

ENGINEERING MEASURES FOR LANDSLIDE PREVENTING AND MITIGATION IN REDIU-ALDEI AREA, IASI COUNTY

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Abstract

The annual rainfall, relief and inappropriate anthropogenic interventions, in the absence of specific landscaping works in the slopes, have resulted in severe degradation processes in the Rediu-Aldei area. In the perimeter, some physico-geological processes were identified and localized, such as active, semi-active and stabilized landslides, ravines, collapsing areas, areas with excess humidity, the main weight being nonetheless landslides. The slope landscaping is opportune because the sliding process over time intensifies and has a major negative economic and social impact and even unpredictable environmental conditions. In this way the protection and the avoidance of particularly serious damages on the agricultural land in the perimeter, as well as other social-economic objectives in the area, consisting of numerous individual households, roads, electrical networks, can be ensured. At the same time, the degradation of environmental conditions and the improvement of existing ones, which are severely affected due to the landslides produced, are avoided. In the paper will be proposed and analyzed specific works on the existing field problems.

Key words: anti-erosion works, soil erosion, landslides, Iasi county.

INTRODUCTION

From an administrative point of view, the area where to propose solutions and works to prevent and combat landslides is located in Iasi County and is part of the Aroneanu village.

The area under study is delimited as follows: to the north - Valea Leta, to the east - Valea Leta and Valea Satului, to the south - the limit of the territory of the commune of Holboca and to the west Chirita brook. The access to the area is made on the communal road DC 17 Iași and DC 19 Iași - Golaești.

Rediu Aldei perimeter is located at the contact between the major geomorphological units - Moldavia Plain to the north and Moldavian Central Plateau to the south.

From the morphological point of view, the studied area meets the characteristics of both units, specific being the presence of the cue relief of cuestas.

The main hills that appear in the area on the left bank of the Chirita stream are oriented from north to south as follows: Leta hill, Coman hill and Rediu Aldei hill.

The physico-geological phenomena affect the entire morphology of the studied area, they are

represented by active, semi-stabilized and stabilized landslides.

Due to the appearance loessoid soils and high relief of the area, there have been numerous active ravines and slopes on the slopes with depths of 2-10 m, the only stable areas being hillocks occurring in the confluence areas.

From a geological point of view, the researched area represents a small part of the large unit of the Moldovan Platform, which develops Sarmatian (Bessarabian and Kersonian) and quaternary deposits.

The underground waters in the perimeter are cantonated at the base of the quaternary deposits in the sandy formations of the latter. Their flow and chemistry varies greatly depending on the geological formations in which they are cantoned (on the slope or the meadow). In areas of landslides, several springs are reported, which are cantonated in the sandy intersections of the loessoid complex, some of which flow constantly, sometimes forming muddy portions. The number of springs can be higher, especially during precipitation periods.

From a climatic point of view, the area has a prominent continental character, falling into the sub-wet steppe. According to data from Iasi,

the average annual air temperature is 9.4°C. The average for January is -3.7°C, and June for 20.4°C. The main feature of the area is the uniform distribution of rainfall and their torrentiality. Thus, the average annual precipitation value is 537.5 mm, with maximum rainfall values in 24 hours during the vegetation period between 50 and 110 mm.

The water regime from precipitation indicates a low rate in the cold season with a minimum in February. In the warm season, rainfall sometimes has a pronounced torrential character, especially in the summer, when the showers are recorded with a high intensity. Hailstones are very rare and have a local character.

The wind regime shows that 27% of the time is calm, the rest of the time manifested in winter, winds from the northwest and north, and in the spring from the south-east and east.

From a hydrographic point of view, the area falls into the lower basin of the Bahlui River, whose valley flows from west to east and the Jijia River, which has the same flow direction.

The surface waters concentrated on the valleys separating the hills in the area represent the tributaries on the left side of the Bahlui River, of small importance and with low flows, oriented to NNW-SSE, the most important of which constituted the western limit of the studied area: the Chirița stream, which springs from the north of Icușeni, crosses the villages of Rediu Aldei, the Lungă Valley and flows southwards into the accumulation of Chirița (Aroneanu).

