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SOIL COVER, LAND USE AND TERRAIN DEGRADATION RELATIONS IN THE MIDDLE AND LOWER VASLUIEȚ BASIN

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Key words: land degradation, soil cover, landslides, erosion, land use

Abstract. The present study approaches the relations between soils, land use and degradation processes in the middle and lower basin of Vasluieț. Almost all the components of the landscape make this area susceptible to degradation processes. Surface erosion affects large surfaces, although only 30% of the basin is moderately-strongly affected. The most affected areas are the degraded orchards and vineyards, where erosion rates exceed 20 t/ha/y. Pastures are on the overall characterized by an erosion rate of 9.6 t/ha/y, and arable terrains by 8.82 t/ha/y. The second process as intensity and extension is landsliding, which also finds good conditions. They cover 28% of the basin surface, with 3500 ha (11.32%) active and 4986 ha (16.13%) stabilized. The main problems are given by the use of regosols (23%), erodosols and anthrosols as arable terrains (23%). From the total surface of the basin of 30900 ha, 2000 ha of erodosols and regosols are used as arable terrains. These problems have lead to the large extension of erosion on several land use categories. Almost 35% of the arable terrains are affected by moderate to severe erosion. Degraded orchards are affected 33.6% by strong and 15% by very strong erosion. Pastures are affected in a 45% proportion by moderate erosion and 10% of them by strong and very strong erosion. In conclusion, there is a clear need for a part of the terrains from the middle and lower basin of Vasluieț to have their utilization changed, mostly from arable to pastures or even forests.

Introduction

The middle and lower Vasluieț basin is situated in the eastern part of Romania, in the Central Moldavian Plateau (fig. 1). The region is characterized by a hilly landscape, the dominant landforms being sculptural (hilltops, deluvial slopes). The outcropping sedimentary deposits are Basarabian, Chersonian and Meotian, made up of sands, clays, sandy clays, clayey sands, rarely limestone and sandstone.

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The mean annual temperatures (9.2ºC) and rainfall (532.7 mm) at Vaslui, together with the amplitudes of these elements (70.9ºC, rainfall amounts between 300 and 850 mm) reflect the excessive character of the climate.

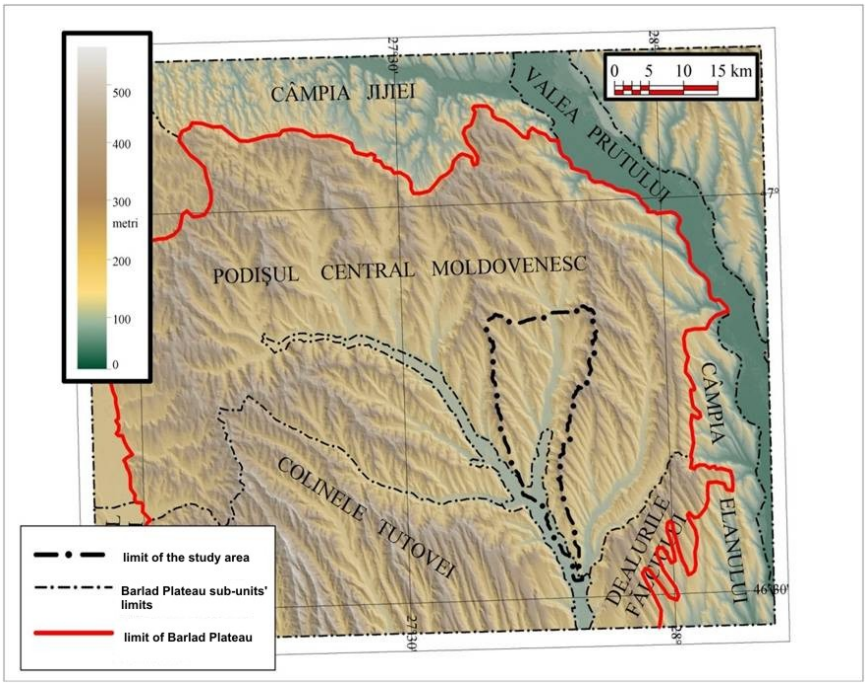

Fig. 1 - Geographical position of the study area

2. Materials and methods

The main methods used belong to Geographical Information Systems (GIS) and remote sensing. Using these methods a series of digital materials have been processed into raster and vector maps, which have been analyzed so as to reveal certain characteristics of the landscape in the area of study.

