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Study regarding implementation of torrents' correction in the basin of production unit no. II Valea Nerei, Bozovici Forest District

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Abstract
This study refers to the implementation of torrent correction works, in order to avoid floods, soil washing and its erosion. In areas with abundant rainfall, the soil is prone to erosion and landslides, and these torrent correction works are beneficial and necessary. By applying these torrent correction works, the course of some water flows can also be changed, thus avoiding the flooding of some lands and human settlements. One of the great advantages of these works is that they prevent the introduction of alluvium. The study is carried out in the Valea Nerei River Basin, located in the South-West of the country, on the course of the Nera, inside the Banat Mountains. The river basin extends over an area of 190 hectares, of which 110 hectares are occupied by forests and 80 hectares by pastures. The interventions proposed for the slopes are designed to strengthen both the hydrological balance and the protective role of forest vegetation against erosion, while in the meadow areas the objective is to ensure the formation and long-term persistence of a continuous grass cover, capable of preventing the initiation of erosion processes or, where they occur, of reducing their rate of development.

Keywords: torrent correction works, river basin, forest, pastures, hydrological improvement

Introduction

One of the basic conditions for efficient forest management and administration is accessibility. An inaccessible forest area removes appreciable timber and non-timber resources from the economic circuit, hinders and even blocks the execution of forest works, creates a high potential for an ecological risk, and limits tourism and the economic development of the area [6,11]. Torrential rains that fell in the forest basins produced torrential floods that affected those objectives, which are under execution, caused significant damage. If the rehabilitation works of the forest roads and those of the correction of torrents remain unfinished, access may be blocked for a forest area. The lack of access to these forest basins has interrupted the process of forest exploitation and makes it impossible to intervene in case of fire or natural disasters [10].

A major effect of torrential correction works is the protection of socio-economic objectives, of localities with high flood risk. Through these works, the overflow of rivers caused by long-term precipitation is improved, and often even eradicated, as well as by building pressure-breaking dams or by building dikes [1]. They also have a beneficial role in the case of slopes that have been deforested and where very strong torrential flows can occur, which in the absence of these torrential correction works could give rise to landslides, erosion or other forms of soil destruction.

Material and method

The works in this study were realized through measurements and works on the slopes of the basin, measurements and works for hydrological improvement of the forest fund, measurements and works for hydrological improvement of pastoral areas, the organization and practice of rational grazing, the development of green mass production and the development of the zoo-technical sector.

Bibliographic documentation methods were used in the traditional form, which was based on materials from the Forestry Research and Management Institute from Timișoara archive and specialized literature; also, the Internet was used for documentation as well as discussions with various specialists; direct observations, measurements and laboratory analyses, carried out both expeditionary (on route) and stationary; the experiment, in the classic version; theoretical analysis (including statistical calculations) and logical interpretation of the results obtained [6,9].

Results and discussions

The main objective of the torrent correction action is to protect forest roads in order to increase the safety of traffic on them and ensure accessibility for the entire basin, especially in order to avoid frequent traffic interruptions with effects on the rhythm of removing wood from the basin and the high risk of disasters [13]. Starting from the fact that the most intense and varied forms of degradation were observed at the level of the hydrographical network, specific hydro-technical construction works are envisaged to be carried out in the main riverbed and on the tributary beds.

The destructive nature of torrential manifestations and the extent of the degradation produced, make timely and necessary interventions with torrential correction works in the torrential basins within the Bozovici Forest District. The particularly high intensity of precipitation in recent years has produced floods that have led to the amplification of the degradation of the hydrographical network and adjacent lands, through deep erosion, surface erosion, landslides, collapses and bank collapses.

The forest fund is affected by torrential phenomena through erosion produced at the base of the slopes during floods, which favours slide ground. From this point of view, the most exposed were the plots located in the immediate neighbourhoods of the riverbeds. Considering the natural framework and the socio-economic context that have influenced the triggering and evolution of torrential processes, the technical solutions applicable to the basin slopes must be adapted according to land use, the composition and structure of vegetation, as well as the type and intensity of the degradation phenomena present.

Regarding the combined action of climatic, geomorphological, lithological, pedological conditions on the geomorphological processes of land degradation in the specific conditions of the area, it was concluded that in establishing the urgency of intervention with afforestation works on degraded lands and development of torrential hydrographical basins, it is necessary to take into account the following criteria:

- the extent and severity of the ecological imbalance and the economic and social impact generated following the reduction or diminution of the productive potential of the lands in question as well as the direct damage caused by torrential floods;
- The degree or percentage of forest vegetation coverage of the torrential hydrographical basin or of the area of land subject to anti-erosion and hydrological development;
- The economic efficiency of the investments necessary for the execution of the development works on torrential hydrographical basins and respectively for the installation of forest vegetation on degraded lands.

