upper part of the slopes of the hills previously mentioned, on the western, deforested front of the volcanic plateau near Herculian (plough and hay lands), the off-spring areas of some small creeks, and on the surfaces of the open pits.

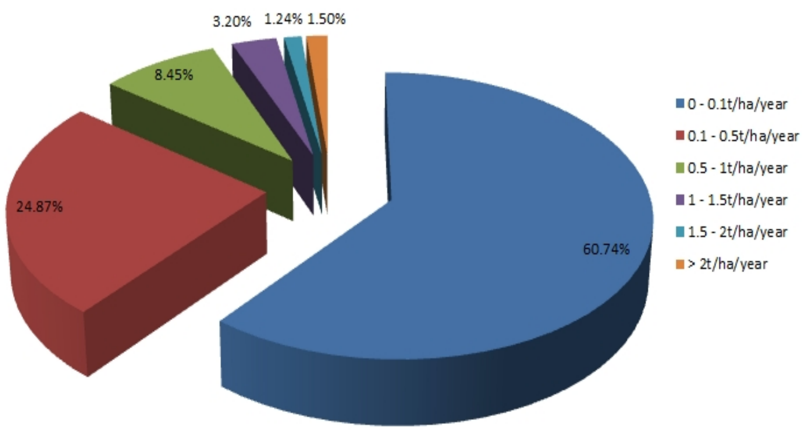
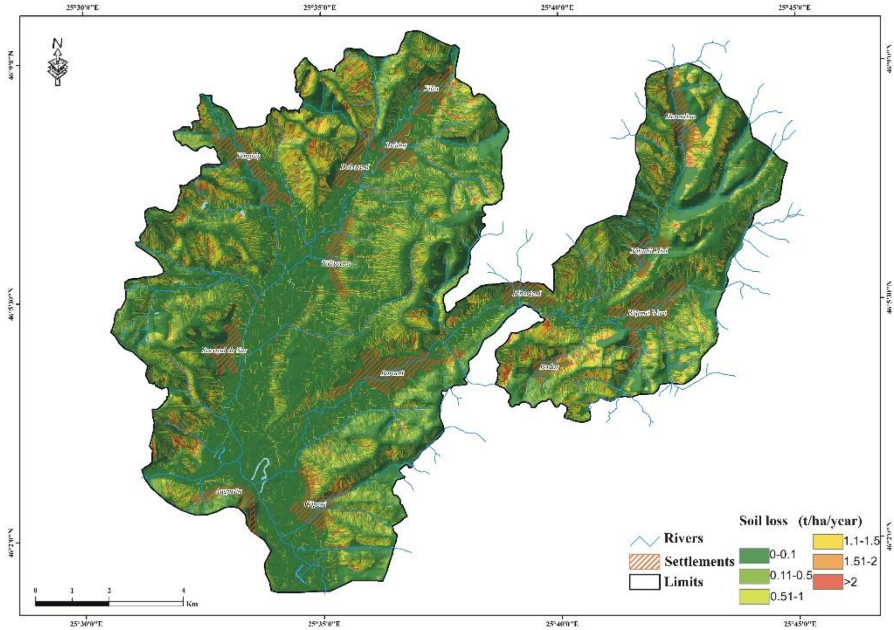


Figure 1. Areal distribution of the soil loss



Map 4. Soil loss map for the Baraolt Depression

4. Conclusions

The main factors to influence the quantity of soil loss in the Baraolt Depression are: 1. the land use (and we can notice the small values on forested areas and the values over 2 t/ha/year on the open pits); 2. the length and steepness of the slopes – small values on the meadows, on the terrace, and on the volcanic plateau and high values on the upper part of the slopes of the hills and on the front of the volcanic plateau, all of them with also high values of steepness.

References

[1] Anghel, T., Bilasco, St. (2008), The Motru Mining Basin – Gis application on sheet erosion. *Geographia Napocensis* 2(1), 90–108.

[2] Bilasco, St., Horváth, Cs., Cocean, P., Sorocovschi, V., Oncu, M. (2009), Implementation of the USLE model using GIS techniques. Case study the Someșan Plateau. *Carpathian Journal of Earth and Environmental Sciences*, 123–132.

[3] Browning, G. M., Parish, C. L., Glass, J. (1947), A method for determining the use and limitations of rotation and conservation practices in the control of soil erosion. *Iowa. J. Am. Soc. Agron.* 39(1), 65–73.

