MIDDLE PRUT PLAIN'S EROSION SUSCEPTIBILITY EVALUATION

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ABSTRACT:

The given article is dedicated to Middle Prut Plain's erosion susceptibility evaluation using factorial analysis and methodology of principal component analysis implemented by Geographical Informational System GRASS. Susceptibility evaluation is executed in a qualitative mode, and the results have preliminary character, for further quantitative and more precise study. This type of natural hazards analysis offers information on probable localization and severity of erosion phenomena, as well as their manifestation probability in a given place.

1. Introduction

The purpose of this work is to tackle the soil's erosion issue in qualitative mode in order to develop a methodology that would allow the identification of the zones sensible to erosion as well as to apply the given methodology for evaluation of soil's erosion danger on Republic of Moldova's territory.

There are many models for erosional accumulative processes modeling. The most known is USLE model (Universal Soil Loss Equation) developed by Wischmeier & Smith (1978) and re-visited by Renard and others (1991), which resulted in RUSLE model (Revised Universal Soil Loss Equation), with reference to sheet and rill erosion on agricultural terrains on the basis of *in situ* measurements. The application of these equations requires a complicated and costly methodology, which includes field samples drawing, chemical analysis etc. The same methodology offers precise results with soils losses quantification at localized areas, as agricultural lots are.

Our approach is aiming to implement a methodology based on erosion's indicators, using GIS (Geographical Informational Systems), spatial analysis of erosion hazard. The quantity of eroded matter does not interest us, but spatial distribution of the territories susceptible to erosion (as natural hazard) does.

Natural hazards evaluation offers data about probable localization and severity of dangerous natural phenomena, as well as their manifestation probability in a certain period of time and certain place. (Goțiu, Surdeanu, 2007).

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2. Data sources

The evaluation of water erosion hazard on a big territory calls upon choosing an adequate approach (model type) and relevant parameters. The approach used in the given study is based on multifactor classification. The method was applied previously in France (Le Bissonnais and others, 2002). Erosional processes are the consequences of the various factors and agents interaction, that's why erosional processes' modeling is difficult, because of the complexity of the interactions between them. The principal factors are considered to be: terrain's cover, soil, relief and climate.

The following data were used:

1. Database of landcover/landuse of terrains in digital format at the scale of 1:50.000 for the whole Republic of Moldova's territory (Mitrofan, 2003);

2. Soils map at scale of 1:200.000 – digitized in Landscape Ecology Laboratory, Institute of Ecology and Geography of AS of RM;

3. SRTM derived (Shuttle Radar Topography Mission) Digital Elevation Model;

4. Data on maximum values of atmospheric precipitations (according to State Hydrometeorological Service), on the basis of which the map of maximum values of atmospheric precipitations values distribution was realized.

The model has a structure similar to the European SERAE/MESALE (figure 1).

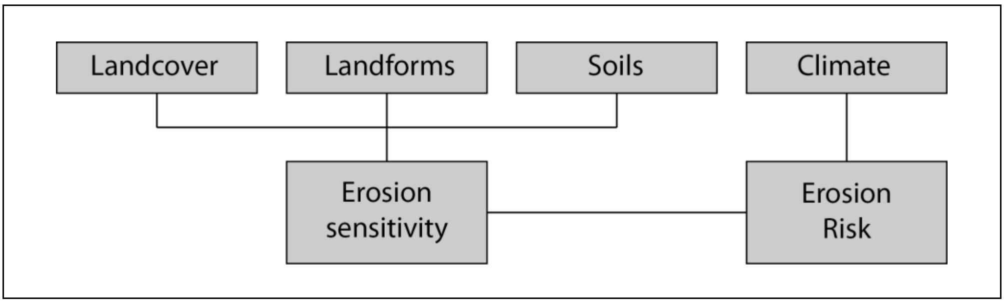

Fig. 1. Model's conceptual scheme.

Land use / land cover represents an important factor for erosional processes study, as it is known that it conditions the soil's protection degree, especially according to vegetation cover type by its rate of recovery.

