QUANTITATIVE ESTIMATION OF SOIL EROSION IN THE DRĂGAN RIVER WATERSHED WITH THE U.S.L.E. TYPE ROMSEM MODEL

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***ABSTRACT.-* Quantitative estimation of soil erosion in the Drăgan river watershed with the U.S.L.E. type Romsem model**
Sediment delivered from water erosion causes substantial waterway damages and water quality degradation. A number of factors such as drainage area size, basin slope, climate, land use/land cover may affect sediment delivery processes. The goal of this study is to define a computationally effective suitable soil erosion model in the Drăgan river watershed, for future sedimentation studies. Geographic Information System (GIS) is used to determine the Universal Soil Loss Equation Model (U.S.L.E.) values of the studied water basin. The methods and approaches used in this study are expected to be applicable in future research and to watersheds in other regions.

1. General problems

There is increasing interest in improving water resource development, watershed management, land use and land productivity. Problems caused by soil erosion and sediments include losses of soil productivity, water quality degradation, and less capacity to prevent natural disasters such as floods. Also sediments may carry pollutants into water systems and cause significant water quality problems. Sediment deposition in streams reduces channel capacity and could result in flooding damages. The water storage capacity of reservoirs can be calculated by accumulated sediment deposition.

Sediment yield is a critical factor in identifying non-point source pollution as well as in the design of the construction such as dams and reservoirs.

However, sediment yield is usually not available as a direct measurement but estimated by using a sediment delivery ratio. An accurate prediction of sediment delivery ratio is important in controlling sediments for sustainable natural resource development and environmental protection. The rate in which sediments are moved can be affected by a number of factors including sediment source, texture, nearness to the main stream, channel density, basin area, slope, length, land use/land cover, and rainfall-runoff factors.

2. Study area and geographic methods

With a 40 km longitude and 5,556 m^3/s average annual runoff the Drăgan River is the biggest from the Crişul Repede river upper basin. It spawns at 1500 m altitude under the Piatra Bohodeiului Peak, with a 26 m/km fall witch explains the high hydro energetic potential. We peaked for our study this basin because of the Floroiu reservoir behind the Drăgan Dam which was formed here in year 1985. Although the Universal Soil Loss Equation (USLE) doesn't deliver sedimentation in future analysis we will use its elements and factors for other sedimentation models.

The Universal Soil Loss Equation (USLE) predicts the long term average annual rate of erosion on a field slope, based on rainfall pattern, soil type, topography, crop system and management practices. USLE only predicts the amount of soil loss that results from sheet or rill erosion on a single slope and does not account for additional soil losses that might occur from gully, wind or tillage erosion.

In Romania the equation adopted for USLE was changed several times for calibrating its features to the pedo-climatic condition and characteristics of our country. The last most accepted form of USLE was developed by *Moţoc et al.* (1999), they propose the same methodology but with some changes. The model should be named ROMSEM (Romanian Soil Erosion Model) and the equation should be changed to:

$$E_S = K \cdot L^m \cdot i^n \cdot S \cdot C \cdot C_S$$

Where:

E_S: is the average annual surface erosion rate in tons/ha
K: correction coefficient for climatic (rain) aggresivity
L^m: slope length influence
i^n: slope steepness influence
S: correction coefficient for soil erodability
C: correction coefficient for cover-management factor and vegetation characteristics

C_S: correction coefficient for the effect of erosion control measurements.

To deliver the average annual surface erosion rate we used the ESRI/GIS software suite which makes possible the overlaying of different spatial characteristic layers to modelate a phenomenon in space.

- K: correction coefficient for climatic (rain) aggressivity which represents the rainfall erosivity index. Although in the original USLE form this represented the annual sum of the products between the energy of the erosive rainfalls (E) and their maximum 30 minutes intensities (I_{30}), due to the difficulty of direct calculation of rainfall erosivity, as the rainfalls intensity is not currently recorded at the meteorological stations, indirect estimative models were elaborated on the basis of statistical relations between the erosivity and other parameters. In our case, the values for this coefficient were taken from the INMH (National Hydrological and Meteorological Service) hydrological regionalization. $K_{Drăgan}$= 0.130