The Digital Elevation Model (DEM) has been created by processing 1:5000 topographic maps (1976-1977), and then was used to obtain several geomorphometric variables. The soil map has been obtained by processing 1:10,000 soil surveys realized by Vaslui Soil Survey Office into GIS. A series of corrections were needed to draw the final map, such as retracing polygons corresponding to localities, aquatic and forested areas or re-classifying some soil types.

The land cover maps were drawn from ortophotoplans (ANCPI, 2009). To evidence the changes that took place in the last century, have also been used maps from the Moldavian Atlas of 1893, topographical maps from 1981 and aerial images from 2009.

In order to analyze soil erosion rates and extension, we have used the formula proposed by Moțoc et al. (1975), adapted version of USLE. Details about the factors used and the results obtained are found in Roşca et al. (2012). The study focused mainly on two erosion estimation models: USLE and RUSLE3D, each with two versions according to the choice of factors. In addition to these models, we also computed the USPED model of Mitasova and Mitas (1998).

3. Results and discussions

Soil cover and land use. The studied area is placed at the limit between molic soils corresponding to steppe and silvo-steppe and argic soils corresponding to the higher hills of the Moldavian Plateau. If at the upper classification level have been separated two zonal soil classes, the soil cover is also highly diversified by azonal and intrazonal soils. Chernisols dominate the soilscape with 56% of the arable terrains. Luvisols are found in the higher areas, in association with Regosols, Phaeozems or cambic Chernozems, and occupy only 2.28% of the territory. The second class as percentage (28.19%) is that of Protisols, represented mainly by Regosols and Aluviosols. Antrisols occupy 8.31% of the arable terrains, the soil cover being completed, in small percentages, by Hidrisols, Pelisols and Salsodisols.

The dominance of the Chernisols is much clearer if we analyze the repartition at soil type level, Chernozems having 50.55% of the whole arable surface. The most important soil types that contribute to the fragmentation of the soil cover are Regosols (17.82%), Aluviosols (10.29%), Erodosols (6.40%) and Phaeozems (5.65%) (fig. 2).

Regosols are met on large surfaces, on unconsolidated or weakly consolidated deposits (loess-like deposits, sands, clays). The most important area is on Vasluieț's cuesta, on its right slope, between Viilor and Popeşti valleys. Other significant, yet dispersed, surfaces with Regosols are met on the left side of the basin. Surfaces occupied by Erodosols are found in the entire area, among the most affected areas being those around Moara Domnească (Odăii valley, Rupturi, Costişa and Moara Domnească Hills), Sărata basin (Morii, Telejna and Sărata hills) and Fereşti basin (the upper sector).

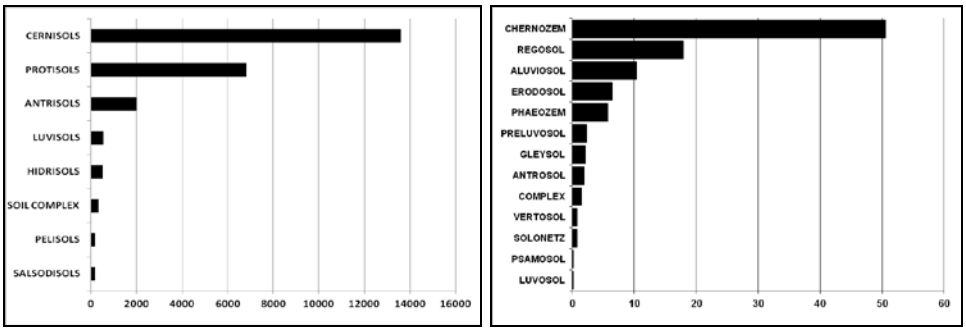

Fig. 2 - Percentage of soil classes and types in the middle and lower Vasluieț basin

As Băican (1987, 1996) and Bojoi et al. (1996) have demonstrated, this area has been covered in the past by large forests. From the 14th-15th centuries, with the numerical evolution of the population and the establishment of new localities, an extensive development of agriculture begins. After the Peace Treaty of Kucuk-Kaynarka from 1774, Moldova obtained some rights, such as that of having commercial relations with other states than the Ottoman Empire. This favored the extension of cultivated terrains and implicitly of localities, on the expense of forested surfaces.

