# THE IMPACT OF ENVIRONMENTAL FACTORS ON THE EVOLUTION OF THE SLOPES IN THE NARUJA BASIN

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**ABSTRACT. –The action of environmental factors in the evolution of slopes of the Naruja basin**. The environment's evolution by means of erosion processes takes places wherever the water acts, but the intensity of the phenomenon varies a a lot from one place to another depending on the resultant of two categories of dynamic components. On one side there are the components providing the surface of land with resistance by means of vegetal layer, soil profil, geological sub-layer and human intervention within the landscape which by means of a series of actions contributes to increase or decrease of the resistance of the land's surface. On the other side, there are the components tending to level the surface of land by means of subaerial modeling processes involving the precipitation with variable intensity, gravitational forces, overland flow and channel discharge. The resultant of the two groups of dynamic components consists, among other things, in production of suspended sediment load, transported and deposited with different intensities depending on the matter and energy flow at the level of hydrographical basins.

**Keywords:** hydrographical basin, slopes, the surface of land, the erosion processes, the human intervention

## 1.INTRODUCTION

In the geomorphological system, the slopes take over the largest area among all forms of relief. In the beginning, the slopes used to be regarded as mere land areas, flat or slightly tilting. However, in the second half of 20th century, Penck (1924) brought a significant contribution to the subject; the meetings of the Commission for the Study of Slopes, in UIG add, too.

There are many opinions regarding the notion of slopes, such as Posea's (1976), who mentioned, in 1976, that the slopes might be considered „only those sides of the mountains with a gradient of minimum 2 – 3 degrees". The slope might also be defined as the surface tilted less than 40 degree; surfaces with a gradient of 40 degrees are considered steep slopes. Surfaces with a gradient less than 5 grade are regarded as landforms or sub-horizontal.

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On the whole, the slopes are tilted landforms which link the rivers or the ridges, to the adjacent drainage system. Consequently, we may talk about a relationship of interdependency between the slopes, the river bottoms, and the geometry of the basins or drainage cuvettes. Dynamically speaking, the slope is the space of morphogenetic processes which occur between the streams and an erosion base; the latter is indispensable for the slope evolution and, in the same time, as guidance for the processes.

The modern vision upon the slopes is grounded on the fact that between their geometry and the modeling processes there is a reciprocal dynamic adjustment. Mac (1986) claimed in 1986 that „the slope has a time-space geomorphological structure (surface, process, deposit) with the role of upright /cvasi-upright distribution of matter and energy".

## 2. PARTICULARS OF THE MOUNTAINOUS AND SUB-RANGE SPACES, FOCUSING ON SLOPES

A landform consists of an aggregate of elements with different characteristics, which are quantified qualitatively (e.g. relief morphography) and quantitatively (relief morphometry).

Landform morphometric characteritics, particularly hypsometry, relief energy, fragmentation density and declivity (downward inclination) are relevant not only for the natural space division but also for the man-made division, the anthropical one.

A hydrographic basin may evolve on various relief levels, such is the case of the hydrographic basin with the springs in the Carpathian Mountains. On the whole, the topographic surfaces drained by the Putna Hydrographic Basin (Naruja collector) is made up upon levels (including the major landform units) decreasing in altitude from west to east (from 1785 m (5856 ft ) Goru Peak, to 25 m (82 ft), at the junction of the Putna with the Siret).

The Hypsometric Curve plays a very important role on the environment, including the weather factors, with implications on the runoff system. For example, the Naruja Hydrographic Basin has evolved over three levels: high hills, low hills and sunken landform (depression); each of these levels shows various altitudes and slopes, all of them result in an irregular distribution of caloric energy over the topographic surface.

The Energy of Landform is the consequence of the hydrographic network deepening during the geological and historical ages, a catalyst triggering erosion and gravitational processes (downfalls, rollings, landslides) with significant impact on the natural landscape, and, more serious, on social and economic activities.

