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Mudflow Phenomena in Eastern Georgia (Kakheti Region) and Their Development Trends Related to Climate Change

Geography

KEYWORDS : Mudflow phenomena, Hazard risk, Climate change

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ABSTRACT

Kakheti Region, which occupies 17.5% of Georgia's territory, occupies one of the leading places in the country's economic development, especially in the field of agriculture according to its natural landscape conditions. At the same time, the region is the most complicated area in Georgia and in general, within the Caucasus by the development scales of mudflow phenomena, recurrence rate, economic prejudice and risk of danger. More than a half of the territory is under the threat of the highest and high risk category.

According to historical reports in the Kakheti region even in the past the mudflow processes were extensively developed and created certain problems to settlements, as most of them are built in the old mudflow cones (including cities of Telavi, Sagarejo and Kvareli), due to which sometimes there were human victims.

If we rely on the expected trend of climate change for the period of 2020-2050, which has been developed by the Caucasus Environmental NGO (CENN) on the basis of the data of Sagarejo and Dedoplistskaro meteorological stations, the precipitation index indicates that for the next 30 years both the daily maximum amount of precipitation and the sum of 90-day precipitation will be increased. The number of the days per year will be increased as well, when the sum of daily precipitation is more than 10, 20 and 25. Correspondingly the annual sum of precipitation, among them more than 200mm, is increased, which will help to provoke the landslide processes and therefore, will increase the risk of danger of extreme mudflows transformation.

Thus, we should assume that according to the long-range forecast of landslide-mudflow processes a high risk of danger remains again in the region of Kakheti.

INTRODUCTION

Kakheti Region, which occupies 17.5% of Georgia's territory, occupies one of the leading places in the country's economic development, especially in the field of agriculture according to its natural landscape conditions. At the same time, the region is the most complicated area in Georgia and in general, within the Caucasus by the development scales of mudflow phenomena, recurrence rate, economic prejudice and risk of danger. All of the geomorphological units are damaged by the mudflow processes or are located in the hazardous areal, except the plain relief. More than a half of the territory is under the threat of the highest and high risk category (by ratios of 0.6-0.9) (Figure 1).

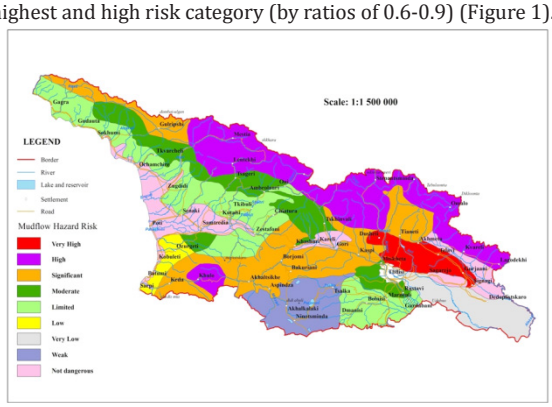

Figure 1. Zoning map of Georgia on the degree of exposure and the risk of mudflow activity processes

Kakheti mountainous area is almost unsettled. Great majority of the population is concentrated in the Caucasus foothills and Tsiv-Gombori bottom zones, the majority of whom are in the high-risk areas of mudflows, including the cities of Sagarejo, Telavi, Kvareli, Sighnaghi, Lagodekhi and Gurjaani. Mudflows periodically damage the roads and melioration-irrigation communications. Hundreds of hectares of highly fertile lands and vineyards are covered by stone – muddy mass. At the same time, it is noteworthy that the extreme revelation of mudflows is always accompanied by floods, which usually arise due to free water discharge after the power extinguished from the mudflow streams saturated by a solid material, after which in the plain relief area in the vast farm lands starts flooding, river banks washing and damage-destruction of nearby populated residential houses.

