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THE IMPACT OF CLIMATE CHANGE ON SLOPE GEOLOGICAL PROCESSES (WITH THE EXAMPLE OF HOVK COMMUNITY LANDSLIDE)

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Summary: *Climate change in mountainous areas increases the likelihood of activation of slope geological processes. Due to climate change, the total amount of precipitation in the South Caucasus has decreased by 10-15%. At the same time, the intensity of precipitation increases, as a result of which surface and groundwater flows increase. Increased intensity of surface erosion and the rise of groundwater level, especially in steep slopes, contribute to activation of landslides or their reactivation. For sustainable and safe development of communities, it is very important to study the risks and hazards of climate change, to assess them, and to plan the measures to mitigate the effects.*

Key Words: *Climate change, landslide, risks and hazards*

Introduction.

The area of the Republic of Armenia is characterized by intense and wide-scale development of landslide processes. More than 3,500 landslides have been mapped in the entire area of Armenia. These landslides and zones exposed to their likely impacts cover about 4% of the area of Armenia, and more than 10% of all populated areas are located within landslide-prone areas or adjacent to them. Landslides exist in any region with steep and high-elevation mountain slopes [1]. During the last 20 years, the Ministry of Emergency Situations of the RA recorded 166 cases of landslide activation, of which 25% occurred in Tavush region. To understand the reasons for the activation of landslides in the Tavush region, let us consider the landslide of Hovq community. The settlement of Hovq is situated in Tavush region, on the Yerevan-Ijevan inter-state M4 Highway, on the left-bank slope of the Aghstev River valley. Active slope effects that are observed in the eastern part of the Hovq settlement manifest themselves as landslides. The landslide develops in an area south of the watershed of the Ijevan mountain range, delimited by the Aghstev River. Two landslide toes rest upon the left bank of the Aghstev River. Landslide dimensions encompass almost the entire area of the settlement (Figure 1). The landslide has developed on a natural slope with an angle of 35-50°. The annual intensity of precipitation in the Hovq settlement corresponds to 800-900 mm. The Hovq landslide has been activated several times, and, as a consequence, 70 houses in the settlement turned extremely dangerous to live in, about 350 m long site within the 117 kmth section of the Yerevan-Ijevan Highway was completely closed, and the channel of the Aghstev River was partially dammed; as a result people, vehicles, etc were damaged [2].

Study.

The Hovq landslide represents a slide displaying very slow (creep-like) dynamics, characterized by motion dynamics at the rate of 0.3 m during up to 5 years. Landslides of this type do not pose hazard generally, and are not risky for the communities. Abundance of deformations and cracks (joints) are characteristic for creep-type landslides (Figure 2).

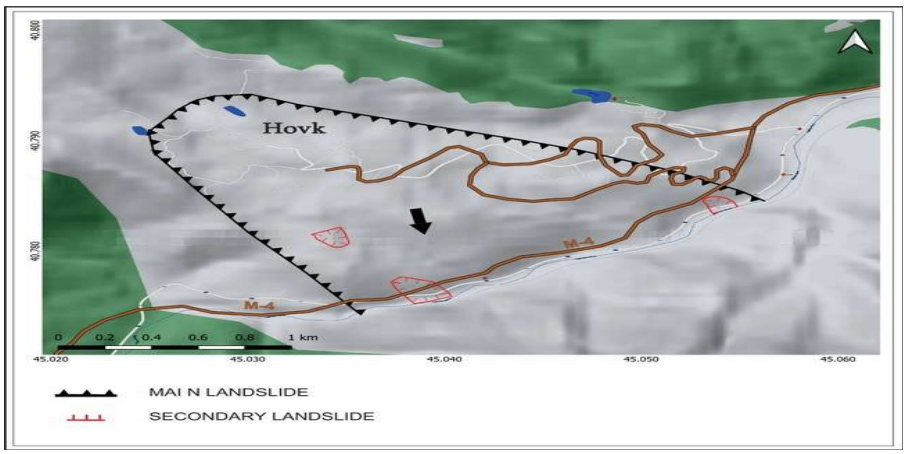

Fig. 1. Structure of the Hovq Community landslide, black lines outline the general area of the landslide (main landslide body), and red lines contour the secondary landslides that have developed this year

