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Satbayev University

Х А Б А Р Л А Р Ы

ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ
НАУК РЕСПУБЛИКИ
КАЗАХСТАН
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NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.

Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

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**INDICATORS OF ECOGEOLOGICAL RISK FOR THE
PURPOSE OF SUSTAINABLE DEVELOPMENT OF MOUNTAIN
TERRITORIES**

Abstract. The study of natural geosystems and the features of their transformation under the influence of natural and anthropogenic factors is caused by the need for a scientifically based approach to solving of regional environmental problems. Mountain geosystems are highly susceptible to climate change and ill-conceived anthropogenic activities.

Anthropogenic activity in the mountainous region of the Greater Caucasus within Azerbaijan is often associated with the problem of assessing landslide processes and implementing anti-landslide measures. The regional assessment of the development of landslide processes suggests the possibility of their occurrence and the intensity of their formation, as well as the identification of the nature of their impact on economic facilities and the amount of damage inflicted within the territories. The basis for the regional assessment of the development of landslides is a special zoning. For this reason, it is urgent to develop a GIS technology for studying landslide processes, which makes it possible to assess in real time the degree of danger, predict the formation of dangerous trends, promptly inform and, if possible, prevent threatening phenomena.

The article reveals the reasons for the development of landslides in the southeastern part of the Greater Caucasus, namely on the example of the territory of the Shamakhi administrative region, and also gives recommendations on minimizing the consequences of their activation.

Key words: landslide, risk, regional assessment, GIS technologies, anthropogenic impact, anti-landslide measures.

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ТАУ АУМАҚТАРЫНЫҢ ТҰРАҚТЫ ДАМУ МАҚСАТЫНДАҒЫ ЭКОГЕОМОРФОЛОГИЯЛЫҚ ҚАТЕРДІҢ КӨРСЕТКІШТЕРІ

Аннотация. Табиғи геожүйелерді және олардың табиғи және антропогендік факторлардың әсерінен өзгеру ерекшеліктерін зерттеу аймақтық экологиялық мәселелерді шешуге ғылыми негізделген көзқарастың қажеттілігінен туындайды. Тау геожүйелері климаттың өзгеруіне және ойластырылмаған антропогендік әрекеттерге өте сезімтал.

Әзірбайжан шегіндегі Үлкен Кавказдың таулы аймағындағы антропогендік белсенділік көбінесе көшкін процестерін бағалау және көшкінге қарсы шараларды жүзеге асыру проблемаларымен байланысты. Жер сілкіну процестерінің дамуын аймақтық бағалау олардың пайда болу мүмкіндігін және олардың пайда болу қарқындылығын, сондай -ақ олардың шаруашылық объектілерге әсер ету сипатын және аумақтар шегінде келтірілген залал мөлшерін анықтауды болжайды. Көшкіндердің дамуын аймақтық бағалаудың негізі арнайы аудандастыру болып табылады. Осы себепті, көшу процестерін зерттеуге арналған ГАЖ технологиясын әзірлеу өте маңызды, бұл нақты уақытта қауіптілік дәрежесін бағалауға, қауіпті тенденциялардың пайда болуын болжауға, шұғыл түрде хабарлауға және мүмкін болса, қауіпті құбылыстарды болдырмауға мүмкіндік береді.

Бұл мақаланың мақсаты - Үлкен Кавказдың оңтүстік -шығыс бөлігіндегі көшкіндердің даму себептерін анықтау, атап айтқанда Шемаха әкімшілік аймағының мысалында, сондай -ақ оның салдарын барынша азайту бойынша шаралардың сипаттамасы. олардың белсендірілуі. Бұл жердегі көшкін процестерінің теріс әсер ету мәселесі рекреациялық мақсатта аумақты белсенді кешенді дамытуға байланысты соңғы онжылдықтағы ең өзекті мәселеге айналды.

Түйін сөздер: көшкін, қауіп, аймақтық бағалау, ГАЖ технологиялары, антропогендік әсер, көшкінге қарсы шаралар.

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ИНДИКАТОРЫ ЭКОГЕОМОРФОЛОГИЧЕСКОГО РИСКА С ЦЕЛЮ УСТОЙЧИВОГО РАЗВИТИЯ ГОРНЫХ ТЕРРИТОРИЙ

Аннотация. Изучение естественных геосистем и особенностей их трансформации под влиянием естественных и антропогенных факторов вызвано необходимостью научно-обоснованного подхода к решению региональных экологических проблем. Горные геосистемы весьма восприимчивы к изменениям климата и непродуманной антропогенной деятельности.