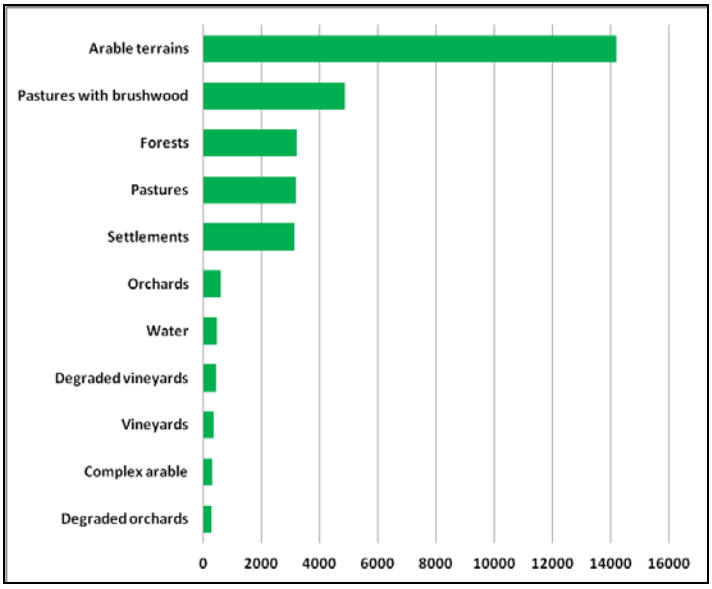

Fig. 3 - Surfaces occupied by the main land use categories

According to the map of the Russian general Bawr from 1769-1772, the Central Moldavian Tableland was covered by 68.84% forests. Between 1772 and 1829 forests register a sudden decrease, reaching only 38.52%. The process continued, in 1915 forests summing up 29.05% and in 1974 only 28.52%. In our area of study, in 1893 forests occupied a surface of 2175 ha (7%), in 1981 about 2608 ha (8.4%) and in 2009 a surface of 3206 ha (10.4 %). The small increase during the last decades is explained by the measures taken after 1960 to plant forests on the strongly degraded terrains.

The basin is dominated by arable terrains, which occupy 46%. These are positioned mainly on the right side of the basin, where slopes are longer and declivities smaller. The second land use category is that of pastures, simple or mixed with brushwood (26%), distributed on terrains with moderate declivities, affected by surface erosion or landslides. With percentages close to 10% follow forests and human settlements. Reduced proportions are held by other land use categories, such as vineyard and orchard plantations, which suffer in the last decades a continuous process of degradation and reduction in surface in the favor of constructed terrains (fig. 3).

If along time the surfaces occupied by agricultural terrains have increased, this process hasn't always taken place on the most favorable terrains, fact that led to the acceleration of some degradation processes. This extension has contributed on the one side to the intensification of slope processes, and on the other to the complication in some cases of land utilization.

Terrain degradation.Surface erosion has a large extension, being influenced by natural conditions and by human intervention. The process is present on slopes but also on hilltops, the highest values being registered on strongly inclined slopes occupied by degraded pastures or annual crops. The most exposed to erosion action are Preluvosols, but also cambic and argic Chernozems. The large extension of Regosols and Erodosols (24 %) certifies the high values of surface erosion.