Water flows generated during rapid snow melting or long-term precipitation periods infiltrate also through these cracks inside the landslide body, and lead to the rise of groundwater level and over-saturation of the soils with water (Figure 3). The over-moistening leads to changes of the physical parameters of soils such as cohesion coefficient, internal friction angle, and other indicators. Therefore, it is not by coincidence that landslides found in critical equilibrium state can become active under the impact of weather anomaly manifestations resulting from climate change. In 2010, intense atmospheric precipitation preceded landslide body activation recorded at the settlement of Hovq [4]. The over-moistening leads to changes of the physical parameters of soils such as cohesion coefficient, internal friction angle, and other indicators. Therefore, it is not by coincidence that landslides found in critical equilibrium state can become active under the impact of weather anomaly manifestations resulting from climate change.

Fig. 2. Cracks (joints) observed in the landslide site of the Hovq settlement

In 2010, intense atmospheric precipitation preceded landslide body activation recorded at the settlement of Hovq [4]. The landslide became active also in February 2021, which led to the damage of houses, generation of two new landslides, and more features of soil deformation and cracks developing in the settlement area. As per accounts of the villagers, intense precipitation preceded the landslide activation. The amounts of precipitation in the month of February recorded in the community over the last 30 years were analyzed to clarify if the last landslide activation at the Hovq settlement could have been related with climate change.

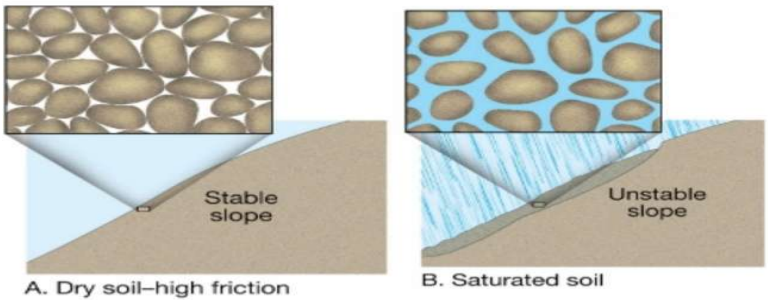

Fig. 3. Schematic layout illustrating the impact on the soils caused by water infiltrating into the landslide body in case of intense precipitation – stable slope, unstable slope, dry soil, water-saturated soil [3].

The analysis makes it clear that the daily precipitation rate in February of this year exceeds the average precipitation rate for the month of February recorded during 30 years [5]. Hence, it is possible to suggest that among other factors, weather changes determined by climate change, and the growing intensity of precipitation and snow melting, in particular, also influence re-activation of the landslides.

Conclusion.

In mountainous countries, climate change produces new hazards and risks. Studies have demonstrated that among other circumstances, growing intensity of precipitation and weather anomaly manifestations determined by climate change contribute to landslide re-activation and increase the rate of vulnerability of settlements located in landslide-prone areas. Climate forecast scenarios attest that in spite of general reduction of the total rate of precipitation, its intensity is growing. Therefore, sustainable development of landslide-prone communities requires assessment of the hazard and risks, followed by elaboration of mitigation measures. To achieve this goal, it is extremely important to undertake capacity-building actions at the vulnerable communities, elucidate and familiarize the population with natural hazards specific for community settlements, develop skills that help both to recognize effects facilitating activation of natural hazards and precursory signs of such activation, and to work with the toolkit of simple techniques to cope with, mitigate and monitor such effects. This knowledge will contribute to the sustainable community development, reasonable land use of areas exposed to landslide hazard, and reduction of risks posed by natural hazards. Moreover, better awareness might preclude or reduce intense irrigation of landslide-prone areas, realization of earth works in sloping sections, and deforestation, and help to build a system of ditches in upper sections of the slopes to protect against intense precipitation, and other. Hence, communities can develop local capacities, elaborate climate change adaptation plans independently and reduce natural hazards and risks.

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