Антропогенная деятельность в горной области Большого Кавказа в пределах Азербайджана зачастую связана с проблемой оценки оползневых процессов и выполнения противооползневых мероприятий. Региональная оценка развития оползневых процессов предполагает возможности их возникновения и интенсивности формирования, а также выявление характера их воздействия на хозяйственные объекты и размера нанесенного урона в пределах территорий. Основой региональной оценки развития оползней является специальное районирование. По этой причине актуальной является разработка ГИС-технологии исследования оползневых процессов, которая дает возможность оценить в режиме реального времени степень опасности, спрогнозировать образование опасных тенденций, своевременно информировать и по возможности предупредить угрожающие явления.

Целью данной статьи является выявление причин развития оползней в юго-восточной части Большого Кавказа, а именно на примере территории Шемахинского административного района, а также описание мероприятий по минимизации последствий от их активизации. Проблема негативного влияния оползневых процессов здесь стало наиболее актуальной в последнее десятилетие в связи с активным комплексным освоением территории в целях рекреации.

Ключевые слова: оползень, риск, региональная оценка, ГИС-технологии, антропогенное воздействие, противооползневые мероприятия.

Introduction. The territory of the Greater Caucasus within Azerbaijan, characterised by optimal natural conditions for agricultural and tourist

development, is one of the regions with multiple developments of landslide processes. Although landslide processes here are developed in almost all vertical belts, they are most common in the mid-mountain belt. Landslide formation is associated with the widespread development of limestone, clays, sandstones and fissile shales, with a complex tectonic structure, dense fracturing of rocks, and presence of actively developing splits and thrusts, and an abundance of atmospheric precipitation. In addition, the study region is seismically active, where frequent earthquakes contribute to the separation and sliding of landslide material. For example, the largest landslides are found in the Girdimanchay River basin, where most of the landslide areas are occupied by landslide streams. On the southern slope of the Main Caucasian ridge, in the interfluve of the Mazimchay-Goychay Rivers, landslides are mainly located at an altitude of 1300 to 3000 m, which are composed of a marly-clay stratum of rocks and caused by the presence of active faults and rock fractures. Landslides are located on the slopes of the lateral spurs, characterised by large slopes, clay deposits, and the condition of significant moisture (from 300-600 mm to 900-1400 mm/year). The steepness of some slopes is more than 35-40°, in some places up to 70-80°. The most active landslides are confined to the northern exposures of the slopes, and the area of their distribution is small on the southern slopes.

Landslides in the high-mountain belt of the southern slope are relatively weak and are observed in the headwaters of the Shinchay River, on the slopes of the lateral spurs of the Gdim passage, on the slopes of the Gotur, Peygambarbuloğ mountains, etc., where tectonic faults are widely developed. Landslides on the southern slope of the Main Caucasian ridge cover the northern, northwestern, and northeastern slopes of the middle mountains between the left tributaries of the Ganikh River and the Vandamchay River basin, within the range of heights from 1400 to 3000 m. The middle parts of the landslide slopes are characterised by hilly dissection, and a forest is developed in the interhill depressions. The so-called “drunken forest” is developed where landslide masses are actively moving. In such areas, there are observed peaks, as well as parts of intensively growing ravines, dry lands, and small valleys. The most mobile parts are confined to the lower parts of the landslide slopes. In addition, landslides contribute to the development of a gully-ravine network on the slopes of the northern, northwestern, and northeastern exposure. Areal landslides and landslides-flows are widespread in the Girdimanchay river basin (Dvoriānsky, Khimrānsky, Garchinsky, Lagichsky, Gaidānsky, Severo-Khimrānsky, etc.). Landslides, landslide-landfalls, and landslides-mudflows are widely developed on the northeastern slope of the Greater Caucasus. In the development of landslides, there is observed their natural confinement to the northern exposures of the Lateral Ridge and the slopes of the erosion-structural mountains of the Main Caucasian

Ridge, which is due to the stratification of rocks of clay and calcareous facies that compose these slopes. In comparison with the southern and northeastern slopes, landslide processes are most widespread in the southeastern part of the Greater Caucasus. Their intensity is determined by large faults and thrusts (landslides along the Malkamud, Gaynar, Gamirvan, Gazmakriz, Siyazan, Germian, and other faulting), as well as by the wide distribution of clay deposits of the Maikop series. Periodic activation of landslides is associated with heavy precipitation and high seismicity (up to 9 points).

