Lucrările Seminarului Geografic Dimitrie Cantemir
Vol. 42, October 2016, pp. 39-48
http://dx.doi.org/10.15551/lsgdc.v42i0.04

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To cite this article: Bojoagă, I. (2016). Land degradation processes in the catchment of Stemnic river (Buda). *Lucrările Seminarului Geografic Dimitrie Cantemir*, Vol. 42, pp. 39-48. DOI: 10.15551/lsgdc.v42i0.04

To link to this article: http://dx.doi.org/10.15551/lsgdc.v42i0.04

ISSN: 1222-989X www.seminarcantemir.uaic.ro

LAND DEGRADATION PROCESSES IN THE CHATCHMENT OF STEMNIC RIVER (BUDA)

Ioan Bojoagă[1]

Abstract: The present paper proposes a study of the land degradation processes in the catchment of Stemnic river (Buda). Also, there is an analysis of the control factors, a differentiation of the degradation processes, their distribution and intensity, the evaluation of the impact upon the environment. The cumulated action of the natural factors, especially the coupling of the Kersonian sandy – clayey facies and the anthropogenic ones resulted in triggering degradation processes. Among these, the most frequent are: landslides, soil erosion, gullying and alluviation. The landslides represent the most relevant geomorphologic process in Stemnic basin (Buda), affecting 45% of the basin's surface, predominantly being stabilized landslides, spread especially on the cuesta fronts. The recent maximum rainy period in Moldavian Plateau (1968 - 1973) provoked the significant reactivation of the landslides: 2% (330 ha). After 1982, because of the extended period of aridization, the landslides stabilized. The soil erosion exhibits at different intensities on slope lands that exceed 5%, having an extended spread in the studied catchment. The gullying is less spread in the studied area, occupying only 64 ha, with slope and valley floor gullies. By soil erosion, gullying and landslides significant quantities of solid material are carried to the base of the slopes, although the sedimentation average rate remains low.

Keywords: surface erosion, landslides, gullying, Stemnic basin

Introduction

The catchment of Stemnic river (Buda) is a fusiform catchment oriented to the direction North–North–West – South-South-East. It occupies the South – West area of the Central Moldavian Plateau (figure no. 1). Latitudinal catchment is spread between 46°39'33" N and 46°48'26" N, and longitudinal between 27°18'34" E and 27°40'04" E, having within these limits a surface of 15662,2 ha. It is limited at North and East by the valley of Bârlad river and at West and South by the valley of Racova river (fig. 1).

From an administrative point of view this catchment extends on the territory of fifteen communes. The greatest percentages are held by the communes Oșești (31,6%), Cozmești (26,8%), Rafaila (14,4%), Delești (13,0%), Bălteni (11,2%), while the communes Todirești and Pușcași held less than five hectares together (1,1 ha respectively 3,6 ha). Four of the communes occupy surfaces under 50 ha, and the other four have surfaces over this value, of these only Stefan cel Mare commune holds over 100 ha (135,05 ha). Geologically, there are

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predominant the Kersonian formations (71,6 %), represented by a succession of sands, sandy clays and crossing structure clays. There come as weight the Basarabian ones (23,1%), while Meotian formations occupy only 1,2% of the catchment surface, being present on the interfluves that separate the catchment of Stemnic river (Buda) by the catchment of the Racova.

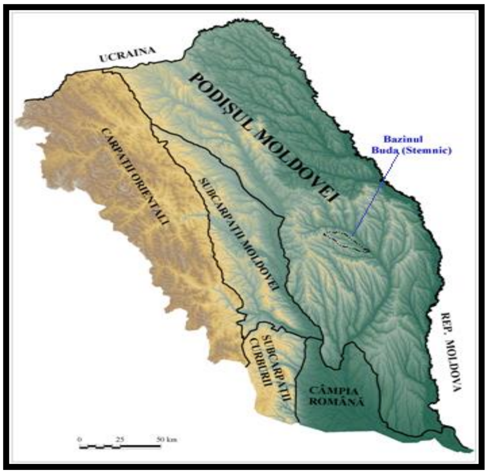

Figure no. 1 Geographic position of the catchment of the Stemnic (Buda)

The quaternary age formations appear in the meadows of the rivers (alluvial deposits), representing only 3,6% of the catchment's surface, along with the terrace deposits that occupy only 0,5% (fig. 2).

