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ABSTRACT

of the dissertation for the degree of Doctor of Science

THE APPLICATION OF GEOMORPHOSYSTEMS OF THE GREATER CAUCASUS-MORPHOMETRIC ANALYSIS (WITHIN AZERBAIJAN)

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GENERAL CHARACTERISTICS OF THE RESEARCH

Actuality and investigation degree of the topic. Geomorphosystem is an integral part and basis of the geographical landscape. It is of great importance to study it from a morphometric point of view for its effective utilisation and protection. Such research is of great scientific, theoretical and practical significance for any field of people's economic activity (engineering, agriculture, tourism-recreation, ecology, etc.).

For the first time, the issues of morphometric investigation of mountain geomorphosystems on elementary slopes are considered in the dissertation. Such research is fairly useful for specialists and has great practical significance.

Slopes are the most prevalent elements of mountain geomorphosystems. Any part of mountain geomorphosystems can be thought of as a set of slopes with different geological-geomorphological features and morphometric characteristics. In the study area, they cover 16427.75 sq. km (82.87%) area. Even though the main issues of the study of slopes were investigated by V. Penk in 1924, the studied area has not yet been analyzed for application on a single scientific and methodological basis. To carry out the research, the study area is divided into river basins, mountain ranges and others, and the slopes are sectioned within them. In total, there are 3960 slopes here. First of all, the study was conducted over the entire area, from there, the typical research areas were selected for more accurate research and methodology development.

Thus, taking into consideration above-mentioned indicators, it can be said that a comprehensive, complex and partial morphometric study of geomorphosystems is one of the most promising areas of geomorphology.

People's economic activity is closely related to geomorphosystems. Therefore, a comprehensive study of the genetic and morphometric characteristics of geomorphosystems is quite important for figuring out economic issues. Morphometric indicators play a pivotal role in the selection of the location of various economic objects, hence, taking them into account plants can curtail their cost

of facilities, provide their longterm operation and take advantage of other facilities.

Ignoring morphometric indicators in agricultural areas can lead to a decrease in crop productivity, the development of erosion and other challenges. Moreover, for melioration activities (especially irrigation) complex morphometric study of geomorphosystem is completely important. Along with, morphometric indicators of mountain geomorphosystems are widely used in environmental protection, restoration and use of natural resources. With a comprehensive morphometric study of mountain geomorphosystems, it is also possible to select a favourable area for the location of facilities.

It stands to reason that the mountainous areas differentiate with the existence of several natural disasters (landslides, rockslides, floods, avalanches, etc.) These natural disasters in turn bring about calamities and an immense amount of financial damage. For this reason, embarking on such regions necessitate a wonderful morphometric investigation of geomorphosystems. It is undeniable fact that the recurrence and intensity of natural disasters depend on the horizontal and vertical splitting, inclination, and exposition of the slopes. To tackle these unexpected problems we can identify the emerging source of avalanches, calculate their probability of occurrence, predict a natural disaster and prevent financial losses with the help of morphometric indicators.

By analyzing morphometric indicators together with geological and geophysical data, it is likely to determine areas rich in natural resources with various origin as well.

Along with, based on accurate morphometric studies, the area can be split into convenient areas for various areas of economic activity. In this respect, this research paper is principally devoted to such an urgent problem.

The research area constitutes approximately 22,89% of The Republic of the Azerbaijan.

The purpose and mission of the study. The purpose of the research is to study the morphometric features complexly with the aim of applying the geomorphosystems of the Greater Caucasus (wit-

hin Azerbaijan). According to the purpose, **the objects** of the research are as follows:

- Analysis of the current state of morphometric research of geomorphosystems for economic activity of people;
- Selection of characteristic research areas to develop a methodology that requires perfect morphometric analysis;
- Compilation of a plethora of interconnected maps of slopes;
- Morphometric analysis of the compiled maps, geological-geomorphological analysis of the obtained results taking into account the physical-geographical conditions of the studied area;
- Identify the primary statistical distribution features of slopes with different morphometric parameters;
- Investigation of the relationship between the morphometric indicators of slopes;
- Evaluation of morphometric indicators by points for engineering, agriculture, tourism-recreation, ecology purposes, zoning, a compilation of maps and others.

Preliminary materials. The results of perennial chamber research (1983-2020), topographic maps of different scales of different years, more than 15 thematic maps and atlases were used in writing the dissertation. Morphometric studies were performed based on topographic maps at a scale of 1: 100 000.

