Dynamics of the Development of Natural Gravitational Processes (Landslides) In the Medium-Mountain Regions of Georgia: The Case of Imereti (2010–2022)

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ABSTRACT

Georgia, along with one of its most densely populated regions, Imereti, is considered one of the most challenging areas in terms of the scale of natural disasters, their temporal recurrence, and the damage they cause.

Out of a total of 544 settlements in 11 municipalities of the Imereti region, 73 are located in the high-risk zone of landslide processes, 151 in the medium-risk zone, 152 in the low-risk zone, and 168 settlements belong to the non-hazardous zone; In the study region, there was an extreme activation of landslides in those years when the quantitative indicator of atmospheric precipitation significantly exceeded the multi-year average, especially in the amount and frequency of precipitation.

It is necessary to conduct geomonitoring in all settlements of the study region in the future, regardless of the hazard risk; it is desirable that in the near future (2-3 years) all settlements and the land plots and infrastructure within their area be assessed, on the basis of which appropriate specialized maps should be created for individual municipalities and communities according to hazard risk;

Keywords: landslides, gravitational processes, landslides and average long-term precipitation.

INTRODUCTION

Imereti is one of the most difficult medium-mountainous regions of Georgia in terms of the scale of development of natural and catastrophic events, their recurrence over time, and the consequences they have on the population and engineering and economic facilities.

The large-scale activation of natural processes in recent times and the increase in their recurrence intervals have been caused by: a sharp deviation from the average multi-year norm in the increase and frequency of monthly, daily and weekly precipitation caused by global climate change. The frequency of earthquakes in Georgia and the extremely high pressure of human activity on the environment - unsystematic urbanization of the territory, various types of engineering construction, which are often carried out with disregard for construction norms and rules, intensive and even unsystematic exploitation of agricultural lands, deforestation, improperly conducted mining operations, etc.

METHODOLOGY

Field-expeditionary, statistical, comparative analysis, cartographic, and other methods were used in the work. Imereti is a medium-mountainous region, in which four geomorphological units are distinguished: 1. The hilly foothills of the Guria-Imereti Range, 2. Upper Imereti Upland, 3. Guria-Imereti Range, 4. Colchis Lowland. The geological structure of the region includes rocks from the Paleozoic to the Quaternary age, which are represented by gneisses, diorites, granites, granitoids, tuff breccias, tuff sandstones, argilites, shales, sandstones, limestones, marls, conglomerates, sands, clay-loams, and others (8). Among the dangerous geological processes in Imereti, landslides dominate, which are manifested with greater or lesser activity in all municipalities of the Imereti region.