[4] Csiszér, L. (2015), *Depresiunea Baraoltului – studiu integrat de geografie fizică*. Editura Presa Universitară Clujeană, Cluj-Napoca.
[5] Csiszér, L., Petrea, D. (2012), The reflection of the geological factors within the morphology of the Baraolt Depression. *Revista de geomorfologie* 14, 57–66. Editura Universităţii din Bucureşti, Bucharest.
[6] Desmet, P. J. J., Govers, G. (1996), A GIS procedure for automatically calculating the USLE LS factor on topographically complex landscape units. *Journal of Soil and Water Cons.* 51, 427–433.
[7] Filip, S. (2008), *Depresiunea şi Munceii Băii Mari. Studiu de geomorfologie environmentală*. Editura Presa Universitară Clujeană, Cluj-Napoca.
[8] Lloyd, C. H., Eley, G. W. (1952), Graphical solution of probable soilloss formula for Northeastern Region. *J. Soil Water Conserv*. 7, 189–191.
[9] Mitasova, H., Hofierka, J., Zlocha, M., Iverson, L. R. (1996), Modeling topographic potential for erosion and deposition using GIS. *Int. Journal of Geographical Information Science* 10(5), 629–641.
[10] Mitasova, H., Mitas, L., Brown, W. M., Johnston, D. 1998. Multidimensional soil erosion/ deposition modeling and visualization using GIS. Final report for USA CERL. University of Illinois, Urbana-Champaign. Online tutorial.
[11] Moore, I. D., Wilson, J. P., 1992. Length-slope factors for the Revised Universal Soil Loss Equation: simplified method of estimation. Journal of Soil and Water Conservation 47, 423–428.
[12] Moţoc, M., Munteanu, S., Băloiu, V., Stănescu, P., Mihai, Gh. (1975), *Eroziunea solului și metode de combatere*. Editura Ceres, Bucharest.
[13] Moţoc, M., Sevastel, M., (2002), *Evaluarea factorilor care determină riscul eroziunii hidrice în suprafaţă*. Editura Bren, Bucharest.
[14] Patriche, C. V., Căpăţână, V., Stoica, D. L. (2006), Aspects regarding soil erosion spatial modeling using the USLE/RUSLE within GIS. *Geographia Technica* 2. Cluj-Napoca.
[15] Renard, K. G., Foster, G. R., Weesies, G. A., McCool, D. K., Yoder, D. C. (1997), Predicting soil erosion by water – A guide to conservation planning with the revised universal soil loss equation (RUSLE). *U.S. Dept. of Agric., Agr. Handbook No 703*. University of Illinois, Urbana-Champaign, p. 24.
[16] Wischemeier, W. H., Smith, D. D. (1965), Predicting rainfall-erosion losses from cropland east of the Rocky Mountains. Guide for selection practices for soil land water conservations. US Department of Agriculture in cooperation with Purdue Agricultural Experiment Station. *Agriculture Handbook* 282, 47.
[17] Zingg, A. V. (1940), Degree and length of land slope as it affects soil loss in runoff. *Agr. Ing.* 21.
[18] * * * (2006), RUSLE online. 2006. http://www.iwr.msu.edu/rusle.
[19] https://books.google.ro/books?id=l5MHCAAAQBAJ&pg=PA196&lpg=PA196&dq=Eurosem+1992&source=bl&ots=GKM9BbyZK9&sig=IQzgBnf5rJJiBopiEVWEl_9sJCo&hl=hu&sa=X&ved=0ahUKEwj_kpD7_qrbAhWE_ywKHeXVBAAQ6AEIPzAC#v=onepage&q=Eurosem%201992&f=false.
[20] * * * https://www.ars.usda.gov/southeast-area/oxford-ms/national-sedimentation-laboratory/watershed-physical-processes-research/docs/revised-universal-soil-loss-equation-rusle-welcome-to-rusle-1-and-rusle-2/.
[21] * * * https://www.ars.usda.gov/southeast-area/oxford-ms/national-sedimentation-laboratory/watershed-physical-processes-research/research/rusle2/revised-universal-soil-loss-equation-2-overview-of-rusle2/.
[22] * * * http://www4.ncsu.edu/~hmitaso/gmslab/reports/cerl01/finalreport/report01/default.htm