Regarding the functional efficiency of afforestation works on degraded lands, the surface erosion on degraded afforested lands, previously used as pastures, was practically stopped after 5-15 years from the execution of afforestation works, in relation to the species (afforestation compositions) used, the nature and intensity of degradation, through the direct effect of protective forest crops; for example after 5-10 years, on moderately to heavily eroded slopes and 8-15 years, on very heavily to excessively eroded slopes [5,8].

The stabilization of lands affected by deep erosion processes and mass displacement occurred more slowly, as a result of the less active growth of the few forest species that could be installed in the seasonal conditions specific to these lands (scots pine, black pine, acacia, mountain ash, White Sea buckthorn, hawthorn and white alder).

On large deep erosion formations where afforestation works were not adequately supported by works to consolidate the hydrographical network, the stabilization of deep erosion was partially achieved, and in areas not affected by active erosion and mass displacement processes, after 15-20 years from the execution of the works.

Mass displacement processes (predominantly landslides) were stopped or considerably reduced, on more than 80% of the surface, after a period of 15-25 years from the execution of the works to consolidate the riverbeds and slopes and to plant forest trees and shrubs. The analyses carried out highlighted the following representative situations regarding the period of time after which the extinction of displacement processes or their considerable attenuation was achieved: superficial mud or plastic flows, after 15 years from the execution of the works; superficial landslides, after 10-15 years from the execution of the works; deep landslides, after 15-25 years from the execution of the works [2,4].

The research also highlights situations where the emphasis was placed on the execution of a large volume of hydrotechnical works, with exaggerated emphasis on ensuring a high alluvial retention capacity (i.e. on mitigating the effects). Under the specific conditions shown, of the torrential formations in the Curvature Subcarpathians area as well as other areas with similar conditions, after the retention capacity of the executed works has been exhausted, in situations where there has been no significant intervention with development works in the hydrographical basins, the alluvial transit and liquid flows remain substantially equal to those achieved before the transverse hydrotechnical works [7,8].

These works are, in turn, exposed to continuous degradation over time. Some of these deficiencies are also due to the fact that the development works in the basin (on the slopes) have in most cases been of a limited nature, both in terms of hydrology and anti-erosion. It is necessary to specify that the failure to execute the entire complex of development works was mainly due to the fact that in the territories we are referring to there were different forms of ownership, and the necessary coordination and combination of financial and human efforts could not be achieved at the level of the entire river basin [3,7].

Regarding the functional efficiency of silvotechnical works for the consolidation and arrangement of the slopes and slopes adjacent to torrential streams, associated with protective forest crops; on the slopes in the neighbourhoods of the torrentialized hydrographic network „with very strongly and excessively eroded lands, banks and slopes (often affected by mass movement processes), the reduction of degradation processes was achieved in most situations by installing forest vegetation.

To ensure the success of this action, sustained interventions and adequate technologies are necessary to ensure at least the minimum conditions of stability and nutrition of forest trees and shrubs, compatible with these situations.

The slope stabilization and improvement works carried out in areas adjacent to the torrential hydrographic network, which have proven effective, include: contour terraces supported by wooden fences, arranged at 2–3 m intervals on land subject to severe erosion and on ravine slopes with a lithological substrate of soft rocks; terraces reinforced with dry stone masonry benches, applied under similar conditions as the fences but on skeletal soils with high stone content; and terraces consolidated with vegetative material, using branches, stems, and shoots of sea buckthorn, applied on the same categories of land where fence- or bench-supported terraces are recommended [7].

The types of forest crops that have shown good evolution and achieved high efficiency in stopping erosion on lands near the torrential hydrographic network (very strongly and excessively eroded slopes and slopes) have proven to be the following: acacia crops, on light to medium soils, from the forest-steppe to the sessile oak subzone; black pine crops mixed with deciduous trees (wild cherry, flowering ash), Turkish cherry, blood cherry, dogwood, etc.), on very strongly eroded lands, as well as black pine crops in association with sea buckthorn, on very strongly to excessively eroded lands, from the forest-steppe to the spruce subzone; Scots pine crops, in mixtures similar to those shown for black pine, on the same categories of eroded lands, but with light to medium soils from the oak subzone to the middle part of the spruce subzone; sea buckthorn crops, on slopes and very strongly and excessively eroded lands, on slopes over 35 degrees, on substrates of marl with sandstone and gypsum, from the forest-steppe to the sessile oak subzone.