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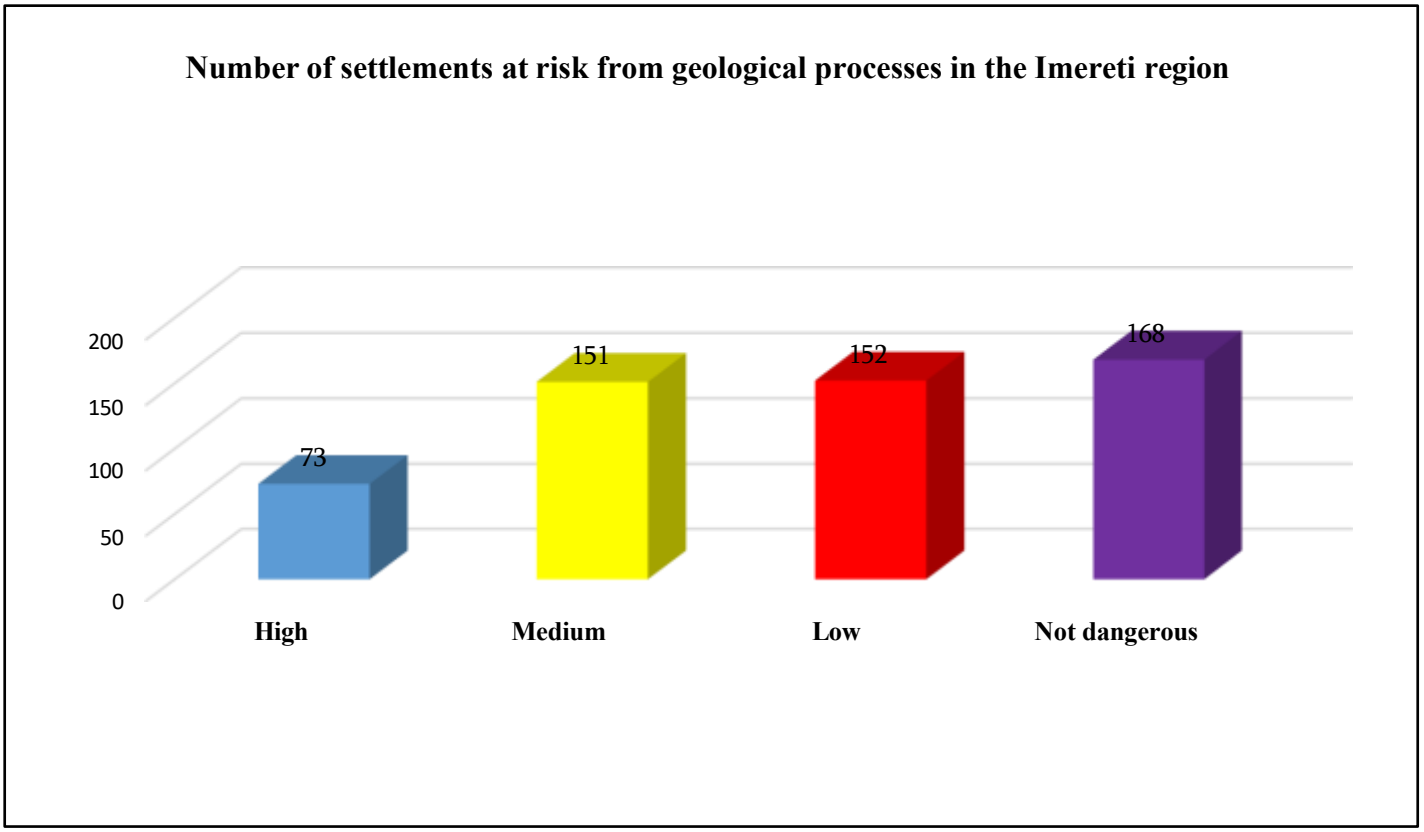
Considering the scale and intensity of the development of landslide-gravity processes, Imereti is located in a region with an exceptionally high damage coefficient (K=0.7-0.9) for the development of landslide processes and a very high potential for the development of landslides (6). There are a total of 544 settlements in the 11 municipalities of Imereti. 73 settlements are located in the high-hazard risk zone, 151 in the medium-hazard risk zone, 152 in the low-hazard risk zone, and 168 settlements belong to the non-hazardous zone (5).

Diagram 1.



The risk of landslides is mainly increased by seismic events (earthquakes), deviations of atmospheric precipitation from the average multi-year norm, and large amounts of precipitation (more than 30 mm) during the day and night. Landslides in the Imereti region manifest themselves with varying intensity in connection with changes in climatic conditions, in particular, the amount of atmospheric precipitation (9).

In the study region, there was an extreme activation of landslides in those years when the quantitative indicator of atmospheric precipitation significantly exceeded the average multi-year average, especially in terms of the amount of precipitation and its recurrence in time. In 2009, 1045 mm of precipitation fell in Sachkhere, while the average multi-year norm was only 910 mm, and the deviation from the norm was + 135 mm, and the following year the deviation from the average multi-year norm was + 105 mm. Against the background of a positive deviation of precipitation, large-scale development of landslide processes was observed. They were provoked by precipitation (48 mm and 54 mm) (1).

In 2012-2014, the amount of atmospheric precipitation in the study region did not exceed the average annual indicator, therefore, less activity of landslide processes was noted (2).

In 2015, landslide-gravity processes were activated in Imereti, as shown in Table #1, there was a deviation from the average multi-year norms of atmospheric precipitation, in particular, 495 mm more precipitation fell in Zestaponi, and an increase from the average annual norm was also noted according to the data of the Sachkhere and Sabueti meteorological stations, which in turn led to the activation of old landslide bodies in certain areas and the emergence of new landslide centers.