According to historical reports in the Kakheti region even in the past the mudflow processes were extensively developed and created certain problems to settlements, as most of them are built in the old mudflow cones (including cities of Telavi, Sagarejo and Kvareli), due to which sometimes there were human victims. A good example of this is the Duruji River, where the developed catastrophic floods (in 1899, 1906, 1947, 1949, 1963, 1967, 1975, 1978) took about 200 human lives from the Telavi city inhabitants; and in June of 1977 the mudflow, formed in the Telaviskhevi River in the Gombori range, made a direct economic loss to the infrastructure of Telavi city of about 30

million dollars.

CASE STUDY

At present in the Kakheti region the cadastre of about 250 mudflow river basins has been carried out, that pose a direct threat to the population, its infrastructure and engineering objects. Though, in fact, the total amount of mudflow transforming water pipes is five times more.

The rivers of mudflow character that are formed on the slopes of the Kakheti Caucasus and the Tsiv-Gombori range are of high risk potential for population. However, according to the formation of geological conditions, the mudflows, transformed within the areal of Kakheti Caucasus and the Tsiv-Gombori range, significantly differ from each other in terms of composition, structural – rheological features, volumes and repeatability in time.

Mudflows formed within the Caucasus, appear in the clay shale distribution areals and are characterized with high density of stone-muddy structural streams, large volumes and high-risk's medium repeatability once per 3-5 years.

Mudflows generated on the Tsiv- Gombori slopes are totally formed in the young molassic sediments (domination of loose conglomerates with the clay interlayers), which do not need any prior preparation. In case of heavy rains of more than 30-40 mm per day and night, transformation of the mudflow processes will take place and it will be repeated several times a year during the III-XI months. Their one-time volumes fluctuate in large range – from the several thousands of cubic meters to more than 300-500 thousands of cubic meters. However, their annual transformation, and often their multiple repetition a year makes a great discomfort to local population, farm lands, irrigation canals and highways, which pass through the rivers of mudflow character (Figure 2, 3). In this regard, it can be stated that the mudflows formed in the Tsiv-Gombori range have no analogy.

Based on the above, approach to the decision of protection-mitigation measures from negative results of these mudflows, which are formed in two quite different conditions by morphological point of view and their adaptive effectiveness will be significantly different. Therefore, below we give a short description of the features of the mudflows, formed within the Kakheti Caucasus and Tsiv-Gombori ranges on the example of the Duruji and Telaviskhevi River gorges, as a representative of all other types of mudflow basins as well as the types of adaptive measures, which implementation will result in effective consequences.

Figure 2. Mudflow stone - muddy deposits of the Sagarejo River (2011)

Figure 3. Mudflow bed of the Antoki River (2010)

The Duruji River mudflow basin, as well as all other mudflow rivers presented on the southern slope of Kakheti Caucasus, originates in the high mountainous alpine morphological zone. All they discharge in the Alazani River bed and they have developed a wide (30-100 sq.km), fully populated and utilized debris cones within its depression. The overall falling of the river beds exceeds 1900-2000 m, the average inclination in the mountainous area is 130-135‰ and they have developed the deep narrow gorges, in the down stream, after leaving the canyon –23-25.6‰. All these rivers are characterized by the fan-like opened mudflow forming geological centers and catchment basin. The geological centers of all mudflow rivers of the Kakheti Caucasus are developed in the units of alternation of schistous and clay shales (80%) and sandstones (15-20%) – the terrigenous-metamorphic complex of Lower and Middle Jurassic age that are tectonically extremely mixed and intensely weathered. The mudflow forming geological centers are located above the forest upper belt and the complex of slope processes (rock slides, rock avalanches, landslides, snow avalanches, solifluctions and slope erosion) is involved in the formation of solid mineral mass.

Special engineering studies and stationary observations of "Sakgeologia" conducted in the Duruji River basin identified that from the unstable slopes of the catchment basin due to denudation - gravitation and erosion processes annually from each hectare of the area on average 1000-3500 tons of the mineral mass is transited in the mudflow forming centers, and annually on average 1.0-1.5 million cubic meters is accumulated in the center and in total the predicted storage of the mineral mass exceeds 500 million cubic meters.