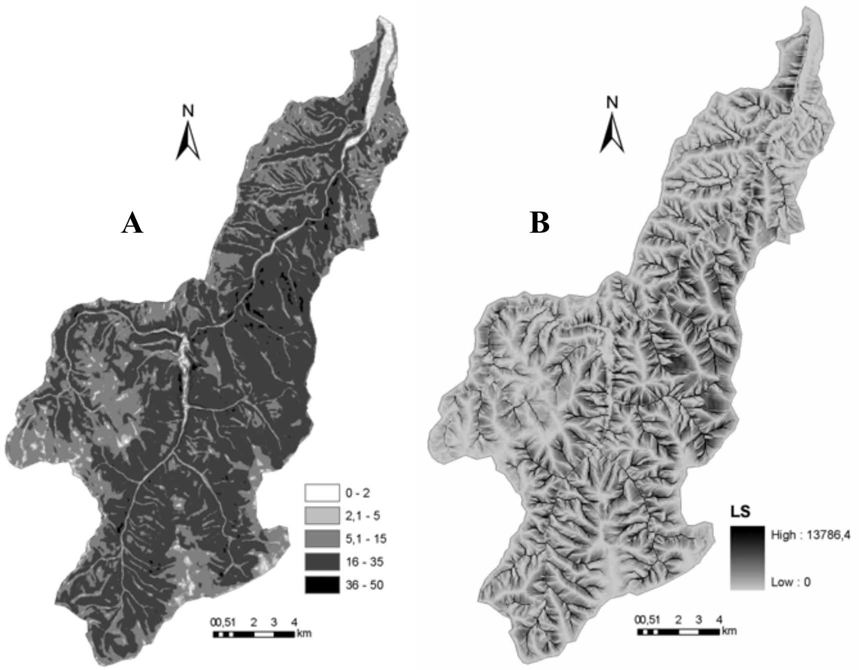

Fig 1. Slope (a) and topographic factor (b) map

- Ls: slope length factor (L^m) and slope degree (steepness) factors (i^n) are typically combined together and defined as the topographic factor which is a function of both the slope and length of the land. The longer the slope length the greater the amount of cumulative runoff. Also the steeper the slope of the land the higher the velocities of the runoff which contribute to erosion. We analyze them together because they are booth delivered form the digital elevation model (DEM). (Fig. 1)

- S: the correction coefficient for soil erodability represents the soil or rock resistance to rain and the micro currents generated by the meteorically water flow. The present study uses the erodability values as specified by the I.C.P.A. standards (1987). The values were obtained from these tables, but in order to produce a coverage of S-factors, the soils map for the Drăgan River Watershed was clipped from the soil map for the entire basin of the Crişul Repede River (originated from 1:200.000 national soil map). Then the layer table was filed with the erodability values tables of the soils coverage. The clipped version was then converted to a grid with the same extent as the watershed and grid cells equal in size as the DEM. (Fig. 2)

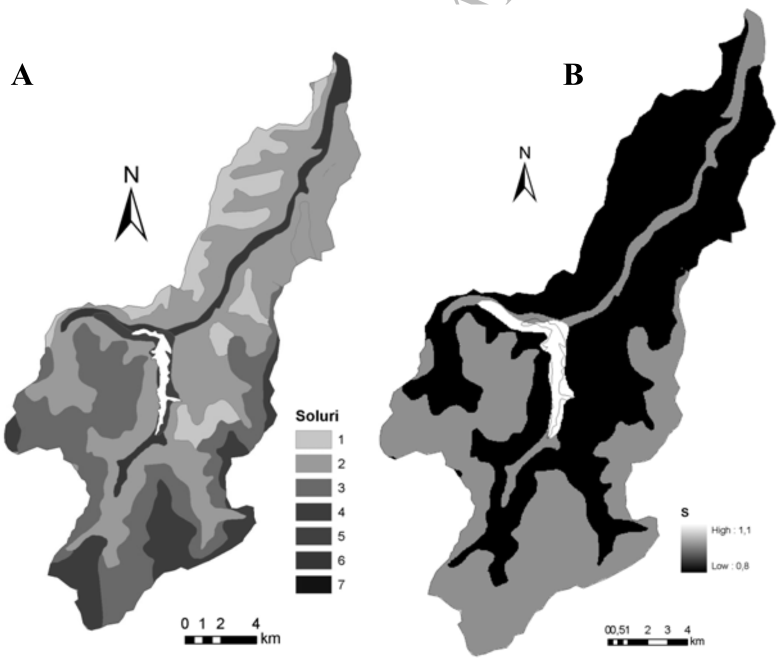

Fig. 2 Soil (a) and soil erodability coefficient (b) map.
(a: 1- districambosols, 2-andisols, 3-luvosols, 4-podzols, 5-gleisols, 6-aluviosols, 7-stagnosols)

- C: correction coefficient for cover-management factor and vegetation characteristics, it is defined as the ratio of soil loss from land with a specific vegetation to the corresponding soil loss from continuous fallow. Its values depend on vegetation cover and management practices. Also, the growth stage and cover at the time when most erosive rain occurs. Expresses the influence of vegetation upon soil erosion, and displays values between 0,005 in the forested areas and 1,2 for the uncovered soils. These values can be taken over from the standards elaborated by *Motoc et al.* (1975) which were evaluated by runoff study patches which had different vegetation overlay characteristics, or can be derived from satellite imagery, through calculation relations, depending on the normalized difference vegetation index (NDVI). In this study the delimitation of the study patches were made with the help of GIS, bibliography, 1:25.000 topographic maps and the Corine (1992, 2000) data base (Fig. 3).