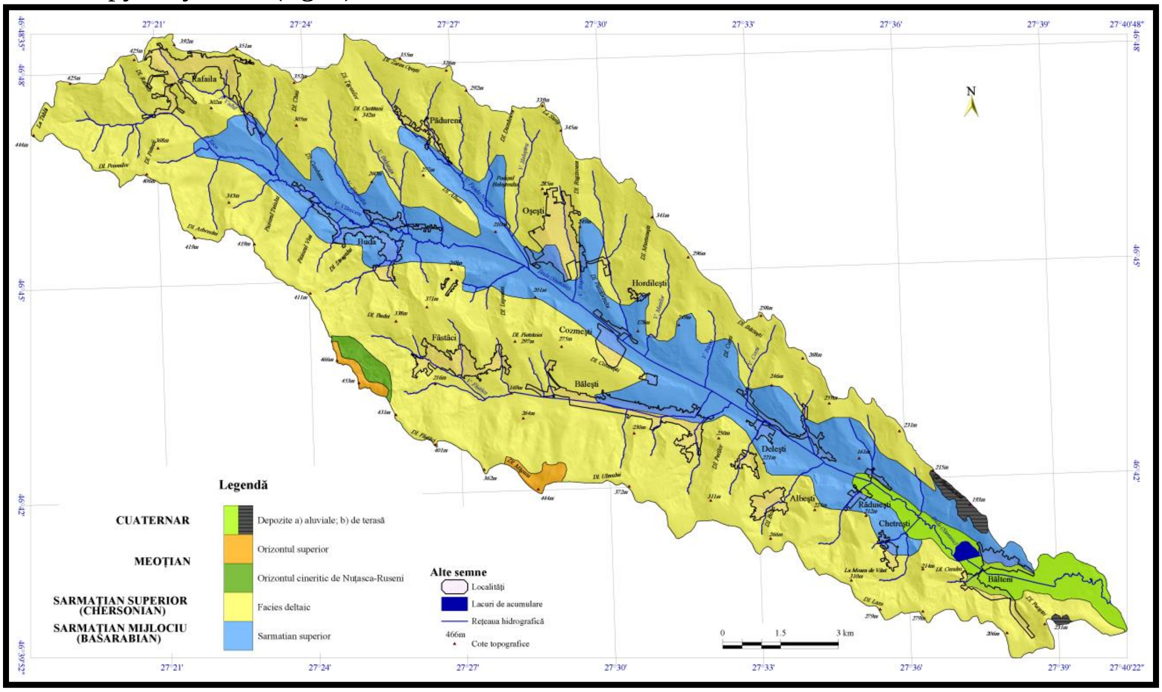

Figure 2 Geologic map of the catchment of Stemnic river (Buda), (processed after Jeanrenaud, 1971)

The climate of the area is temperate continental, with excessiveness nuances. The thermal regime is between 8 and 10°C, and the pluviometric one between 500 and 600 mm. A proof of this type of climate is the absolute thermal amplitudes of over 60°C as well as the non-uniformity of the yearly and monthly regime of atmospheric rainfall, when there merge frequent drought periods with rainy periods, with torrential character.

The hydrologic factor plays a very important role, the researched area being especially the work of the rivers of which multi-yearly flows are relatively reduced. During torrential rain the flows grow very much producing floods.

A very important control factor for the degradation processes is represented by the vegetation, especially the sylvan vegetation that presently occupies 4.353,6 ha (27,7 % of the total area). It has a larger spreading in the middle and upper catchment basin.

Another control factor of the named processes is also the relief's slope. The declivity analyze reveals the fact that 71.4% of the entire territory corresponds to slope surfaces of versant type, while structural – lithologic plateaus, a part of the interfluves hills and forms of fluvial accumulation (alluvial plains, terraces and glacises) hold 28.4% of the surface.

Materials and methods

The main information necessary for this study have been obtained by processing the topographic maps scale 1:5.000. Vectorial and tabelary data base have been realized with the help of TNT Mips 6.9 software.

The working method consists of importing the topographic maps in the GIS software, followed by geo-referencing these within Stereo 70 coordinates system, having as reference ellipsoid the ellipsoid Krassovky 1938-1940. The next step consists of realizing a vector layer of the level curves in order to extract the areas with landslips from the topographic maps.

In order to understand the amplitude and developing intensity of some degradation processes there have been considered information related to the natural framework of the studied catchment basin. There are described the sedimentary deposits, climatic characteristics, hydric characteristics, biogeographic characteristics, but also the morphometric characteristics of the lands, especially the slopes.