In the Duruji River area and in general, in the Kakheti Caucasus region, stone-muddy structural rheological streams of high density (1.8-2.5 g/cm^3) are formed mostly, particularly, in the conditions of development of catastrophic mudflows. Due to this in the composition of stone-muddy mudflow streams often occur the grand-scale boulders (2-5 m or more in size) in the transit accumulation zone, and sometimes in the brought accumulation area. For example, in 1889 the catastrophic mudflow, transformed in the Duruji River, brought a dacite boulder of more than 200 tons in the accumulation zone of the area of the city of Kvareli, which is now included in the "Red Book" as a unique phenomenon for geotourism (Figure 4, 5).

Figure 4. The Kabali River mudflow deposits of high structure

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Figure 5. Boulder brought by the Duruji River mudflow in the territory of Kvareli

It is notable that in the Duruji River gorge for the last 120 years, passing of the catastrophic mudflows has been fixed 39 times: in 1888, 1889, 1903, 1906, 1922, 1934, 1940, 1941, 1943, 1946, 1947, 1949, 1956, 1957, 1958, 1961, 1963, 1967, 1968, 1970, 1972, 1975, 1976, 1977, 1978, 1979, 1982, 1984, 1986, 1987, 1991, 1997, 1998, 2001, 2003, 2007 and 2009. Their simultaneous output capacity ranges within the diapason of 0.7-1.2 1.6-3.0 million cubic meters (Beruchashvili G., 1969), while the volume of fixed mass in the debris cone zone is fixed within the 300000 - 640000 m ^{3}. Duration of the mudflow processes is observed in the range of 1.2-11 hours; it takes 15-20 minutes to reach the debris cones of the mudflows streams. In the Duruji River gorge and in the similar mudflow forming gorges next to the catastrophic mudflows of large volume the streams of relatively low density (1.2-1.7 g / cm ^{3}) pass more frequently, during which the transit accumulation cones zone erosion mostly washing of their beds take place. Transformation of this type of mudflow water-deposits can occur each year in the conditions of corresponding atmospheric precipitations. For example, in the years of 1961-1967 (Beruchashvili G., 1969) In Tetri Duruji River gorge fixed the passing of 150 mudflow streams with about 500 m^3 discharge. Though, most of them cannot reach the debris cones. In general, the variation of mudflow river beds' bookmarks, difference between the mudflow streams of large volume and high density deposited in the zone of the transit accumulation and debris cone and the washed levels by water-deposit streams makes in average 3-4 meters.

Due to the fact that the mudflows occurred in the Duruji River puts the Kvareli population and its infrastructure under a great risk. Since the beginning of the 20th century the different types of measures are being carried out for protection and reduction of psychological stress of the city's population. Many ideas and the project decisions (Tsereteli E., 2001, Tsereteli E., 2002) have been proposed including: 1. Carrying out the phyto-melioration (i.e. bio - engineering) measures in the mudflow forming centers; 2. Throwing the mudflow rivers into the neighboring river basins; 3. River beds cleaning and their extending throughout the transit zone; 4. building of barrages, cascades, mudflow-holding through or holdback strong dams of different height of constructions (including construction of a net-like high dam); 5. arrangement of a barrage dam (of 15-20 meters height) in the debris cone zone along the whole length of the left bank of the river, periodical cleaning of its bed and placement of periodically removed mass on the barrage dam.