The map of mean annual soil losses produced by surface erosion shows that 70.5% of the basin is characterized by unappreciable and weak erosion. Moderate erosion affects 21.2% of the region's surface, while strong and very strong erosion affect only 7.22, respectively 0.98%. The most affected areas are the degraded orchards and vineyards, where erosion rates exceed 20 t/ha/y. Pastures are on the overall characterized by an erosion rate of 9.6 t/ha/y, and arable terrains by 8.82 t/ha/y (Roşca et al., 2012).

Erosion rates increase from landforms with low declivities such as terraces or hilltops to those with higher declivities (cuesta escarpments, slopes). Most of the terrains characterized by strong erosion (20-40 t/ha/y) are found on north- and

west-facing cuestas, as well as on weakly or strongly degraded slopes (fig. 4). The few areas with very strong erosion are to be found on cuesta escarpments.

Fig. 4 - Surface erosion on Portari valley

The highest erosion values are found in the case of a high slope up-and-down hill tillage system and of pastures. In the opposite corner are the cases of good management: stripped crops and contour tillage, in which estimated erosion enters the limits of acceptable soil losses (6-8 t/ha/y, Moțoc *et al.*, 1975).

Gully erosion represents one of the geomorphologic processes with significant implications, due to the negative effects it may have on economic activities (agricultural crops, communications etc). The map of gully density in the Moldavian Plateau drawn by Rădoane et al. (1988) shows for the middle and lower Vasluieț basin small values, between 0.101 and 1.0 km/km^2. By analyzing topographic plans scaled 1:5000 and aerial images and conducting field surveys, have been identified a number of 346 forms of gully erosion, which occupy a total surface of 63.31 ha (0.2% of the total surface). These have small dimensions, most of them with surfaces between 100-1000 m^2. The small dimensions underline the influence of the clayey deposits, responsible for the weak development of large gullies and the large extension of small discontinuous ones.

In what regards the spatial distribution, these erosion forms are located in a few points that generally correspond to cuesta escarpments from the Rac, Soleşti, Grumăzeşti, Fereşti and Valea Pietrelor basins. On terrains with slopes between 15 and 25° is concentrated 43.5% of the gullied surface, situation that underlines the importance of the declivity in the occurrence and evolution of this process (fig. 5).

Fig. 5 - Velnița – Chirceşti Gully

Landslides find good development conditions in the Central Moldavian Plateau, their frequency and extensions being signaled long time ago. In the case of the Vasluieț basin, they make the most spectacular phenomenon, being impressive by development, dynamics and associated landscape. In 2000, ISPIF Bucharest elaborated an improved map of slope potential and probability for landslides, including the study area in the B class – with very high potential and high probability for landslides (Pujină, 2008). Vasiliniuc and Ursu (2008), in an analysis of landslides distribution in the Bârlad basin show that these forms have the highest density in the eastern part of the Central Moldavian Plateau, implicitly in our study area.

According to the Cadastral and Territory Management Office, in the Vasluieț basin 32.9% of the inclined terrains are weakly-moderately eroded, 10.2% are moderately eroded, 12.1% moderately-strongly eroded and 3.2% very strong and excessively eroded. Landslides occupy 162% of the basin surface. According to our survey, we obtained a total surface of landslides of 8487 ha, from which 3500 (11.32%) active and 4986 ha (16.13%) stabilized.

In what regards the dimensions of the landslides, the largest are mainly stabilized. The stable landslides have frequently surfaces of 20-100 hectares, while the active ones are mostly up to 10 hectares (fig. 6).

Fig. 6 - Landslides on a cuesta escarpment in Lunca basin

Soil cover – land use relationships

In what regards the relationships between the soil cover and the land use categories, they reflect how well-balanced the terrains in the area are used.

Aluviosols are covered in a proportion of 40% by arable terrains, 33% pastures and 22% pastures mixed with brushwood. Other land use categories participate in small proportions. Having in view the diverse physico-chemical properties of these soils, frequently not too favorable for crops, we may say that their utilization is judicious (fig. 7).