Relief Fragmentation Density is an indicator reflecting the degree of evolution of the relief in report to the generations. It might prove useful to know such indicator, particularly for the social and economic management of the territory. High values of fragmentation density in the sunken sub-Carpathian spaces are due to the hydrographic convergences and marked sinuosity imposed by the milder slopes.

A particular case might be the basin that changes its orientation from transversal to longitudinal, and vice versa. On the Naruja Basin, the density of fragmentation grows in such spaces because of the diversity of geological formations that are crossed by surface waters.

Relief Declivity is very important for the geomorphological processes, with impact on the environment; this parameter plays a major role in setting the measures of anti-erosion arrangement and reduction of the torrents in the highly tilted sectors, the measures of building dams, and learning the flood risks in the gentler sloped areas, river overflows being among the most frequent, especially due to the upstream deforestations which enhance active torrential erosion and runoff. The slope gradients vary a great deal; their quantification is according to the target (geomorphological processes, land use, slope deposits depending on their position on the slope).

The Exposition of Slopes, together with the other morphometric – slope parameters, altitude, and the degree of fragmentation, is the element which determines the extension of plant cover (influenced by light and heat) and directly influences the habitat conditions, e.g. the hearths of villages along the Naruja Valley, orientated from the north to the south.

## 3. HYDROCLIMATIC PARTICULARITIES RECORDED ALONG THE HYDROGRAPHIC BASIN OF THE NARUJA, WITH IMPLICATIONS ON THE SLOPE EVOLUTION

The Hydrographic Basin of the Naruja springs from the eastern slopes of the Vrancea Mountains, at altitudes of over 1500 m (4,921 ft) and has the Zabala as collector, joining it in the vicinity of Naruja Village; what is more, this space proved the first hydrographic merging between the Sub-Carpathians and the Carpathians.

The slopes are overdeepened by streams in direct proportion with the stream discharge. Over the year, the discharge and runoff distribution of streams vary with the rainfall that feeds the stream, which is more than 80% pluvial and 20% nival feeding in mountainous area. For example, for the Zabala, at Nereju, the average of annual discharge over a period of 48 years (1950 – 1998) was a little over 30 m3/sec, while the Naruja recorded approximately 15 m3/sec at Herastrau, in the Sub-Carpathic (sunken landform); at Herastrau, the highest discharge is recorded in May, then, April, July and October. 2005 was the year of the highest discharge at Herastrau in July, Qmax = 438 m3/sec, q = 3526.38 l/s/km$^{2.}$

Over the entire basin of the Putna, high floods occurred in the years: 1969, 1970, 1972, 1975, 1979, 1991, 1992, 2004, 2005, and 2006. The worst floods, which caused serious damages, were recorded on 11th – 13th July 2005 (the worst in history), and August 2006. The discharges and the historical levels recorded at Herastrau were: discharge, historical peak, 257 m3/sec (25th July 1977), level, historical peak, 150 cm (4.9 ft) (25th July 1977); July 2005: discharge, historical peak 294 m3/sec and peak level 270 cm (8.86 ft) and a multiannual discharge 1.86 m3/sec.

The intensification of geomorphological processes is the consequence of massive deforestations in the Naruja Basin. Heavy rainfall were recorded between 10th and 11th August 2006, Naruja 66 l/ m2, Herastrau 61.41 l/m2.

Morphoclimatic and hydrological factors, together with the biotic ones, resulted in the formation of the following types of soils: (their evolution depended on the tilting and exposition of the slopes): spodosols (brownish, iron-bearing), cambisol (brownish, acid) mountainous sector. The sunken landform consists of cambisols (brown, eumesobasic) and humic luvisols (brownish luvil).

The erosion in depth has affected significant surfaces, as follows: 3800 – 3990 hectares for Nistoresti, while at Paltin – Spulber between 60 and 200; areas have been affected by landslides at Nistoresti and Paltin between 3680 and 4600 hectares, Spulber 920 – 1840 m.