From the above listed measures we consider impossible the implementation of the phyto-melioration (i.e. bio - engineering) measures in the mudflow forming centers due to the extremely complex relief conditions and the intense erosive-gravitation processes within the rocks of a strong and deep tectonic disorder; we consider without effect the implementation of the project on throwing the mudflow rivers into the neighboring basins. High dam construction project, which has been developed by the Institute of "Saktskalproekti", is so expensive that we consider its building unrealistic. Moreover, its maintenance and periodical cleaning will be even more difficult process. In late 70s of the 20th century the through mudflow-holding building has been developed at the Institute of Hydrometeorology and its experimental construction was constructed in the transit zone of the mudflow river. However, due to extremely high density and complex rheological properties of mudflow streams even during the first passage of the catastrophic mudflows the steel - concrete blocks of tens of cubic meters in volume have been removed from the construction and transited at 600-700 meters.

At present the most optimal and effective protection measure against mudflows for population of the city of Kvareli can be considered the river-bank dam, which project included arrangement of 15-20 m high barrage, periodical cleaning of the river bed and raising the dam height by the removed materials. Dam construction was going on gradually by removing 300-400 thousand cubic meters of materials annually from the river bed and stacking them on the dam (removing of 1 cubic meter of materials cost 2 dollars on average). It should be noted that after arrangement of a 7 km long dam in spite of multiple passing of mudflows, its streams did not over flow into the city's territory. However, since 1990 no longer a regular cleaning of the river beds carried out, due to which for today its hypsometrical level is located higher than the city's topography. At the same time, the pillar protective concrete wall is completely covered with mudflow streams and in the conditions of mudflows passing (especially during the water-deposit streams of low density) the intensive washing and deformation of dam takes place. For mudflow risks insurance purposes it is necessary to rehabilitate the erosion protective wall of the dam pillar, periodical cleaning of the river bed in the accumulation zone and storage of removal material on the top of the dam. Currently, to avoid the overflow of mudflow streams into the city's territory in the area of the river going out from the canyon, a stone gabion reach in the wire grid (the so-called "McCaffer" construction) was arranged on the top of the dam, which has played a positive role.

We believe that the arrangement of the bank dams and river-beds periodical cleaning can be considered one of the most effective means for the protection against the dangers of high structure stone-muddy mudflows formed within the Kakheti Caucasus area.

Mudflow forming processes in the Telaviskhevi River is typical to all transforming mudflow rivers on the slopes of Tsiv-Gombori range.

Mudflow basin of the Telaviskhevi River begins on the north-eastern slope of the mentioned range at a height of 1800-1900 m and joins to the Alazani River from the right side at a height of 500 m. Though the Telaviskhevi River water flows into the Alazani River only in the spring snow melting and rainy periods and during the forming mudflows. Upper reaches of the Telaviskhevi River is developed along the 6 km in the Mio-Pliocene molassic conglomerates, where the gorge is cut up to a depth of 100-200 meters by "V"-like profile and the river bed of a large inclination. The debris cone zone along the 3.5-4 km, on which the city of Telavi is built with more than 30 thousand residents and a number of villages, is entirely built by the mudflow deposits. Upper flow of the Telaviskhevi River, where the active formation of mudflow processes take place, like other Tsiv-Gombori's mudflow rivers, is characterized with a fan-like spreading. The mudflow processes are formed geologically in the extremely easily destroyed conglomerates and clays during each heavy rains and sometimes, during the snow melting period earlier in the spring. Accumulation of mineral products in the centers takes place under the influence of erosion and gravitation and landslide processes, important filling of which takes place in the transit zone during passing mudflow streams. We must foresee that in the catchment area of all water flows related to the molassic sediments, the mudflow transforming geological source is of unlimited amount, which does not require any preparatory stage. In case of each falling of mudflow forming rain, the occurrence of mudflow streams is inevitable, and the more is the