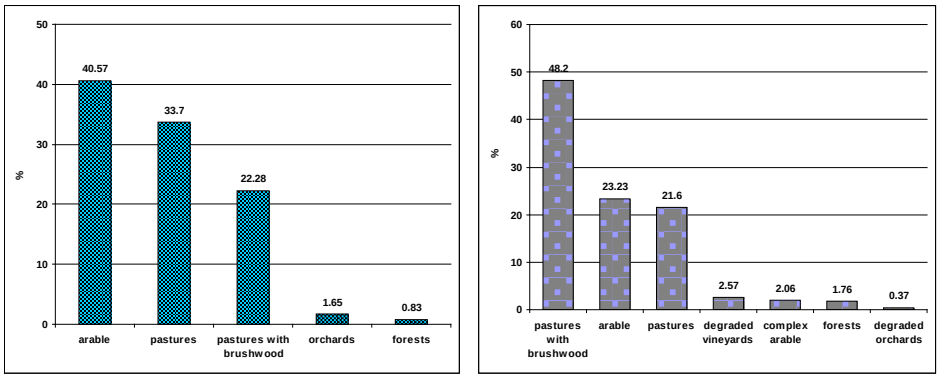

Fig. 7 - The distribution of the main land use classes on Aluviosols and Regosols

Regosols are mostly occupied by pastures (about 70%) and arable terrains (23%). This situation is not very encouraging, because the utilization of these soils as arable terrains may lead in time to an accentuation of erosion processes. More, Regosols situated on higher declivities may be better used for forests (fig. 7).

In the case of Chernozems, the situation is positive, 75% of them being used as arable terrains (fig. 8). A proportion of 10.5% are used as pastures mixed with brushwood, 6% as pastures and 3.63% as vineyard plantations. Chernozems occupied by pastures generally belong to the argic, calcaric and cambic subtypes, while those used as vineyards are calcaric. Problems are met in the case of some alkalic Chernozems which are occupied by degraded vineyards (fig. 8).

Phaeozems are occupied 58.7% by arable terrains, 24% by pastures and 13.26% by forests. This is an atypical situation, because the data used are related to arable terrains, which is explained by the extension of forested surfaces on surfaces used initially in agriculture (fig. 8).

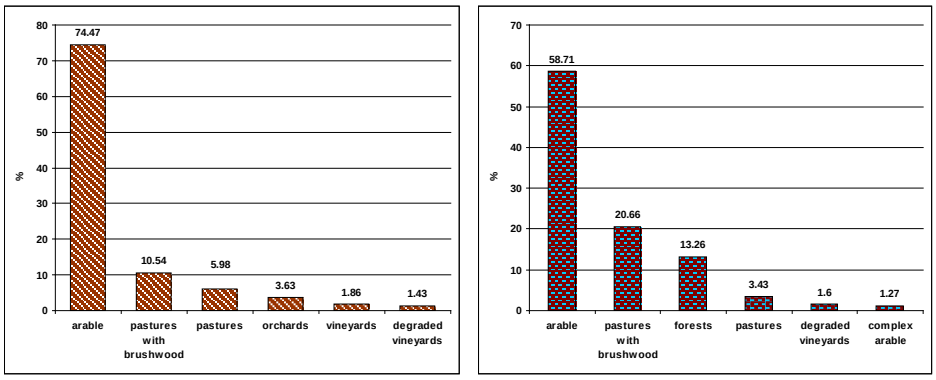

Fig. 8 - The distribution of the main land use classes on Chernozems and Phaeozems

Luvisols, represented mainly by Preluvosols, are used 43% as arable, 35% as pastures and about 20% as orchards and vineyards, most of the later degraded or abandoned. Gleysols are used 53.4% as arable terrains (in the floodplains with a lower phreatic level), 40% as pastures and very low surfaces as degraded orchards. Solonetz, which occupy a small percentage of the study area, in a single perimeter of Vasluieț's floodplain, are used as pastures (56.2%) and arable terrains (43.62%). Vertosols are used half of them as arable terrains (51%), the other half being occupied by pastures and degraded vineyards.

The distribution of land use classes at the level of Antrosols reveals some changes in the land utilization that have taken place during the last decades. Thus, if Antrosols are specific in the Romanian soil taxonomy system to vineyard and orchard plantations, at the present moment only 36% of them have these utilizations. Through the degradation or change in the utilization, 38% of the Antrosols have come to be used as arable terrains, and 17.2% as pastures with brushwood (fig. 9).