## 4. MORPHOLOGIC FUNCTIONALITY OF SLOPES FROM THE PERSPECTIVE OF SLOPE REPARTITION OVER THE TOPOGRAPHIC SURFACE

The displacement of the slopes stands as the fundamental trait in the geomorphological analysis, thus the slopes represent surfaces with different gradients (tilting) separated by inflexion points.

A geometric analysis of the slopes has indentified the basic units: surfaces (faces) and curved surfaces; the first category shows the constant outline of the slope, the second category shows the change of the normal outline of the slope; the curves are divided in concave and convex. For example, in the distribution of the slopes over the hydrographic basins, (the case of the three basins 4th order-see the figure 1 and the figure 3) it has been noticed an interchange in strips of the surfaces with different gradients; such variation, on transverse plane, has provided a general picture of the faces, i.e. slope curves.

Identifying the surfaces of a slope with a certain tilting determines their morphological functionality, as follows: for the mountainous sector of the Naruja Hydrographic Basin, the slope values differ greatly, from 5 degree to 37 or even 41 degree (see the figure 2 and the figure 4).

Depending on the values, and taking into account the other environmental factors, numerous models of slopes with a certain number of morphological and functional units have been drawn. A hypothetical model of the slope with nine units has been designed by researchers Dalrymple, Blong and Conacher (1968), in 1968, a model which might be used in some weather and structural conditions, others than those of the research. It is worth mentioning that these researchers settled a double characteristic for each unit, morphological and functional: $U_1$- interfluve or the unit of eluvium process; $U_2$- distribution unit, $U_3$ – convex surface or the unit of linear and areal erosion displacement, $U_4$ – the backfall or the gradient of insertion of the forms of linear and areal erosion, $U_5$- middle of the slope, known as a unit of maximum morphodynamic mobility, $U_6$- the glacis or the unit of depositing deluvial/ colluvial soils, $U_7$- the callow or the alluvial-proluvial unit, $U_8$- the bottom bank or the unit of side erosion and caving – caving-in, $U_9$- river bed (alluvial bed) changing due to the river dynamics.

Such order is not always respected, as is the case of the Naruja Basin which transits various morphological and structural units. Thus, in the inferior sector, transversal, the riverbed gets steeper, with a height varying between 10 and 40 – 60 m, 3 – 5 m south of Bradetu Village, 10 – 15 m at Podu Schipou Village, the vastest surfaces being recorded at Herastrau and Fagetu villages.

At Podu Naruja, south of the Naruja, the river develops its functional units U7 and U9. In the mountainous sector, the predominant feature are the slopes of over 15 degree, up to 25 degree, i.e. the surface with the linear erosion; we may also find the surfaces with a tilting between 25 and 40 degree, with outline and strong erosion phenomena, and over 40 degree the surfaces whose outlines tend to soil detachment of steep slopes, with caving, landslides, alterations and decays.

## 5. CONCLUSIONS

The study of the slopes involves a complex analysis of all generating factors, active or passive. Also, this paper aims to present slope processes in the Vrancea Mountains influenced by the geological and, more or less the anthropic particularities of the region, and trigerred by climatic factors in the conditions of some changes in the region's precipitation regime mainly in the last decade.

The quantity of precipitation is a triggering factor of slope processes. The current processes of slope triggered by critical slope value in the Naruja's upper basin are: lanslides, stream flow, denudation and rain-wash, the falling-in, etc.

What the Naruja Basin is concerned, the human intervention is ever increasing in intensity, from the spring to the mouth; in the mountainous sector, the human intervention shows clear intensity due to the massive deforestation, thus the convex-concave outline; in the median part of the slope, the outline turns concave because of the gradient increase, resulting in processes like: caving, landslides, gully erosion, and so on.

Studying the slopes proved extremely helpful in taking social and economic decisions, in either the administrative-territorial organization or when using the land.