Starting from the geological map realized by P. Jeanrenaud in 1971, there has been vectorized and elaborated the geological map, automatically generating the surfaces occupied by the same deposit.

The climatic data for the period 1968 – 2010 have been obtained from Moldova Meteorological Centre, Iasi, being processed with the program, Microsoft Office Excel 2007.

The slope of the versants has been determined automatically based on the numerical model of the land. This reflects the morpho-structural context in which the morphogenesis performs.

Results and discussions

I. Ioniță (2000) considers that *“erosion represents a mechanical nature phenomenon of detachment and transport of the particles of solid material under the impact of the rain drops and water currents at the surface of the land.”*

The surface flow has been classified by *M. Moțoc et. Al. (1975)* as it follows: erosion through dispersed currents and erosion through concentrated currents.

Erosion through dispersed currents represents the incipient phase of the flow on the surface of the leaning land. The pulsatile character of the current leads to the appearance of some streams that do not exceed 2-3 cm, uniform distributed in the surface (*P. Stănescu,* 1975; *I. Ioniță*, 2000 c).

The erosion produced by concentrated currents represents a more advanced form of surface erosion. It is characterized by the appearance of some small ditches (2 – 20 cm) appeared after torrential rains or melting of snow. Although these are ephemeral, they realize a continuous transport of soil, generally from the superior part of the versant towards the base, taking to the continuous diminishing of the humus content.

The map of the erosion in surface has been realized based on the pedologic appreciations, pursuant to pedologic mapping (fig. 3).

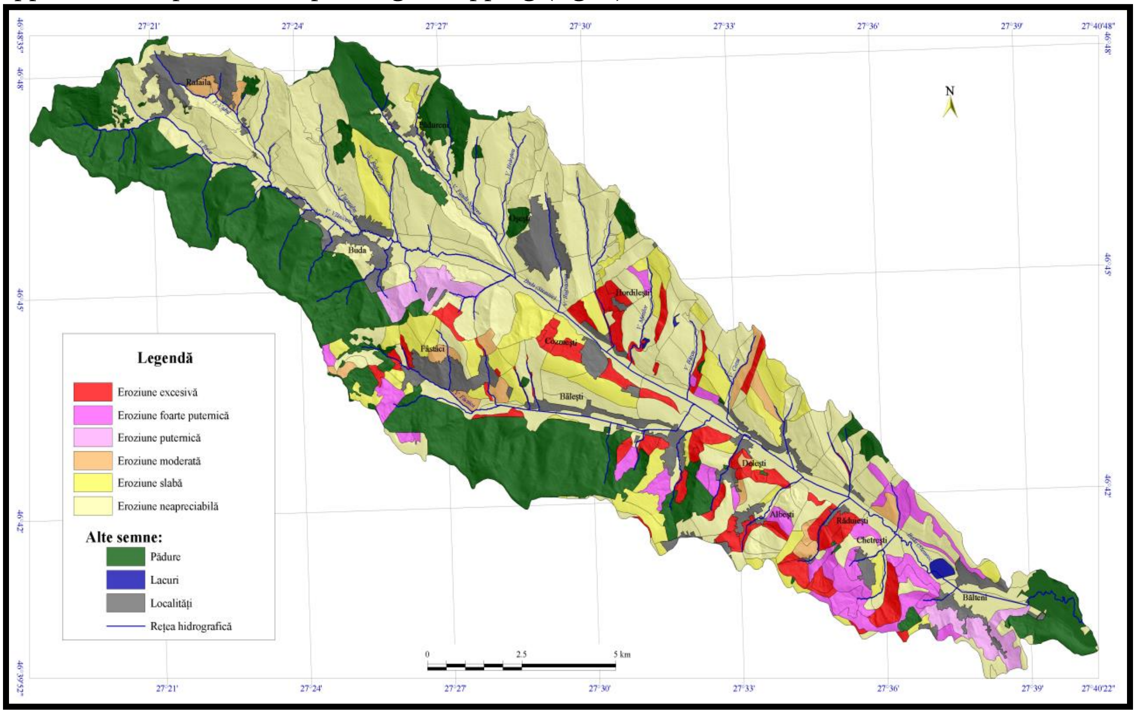

Figure 3. The map of the erosion in surface in the catchment basin of Stemnic (Buda), (processed after the pedologic maps realized by O.J.S.P.A. Vaslui)

The most susceptible to erosion are the strongly eroded variants of the typical chernozemic soils (5.8% of the mapped surface), preluvosoils and luvosoils that totalize a surface of 2.812,3 ha, representing 27.3% of the mapped surface. With a much reduced erodibility are enscribed the chambic and argic cernoziom soils, argic faeoziom and stagnant preluvosoils that totalize 1.342,1 ha, representing 13% of the mapped surface.