In conditions of relief, rock and precipitation, very favourable to the creation of a potential state of torrentially, the main factors that led to the triggering of torrential phenomena in the mountainous and hilly areas of our country and, implicitly, to the disruption of the hydrological regime of most watercourses, consisted of the alteration of the protective functions of the vegetation cover, and the disruption of the physical and biological functions of the soils.

In particular, through the irrational exploitation and wild destruction of forests - this important factor regulating the flow of watercourses - the conditions were created for the triggering of intense torrential phenomena, as a result of which almost all branches of the national economy suffer, year after year, directly or indirectly, significant damage.

Torrential and land degradation phenomena are felt over a much larger area than the one on which they occur, causing damage to the national economy mainly through:
- the decrease or even total loss of soil fertility;
- the disruption of the normal hydrological regime of natural watercourses, with all the particularly damaging consequences that arise from this disruption: favouring the occurrence of catastrophic floods; damage or destruction of objects intercepted by floods (industrial installations, hydroelectric facilities, communication routes, human settlements); clogging of reservoirs; raising the bed of large watercourses in the middle and lower areas.

Table 1. Altitude, slope and exposure of the terrain

Altitude					**Slope**				**Exposure**		
100-400 m	401-600 m	601-800 m	801-1000 m	1001-1200 m	<16º	16-30º	31-40º	>40º	Sunny	Partial sunny	Shady
ha %	ha %	ha %	ha %	ha %	ha%	ha%	ha%	ha%	ha%	ha%	ha%

55,4	654,6	2226,6	1157,5	149,2	57,2	2498,8	1673,9	13,4	1223,9	2329,1	690,3
1	15	53	27	4	1	60	39	-	29	55	16

From the point of view of forest vegetation, the influence is manifested by the fact that on the wetter and colder slopes (Western part of U.P.) beech and fir have settled, while on the sunnier slopes, in addition to beech and fir, linden, oak and hornbeam are also found.

The morphological unit that characterizes the basin is the slope with an undulating configuration, with slopes varying from moderate to very high and steep values.

From a climatic point of view, the region where the production unit is located is characterized by a temperate continental climate, directly influenced by the Mediterranean climate. Winters are moderate and not too long, springs are early and short, summers are warm and less humid, and autumns are long, sometimes dry.

The data entered in the following tables were extracted from the "Climatological Atlas" within the limits of the isohyets and isobars that cross the territory of the production unit, giving them altitudinal values.

Table 2. Thermic regime

Month	Monthly average				Average	
	Altitudinal zone				Daily maximums	Daily minimums
	200-400	401-600	601-800	801-1200		
	1%	16%	52%	31%		
I	0 -1	-1 -2	-3 -4	-4 -6	0 +1	-6 -4
II	0 -1	-1 -2	-3 -4	-4 -6	0 +2	-4 -5
III	+2 +4	+1 +3	0 -2	-2 -4	+6 +8	-2 -6
IV	+6 +8	+5 +7	+4 +6	+4 +6	+12 +14	0 +2
V	+8 +10	+7 +9	+4 +6	+3 +5	+18 +20	+2 +4
VI	+12 +14	+11 +13	+8 +10	+6 +8	+22 +24	+8 +10
VII	+18 +20	+17 +19	+14 +15	+12 +14	+24 +26	+12 +14
VIII	+20 +22	+19 +21	+16 +18	+14 +16	+24 +26	+12 +14
IX	+15 +16	+14 +15	+9 +11	+9 +11	+20 +22	+8 +10
X	+11 +12	+10 +11	+8 +9	+6 +8	+12 +14	+4 +6
XI	+5 +6	+4 +5	+2 +3	+1 +2	+6 +8	0 +1
XII	+2 +1	+1 0	-1 -2	-2 -4	0 +2	-4 -5
Media	+11	+10	+8,5	+7,5	-	-

It can be seen that the duration of the warm period starts in May and lasts until October; the duration of the hot period is in July and August; the absolute minimum temperature is -30ºC; the average duration of the interval with the average temperature above 0ºC is about 200-230 days, and the repeated late frosts damage plantations of sensitive species.