precipitation in the form of rain, the more the risk of danger increases proportionally. A classic example is the case when the mudflows occurred in the Telaviskhevi River on 14th of July of 1977, the transformation of which was stipulated due to the falling of about 80 mm heavy rains for 3 hours. In the river basin the formation of mudflow processes took place in the 8 tributaries simultaneously and in the 5 of them occurred the landslide-breaking streams. In total, mudflows brought out about 1 million m^3 of stone-muddy mass, out of them 300000 m^3 (Tsereteli E., 1978) was deposited in the debris cone zone, where the city is located. Energy extinction of the mudflows streams began in the plain relief zone of the Alazani depression, about 5 km from the confluence, after which the stone-muddy mass moved to the water-deposit and the intensive erosion washing of the river banks has begun (Tsereteli E., 1985). Breakthrough of the landslide deposits in the river catchment basin was happening not at the same time, due to which the pulsation movement of the mudflow streams lasted for 4.5 hours.

In order to prevent a real danger of the recurrence of the mudflow processes in the Telaviskhevi River, it was decided to work out the cardinal mudflow control technologies, which included: 1. Phytomelioration (bio - engineering) measures in the zone of formation of mudflow processes in the areal of mudflow-forming geological centers; 2. At a very flow out of the Telaviskhevi River from the canyon and its throwing into the Matsantsaraskhevi River and of this latter – into the Vardisubniskhevi River (Changashvili G., 1978); 3. at the touching area of the flow out of the Telaviskhevi River from the canyon and the tip of the debris cone construction of the through stream-holding steel - concrete engineering construction of "Construction of Kherkheulidze" and arrangement of concrete waterproof canal along the whole length of the debris cone.

Idea of implementation of the first two measures was excluded at the beginning. As for the stream-holding through construction, it was built in 1978 and is still performing its function (Figure 6).

Figure 6. Mudflow-holding through construction built in 1978 in the Telaviskhevi River

This engineering measure for protection of object from the low-density stone-muddy and water-stony mudflow streams was justified. Since 1978 in the Telaviskhevi River the mudflow transformations had taken place many times, but the streams saturated by stone mud had not entered the city area. The through construction takes the whole mudflow mass, where happens the extinction of its energy, stony mass remains in place, and the released water is freely filtered in the stony mass stored in the head race of the building and overflows into the canal. In addition, the accumulated stony mass is used for construction purposes in an organized manner.

Such kind of engineering construction is quite expensive and its construction is justified for a large settlement such as the Telavi city. But, as there are plenty of mudflow water courses of such type on the both slopes of Tsiv-Gombori range that almost every year do significant harm to the rural population, farm lands and motor roads, it is necessary to adopt certain preventive measures. Such an acceptable measure we consider arrangement of hollows in the extended river-beds when the mudflow gorges going out of the canyon, which will receive the mudflow streams. Periodically a stony mass will be removed from the hollows, which, at the same time, is a great product for different construction purposes. On the other hand, the rivers running through the Tsiv-Gombori slopes, are main sources of water feed for the underground artesian waters of the Alazani and Iori Rivers; though, most of these rivers are functioning only periodically in the snow melting and the rain period. And in the conditions of mudflows passage, the waters presented in the stone-muddy streams are not able to separate from them and move to the under-bed streams until the mudflow streams are extinguished, which usually occurs near the major rivers joining.

Therefore, by creation of the mudflow-holding hollows in the transit zone, it will be able not only to prevent the stone-muddy stream danger, but in this case the water mass will be released from the energy-extinguished low-density stone-muddy streams and flow into the under-bed streams, by which the water feed of underground artesian waters will be increased by at least 50-60%. This problem was developed in due time by the specialists of "Sakgeologia" and was recognized as a rational proposal.

In general, in the areal of Tsiv - Gombori there are so many mudflow-forming water courses and oft-repeated in time that for reduction of risk of their danger tremendous material expenses are necessary. Therefore, the implementation of expensive measures (such as those built in the Telavi city protection) will be available only for a very important object.

In this regard, the most efficient and easy to implement measure is, on the one hand, arrangement of the primitive hollows recipient of above-mentioned mudflow streams and on the other hand, the river-bed cleaning and lining at the mudflow-danger areas.

