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The Stavnic Catchment. Geomorphological study

PhD Thesis

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Abstract

The Stavnic catchment is located in the central part of the Central Moldavian Plateau and occupies 21,341 ha (6% of the total area). Northwards, it is confined by Coasta Iaşilor. Eastwards, it is bounded by the Rebricea catchment and westwards by the Şacovăţ catchment. The Stavnic River springs from Grindeiului Hill, downstream of Pădureni village, Iaşi County and it merges the Bârlad River south of Parpaniţa village. It crosses over the territory of Mădârjac, Horleşti, Voineşti, Mogoşeşti, Mironeasa, Şcheia, Ipatele, Grajduri (Iaşi County) and Rebricea, Negreşti, Vultureşti villages (Vaslui County).

Field geomorphological observations and mapping were combined with the cartographic materials obtained by using the TNT Mips 6.9 software. The first result of the application of this program was the achievement of the Digital Elevation Model or Land Numerical Model (MNT), obtained by digitizing and vectorization of the topographical maps at the scale 1:5000. Based on this, a series of thematic maps have been released (slope map, shape map, shading map) and they were classified through SML language.

The geomorphological map and the maps showing gully and landslides distribution were made by correlation of the field observations, geomorphological mapping and analysis of the orthophotoplans, edition 2009.

The intensity of soil erosion on agricultural land map was obtained by digital processing of information from the soil surveys in scale 1: 10.000, carried out by OJSPA Iaşi and Vaslui, being partially adjusted according to our field observations and the orthophotos. Then, the value of the average annual soil losses from the Stavnic catchment was estimated to highlight more precisely the role of soil erosion in the area. This was made by applying the Universal Soil Loss Equation (USLE), model adapted by Moţoc et al. (1975, 1979) to the conditions from our country.

The study area is a typical hilly one where Miocene sedimentary layers belonging to the Middle Sarmatian (Bessarabian) and Upper Sarmatian (Chersonian) have outcropped due to erosion. In addition, the recent Quaternary formations are mentioned. The Bessarabian formations are prevailing mainly in brackish facies (clayey-marl with sandy seems) and subsequently in coastal facies (the limey-sandstone cap resistant). The Chersonian clayey-sandy layers are discontinuously extended on the higher hilltops, in the form of erosion remnants (*Jeanrenaud P., 1961, 1971, 1995*). These sedimentary formations show a gentle dipping of 7-8 m/km to SSE, typical for a general monocline structure (homocline).

The local climate is temperate-continental with shades of excessiveness due to the high values of the thermic amplitude and the irregular distribution of the rainfalls. Data recorded over the period 1961-2007 provided by the Moldova Regional Meteorological Centre shows the average amount of precipitation is 530.8 mm yr^{-1} at Vaslui, 577 mm yr^{-1} at Iaşi and 779.6 mm yr^{-1} at Bârnova. The average annual temperature varies as follows: 9.6°C at Iaşi, 9.5°C at Vaslui and 8.3°C at Bârnova.

The average altitude of the relief is 244 m, noting that the maximum altitude reaches 472 m in Dealul Teiului-Poiana Mănăstirii, on the hilltop between the Stavnic River basin and the Şacovăţ catchment. The lowest altitude of 114 m is found in the Bârladului floodplain.

The average slope of the land is 14.4%, but most of the hillslopes (81% of total) exceed 5%, which underlines the high erosion potential.

As a consequence of the general monocline structure of the substratum, the Stavnic catchment presents, generally, both a surface asymmetry and an average slope asymmetry, the first one being less pronounced than the second. In the Stavnic river basin can be noticed that

most of the land is located on the right side (of 56% of the total area) with the remaining on the left side. This differentiation is due to the second order structural asymmetry associated to the secondary dipping of the geological layers, towards east (Ioniţă I., 1998, 2000).

Based on the geological characteristics and the morphometric and morphographical analysis of the local topography three main types of relief are depicted, respectively: structural, sculptural and depositional landforms.

The structural relief is represented by the structural – lithological plateaus and by the different types of valleys developed within the monocline structure.

The structural – lithological plateaus are situated in the area of the hilltops larger which are developed on the harder rock, such as Repedea oolitic limestones and Şcheia sandstones, Bessarabian in age. These plateaus (platforms) are typical for the Central Moldavian Plateau and they have been devoted by David M. (1920, 1922, 1941) such as Şcheia, Ipatele and Zarea Domniţei-Poiana Mănăstirii plateaus.