Pursuant to the calculus, considering Motoc model, the average of the potential erosion for the studied region is of 19.6 t/ha/year, corresponding to a moderated erosion risk. The main modal class is that with values of 17-29 t/ha/year that corresponds to a strong erosion risk and helds a percentage of 3%. These surfaces are regularly overlapped to the cuesta reverses with moderate slopes. The potential excessive erosion is specific for 9% of the mapped surface, corresponding to the cuesta fronts.

The versants or versants sectors slightly bended have a medium erosion risk, with values of potential erosion of 8-16 t/ha/year. These lands detain a percentage of 16% of the agricultural surface. The inter-fluvial surfaces present a reduced erosion risk, with values of the potential erosion of 1-8 t/ha/year, that are registered with a frequency of 6.5%.

The upper catchment is less exposed to erosion, because the timbering degree is significant. The overtaking for culture of the lands is relatively recent and the texture is predominantly medium – fine. As an argument we mention the fact that the areas with weak and moderated erosion are situated on the land in the immediate proximity of some localities (Rafaila and Buda).

In the middle catchment it grows obviously the poderosity of the agricultural surfaces and of the anthropic pressure upon the land, to which it is added a series of morphometric particularities (increased declivities, high relief energy, relatively intense fragmentation) (fig. 4).

In the lower catchment is observed the great percentage of the surfaces affected by erosion in the surface, under the conditions in which the catchment basin is obviously narrowed, the woods are considerably reduced and the relief energy and declivity are maintained within high parameters, especially on the right side of the river where there are observed the greatest surfaces affected by erosion.

Figure 4 Erosion in the surface at East of Răduiești locality (5th October 2015)

Pursuant to the information extracted from the ortho-photoplans and from topographic plans there have been identified 320 **gaps** that occupy a total surface of 62 ha (0.4% of the catchment's surface).

Large size gaps develop on the cuesta fronts, like those on cuesta of Buda, cuesta of Bălești (fig 5). The versant gaps occupy 37 ha and are generally discontinuous and have reduced dimensions and depths, while valley bottom gaps have larger dimensions and a continuous character, but occupy a much reduced surface, of 25 ha.

The depth of the gaps varies between 1 and 5 m and can reach greater depths (of over 10 m). The communication ways (roads) may be affected by the appearance and development of the gaps, along with taking off the agricultural circuit of those surfaces (62 ha).

The failures produce following the undermining of a mass of rocks and their mobilization, because the lack of support these were situated on. It takes place on reduced surfaces, limiting the structural plateaus and produce only on some sliding cornices, in quarries, on the margins of the gaps and of the rivers. Because of the lateral erosion there produce failures in the shores of the rivers, minor beds of the rivers, modifying the route, quite visible in a relatively short period. Such failures appear on the lower catchment of the Stemnic (Buda) near the barrier of the former Bălteni accumulation.

Figure 5 Versant gap (8th August 2013)

The extraction of construction materials (sand and clay) leads to the submination of some loose material piles, as it is the case of the small clay pit near Buda locality.

Landslides are displacements of various thicknesses and length of the diluvia, under the conjugated action of both internal and external factors. They are present on most of the moderated and highly bended versants.

With the help of the program TMT maps there have been identified 58 active and semi-active landslides on the topographic plans 1:5000 and ortho-photoplans, totalizing 333.8 ha (2.1% of the surface of the catchment) (table no. 1).

Table no. 1 The landslides in the catchment basin of Stemnic (Buda)

Type of landslides	Surface (ha)	Percentage (%) of the total surface	Percentage (%) of the affected surface
Active landslides	333,76	2,13	3,71
Stabilized landslides	8672,07	55,37	96,29
Total surface affected by landslides	9005,83	57,50	100

Their presence is linked to the cuesta relief, especially to their fronts, with a more accentuated slope and higher relief energy. By analyzing the map of the distribution of the active landslides within the catchment of Stemnic (Buda) we observe that their density is greater in the upper and middle catchments, more intense sectioned by reconsequent valleys and more reduced in the lower catchment where it is concentrated only on the right side of the river (fig. 6).