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Amount of atmospheric precipitation in the Imereti region in 2015

Table #1

Weather station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total	Average multi	Deviation from
Kutaisi	86,7	52,5	61,6	149,3	51,3	46,7	35,1	40,9	1,8	168,9	244,5	-	694,8	1436	-741
Zestafoni	115,5	73,8	126,7	240,9	102,1	130,2	29,9	120,8	8,1	243	356,3	187,7	1191	1258	+495
Sachkhere	41,0	38	32	110,0	99	78,0	33,0	117	5	230	153	40,0	936	960	+12
Sabueti	111,3	70,5	95,1	183,3	96,4	92,4	31,7	66,5	5	93,3	236,2	181,7	1263,3	1238	+25,3

Source: National Environmental Agency, Department of Geology, Newsletter 2015.

In total, in 2015, against the background of an increase in atmospheric precipitation above the average multi-year norm, 29 old landslides were activated in the Imereti region, covering a total area of 33.8 hectares, while 6 new landslide areas emerged and the landslide area amounted to 10.1 hectares (3). In total, 88 old landslides were activated in Imereti in 2019, covering 178.31 hectares.

Amount of atmospheric precipitation in the Imereti region in 2019 by month

Table #2

Weather station	I	II	III	IV	V	VI	VII	VII I	IX	X	XI	XII	Total	Average multi-	Deviation from
Kutaisi	103,1	117,8	146,9	104,2	36,8	69,7	80,7	105,6	179	102,4	63,6	108,8	1218,6	1436	-207
Sabueti	58,1	113,2	130	100,4	59,2	81,6	72,8	41,5	144,3	83,8	30,6	90,4	1600,2	1258	-249,8
Zestafo ni	51,4	61,8	92,6	104,8	90,4	60,9	144,2	103,4	100,3	71	52,0	70	1003,8	960	+43,8
Sachkhere	68,6	79,4	135,1	95,5	77,4	68,3,	82,7	52,1	119	41,1	38	63	1238	1238	-317,7

Source: National Environmental Agency, Department of Geology, Newsletter 2019

Deviation from the average annual norm of atmospheric precipitation was noted only in Sachkhere Municipality in 2019, and it was insignificant (+43.8 mm), therefore, theoretically, the activation of old landslides and the emergence and development of new landslide bodies were not expected, but if we look at the distribution of incoming atmospheric precipitation by months, it turns out that precipitation exceeding 30 mm (during the day and night) was recorded quite often in the study region. Kutaisi stands out for the frequency of heavy

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precipitation, sometimes the total daily precipitation even exceeded 60 mm. Zestaponi Municipality also stood out for heavy precipitation, where precipitation exceeding 30 mm was recorded for 4 days. In Sachkhere, there were 3 days.

In 2022, a total of 61 old landslide sites were activated, with a total area of 960 hectares. Of these, the largest number of old landslide sites was activated quantitatively in Zestaponi municipality with 11 landslide bodies on 15.86 hectares, in Kharagauli and Vani 9-9 landslides, respectively, the area of the landslide area was 469.81 and 179.61 hectares. In total, 35 new landslide sites appeared in the study region on 25.27 hectares. The largest number of new landslide centers appeared in Zestaponi (10; 2.84 hectares) and Tkibuli (8; 0.65 hectares) municipalities (5).

Amount of atmospheric precipitation in the Imereti region in 2022 by month

Table #3

Weather station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Total	Average multi-year rate	Deviation from the norm
Kutaisi	112,8	80,8	69,9	66,9	61,1	180,0	72,4	2,2	167,7	307,2	140,7	58,1	1319,8	1436	-116,2
Zestafoni	199,7	75,0	166,0	90,7	109,2	108,3	90,9	10,5	120,5	217,2	139,0	75,5	1402,5	1258	-144,5
Sachkhere	99,2	36,4	148,8	144,6	81,6	147,1	41,8	0	52,2	213,5	46,6	25,0	1036,8	960	+76,8
Sabueti	198,4	87,9	253,1	48,8	116,9	107,2	46,4	7,0	41,6	61,7	91,4	76,3	1136,7	1238	-101,3