According to the flow direction in relation to the dipping of the outcropping geological layers, the main valley types developed in a monocline structure are consequent/reconsequent and subsequent valleys. Downstream of Hadâmbu village, in the middle and lower reaches, the Stavnic Valley is a consequent one because of shifting its southward orientation. In the upper catchment, between Hadâmbu and Schitu Stavnic, the Stavnic Valley is diagonally orientated, on NW – SE direction and becomes a subsequent skew valley. Upstream of Schitul Stavnic, the Stavnic Valley is crossed orientated, on west – east direction and now it is typical subsequent.

So that, what particularly struck at the Stavnic Valley is the radical change of the direction from west-east in the upper catchment to north-south downstream of Hadâmbu and implicitly results the changing of the valley pattern. This change occurred in the upper Stavnic catchment can be explained by the faster regressive evolution of the stream system from the Voineşti catchment. This development, triggered by the lower base level in the Bahlui catchment, resulted in both the beheading of the former consequent sector in the upper Stavnic catchment and the southward withdraw of the Coasta Iaşilor. A testimony in supporting this hypothesis is the atypical asymmetry of the cross valley of the upper Stavnic, namely that the left valley-side, south looking cuesta back slope, is narrowed and weighing only 29%, while the right valley-side , northern facing cuesta front, is prevailing (71% of the total upper catchment).

The tributaries of the Stavnic River are either subsequent, generally the right tributaries (Ciurdea, Stăvnicel, Urşiţa, Brustureţ, Viscăneasca Valley), either reconsequent, usually the left tributaries, and most valleys show asymmetrical crossed profiles (Carului Valley, Găunoasa Creek, Humăria, Căzăneşti and Glodeni Valley). The scarcity of symmetric valleys is explained by Ioniţă I. (1998, 2000) through the narrow area, corresponding to the "homocline resultant" of the two systems of dipping: north - south of 6 to 7 m/km and west - east of 3 m/km.

The sculptural relief (fluvio-denudational topography) in general monocline structure is dominant in the local morphology (72% of the total) and it is represented by the hilltops and the diluvial slopes.The hilltops are either elongated or widely extended in the form of plateaus, imposed by more resistant cap rocks, such as Şcheia Hill, Ipatele Hill or Teiului Hill-Poiana Mănăstirii.

The hillslopes represent the dominant landform from the study area and they are closely related to the cuesta relief, since most of them are actually cuesta back slope or cuesta front. Northern, north - western or western facing slopes are the cuesta fronts, whereas the east, south and south - east looking slopes are cuesta back slopes.

The diversity of the cuestas from the Moldavian Plateau is explained by Ioniţă I. (1998, 2000) through the evolution of the river system in a "double system of stratigraphic

slopes". Thus, he distinguishes two types of structural asymmetries, namely: the first-order structural asymmetry, corresponding to the main dip of the geological layers, north - south, which includes all the subsequent valleys and the second order structural asymmetry, associated to the secondary dipping, west - east, comprising the majority of consequent/reconsequent valleys, which show western cuesta fronts and eastern cuesta back slopes.

Based on the geological background, the double morpho-structural asymmetry and the landforms characteristics, two distinct compartments have been separated in the study area.

1) **The northern compartment**, typically hilly, upstream of the Stavnic - Brustureţ and Urşiţa junction (up to Cioca-Boca village) includes upper and middle basin, respectively an area of 14,212 ha. The upper Stavnic Valley and of the tributaries Ciurdea and Stăvnicel are typically subsequent and they highlight the first-order structural asymmetry. In the middle catchment, the Stavnic Valley shifts its orientation from north to south and becomes consequent, emphasizing the second order structural asymmetry. The relief amplitude and the network density are more pronounced, which are in the favor of higher intensity of the land degradation. Thus, the mean value of the relief amplitude is 41 m, and the maximum reaches 163 m. Then, it was found that within 61% of this compartment, the density of relief fragmentation varies between 6-13 km km^{-2}, the prevailing class ranging from 6 to 8 km km^{-2}.