This was dictated by the fact that due high-risk of mudflow phenomena formed in the Tsiv-Gombori Range in Kakheti, the Ministry of Environmental Protection of Georgia ordered the National Environmental Agency to identify in which gorge and which object is under the mudflow threat and by ecological point of view, whether it is possible to remove the inert materials for the construction purposes.

Accordingly, the mudflow-danger areas have been identified, which was followed by the proposal of the Ministry to the government in order to issue permit on licenses in advantageous conditions on the selected and studied areas.

In general, it should be noted that the activation degree and the hazard risk of the mudflows formed in the Kakheti Territory on the general background of extremely high sensitivity the geological environment, fully depends on the variation of the climate conditions and the maximum deviation values in time and space of intraannual daily mudflow forming precipitations.

In this regard, the sum of daily precipitation of more than 50 mm will be necessary for the mudflows transflormed within the Kakheti Caucasus areal, while for the mudflows formed on the Tsiv-Gombory range – more than 30-40 mm. At the same time, with the total amount of daily precipitation, the intensity of precipitation fallen in form of rain during a certain time interval, is of great importance, as well as the values of their deviation in the intraannual section, which significantly increases the activation potential of landslide processes in the mudflow-forming areas of the rivers.

The obvious example is the analytical picture of historical - statistical data of intraannual and daily maximum deviations of Kakheti region's weather stations (Figure 7).

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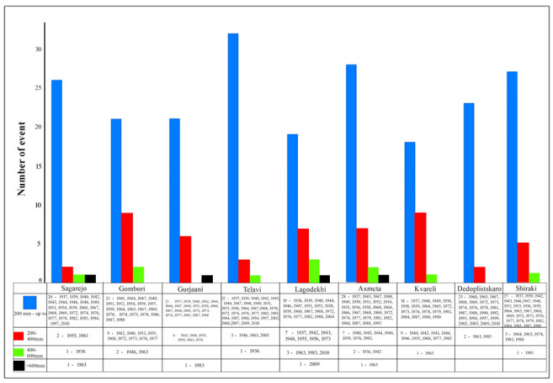

Figure 7. Deviation of mean annual precipitation from the norm (1936-2010)

CONCLUSIONS

The geological environment of Kakheti upland and its plateau distinguish by high sensitivity with respect to provoke the mudflow processes, but the mudflows formation conditions developed within the Kakheti Caucasus and Tsiv-Gombori ranges significantly differ from each other not only by the rheological properties, volumes and frequency, but by the precipitation amount and time coincideness as well.

Occurrence of typical stone-muddy mudflow of high density within the Kakheti Caucasus area takes place in case of daily falling of precipitation of more than 50mm and mainly coincides with the June - September months, while the forming of water-deposit streams of low density is during the daily falling of precipitation of 30-50 mm and in spring and autumn and in the other months too. At the same time, despite the fact that Kvareli and Lagodekhi weather stations, which are located at the foot of the Kakheti Caucasus, are at the distance of 30 km from each other, the heavy rains falling periods and their amounts do not often coincide with each other. For example, according to the Kvareli weather station data (within which activity areal of the Duruji River mudflows are being formed) in 1969 daily precipitations of 30-50 mm were fixed 2 times, in the years of 1977-1983 – 11 times and 80-100 mm – 3 times. There is no data of Lagodekhi weather station in the mentioned years (where the mudflows of the rivers of Lagodekhistskali, Sromiskhevi, Kabali, etc. are being formed).

At the same time within the Duruji River basin during the years of 1936-1992 mudflow forming precipitations have been fixed: 213 times within 30-50 mm; 74 times within 50-80 mm, 13 times within 80-100 mm and 3 times within more than 100 mm. Correspondingly, according to Lagodekhi weather station data of 1955-2010 daily precipitations of 30-50 mm were fixed 123 times and more than 100 mm – one times.