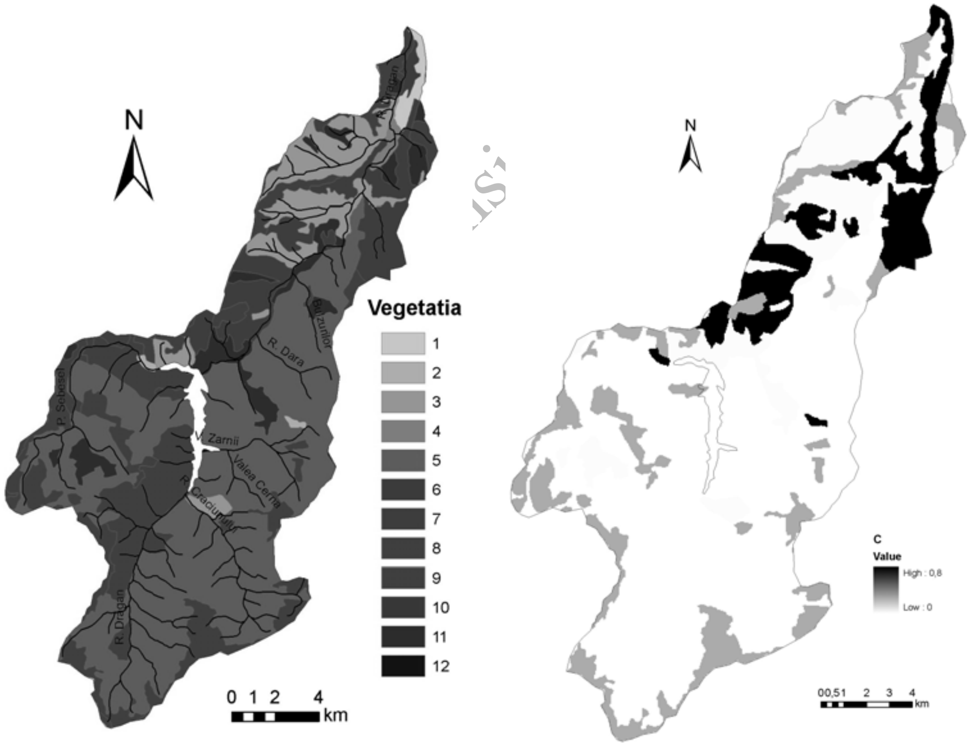

Fig. 3 Vegetation (a) and cover-management factor (b) map
(a:1-annual crops, 2-bare rock, 3- broad-leaved forest, 4-complex cultivation patterns, 5-coniferous forests, 6-discontinuous urban fabric, 7-agricultural and natural vegetation, 8-mixed forest, 9-natural grassland, 10-pastures, 11-shrub, 12-water bodies)

- C_S: correction coefficient for the effect of erosion control measurements. This is the conservation practice factor. Values are obtained from field experience regarding soil conservation practices tables, where the ratio of soil loss where contouring and contour strip-cropping are practiced to that where they are not. With no conservation measures, the value of P is 1.0.

3. Conclusions

After computing de several layers, we have calculated according to the ROMSEM formula the erosion for the watershed. With help of the ESRI/GIS software group we have delivered an erosion map in t/ha. The formula was used to predict soil erosion in the Drăgan River Watershed.

As seen from the derived erosion map, most areas have minor soil erosion which is less than 1 tons/ha/yr. The areas of highest erosion occurred in the places where the slopes are the greatest which is directly moderated by the topographic factor, and also the places located near the water edge, where the reason is probably explained by the sediment travel time, before entering the lake, because in these places is minimum compared to other places.

Other areas with high erosion are linked to the C factor, the cover-management, so areas with bear rock surfaces appear with the highest erosion. Both areas in the Drăgan Lake basin with erosion over 3 t/ha are linked to areas, where bare rock and the topographic optimizes the erosion, the other areas rarely reach this value and they are also explained by the cover-management.