In the present morphogenetic context the stabilized landslides have a very wide range of forms and dimensions. Though, the total affected surface of stabilized landslides exceeds 8.672 ha (55.4% f the entire territory), which offers a concluding image on the degradation of the land in the catchment of Stemnic, the processes in cause contributing to the specific of this catchment basin. The stabilized landslides are characteristic for the entire catchment basin, having a special frequency in the upper catchment as well as in the entire catchment basin of Fâstâca river.

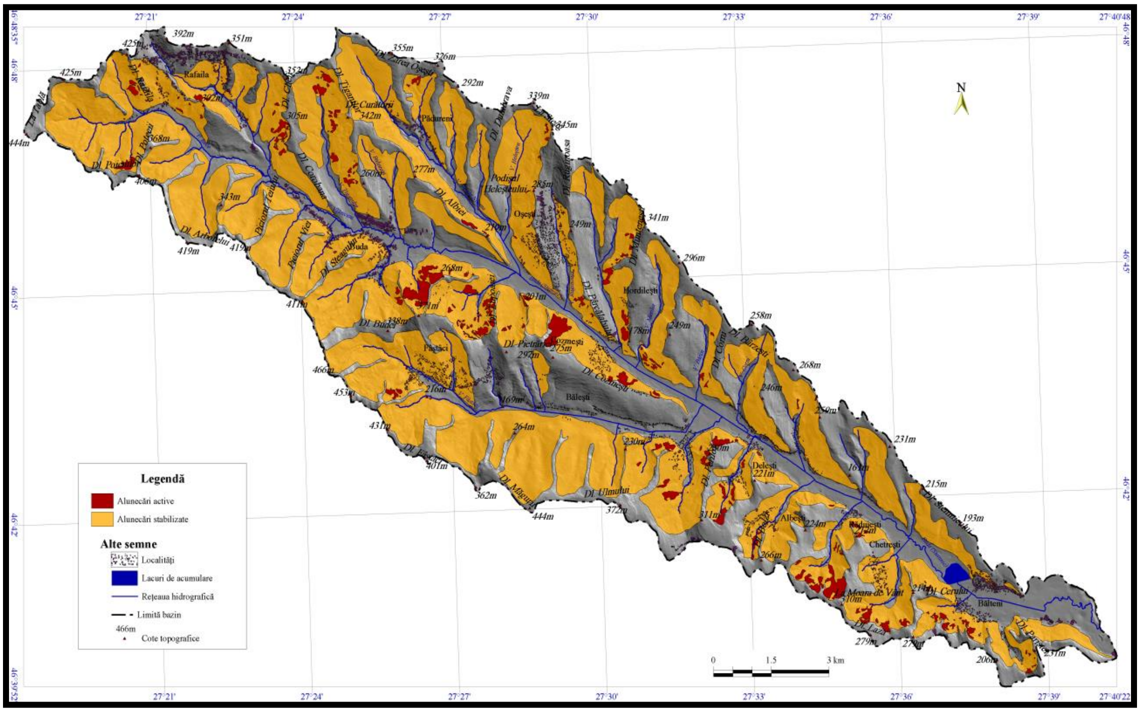

Figure 6 The map of the repartition of the landslides in the catchment of Stemnic (Buda)

The most frequent active landslides are of small dimensions and involve thinner deluvia. They have a detachment flat hollow of 1-3 m height, after which there follow a series of slipping waves with convex course front. They developed especially on the cuesta front versants with North, West, North-West or South-West exposure.

An essential role in the beginning of the landslides is represented by the geological factor, for the study catchment basin being predominant the Kersonian facies 11.208,9 ha, 71,6% of the territory), with clays, sandy clays, clayey sands, sands and little hard insertions, concentrating the most numerous slipping bodies. The superior Sarmatian is characterized by the presence of some psamitic deposits and politic subordinated (with a value of 23.1% of the surface of the catchment basin) totalizing a smaller number of slipping bodies, while the Meotian holds 190.2 ha (1.2% of the total surface), being specific for the interfluves where the landslides cannot initiate.

The relief is another important element in the beginning of the landslides, especially, by morphometric parameters (altitude), declivity, relied energy, fragmentation. The highest frequency of the landslides is observed within the altitudinal interval 200-250 m, with 37.8% of the landslides, which represent 2.633,1 ha, followed in decreasing range, by the intervals 250-300 m with 1.873,9 ha (26.8%), 150-200 m with 1.497.7 ha (21.5%). The most reduced frequencies are met in the interval 350-400 m with 168.6 ha (2.42%) and under 100 m, with 153.3 ha (2.2%), which correspond especially to the interfluves crests and the plateaus (first case) and to alluvial depressions (the second case).