Purpose and methods of research. The risk of activation of landslide processes is necessary for the performance of work on the identification of landslide hazard areas and the identification of the reasons for the development of landslides on the studied territory. The regional assessment of the development of landslide processes implies the possibility of their emergence and the intensity of formation, as well as the identification of the nature of their impact on economic objects and the size of the damage inflicted on the territory. The main regional assessment of landslide development is special zoning (Tarikhazer S.A. et.al, 2020). The results of these studies are widely used in the development of the scheme of territorial planning and the identification of sites for various designed structures and objects. In recent years, new methods of analysis and prediction of landslide processes of different origin have been developed in various countries and by numerous researchers (Pham T.B.et.al, 2016). As the majority of methods of forecasting the landslide risk require a comprehensive analysis of the enormous amount of factual material, there have increasingly been used methods based on GIS technologies (Pendin V.V.et.al, 2009; Lee C.T. et.al, 2008; Komac M.A. 2006; Saro L. 2004). With the introduction of GIS technology, the assessment of the landslide risk became possible in the course of scientific analysis and economic assessment of the predictive development of the territory.

The purpose of this article is to reveal the reasons for the development of landslides in the southeastern part of the Greater Caucasus, specifically in the territory of the Shamakhi administrative district, as well as a description of the activities to mitigate their activation. The problem of the negative influence of landslide processes has become more relevant here in recent decades in connection with the active comprehensive development of the territory for recreational purposes.

The research results. The area of the Shamakhi administrative district makes 1611 km². If landslide processes were manifested in several villages of the district - Mughanly, Maysari, Madrasa, etc. before 2000, where 180 houses were exposed to landslide processes, then after the 2000s, more than 400 houses in only seven villages of the district - Chabany, Madrasa, Maysari, I-Chayli, Mughanly, Ajidere, and Galebyghurd fell into an emergency situation. Most of

the families were evacuated. More than 100 houses in the village of Mughanly were destroyed from April 2010 to March 2012. Currently, there are cracks of various sizes in more than 150 houses in the village of Mughanly, with 460 households and a population of 2400 people. Two houses and 100 hectares of land (private garden plots and arable lands, orchards) are completely destroyed. In addition, the landslide processes are widely developed on highways in the area as well: in three parts in the 3 km of Shamakhi-Pirgulu-Damirchi highway, 147-153 km of Baku-Shamakhi-Aghsu highway and Gushchu-Alabashly highway, 24-25 km and 35-40 km of Shamakhi-Galeybughurd-Kechmeddin highway, 5-6 and 10 km of Chukhuryurd-Gizmeydan-Pirbayli highway, 25 km of Gushchu-Chayli highway, in seven parts in the 19-20 km of Shamakhi-Geylar-Padarchel highway, and Shamakhi-Mughanly highway, and others. There are 15 residential houses in the 48A quarter of the city of Shamakhi in the landslide hazard zone. Landslides destroyed one house, a road, and a water supply system. Numerous cracks were found in seven houses (Tarikhazer S.A. 2020). The specificity of the relief of the territory is one of the basic conditions that facilitate the formation of landslides. It is the relief that determines the reserve of potential energy, which contributes to the development of landslides.

From a geological viewpoint, the Shamakhi district corresponds to two tectonic zones – Zagatala-Govdag synclitorium in the north and Shamakhi-Gobustan structural zone in the south. Deposits of chalk have developed in the northern part of the area, represented mainly by clays, masses of limestones and limestone sandstones. Neogene and Paleogene sediments have developed in the remaining territory. Pliocene (Pontus and Akchagylian) deposits prevail in the central and southern parts of the region, represented mainly by clays, sandstones, sands, etc. Shamakhi district is active from a seismic viewpoint. The most ancient morphostructures of the region began to form within the Middle Pliocene. Kaynar-Zangin and Ajichay-Alat deep faults and other faultings played a significant role in their formation.