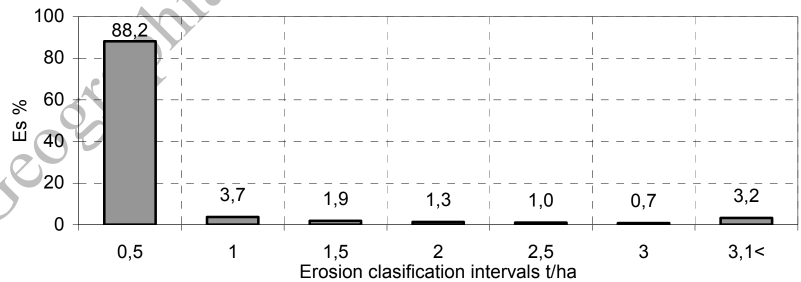

Fig. 4 Erosion is under the "tolerable soil loss"

In the downstream of the river, downwards the lake, there are several zones with high erosion and they are explained also by the C factor, being areas principally occupied by agriculture. We have to say also that foremost, the estimated erosion values are mostly below the usual "tolerable soil loss" of 2-3 tons/ha/yr. (90% of the area is under 1 tons/ha/yr) (Fig. 4) in the whole basin, but this is jut because the upper basin is minimally influenced by the antropic (Fig.5).

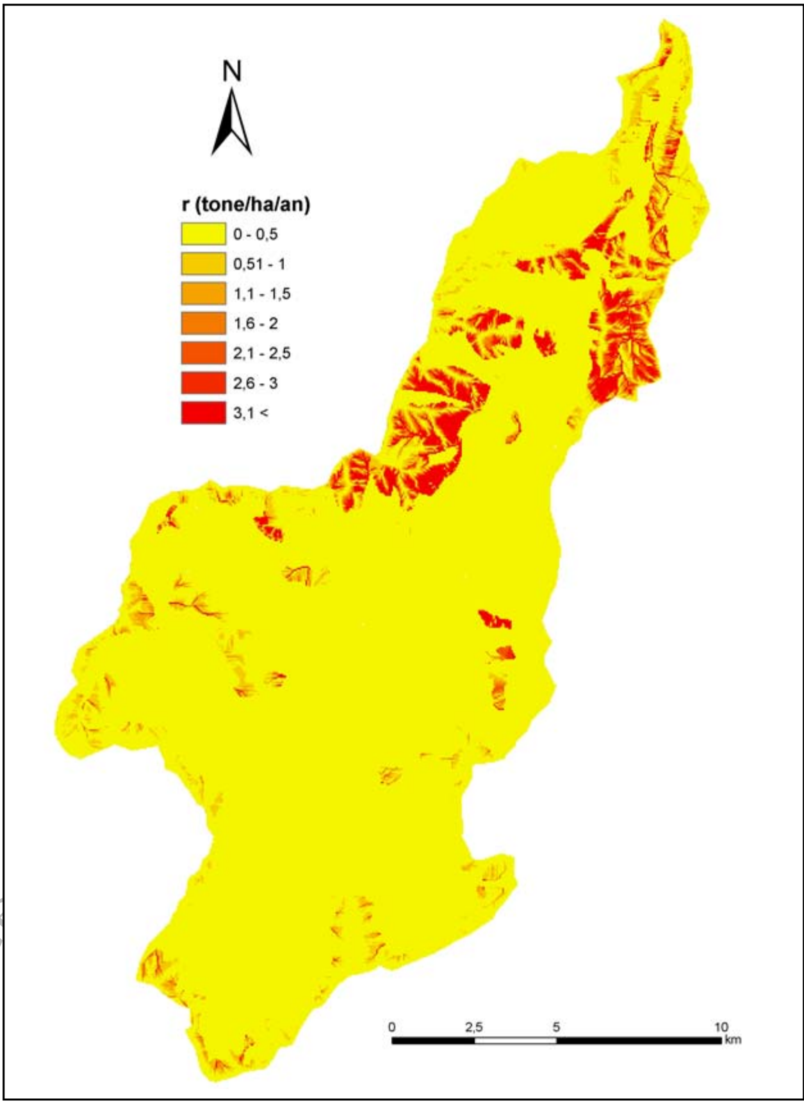

Fig. 5 Erosion Map of the Drăgan River Watershed

We can conclude in this part of the study that errors in this estimation can occur, because the USLE is an empirical equation that does not mathematically represent the physical processes of soil erosion. The equation predicts the amount of erosion but due to deposition the actual amount of sediment reaching a given point may be less.

Another problem is that many of the values used to calculate erosion are assumed or estimated. The use of the USLE may not be a good predictive model for erosion in this study area because the extreme slopes throughout the watershed do not correlate well with the USLE model, which was originally developed for mild slopes in agricultural areas. In particular, the LS values could be over weighted in this analysis.

We must say that the absolute values of the estimation are not helpful. However, the relative results from different years may still be useful to predict the trend of soil erosion and the future development of sedimentation.

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