We have a different situation in the Tsiv-Gombori range and Iori upland areals regarding mudflows extremely transformed within the molassic deposits sensitive to erosion - gravitational processes, which does not require the preparation stage for accumulation of solid material in the geological centers. In such conditions, during each heavy rain in the interval of day and night in the diapason of 30-50 mm the mudflows are formed in all erosion water flows, while during 50-80 mm precipitation an extreme transformation of mudflows took place.

Information of statistical analysis obtained from Sagarejo and Telavi weather stations shows, that these stations, which are located in the southern and northern slopes of Tsiv - Gombori range the daily rainfall amount of precipitation and their repeatability in the period of the year do not coincide with each other.

According to Sagarejo data, in the years of 1936-2010 145 - times was recorded the precipitation of 30-50 mm (among them by most of the repetitiveness in 1936 – 7 times and in 1963 –10 times), 39 times – 50-80 mm, 2 times – 80-100 mm and one times – more than 100 mm.

As for the daily precipitations fixed at the Dedoplistskaro weather station, which must characterize the development features of Kakheti (Iori) upland mudflows, the following regularities are revealed. Generally, from the natural processes in the Iori upland area in spite of high sensitivity of its geological environment, the hazard risk is low. The highest risk for this area arises from climate drying, which stipulates the wind erosion and maximal activation of salination and accelerates the desertification process.

It is worth to note that within the Kakheti upland there are surface (soil erosion) and ravine processes and associated mudflow outputs of small volumes, which activation conditions are directly linked to the regime of heavy rains. However, the mudflow formations of such nature are not dangerous to local population and its infrastructure. Therefore, among the soil protection adaptive measures the phytomelioration will give an important outcome.

If we rely on the expected trend of climate change for the period of 2020-2050, which has been developed by the Caucasus Environmental NGO (CENN) on the basis of the data of Sagarejo and Dedoplistskaro meteorological stations, the precipitation index indicates that for the next 30 years both the daily maximum amount of precipitation and the sum of 90-day precipitation will be increased. The number of the days per year will be increased as well, when the sum of daily precipitation is more than 10, 20 and 25. Correspondingly the annual sum of precipitation, among them more than 200mm, is increased, which will help to provoke the landslide processes and therefore, will increase the risk of danger of extreme mudflows transformation.

Thus, we should assume that according to the long-range forecast of landslide-mudflow processes a high risk of danger remains again in the region of Kakheti.

REFERENCE

[1] Beruchashvili G. (1969). Some results of the research of mudflows. Proceedings of Kaz NIGMI, the quest. 33, M. | [2] Changashvili G.Z. (1978). Appearance of mudflow on June 14, 1977 in the region of the city of Telavi. XV All-Union scientific and technical confederation for anti-mudflow measures. Moscow, pp. 176-179. | [3] Tsereteli E., Maguadze O., Chelidze T., Massue J.L., Tatashidze Z., Kherkheulidze G. (2002). Peculiarities of formation of catastrophic mudflows in the Duruji River basin (eastern Georgia). Journal of the Georgian Geographical Society. Vol. 7, pp. 45-55. | [4] Tsereteli E.D., Berdzenishvili D.P., Tatashidze Z.K., Chelidze T.L., Tevzadze V.I., Kherkheulidze G.I. (2001). Peculiarities of formation of catastrophic mudflows in the Duruji River basin and safety of the city of Kvareli. Proceedings of the Institute of Water Resources of Georgia. ASG. Tbilisi, pp. 229-234. | [5] Tsereteli E.D., Tsereteli D.D., Kurdadze M.Z. (1978). Analyzis of the engeneer-geological factors in the formation of mudflows in the Telaviskhevi River basin. XV All-Union scientific and technical confederation for antimudflow measures. Moscow, pp. 172-176. | [6] Tsereteli E.D., Tsereteli D.D. (1985). Geological conditions of development of mudflows in Georgia. "Metsniereba", Tbilisi. |