During monitoring surveys and decoding of the space images (SI), 76 most active landslides of various types and scales were identified in the Shamakhi administrative district (figure 1). It was found that the periods of formation of new landslides and different movements coincide with the rainy season. This is related to the change in the properties and condition of the soils composing the slopes due to their excessive moistening. Besides, there is a rise in the level of groundwater consequently with the growth of soil pressure. The amount of atmospheric sediments exerted an impact on the hydrological regime of the rivers, which determines the intensity of erosion processes and the activation of landslides on coastal areas (Bui T. Et.al, 2017).

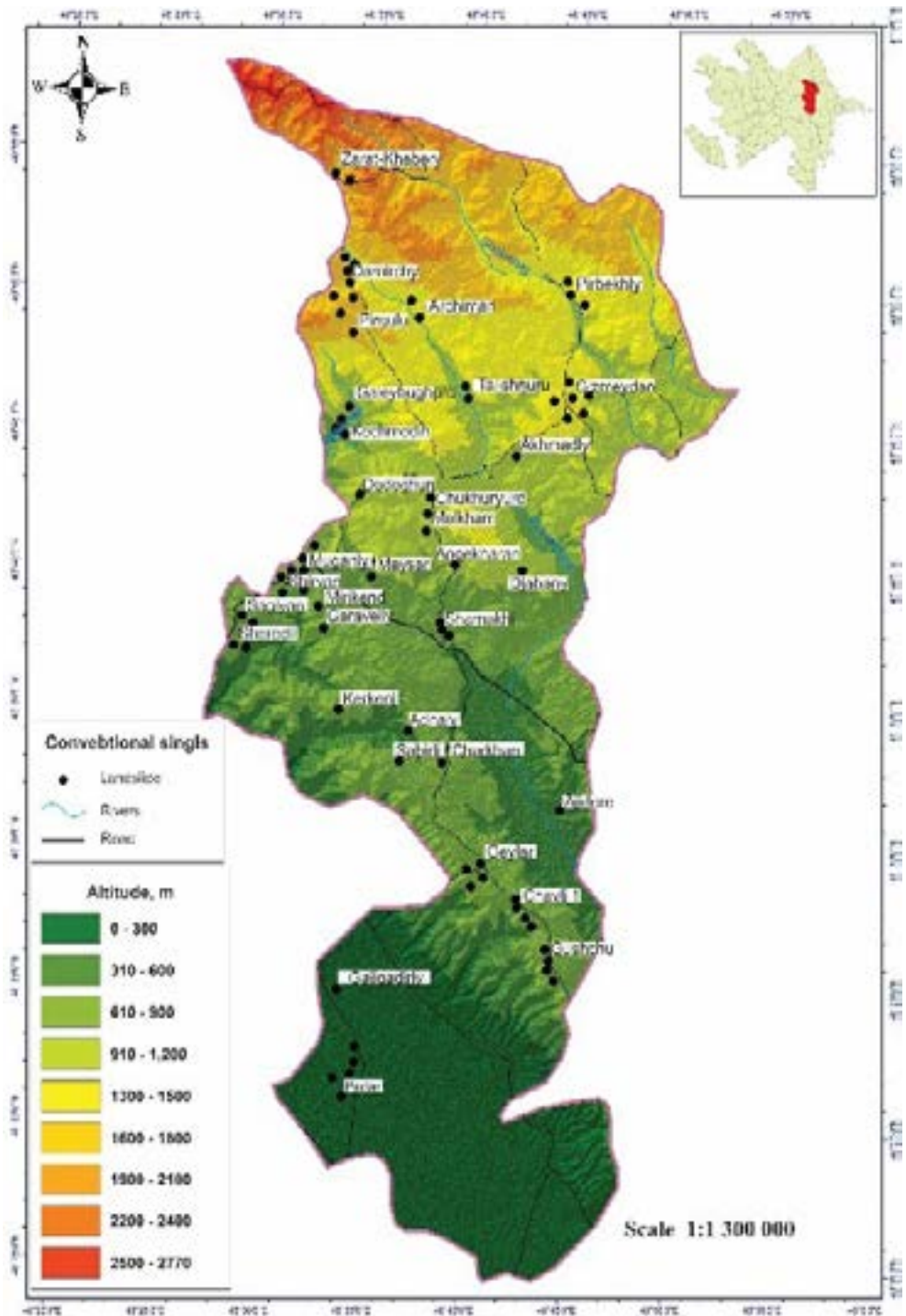


Figure 1 – Overview map of the development of landslides in the Shamakhi region.