Table 3. Precipitation amounts

Month	Amounts (mm)		
	Altitude zone		
	180 – 650 m	651 – 900 m	901 – 1100 m
I	50 – 80	60 – 80	80 – 100
II	40 – 60	60 – 80	80 – 100
III	50 – 80	60 – 80	80 – 100
IV	60 – 80	80 – 100	80 – 100

V	70 – 100	110 – 130	120 – 140
VI	100 – 140	130 – 150	140 – 160
VII	60 – 100	110 – 150	120 – 160
VIII	80 – 100	90 – 110	100 – 120
IX	50 – 80	70 – 90	80 – 100
X	60 – 80	70 – 90	80 – 100
XI	50 – 90	70 – 90	80 – 100
XII	60 – 90	80 – 100	80 – 100
Total	750 – 900	900 – 1050	1050 – 1200

Table 3, presents the monthly and annual average precipitation values corresponding to the three altitudinal zones. The data indicate the following: the annual number of days with measurable precipitation (≥0.1 mm) ranges between 140 and 160; the number of days with snowfall varies between 30 and 50; snow cover persists for approximately 60 to 100 days per year; while the mean aridity index has a value of 49.

The climate data were taken from the Bozovici meteorological station. Due to its location in the southwestern part of the country and benefiting from the shelter of the Semenic and Anina Mountains, the temperate-continental climate has Mediterranean influences, which confers a moderate character to the thermal regime, with frequent warming periods in winter, early springs and relatively high amounts of precipitation.

The advection of moist air masses from the west and southwest prevails throughout the year, with more intense atmospheric front activity. For this reason, the average annual and monthly temperatures have smaller amplitudes than in other areas of the country, located at the same altitude and latitude.

The surface of the Nera Valley basin is mainly occupied by forest. The dynamics of the development of torrential processes in the basin, as well as the nature and importance of the objectives endangered by floods, justify the necessity and opportunity of intervention with hydrotechnical works within the torrential network in the basin. These works will supplement the effect of the measures and works designed on the slopes of the basin. The hydrotechnical solution for the arrangement of the hydrographic network will be designed from a suite of several transverse hydrotechnical works (dams) connected to the downstream bank of the first dam through an outlet channel.

Transversal works that will be carried out in the river basin will have the following functions: levelling and consolidating the riverbed; mitigating floods and retaining alluvium brought by floods; creating favourable conditions for the installation of forest vegetation on the landings between the works and on the alluvium source lands on the bank.

Given the energetic function of torrential watershed management works, and considering that the pronounced dynamics of hydro-morphogenetic processes are associated with high kinetic energy flows, the selection of both the location and type of intervention requires a careful quantification and analysis of the energy-related factors involved.

Conclusions

The analysis of the data obtained in the present study allows us to outline several important conclusions:

- the investigated basin covers an area of 190 ha and is characterized by steep slopes. With gradients averaging 21%, water flow along the slopes does not concentrate very rapidly.
- the calculated Gravelius coefficient is 1.84, indicating that the basin is relatively large and elongated in shape, a factor that can favor a relatively fast concentration of flood discharges toward the control section.
- the hydrographic network, extending over approximately 2700 m, presents numerous branches, leading to a dissected relief marked by short and steep slopes.
- because of the friable substrate and the high velocity of flood flows, significant erosion processes occur in the riverbeds, often accompanied by landslides and bank collapses.
- the mean runoff time along the slopes is about 27 minutes, while the travel time along the main riverbed, from source to the outlet section, is approximately 19 minutes.
- high sediment transport contributes to the accumulation of deposits, and due to the instability of the channel, strong floods may generate secondary watercourses.

- the hydrographic network shows pronounced degradation, with frequent changes in channel shape and position following flood events, largely due to sediment deposition.
- forestry operations in the catchment area have left behind woody debris (branches, stumps, logs) in the riverbed, narrowing flow sections and diverting water onto routes that pose risks to the forest road.

In light of the natural, social, and economic conditions that have influenced the occurrence and development of torrential processes, technical measures for slope stabilization must be tailored to land use, vegetation type and structure, as well as to the characteristics and intensity of degradation processes.

The overall strategy for improving torrential basins involves a complex of hydrotechnical works aimed at enhancing the hydrological balance and reducing erosion risks. These measures also seek to optimize the protective and hydrological role of forest stands, while ensuring the maintenance of a continuous grass cover in meadow areas, which prevents the initiation of erosion processes and slows their development where they occur.

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