If we consider the versant's slope, nearly all the landslides are distributed between 5-25°, 6.956,2 ha (99,9 %). Of these 3.340,4 ha (48.0%) are found on lands with slope of 10-15°, 2.329,6 ha (33,5%) are disposed on lands with the slope between 5-10°, and 1.286,2 ha (19,5%) in the slope category between 15°-25°.

We can see landslides on the right versant of the Fâstâca river, near Bălești locality, on the right versant of Stemnic, downstream Buda locality or near Răduiești locality (fig. 7).

Figure 7 Landslides in steps in theupper catchment basin of Stemnic (Buda) (17th May 2014)

The landslides of pothole type are due to the presence of a great percentage of some sand layers in the middle part of the abrupt versant, determining the narrowing of the slipping body, and the material subdue to movement converges towards the main axle of the catchment basin. Such landslides are formed at the origin of some torrential valleys with semicircular reception basin, limited by a detachment cornice well individualized as it is the case of Bălești Valley.

The flowing landslides are sub served by a high plasticity of deluvia and a higher movement speed, regularly developed on marl or clayey - sandy rocks, having though a limitary spatial extension with an ephemerous existence.

Sedimentation represents the process of slow deposit of solid particles that are in suspension, by free fall, because of the diminishing of the flowing slope. In the catchment of Stemnic (Buda) this process exhibits especially by drowning of ***minor bed of rivers, the aggradation of the alluvial plains and alluviation of storage lakes.***

The rivers have an important geomorphologic role by the fact they evacuate from a geomorphologic system the material that comes from the erosion at the level of the versants. In the case of these rivers with semi-permanent or temporary flow, the minor beds of rivers are drowned in their own alluvions and the meadows of the rivers are covered especially with colluvial deposits. Only in the case of big spring waters or of the floods there takes place an evacuation of the material, except for the situations when there produce overflows and floods, which determine the sedimentation of the transported material in its own alluvial plains.

Aggradation of the alluvial plains represents the geomorphologic process of elevating by alluviation of the flooded meadows (figure no. 8). The floods produced as a result of snow melting, the torrential rains or some long term rains are responsible for the deposit of the materials on the alluvial plains, sometimes being accumulated large quantities of material, with effect in burying the preexisting soils.

Figure 8 Aggradation of the plain of Stemnic (Buda) (10th August 2013)

The observations made in the field lead us to the conclusion that the value of the aggradation rhythm of the meadows in the catchment of the Stemnic (Buda) is medium, a fact confirmed also by the relatively reduced thickness of the alluvion. This thing is possible because of the high degree of timbering (27.8%), the predominantly clayey lithology of the sub layer, the spreading of soils with clayey and loam – clayey texture (17.2%), with an increase resistance to erosion, deposit of a significant part of the eroded material at the junction of the versants with the alluvial plains.

The colmation rhythm of some accumulations in the surface of Bârlad Plateau has been studied by *I. Ioniță et al* (2000, 2005, 2007, 2013) following as mark the presence of the isotope Cs-137. The authors appreciated that the medium sedimentation rate for the accumulation of Pungești is of 3.1 – 3.5 cm/year, considered to be moderated.

In the studied catchment basin there existed two small size accumulations (2.5 ha each) and one large dimensions accumulation (24 ha), but of which blocking zone fell in 1986. Up to this moment we do not have data regarding the colmatation rhythm of this former accumulation.

Conclusions

The erosion in surface has anthropogenic causes because of intensive depasturage, rooting out of large surfaces, but especially because of the use of some deficitary agro-techniques after 1991 (ploughing on the direction hill – valley and not on that of level curves, use of some agricultural cultures that are slightly protective for the soils, cultivation of scufflers in conditions of relatively high slope, unrespecting the cultures' rotation). This way are justified those over 4129 ha (40% of the agricultural surface) excessively, very highly and highly degradated.

The main causes of the landslides are: accidented relief, gravitation, forming of the slipping conditions in the context of permeable rocks alternance (sands) with floating rocks (clays) that become impermeable and the anthropogenic activity. In the catchment basin of Stemnic (Buda) the landslides are omnipresent occupying 9005.8 ha (57.5% of the mapped surface).

Gaps, failures, collapses are the processes of degradation subordinated to the other processes occupying small surfaces within the catchment basin of Stemnic (Buda).

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