It was found that a large part of the Shamakhi administrative district is characterised by a high risk of landslides. From a geological viewpoint, the zone with a high landslide hazard includes territories where soil massifs are composed of carbonate-terrigenous flysch: sandstones, mudstones, silts, clays, and clay slates, which are located in the zone of influence of active tectonic faults. The reason for the activation of landslide processes in this zone is the high energy of the relief, as well as the weak strength of the soil massifs and their fracturing by tectonic faults. The zone with a low landslide hazard includes areas and soil massifs composed of sedimentary clays with stratified sands, sandstones, and marls (Tarikhazer S.A 2020). By the development mechanism, most of them are delapsing. A large part of the landslides is associated with carbonate-terrigenous flysch (sandstones, argillite, siltstones, clays, and clay slates). In the Shamakhi administrative district, landslides are particularly intensively developed in the basins of the Girdimanchay River, in the upper and middle reaches of the Aghsuchay and Pirsatchay rivers, on the Govdag ridge, in Lagich, on the Nialdagh ridge, in the Mudri basin, and others.

The intensification of anthropogenic impact on natural geo-complexes causes the revival of undesirable processes that provoke a tangible threat to the population of these regions. Among all geomorphological systems, alpinotype orogenic areas, which include the territory of the Shamakhi administrative region of the Greater Caucasus, have the overwhelming vigour of endo- and exogenous processes. Therefore, the topic of comprehension and conclusion of the eco-geomorphological threat that people encounter when settling in a specific area is topical now. An important part of this problem is the development of new methods for compiling maps of hazardous exodynamic processes and the risk of natural resource use in the mountain geosystems of the Greater Caucasus based on them. It is relevant and topical to use the indicator of protection against natural disasters and natural calamities in the work to assess the eco-geomorphological risk. There are a large number of methods for analysing the risk of environmental management and predicting threatening eco-geomorphological processes. However, these techniques are not sufficiently reliable under present-day conditions. This, in turn, determines the relevance and need for the development of original or modernised methods of strategies for the prevention, protection, and elimination of the consequences of calamities and natural disasters. The critical ecological situation that has developed in the Greater Caucasus, coupled with an excessive revival of the settlement processes of a certain zone, becomes the reason for the need to develop modern scientific and methodological tactics for the dilemmas of environmental protection and the conservation of the natural habitat. The issues of environmental protection, conservation of the natural habitat, and their reasonable use should be resolved not only by the method of

eliminating the negative outcomes of natural phenomena and economic activities but also by the method of developing a device for alerting their permissible results. The development of the basis for the formation and implementation of regional policy in the field of ensuring environmental safety is an important component of achieving sustainable socio-economic development of the country and its regions. The urgency of the problem of ensuring environmental safety in Azerbaijan stems not only from the natural features of high mountain ecosystems, which predetermine their increased vulnerability under the man-caused impact but also from a sharp deterioration of the environmental situation in many regions of the country.

The study of natural geosystems and the features of their transformation, under the influence of natural and anthropogenic factors, is caused by the need for a scientifically based approach to solving regional environmental problems. The mountainous geosystems of the Greater Caucasus are characterised by the high-altitude zoning of landscapes, the complexity of the space structure, and the dynamism of development. Mountain geosystems are highly susceptible to climate change and ill-conceived anthropogenic activities. As a result, the quality of the habitat is reduced, and the ecological situation is deteriorating. The lack of modernised technologies for sustainable nature management in the mountains, the legislative base that does not work on the ground, the hitherto prevailing opinion about the infinity of natural resources, and a very weak ecological culture of relations between people and the natural environment have tangibly affected the natural complexes of the region. The growth of the human factor in the surrounding geo-complexes in the past years provokes the revival of landslide processes, which form a colossal threat to the population of specific regions.

The main features that reflect the degree of risk of landslide processes are the intensity and the activity of their manifestation, as well as the speed and power of the flow. Based on the before-mentioned, namely, the features of the manifestation of landslide processes and their impact on the eco-geomorphological situation and living conditions of people, a geomorphological risk map was compiled using the example of the Shamakhi administrative region (figure 2). We have identified three zones with different levels of geomorphological risk on the map: low, medium, and high.