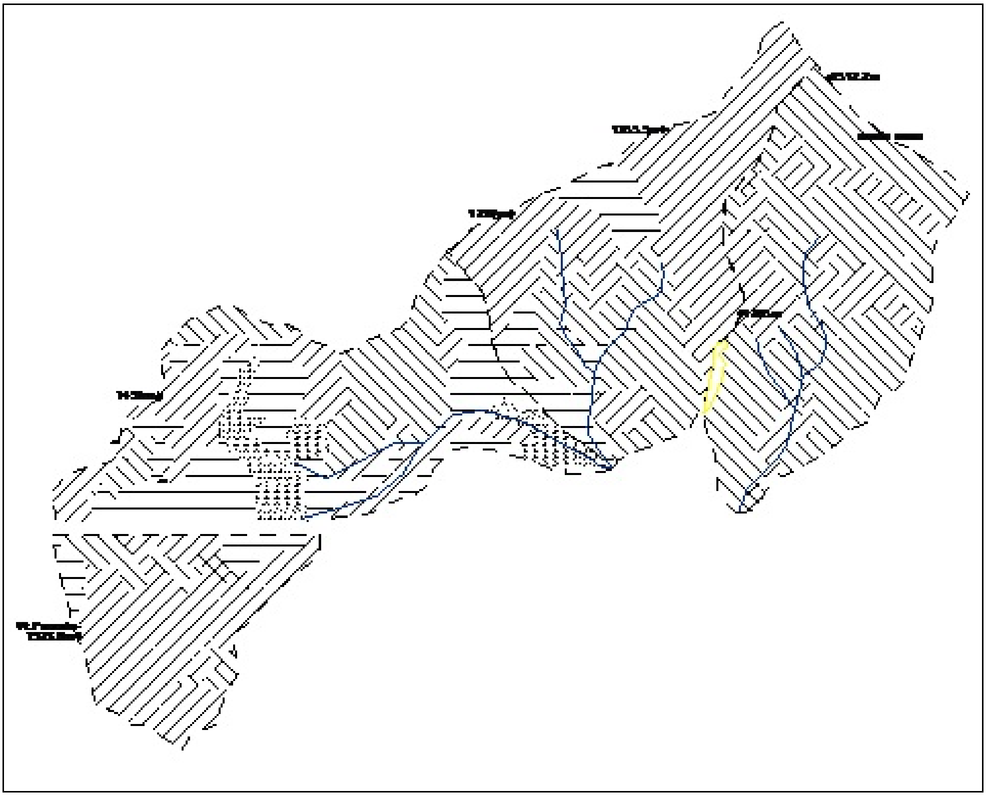

**Fig. 1** ***Map of slopes for the basins of 4th order, no. 1, 2, 3 in the sectors of the Naruja Springs; scale 1:25000.*** **5gr-10gr** **10gr-15gr** **15gr-25gr** **watershed** **25gr-40gr** **peste 40gr**

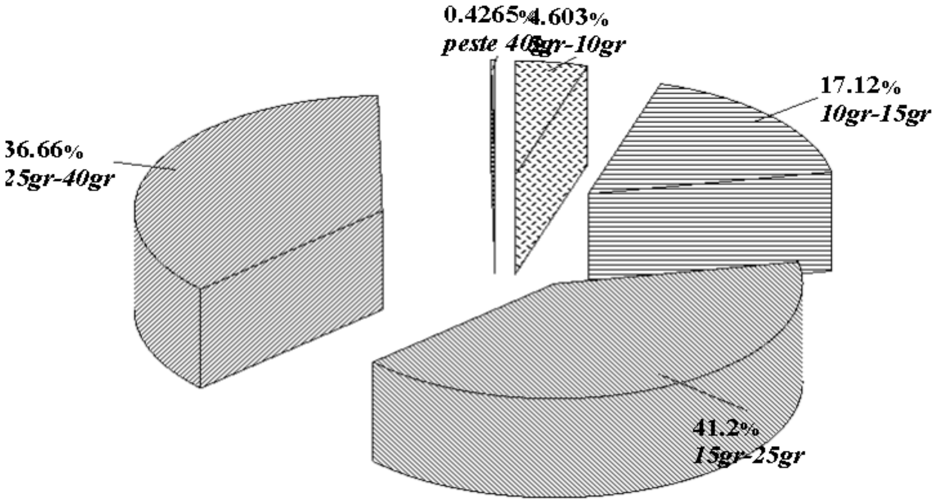


**Fig. 2 Share with certain values of surface slopes for the basins of 4th order, no. 1,2,3 in the sectors of the Naruja Springs**