2) **The southern compartment** covers 7,129 ha and it is oriented from north to south, highlighting the consequent character of the Stavnic valley. However, the left side, initially a western facing cuesta front, was sectioned by diagonal (skew) valleys (Găunoasa, Humăria, Căzăneşti, Glodeni), NE-SW oriented. These valleys have reaches where the first order structural asymmetry alternates with the morphostructural asymmetry of the second order. Also, the size of the initial cuesta back slope of the lower Stavnic was reduced by the insertion and the regressive evolution of the reconsequent Velna valley. The mean value of the relief amplitude is 30 m and on 46% of the area the density of relief fragmentation varies between 6-13 km km^{-2}, the dominant class ranging between 4 and 6 km km^{-2}.

Depending on the type of structural asymmetry, the first order or the second order, it could be highlighted the “mirror arrangement” of the cuestas in the middle Stavnic catchment. Thus, on the right side of the Stavnic River emerge northern or north – eastern looking cuesta fronts and south, south-western facing cuesta back slopes. Instead, on the left side, western and north - western cuesta fronts are prevailing and the cuesta back slopes are eastern and south - eastern looking.

The depositional landforms are represented by floodplains, fluvial terraces and glacises. The floodplain of the Stavnic River is widely developed due to both the alluvia accumulated during the wetter periods of the Holocene and the reduced longitudinal slope.
The small area covered by fluvial terraces in the Stavnic catchment of 166 ha (0.8% of the total) is resulting from the friable substratum (mainly scarcity of gravels), high relief fragmentation and high intensity of land degradation. Ploscaru D. (1973) mentioned four levels of fluvial terraces of Bârlad Valley with the relative altitude of 100-110 m, 65-70 m, 20-25 m and of 5-8 m. Glacises are quite widespread in the Stavnic catchment, where occupies 2,111 ha, (10% of the total).

Among the present day geomorphologic processes are mentioned soil erosion, gullying, landslides and sedimentation.

By processing data from the pedological studies, carried out by O.S.P.A. Iaşi and Vaslui, it has been noticed that almost a quarter of the mapped area (8,655 ha) is depicted by unappreciated erosion and the land with moderate to excessive erosion have a share of 52%.

Based on the Moţoc M. et al. (1975, 1979) model, the average annual soil loss on the agricultural land was estimated at 22.15 t/ha/yr. From the mapped area of 8,655 ha, 3,356 ha (39%) has an average value below the annual tolerable limit of 7 t/ha/year. Greater values

were calculated for an area of 5,230 ha, respectively over 60% of the total agricultural land in the Stavnic catchment. Depending on the principal soil types, the more intensely affected by soil erosion are regosols (51 t/h/yr), anthrosols (42 t/h/yr), and phaeozems (23 t/h/yr).

Through the occupied surface, of 823 ha (4% of total), gullying seems to have a secondary role in Stavnic basin. Apparently, the rate of gullies is reduced, but the number and their density are high, which favors triggering of mass movements on large areas. Numerically, slope gullies are prevailing, which are usually discontinuous single, and rarely successive.

Landslides are the most representative geomorphologic processes that contribute to land degradation within the Stavnic catchment. They occupy an area of 12.006 ha which represents 56% of the total area. In the context of the climate aridization, occurring since summer of 1982 and so far, most of the landslides (96%) are stabilized. The larger extension of the landslides justifies the significant share of the highly degraded back slopes (22% or 4,664 ha). This value is higher with 10% than the average calculated for the Central Moldavian Plateau and is specially associated to the more accentuate fragmentation of the topography in the Stavnic catchment. Most of the active landslides are actually representing reactivation of the old ones, dating from the wetter periods of the Holocene or from the end of Pleistocene.

Another geomorphic process in the studied area is reservoir sedimentation. According to Ioniţă et al. (2000), by using the Cs-137 technique, it was calculated an average sedimentation rate of 4.5 cm/year in the Căzăneşti reservoir (in the lower Stavnic) for the period 1975-1999.

By implementation of the provisions of the Act No.18/1991, it is noticeable the coming back to the traditional agricultural system on slopes in the shape of up-and-down hill farming, So that, over last two decades, favorable conditions for the revival of the land degradation are on the screen again.

A particular attention was paid to the development of area occupied by the forest, which still holds an important surface in the Stavnic catchment of 8,304 ha. On the other hand, it is outstanding that forest is spread almost exclusively in the northern compartment, where around 70% of the landslides are located.