In this brook a series of torrential runoff from the existing ravines on the adjacent slopes, and plugging existing beds and ponds downstream, causing excess humidity in the low meadow areas.

By regressive erosion and implicitly the deepening of the depth erosion formation, there has been a submergence of the sloping foot, the emergence of new springs, these being one of the main causes of the stability of the slopes and, implicitly, of the landslides in the area of Rediu Aldei.

For the pedological characterization of the analyzed area, the studies elaborated by the County Office of Pedological and Agrochemical Studies Iași.

From an economic point of view, agricultural lands represent 87.8% of the proposed surface

area to be arranged with a capacity to works, of which the degraded grasslands have a significant share due to erosion and landslides, and non-agricultural land represents 12.2% of the total area proposed for landscaping, generally made of non-productive land due to active landslides and deep erosion.

MATERIALS AND METHODS

The detailed mapping carried out in the Rediu Aldei perimeter led to the identification and localization of physico-geological processes, such as active, semi-active and stabilized landslides, ravines, collapsing areas, humid excess areas, the main weight being the landslides.

As a working methodology, was used the inventory of agricultural lands in the studied area, as they were recorded in the cadastral registers of Iasi County, on administrative units, on the most recent topographic maps and even with the help of the Google Earth site.

In order to know the complex problems of the quality of the ground-land units in terms of the sustainable use of land resources, a study was carried out on the current state of the land and land improvement works in the Rediu-Aldei area; at OSPA Iasi, APIA Iasi, North-East Region ANIF, Agricultural Chamber in Aroneanu. Soil maps were also used at scales 1: 200 000 and 1: 100 000.

RESULTS AND DISCUSSIONS

To prevent and combat landslides, a series of works are proposed, namely:

- land planning with landslides on an area of about 420 ha through drainage channels of interception - capture - evacuation of groundwater which feeds landslides and eliminates excess moisture from the soil profile, collecting springs, interception and control channels for surface leakage and forest protection plantations.
- planning of valleys and ravines on approximately 8 km through transversal works which consists of reinforced soil dams, concrete thresholds and forced slopes, storm drains, including culverts on agricultural technology roads and forest protection plantations.

I Improvement works proposed and variants analyzed

Starting from the new existing conditions, regarding the land ownership structure in the perimeter, with a share of 59% of the private property, it is planned to design and carry out the works for prevention and control of the landslides, including the other works to combat soil erosion associated with a new design concept, with viable solutions that can be applied in stages.

On arable surfaces affected by surface erosion, specific works such as terraces and buffer strips can be done by landowners after increasing their private property or creation of associations, which will lead to an even more substantial reduction of soil loss on these lands. Taking into consideration the specificity of the necessary fitting works and their purpose, it is important to perform a comparative technical-economical analysis of two or more variants. Several variants will be analyzed from the point of view of the planning scheme, as well as several constructive solutions for the realization of the works. So, the general scheme of landscaping proposed, results from the composition of the optimal technical and economical constructive solutions for each capacity, respectively type of works.

1. **Arrangement of slips** - They make up the main improvements works proposed by the present study, in terms of effect on improving the stability of sliding slopes and are proposed to be carried out on an area of 400 ha and comprises:

a) ***Works with interceptive, uptake and evacuation of groundwater*** - Interceptions, capture and rapid evacuation of groundwater, which feeds the landslides from the fronts groundwater, coming from the high plateau or rain fallen directly on the surface slopes and which is currently the main cause of landslides produced, complemented by the collection and discharge of stagnant water at the surface of the land, which produce significant beneficial effects, leading to a substantial increase in the stability factor of the slopes by:

- reducing the heap of the sliding mass, by maintaining a low moisture content of downstream land;
- reduction or disappearance of the erosion-reducing process and the internal

friction angle of the soils forming the slipping mass;

- reducing the hydrodynamic force acting on downstream land by essentially modifying the underground current spectrum;
- avoiding infiltration of water at the level of the slip surface;
- avoiding the softening of the slope at the base of the detachment fronts;
- the delay of the physico-mechanical alteration process of the rock forming the massive at the top, by the catalyst factor that represents the water in the process of alteration;

b) ***Biological consolidation works through forest protection plantations*** - Are planned works both for the consolidation of the lands through the roots that carry out their biological reinforcement, and for the provision of forestry use on degraded surfaces due to landslides.