Research methods. Mathematical-statistical,cartometric, morphometric, cartographic, correlation, graphic and other methods were used in the implementation of research work. GIS technology has also been widely used in the research that it has great potential and perspectives in the morphometric study and mapping of geomorphoses. Systematic, dialectical, genetic, correlation and other approaches were used in morphometric research, the morphometric method is especially more widely used. Based on morphometric indicators, the suitability of mountain geomorphosystems for this or other areas of people's economic activity was determined. The study was conducted mainly in the chamber. Maps of morphometric indicators of slopes were compiled based on actual materials obtained from topographic maps. Contemporary methods of data

processing have been widely used. The current state of affairs and international experience has been studied.

In our opinion, it is more expedient to carry out a morphometric study of mountain geomorphosystems on slopes, because they include climate, tectonics and other elements. The slopes have a natural boundary and their boundaries are clearly marked on the topographic map, aerospace and neighbourhood. Therefore, the term slope will often be used in our research.

One of the fundamental methods of morphometric study of mountain geomorphosystems is GIS technology since GIS technology allows morphometric indicators to be identified and pro-cessed in a short period of time. For this purpose, a Digital Model of Relief (DMR) of the terrain is created, which allows the definition of the slope and exposition of the slopes. Besides, the morphometric GIS of each slope (exposition, slope, horizontal and vertical splitting, average, maximum and minimum heights, average length, area, etc.) can be created. These indicators are very easily developed and are extremely important for economic activity. One of the most important functions of GIS is the compilation and publication of the map, the ability to display the content elements of the map in layers, which allows for more accurate and meaningful analysis.

The primary provisions of the defence:

- The first developed theory and theoretical provisions of morphometry and morphometric research methods;
- Developed classification of cartometric and morphometric indicators and their relationship;
- Development of methods and scheduling of morphometric indicators of geomorphosystems for engineering works, the content of engineering assessment maps and methodology of compilation and zoning;
- Methodology for assessment of morphometric indicators of geomorphosystems for agricultural purposes, development and zoning of the content and methodology of a compilation of agricultural maps;
- Development of a methodology for evaluating the morphometric indicators of geomorphic images with points for rec-

reational, tourism and ecological purposes, development of the content and methodology of recreational, tourism and ecological maps and zoning.

The scientific novelty of the research. The main scientific novelties of the research is:

- For the first time, the slope division features of mountain geomorphosystems with various morphometric indicators were studied in a complex way and this process allows the creation of a morphometric model of the geomorphosystem. Based on such a model, it is feasible to obtain information about the tectonic features of the area, to assess the possibility of using morphometric indicators in economic activities. With the help of this model, either this or that suitable area for people's economic activity have been allocated to different degrees;

- For the first time, in the example of the studied area, mountain geomorphosystems have been comprehensively and thoroughly studied for application on slopes. Based on it, the objectivity of the research and the accuracy of the demarcation of the regions were ensured;

- The exposition of 3960 slopes of the studied area, average angle of inclination, horizontal and vertical splitting (relative height), extreme (maximum and minimum) and average height, average length, area and other indicators have been appointed. Based on these indicators, slope inclination, average height, average length, ecogeomorphological stress, suitability for winter tourism and other classification has been developed;

- The nature of the statistical distribution of slopes with different morphometric parameters was studied. No mathematical regularity was found in the distribution of morphometric indicators;

- The relationship between all morphometric indicators were studied, it was determined that there is no relationship between the neighbourhood and so on;

- Classification of all morphometric and cartometric indicators are given and this classification is the basis of the study and is one of the main factors of zoning;

- Morphometric indicators of slopes - their morphotypes are divided according to the relationship between the average angle of inclination, the density and depth of the split. The separation of 21 morphotypes show that the relationship between morphometric indicators is fairly complex;

- The relationship of rivers of different degrees with the exposition of slopes at different stages have been studied. Comparative analysis of morphometric indicators at different stages shows that there is a close relationship between them;

- The effect of morphometric indicators on the configuration, planning and location of settlements were studied. It was found that the morphometric parameters of geomorphosystem have a significant impact on these characteristics of settlements;

- Morphometric maps of the slopes of such a large area were first compiled using GIS technology. These maps are an invaluable tool in the study of geomorphosystems for applied purposes;

- Methodology and content of synthetic morphometric assessment maps based on scoring of slopes were developed;

- A methodology for evaluating morphometric indicators by points have been developed and other work has been done for the scientific novelty of research.

Novel maps. During the research, 27 new maps of different scales were developed.

Theoretical-practical significance of the research. The perfect morphometric study of mountain geomorphosystems is of great scientific and theoretical importance in the separation of regions and tectonic structures with different tectonic activity, in the study of denudation-accumulation processes, lineaments, distribution patterns of various elements of the geomorphosystem and surface movement.

The results, methods, methodology, cartographic materials of the research can be used by various scientific, design, production organizations engaged in palaeogeography, agriculture, construction, ecology, recreation, tourism, prospecting and exploration of mineral resources and other purposes.