Source: National Environmental Agency, Department of Geology, Newsletter 2022

Landslide processes either develop under favorable hydrological conditions or are associated with human economic activity. The role of the anthropogenic factor is also evident (Chiatura Municipality), where the development of landslide processes is associated with the extraction of buried manganese - there are frequent cases of collapse of abandoned tunnels, which, in the conditions of sloping terrain, give rise to landslides of the flowing type (6). As a result of mining operations, huge masses of rocks are disrupted. The total area of the so-called "industrial tailings" resulting from the enrichment of manganese ore is 18.5 ha, and the total mass is 6 million tons. Within the Chiatura structural plateau, unprecedented human activity has reached such a scale that there is every reason to declare this region an area of acute geoecological disaster. Because the naturally balanced landscapes created over centuries have been completely destroyed, and in their place are forming so-called "industrial deserts" - piles of rubble and uneven pits.

RESULTS

- In Imereti, as well as in Georgia as a whole, natural geological processes have become much more active since the beginning of the 21st century, which, together with extremely sensitive geological conditions, has led to: a) the intensification of high-intensity earthquakes; b) the increase in the frequency of meteorological events provoking geological processes against the background of global climate change -

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deviations from the average multi-year norm of atmospheric precipitation and an increase in the intensity of daily and nightly rainfall; c) large-scale human impact on the geological environment and a sharp disruption of its equilibrium - an increase in the scale of urbanization, the development of new territories, massive deforestation, etc.;

- Based on the analysis of the amount and distribution of atmospheric precipitation in the study region, it was found that if the annual precipitation rates are lower than the indicators characteristic of the multi-annual climate regime of Imereti, landslide processes do not activate; if the annual precipitation rate exceeds the multi-annual norm (within 100 mm), the degree of activation of landslide processes is within the background, and when the annual precipitation rates exceed the multi-annual norm by 400 mm, landslide processes begin to activate;

- Considering the scale and intensity of the development of landslide-gravity processes, Imereti is located in a region with an exceptionally high damage coefficient (K=0.7-0.9) for the development of landslide processes and a very high potential for the development of landslides;

- Out of a total of 544 settlements in the 11 municipalities of the Imereti region, 73 are in the high-risk zone, 151 in the medium-risk zone, 152 in the low-risk zone, and 168 settlements belong to the non-risk zone;

- Four main areas of landslide processes are distinguished in Imereti: a) the area of very high intensity of landslides, which mainly covers the Upper Imereti Plateau; b) the area of high intensity of landslides - includes the lower Okatse River basin and the inner Okriba in northwestern Imereti; c) the area of significant intensity of landslides extends over the Tskaltubo undulating plain, the foothills of Southern Imereti, and the northern slope of the Meskheti Range; d) the area of medium intensity of landslides includes the southern slope of the Racha Range, the upper Kvirila River basin, and the southern and southeastern narrowed arc-shaped part of the Okriba, which continues northeastward within the Mukhura-Khreiti range;

- In 2015, there was a deviation from the average multi-year norms of atmospheric precipitation in Imereti, namely, 495 mm more precipitation fell, as well as an increase from the average annual norm, which in turn led to the activation of old landslide bodies and the emergence of new landslide foci. In total, in 2015, against the background of an increase in atmospheric precipitation from the average multi-year norm, 29 old landslides were activated in the Imereti region, which covered a total area of 33.8 hectares, while 6 new landslide areas emerged and the landslide area amounted to 10.1 hectares.

- In the study region, a total of 61 old landslide areas were activated in 2022, and 35 new landslide areas emerged. Due to a slight deviation from the average annual norm of atmospheric precipitation (76.8 mm), the activation of old landslides and the emergence of new foci were theoretically not expected, but there was an influx of more than 30 mm of precipitation during the day and night, which was sufficient for the development of landslide processes.

- We consider it necessary to conduct geomonitoring in all settlements of the study region in the future, regardless of the hazard risk; it is desirable to assess all settlements in the near future and, based on this, create appropriate specialized maps according to hazard risk for individual municipalities, and it is important to create a reliable early warning system for geological disasters.

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