The percentage of land use types at the level of Erodosols also presents an unfavorable situation. Thus, almost 65% of the Erodosols are used as arable terrains and 26% as pastures. Certainly, the arable terrains that occupy surfaces with Erodosols should have their utilization changed to pastures or forests (fig. 9).

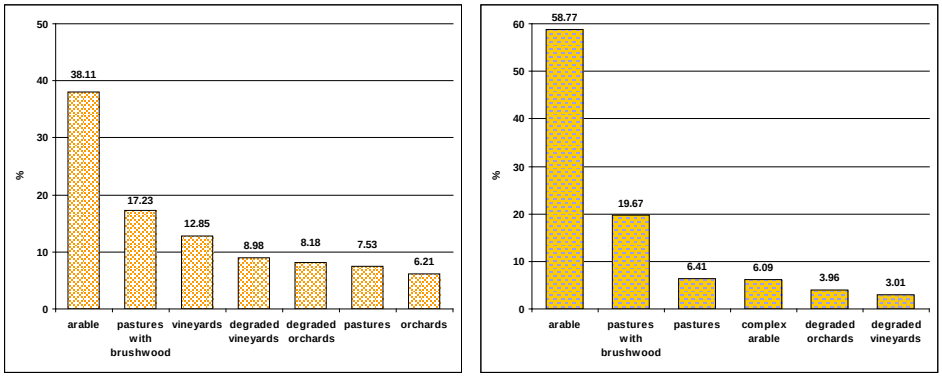

Fig. 9 - The distribution of the main land use classes on Antrosols and Erodosols

Land use – erosion relationships. Arable terrains are in a large proportion unaffected or weakly affected by erosion (66%). Almost 25% of the arable terrains are affected by moderate erosion, 8.3% by strong erosion and only 0.9% by severe erosion. Although the numbers seem to indicate a situation not too worrying, if we keep in mind that arable terrains make up half the basin's surface, then the size of the phenomenon becomes clearer. Complex arable terrains, which are made up of small dimensions parcels of arable, orchards, vineyards and even forest vegetation, which contribute to reducing water currents concentration on slopes, are affected by erosion in a smaller proportion. Thus, 10% are unaffected, 75.5% are affected by weak and very weak erosion, 13% by moderate erosion and only 1.5% by strong and very strong erosion.

42.35% of the orchards are affected by weak erosion and 43% by very weak erosion or unaffected. Only 12.7% of the orchards are affected by moderate and 1.5% by strong and very strong erosion. The situation is completely different in the case of degraded orchards, situation in which clearing and cutting have stimulated erosion processes on the inclined slopes on which these were planted. Thus, only about 22% of the orchards are characterized by weak and very weak, and 30% by moderate erosion. In comparison to other uses, degraded orchards are affected 33.6% by strong and 15% by very strong erosion (fig. 10).

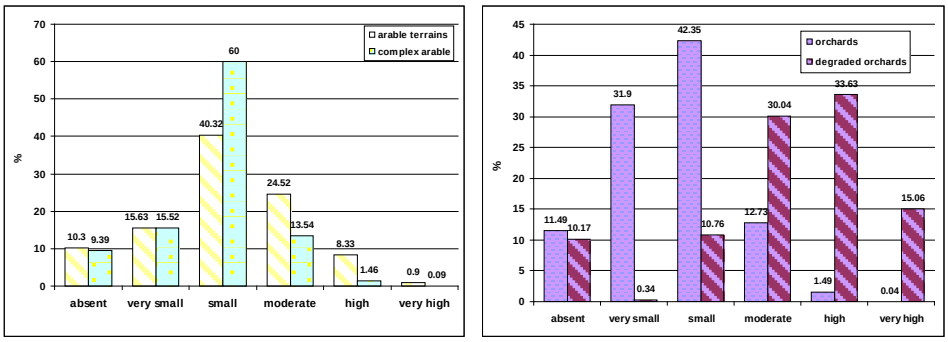

Fig. 10 - Distribution of the erosion risk classes on the arable terrains and orchards

Pastures are affected in a 45% proportion by moderate erosion and 10% of them by strong and very strong erosion. Pastures mixed with brushwood present smaller percentages of these erosion risk classes: 21% moderate, 5.4% strong and 0.5% very strong (fig. 11).