Approbation and application of research. The results of the research were presented in parts at the conferences held at the

faculties of Geology (1998) and Geography (2003) of BSU, at the conference held at the Institute of Tourism (2008), at the scientific seminars of BSU (1999, 2006, 2010, 2011, 2015, 2016) and the Institute of Geography of ANAS (2008,2010,2012,2018,2021), VIII Scientific Conference on Topic Mapping (Irkutsk, 2006), at the VII International Scientific Conference on sustainable development of mountainous areas in the context of global change (Vladikavkaz, 2010), Youth and Science: Reality and the Future: III International Scientific and Practical Conference (Nevinnomyssk, 2011), at the international scientific-practical conference on geographical problems of tourism, ethnography and ecology (Almaty, 2014) and other conferences.

The results of the study were not applied. However, they are especially advantageous for tourism, agriculture, ecology, engineering and other objects. Compiled maps are very necessary for teaching and practice. A topic atlas can be compiled based on maps.

Publications. On the topic of the dissertation 110 treatises of the author were published.

Name of the organization where the dissertation work is performed. The dissertation work was carried out at the Department of Geodesy and Cartography of the Faculty of Geography of Baku State University.

The volume, structure and content of the dissertation. The dissertation consists of an introduction, 7 chapters, conclusions, references and appendices. Its volume is 374 computer pages. Introduction – 10 pages, Chapter I-39 pages, Chapter II-23 pages, Chapter III-49 pages, Chapter IV-36 pages, Chapter V-34 pages, Chapter VI-47 pages, Chapter VII-88 pages, results-6 pages, bibliography-25 pages and appendices-14 pages. 6 map-schemes, 1 graph, 2 histogram, 46 maps, 72 tables were given in the work, 244 titles of literature were used. Its total volume is 411132 characters.

PRIMARY CONTENT OF THE RESEARCH

The introduction includes and gives brief information about the statement of the issue, the actuality of the topic, the object of

research, the purpose and objectives of the research, the used materials, methods and techniques, the scientific-theoretical and practical significance of the investigation, the defended provisions, reports, publications and others.

The first chapter is devoted to "Morphometry and methods of morphometric study of mountain geomorphosystems".

The current state of morphometry, development features, future state are analyzed, and methodology and theoretical provisions of morphometric research are considered. Based on excellent research, 24 areas of modern morphometry have been identified: geological (structure), nature (landscape, soil, geobotanical, relief, hydrography), socio-economic (medical-geographical, humanitarian), forecasting, genetics, indication, astronomical, discrete, continuous, paleogeographical, modern, new, subject, general geographical, practical and theoretical.

As a result of research, it was argued that morphometry is a young, independent, intensively developing science that has its own method, which is called the morphometric research method. Just as geomorphology originated at the border of geology and physical geography, geophysics at the border of geology and physics can be considered as a science that arises at or between two sciences (cartography and geomorphology).

From point of our view, morphometry is the science of quantitative indicators obtained from morphometric studies. Morphometry, morphometric research, morphometric analysis, expressions of morphometric indicators, relations of morphometry with other sciences, subject, object, method and others were ana-lyzed.

There are two primary areas of morphometry: theoretical and practical. Their subject, object, purpose, tasks, problems, perspectives, research methods and other symptoms have been identified. The methodology of morphometric research, the main theoretical provisions - correlation, system and hierarchy have been developed.

Correlation is the main feature of the geomorphosystem. The study of the relationship between the morphometric parameters of 572 slopes in the southeastern part of the Greater Caucasus showed that the relationship between them is correlated. Functional correl-

ations between morphometric parameters can be observed very rarely. In our opinion, the correlation and interdependence between morphometric indicators can be a splendid example of correlation.

Systematicity considers it important to study the geomorphosystem with a systematic approach. It is no coincidence that in the twentieth century, a new term morphosystem (geomorphological system) was introduced into geomorphology. Morphosystem is not a union of separate relief forms, it is a single system consisting of a watershed, a slope and a ravine. Therefore, the morphometric study of geomorphosystems should be carried out based on a systematic approach, which allows a deeper understanding of the geomorphosystem.The application of a systematic approach is also extremely important in morphometric studies. Only a thorough study of the geomorphosystem based on a systematic approach can find an appropriate area for the location of economic establishments.

Hierarchy is one of the main theoretical provisions of morphometry. It is expressed by morphometric indicators. Hierarchy is typical for all elements of the geomorphosystem (slope, watershed and valley).

The theoretical scheme of the geomorphosystem shows that it combines three basic provisions of morphometry (correlation, systematicity and hierarchy). The theoretical provisions of morphometry create a connection between them and form a single theoretical basis of morphometry.