Database of land use / land cover at 1:50.000 scale for the whole Republic of Moldova's territory was realized by Landsat satellite images interpretation (acquisition year - 2004). Initial classification of occupation categories was executed within FAO's Land Cover Classification System (LCCS). Data is presented in ESRI shapefile format. For data integration in the given study, initial categories were reclassified into 7 classes, listed by order of increase of susceptibility to erosion:

1. Water bodies and humid zones;
2. Forests – presenting a reduced sensitivity to erosion, lesser on steep slopes;
3. Constructed areas.
4. Lawns – that protect terrain and contribute to infiltration;
5. Terrains occupied by multiyear cultures, including vineyards and gardens, which represent a situation similar to the first category, only slightly more favorable;
6. Arable lands, that remain uncovered in certain periods and are therefore predisposed to erosion;
7. Terrains uncovered by vegetation.

Relief is the biggest information source about erosion. Using the Digital Elevation Model is essential in order to determine parameters important for erosion, and its slope seems to be the most valuable parameter (Dumas, 2004).

Digital Elevation Model derived from SRTM data with resolution of 90 m covering the whole Republic of Moldova's territory was resembled to 100 m resolution in order to correspond to the other used data layers. On the DEM basis we have generated Slope map and Vertical Distance to Channel Network map (Cimmery, 2007-2010).

Slope map was reclassified into 5 classes, the intervals being defined (according to usage) as it follows: 0-2%, 2-5%, 5-10%, 10-15%, >15%, susceptibility growing together with slope's inclination angle growth.

Vertical Distance to Channel Network was generated using specialized tool from SAGA GIS software. Vertical Distance to Channel Network is a form of determining and presentation of relief's fragmentation depth. The given VDCN map has been thus reclassified: 0-25 m, 25-50 m, 50-75 m, 75-100 m, 100-125 m, 125-150 m, 150-175 m, susceptibility to erosion increasing from inferior heights to superior ones.

Soil is a major factor for erosion development, seeing as soil particles washing-off depends directly from soil's properties. I have used Republic of Moldova's Soils Map at the 1:200.000 scale, digitized in Landscape Ecology Laboratory, Institute of Ecology and Geography. On its basis there was realized the informational layer of soil's texture, identifying the following classes: 1 – rivers flood plains and constructed areas, 2 – loamy-sandy soils, sandy and sandy-loamy ones, 3 – medium loamy soils, 4 – loamy clayey soils, 5 – clayey soils and 6 – degraded terrains including landslides, susceptibility to erosion is increasing from 1 to 6th class.

Precipitations represent the principal erosional factors and their erosional effect is connected to their quantity and intensity. We had taken into consideration precipitations intensity, realizing the map of (monthly) maximum atmospheric precipitations values (Kriging interpolation method), classified in 6 classes (big precipitations values determine their maximum erosion).

3. Method

The Principal Component Analysis (PCA) is a technique of multi-variable statistical analysis in which a number of correlated variables is transformed into a set of uncorrelated variables. The Principal Component Analysis method was proposed by K. Pearson in 1901, and was developed into the form which is known today by H. Hotelling, whose work appeared in 1933. The studies in this field were seized a certain period until appeared the computers that allowed applying this technique into concise problems tackling (Jackson, 1991).

The stages of Principal Component Analysis are:

1. Identification of „aberrant” observations (individuals with extreme values, that affect average values; non-responses);
2. Centering and reducing of initial observations – necessary due to measurement units homogeneity;
3. Correlation matrix calculation between initial variables;
4. Linear combinations calculation – the result being a table with variants of each Principal Component Analysis and determination degree for each;
5. Principal Component Selecting.

Principal Component Analysis was realized using tool from GRASS GIS software (GRASS, 2008). Input data was: Vertical Distance to Channel Network, land cover/land use, daily maximum precipitations, slope, and soil’s texture.

4. Results

Analysis were applied to the whole Republic of Moldova’s territory and for Prutul de Mijloc Plain only, obtaining values given in tab. 1 and tab. 2.

Table 1. PCA results for the whole Republic of Moldova’s territory.