Forest protection plantations are proposed to be built on an area of about 35 hectares, in the areas of cornices, detachment steps, land with excessive erosion and active landslides, which cannot be used in the agricultural circuit. Plantations may be of the following species: willow (*Eleganus angustifolia*) - 20%, acacia (*Robinia pseudoacacia*) - 60%, wicker (*Salix purpurea*) - 20%.

2. **Planning of valleys and ravines.** It is proposed to be improvement about 10 km of valleys and ravines to prevent the development of landslides by undermining their base and defending neighboring agricultural lands through transversal works, escape channels and forest protection plantings.

a) ***Cross-sectional work.*** A possible scheme landscaping with works could be designed for production a compensation slope in the longitudinal profile on ravines, optimal technically-economical, comprising 1 earth dam, 7 concrete thresholds and 3 forced slopes. In order to establish an optimal technical and economical solution development for the formation of deep erosion with transversal works to stabilize them and to retain the alluvial material, can be analyze several constructive solutions for the accomplishment of the works, with the provision of technologies and

performance materials at the level those currently used worldwide.

Earthfill dams and forced slopes with heights between 3 and 5 m. The earthfill dam is analyzed in four constructive solutions, namely:

- ❖ Earthfill dam, with the spillway, rapid channel and dissipator basin consolidated with reinforced concrete casting on the spot;
- ❖ Earthfill dam, with the spillway, rapid channel and dissipator basin, consolidated with modulated prefabricated of reinforced concrete;
- ❖ Earthfill dam, reinforced with geogrids, with the spillway and the dissipator basin consolidated with modulated prefabricated of reinforced concrete;
- ❖ Filterable dams, from prefabricated elements.

Thresholds, with heights between 1.0 m and 1.5 m, were analyzed in three constructive solutions:

- ❖ Concrete thresholds;
- ❖ Thresholds made of modulated prefabricated of reinforced concrete;
- ❖ Gabion thresholds with galvanized wire mesh.

b) **Drainage channels** of water from valleys and ravines in the emissary. It is proposed for a length of 5 km to ensure the ability to transport of natural river bank and to avoid flooding in the locality of Rediu-Aldei and on the neighboring agricultural lands, in part to ensure the collector drainage rates.

In the built-up area, in small spaces or the dejection cones of the ravines, a consolidation solution that could be analyzed is the one with 100 mm geo-cell, filled with earth and covered with a layer of biodegradable geotextile, fixed by means of concrete steel anchors, a solution that would be very expensive.

c) **Biological consolidation works** through forest protection installations. Are proposed for a surface area of 7.0 hectares, for the consolidation of their embankment and thalweg with a planting scheme consisting of species which are agreed by the animals: the willow (*Eleagnus angustifolia*), 2-3 rows on the banks of the ravine - 20%, sea-buckthorn (*Hippophae rhamnoides*), on embankment - 70% and wicker (*Salix purpurea*) on thalweg - 10%.

3. **Works to track evolution over time on landslide.** For the time tracking of the

evolution of the landslides and the efficiency, respectively the behavior of the designed works, the following are proposed:

a) **A topometric landmarks network, consisting of:**

- The topometers that will highlight the support points that will be at the same time and the points of the station where the measurements will be made and which will be materialized by 8 reinforced concrete beams in the shape of a pyramid of great dimensions, planted in the lands stable;
- Topometric tracking landmarks, materialized by 20 reinforced concrete bollards, planted on lands with active landslides.

The final positioning of the topometric landmarks in the field and their installation will be done after the basic work has been done.

b) **A network of stationary hydrogeological**, composed of 12 observation wells with an average depth of 12 m, arranged in 3 hydrogeological profiles through main slides, to track the evolution of groundwater levels and chemistry.