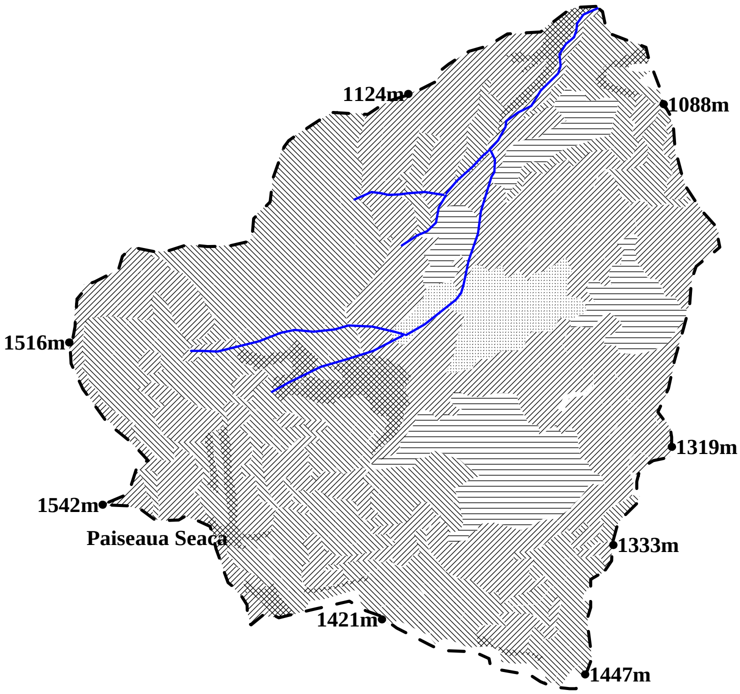


**Fig. 3** ***Map of slopes for the basin of 4th order, no. 4 in the sectors of the Naruja Springs; scale 1:25000.*** **5gr-10gr** **10gr-15gr** **15gr-25gr** **watershed** **25gr-40gr** **peste 40gr**

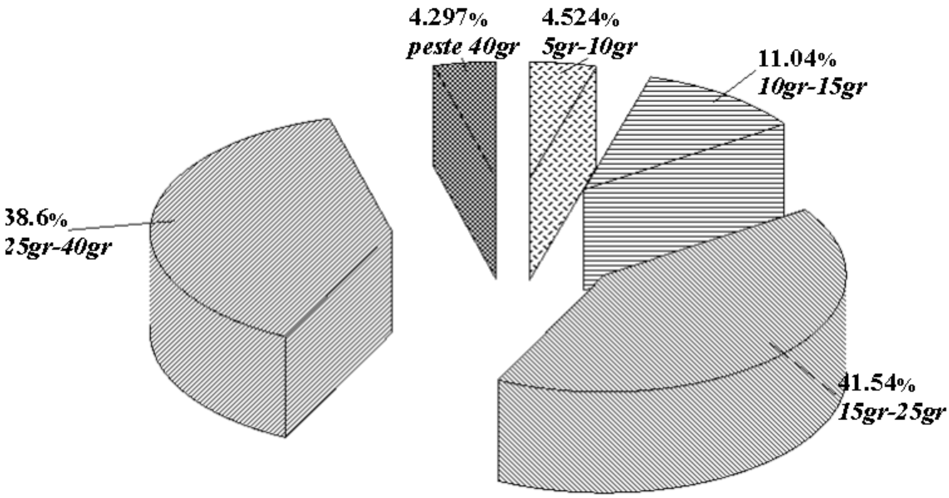


**Fig. 4 Share with certain values of surface slopes for the basin of 4th order, no. 4 in the sectors of the Naruja Springs**

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