Proper values	Proper vectors					Variation percentage
PC1	-0,0719	-0,6532	-0,5205	-0,2244	-0,4969	**73,33%**
PC2	0,1105	-0,6188	0,4068	0,6587	0,0739	**10,45%**
PC3	-0,0212	0,2668	0,4480	0,0729	-0,8499	**9,52%**
PC4	0,0539	0,3452	-0,6010	0,7031	-0,1495	**4,67%**
PC5	0,9896	0,0085	-0,0409	-0,1266	-0,0544	**2,04%**

S=73.33*PC1+10.45*PC2+9.52*PC3+4.67*PC4+2.04*PC5 (1)

Table 2. PCA results for Middle Prut Plain.

Proper values	Proper vectors					Variation percentage
PC1	-0,0584	-0,5945	-0,5728	-0,2333	-0,5105	**85,77%**
PC2	0,0471	-0,3879	-0,3813	0,0901	0,8330	**6,13%**
PC3	0,0334	-0,6632	0,5814	0,4605	-0,0944	**4,86%**
PC4	0,0586	0,2371	-0,4340	0,8476	-0,1832	**2,46%**
PC5	-0,9949	0,0082	0,0095	0,0833	0,0555	**0,78%**

S=85.77*PC1+6.13*PC2+4.86*PC3+2.46*PC4+0.78*PC5 (2)

Using Raster Map Calculator, above-mentioned formula 2 was applied, and the resulting raster has been reclassified into five equal classes (fig. 2).

From results of analysis we can observe a bigger ratio of very high and high susceptibility classes in hydrographic basins from plain's South-East, such basins as Garla Mare, Soltoaia, Sovetul Mic and Caldarusa, where classes with high and very high susceptibility occupy more than 6 % of their territory.

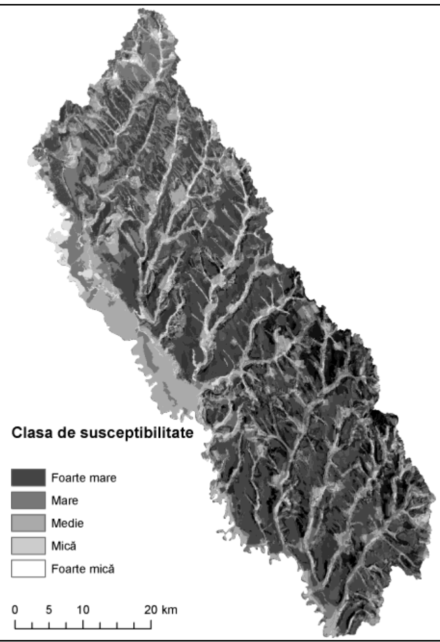

Fig. 2. Susceptibility to erosion of Middle Prut Plain.

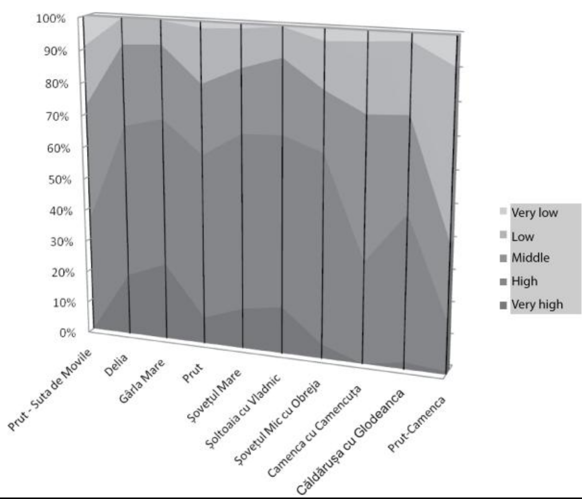

Fig. 3. Erosion susceptibility classes overlaying on hydrographical sub-basins.

Classes of medium and small susceptibility have a relatively big presence in the basins of Caldarusa and Camenca, including Camenca-Prut sector.

On the level of the whole plain's territory, areas with bigger susceptibility have the biggest ratio – 44.3%, being followed by those with medium and small susceptibility, which occupy respectively 26.4% and 17.2% from the total surface.

5. Conclusions

Presented methodology allows creating maps of erosion susceptibility of territory, thus allowing comparing the regions. At the same time, correct selection of factors used in analysis is also of great importance. The work may be improved if taken into account 1) more precise factors selection 2) more precise input data usage.

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