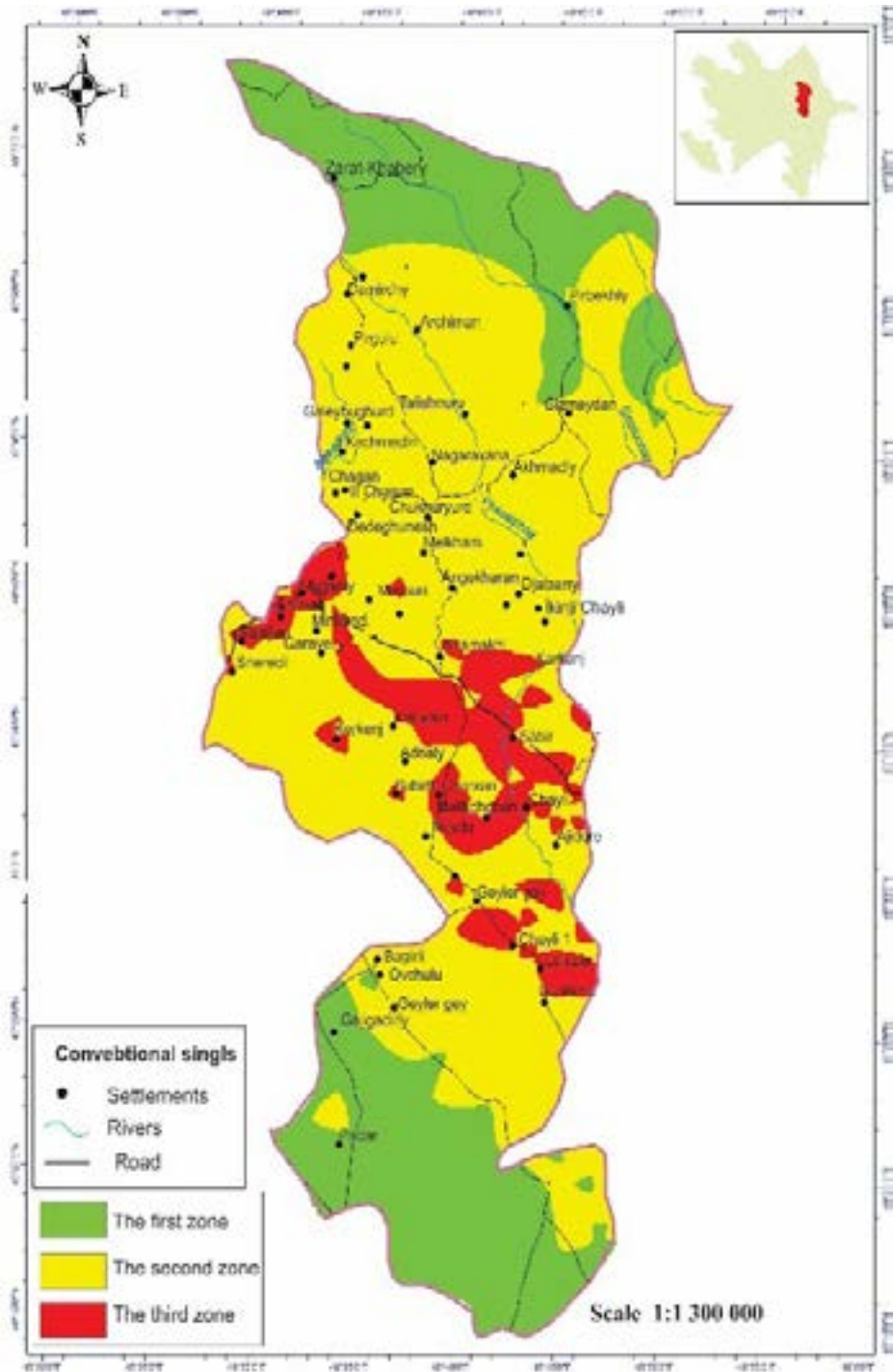


Figure 2 – Map of geomorphological risk from landslide processes in the Shamakhi administrative region.