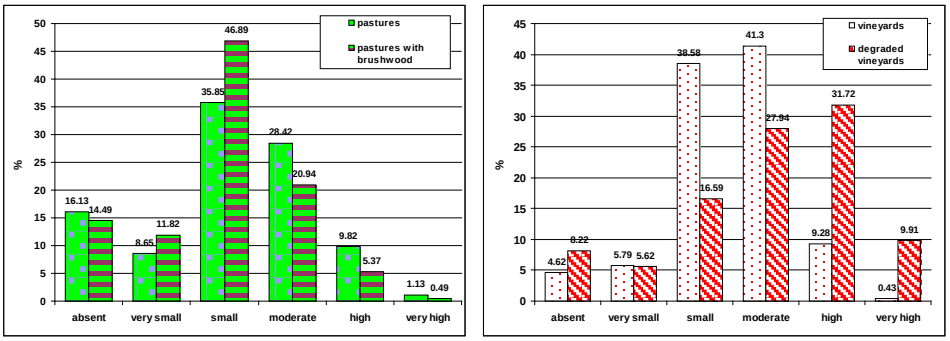

Fig. 11 - Distribution of the erosion risk classes on the pastures and vineyards

Vineyards also make up a land use class possible of being affected by erosion, thus having percentages of 38.5% weakly and 41.3% moderately affected. About 10% of the vineyards are affected by strong and severe erosion. Degraded vineyards are much more stronger affected, with 31.7% characterized as having a high and about 10% very high erosion risk (fig. 11).

Conclusions

The area under study is characterized at a quick glance by unconsolidated deposits, excessive climate, a soil cover dominated by Chernozems (a good part of which are highly or moderately erodable), Regosols and Erodosols and a land use

dominated by arable terrains and pastures. On the overall, this makes a perfect equation for the development of geomorphologic degradation processes, which affect a large part of the basin.

Thus, surface erosion affects large surfaces, although only 30% of the basin is moderately-strongly affected. The most affected areas are the degraded orchards and vineyards, where erosion rates exceed 20 t/ha/y. Pastures are on the overall characterized by an erosion rate of 9.6 t/ha/y, and arable terrains by 8.82 t/ha/y.

The highest erosion values are found in the case of a high slope up-and-down hill tillage system and of a pasture. In the opposite corner are two cases of good management: stripped crops and contour tillage, cases in which estimated erosion enters the limits of acceptable soil losses.

The second process as intensity and extension is landsliding, which also finds good conditions. They cover 28% of the basin surface, with 3500 ha (11.32%) active and 4986 ha (16.13%) stabilized.

In what regards the relation between soils and land utilization, the main problems are given by the use of Regosols as arable terrains (23% of them), the presence of vineyard surfaces on alkalic Chernozems, the degradation or even elimination of vineyards and orchards and the use of Antrosols as arable terrains, the large proportion of Erodosols also used as arable. Thus, from the total surface of the basin of 30,900 ha, 2000 ha of Erodosols and Regosols are used as arable terrains.

These problems have lead to the large extension of erosion on several land use categories. Almost 25% of the arable terrains are affected by moderate erosion, 8.3% by strong erosion and only 0.9% by severe erosion. 12.7% of the orchards are affected by moderate erosion. Degraded orchards are affected 33.6% by strong and 15% by very strong erosion. Pastures are affected in a 45% proportion by moderate erosion and 10% of them by strong and very strong erosion. About 41% of the vineyards are moderately affected and 10% strongly affected by erosion.

In conclusion, there is a clear need for a part of the terrains from the middle and lower basin of Vasluieț to have their utilization changed, mostly from arable to pastures or even forests.

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