II. Works and agro-technical measures

In addition to the forest protection plantations, it is necessary to complement in addition a complex of works and measures of agropodoameliorative character, which ensure:

✚ Achieving a continuous slope of the land, including a gutters system, with the elimination of microdepressors where water stagnates and the sealing of cracks, allowing the regulation of superficial runoff and avoiding rapid infiltration of water to the sliding bed;

✚ Biological consolidation by grassed, by creating a well-worn herbaceous carpet on the lands covered with meadows;

✚ Transforming the non-agricultural use categories provided as a result of carrying out investment works for agricultural purposes;

✚ Increasing the productive capacity of the arable land and of the agricultural productions at the foreseen levels, mainly due to the elimination of the excess moisture in the soil profile in the areas where it is manifested on extended surfaces but also the reduction of erosion soil losses.

The necessary agropodoameliorative works and measures are:

1) Correction of the slope of the land by its easy modeling and the creation of drainage gutters on active landslides on a surface of 46 ha with a specific landfill volume of about 200 m³ / ha;

2) Works of creations and improvements of meadows on a total area of 218 ha, of which 46 ha of sowing (active landslides and non-agricultural lands which are transformed into pastures and meadows and on where land-modeling works are carried out) and 172 hectares of over-sowing (on semi-active and stabilized landslides), including necessary fertilization work. The following mixture of perennial herbs is recommended for sowing: *Bromus inermis* - 70% and *Onobrychis viciapholia* - 30%. In case of oversowing, the following mixture will be used: *Bromus inermis* - 50%; *Agropyrum cristatum* - 10%; *Onobrychis viciapholia* - 20%; *Lothus corniculatus* - 20%.

For fertilization of meadows for optimal germination conditions of herbaceous seeds and the creation of a rich herbaceous carpet, 200 kg/ha of active substance and calcium superphosphate 100 kg/ha of active substance will be used. These chemical fertilizers can be replaced by 20 t/ha of manure.

3) Works of deep loosening (scarification) 50-60 cm, an area of about 100 hectares to improve soil permeability for water and air, on land where excess moisture in the soil profile is manifested on extended surfaces and on which horizontal drainage works are planned.

4) Measures on the application on arable lands of specific agrotechnics on lands in the slope by performing all the cultural works only on the level curve and the crops in strips.

CONCLUSIONS

By realizing the entire complex of proposed works for preventing and fighting the landslides in the Rediu Aldei area, it will be ensured first of all avoiding the reactivation and intensification of the landslides and of the deep erosion formations respectively, eliminating the possibility of extension of the out-of-area areas. At the same time, about 2 ha of land is transformed into productive agricultural land and turns into forest plantations about 42 ha, currently non-agricultural land, while removing

excess surface moisture and soil profile and reducing soil loss through erosion, resulting in a significant increase of the agricultural output obtained on the other lands.

There are also beneficial effects on other socio-economic objectives, namely: avoiding to the damage to individual households in the vicinity of the slopes, avoiding damage to municipal roads in the area, reducing the intensity of clogging of Chirița accumulation.

Active landslides have profound consequences both on the environment and especially on the water regime, the floods being generated and aggravated by erosion as well as on social economic objectives.

Unlike the above synthetically presented, it results that landslides landscaped, simpler or more complex, can only have positive ecological consequences (favorable impact). Through the landscaping work, ecological changes are expected in wider spaces, including climate, flora and fauna.

Drainage works proposed in areas affected by landslides will allow the removal of excess moisture from the soil profile, preventing the infiltration of water to the sliding bed, thus reducing the risk of landslides triggering.

Designed transverse work will help to achieve the compensation slope so that the volume of the entrained materials is equal to the volume of deposited alluvial materials, leading to a deformation of the depth erosion process that could have negative influences on the stability of the slippery slopes. Thus, alluvial spills will be reduced and their deposition in watercourses, agricultural lands, crops will be diminished. At the same time, in the area of each transversal work, it will be possible to cover the soil with vegetation, which will lead to stabilization of the base of the slopes that will develop over time and due to the forest protection plantations.

Forest plantations in the area of transverse works, from torrential formations, cornice and with landslide areas, will have multiple functionality, besides the role of soil fixing in areas with high potential for landslide activation and environmental protection and can be used later as natural resources. These plantations also contribute and to brake leakage, maintenance of fertile soil in the perimeter, and cessation of landslide.

By carrying out the proposed works, the soil erosion process will be reduced, it will limit and reduce the areas affected by landslides, and the zone microclimate will also be modified.

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