According to the State Statistics Committee of Azerbaijan, the population of the Shamakhi region is 103 thousand people (for 2018). There are 1 city, 3 towns, and 61 villages in the Shamakhi region. The first zone with an area of 481 km² (29.8%) and a population of 13781 (17 settlements) people is characterised by a low risk to the population against the impact of landslides. The second zone with an area of 973 km² (60.4%) and 80500 people (33 settlements) is characterised by an average risk for the population against the impact of landslide processes. The third zone with an area of 157 km² (9.8%), where 8719 people (15 settlements) live, is characterised by a high risk for the population against the impact of landslide processes (figure 3).

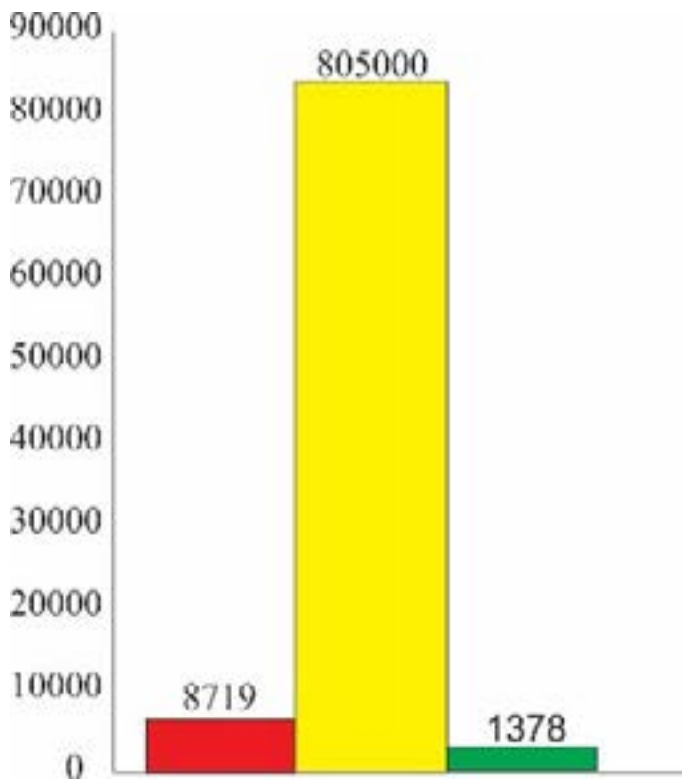


Figure 3 – Diagram of the population of the Shamakhi administrative region by risk zones.

Thus, if landslide processes, significant in their manifestations, practically do not entail unintended socio-ecological consequences, this may be due to the poor development of the territory. Conversely, minor landslides can cause serious damage to nature and people if they occur in areas with a high population density.

Landslide protection measures. The design of the entire complex of landslide prevention measures should be based on a detailed analysis of the reasons for the development of the process and the conditions in which it occurs. The main requirements of landslide prevention measures should be: 1) effective; 2) reliable; 3) sustaining; 4) ensuring the manufacturability of the device of protective structures and their operation. By efficiency, we mean both the economic (feasibility of an event) and technical (the likelihood of ensuring its sustainability during the implementation of measures) side. A number of authors (Pendin V.V. et.al, 2015) distinguish “active and passive” among measures to prevent the development of landslide processes. The active measures include the elimination of the main causes of this process, namely the creation of a drainage facility for the removal of groundwater from the landslide mass and the regulation of surface-water flow due to atmospheric precipitation. Passive measures include the construction of retaining walls of concrete and reinforced concrete. To mitigate unintended consequences in the landslide zone, a regime is established that regulate the rules for the production of any economic activity, including the operation of various structures (Pendin V.V. et.al, 2008).

Conclusion. Construction of facilities, road building, etc. in mountainous areas are always accompanied by cutting of slopes, which contributes to the formation and activation of landslides. To ensure the safety of the operation of objects in landslide zones, it is necessary to arrange technical protection measures, the main stage of the development of which is risk analysis. This will allow both minimising possible economic losses from landslides and optimising the complex of the landslide protection measures. One of the main elements of risk analysis is the assessment of damage from undesirable effect. We believe that the review of the damage from landslide processes in the Shamakhi administrative region carried out in the work can be used in the future to take administrative measures to mitigate landslide risks based on the designing (economic and technical) the implementation of measures for the technical protection of the study area.

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