Thus, the theory of morphometry and the method of morphometric research have not been fully developed and need to be improved and enhanced in the future. Its field of application is growing year by year, the application of new technology requires a solution to this problem at the level of today's requirements. Theoretical morphometry originated relatively earlier. However, applied morphometry is evolving more rapidly. Because humans have been surrounded by different types of geomorphosystems since ancient times. Therefore, they had to study geomorphosystems from a morphometric point of view to apply them. An analysis of the current state of GIS technology indicates that it is now an indispensable tool for the morphometric study of geomorphosystems.

There are great opportunities and prospects for its implementation. To the best of our belief, its potential for morphometric studies has not been fully elucidated.

The second chapter explains "The application of GIS technology in the morphometric study of mountain geomorphosystems". There are two stages in the history of morphometric research: 1. Before the emergence of GIS technology; 2. After the emergence of GIS technology. In the first stage, morphometric and cartometric work was performed manually by certain auxiliary means. Morphometric research of this period is characterized by plenty of time and effort with low quality.

In the second stage, cartometric and morphometric work is performed with the help of a computer program (primarily ArcGIS). Computer programs perform cartometric and morphometric work quickly and accurately and computer-generated maps are characterized by accuracy, attractiveness, quickness, and the ability to display individual content elements in layers (which allows for more accurate research). All cartometric and morphometric works in our research were performed with the help of the computer program ArcGIS 10.2.1. Computer programs have been widely used in the mapping.

The brief history of the development of GIS technology, the scientific-theoretical and practical significance of morphometric GIS are explained in the work. The morphometric GIS was created based on a 1: 100,000 scale topographic map for 176 slopes on the example of the Pirsaat survey area (S = 1039.39 sq. km). A comparative analysis of the calculated morphometric parameters of the valleys and slopes of the Pirsaatchay basin by traditional methods and the application of GIS technology is given. On the map of valleys of different degrees compiled by the method of "Khorton-Philosophov (1975)"[1] the length of all-grade valleys and the area of slopes were measured by the traditional (classical) method and computer. The

[1] Philosophov, V. Fundamentals of the morphometric method of searching for tectonic structures / V. Philosophov-Saratov: Sartovsky University, -1975, -232 p, (In Russian).

survey was conducted on 525 ravines and 264 slopes of various degrees. A comparative analysis of the morphometric characteristics of the slopes refers that they are similar (namely they are slightly different).

For morphometric analysis of mountain geomorphosystems based on GIS technology, the Digital Model of Relief (3D model) should build based on horizontals, elevation values and other indicators. In our research, the 3D model 1: 100,000 scale topog-raphic map was built on the example of the area under study with the help of ArcGIS 10.2.1 program. Based on the model, the average slope angle and exposition maps of the studied area were compiled. The cartometric and morphometric indicators obtained from these maps are presented in tabular form. The analysis of the table points out that the studied area is dominated by slopes with northeastern slope and average slope angle of 0-1.50 (41.74%) by area (14.73%).

The third chapter deals with "The practical significance of the morphometric study of mountain geomorphosystems", substantiates the importance of their morphometric study.

Morphometric study of the geomorphosystem is required along with the other studies for the protection and efficient use of natural resources, efficient placement of engineering facilities, search and discovery of mineral deposits, cultivation of crops, efficient selection of tourist routes and location of facilities and other areas. For this purpose, morphometric studies are conducted, morphometric maps are compiled and analyzed. River basins, mountain ranges and the slopes are separated within them on a topographic map at a scale of 1: 100 000. The area of each of the 3960 slopes (S), the angle of inclination (α), the exposition (B), the horizontal (K) and the vertical (h), the average height ($H_{average}$), the average length ($L_{average}$) are determined and have different morphometric parameters. The density of the slopes (K_y), the average area ($S_{average}$) and their percentage were calculated. Thus, 35640 cartometric and morphometric indices of all slopes were studied. Maps were compiled using cartogram and quality background methods, tables, graphs, flower diagrams, histograms and others were established.

This chapter provides an analysis of the main morphometric maps of the study area based on the above work and substantiates the importance of their application. Areas are allocated according to the degree of suitability for either this or that area of economic activity.

The average inclination angle of the slopes. The map of the average slope angle of the study area was compiled based on a DEM file on a scale of 1: 100000 based on a scale compiled by "E.M.Nikolayevskaya (1966)"[2] to provide practical solutions. Classification according to the steepness (inclination) of the slopes is given: 0^0-$1{,}5^0$ (straight), $1{,}5^0$-3^0 (slightly inclined), 3^0-6^0 (moderately inclined), 6^0-12^0 (very inclined), 12^0-20^0 (weakly steep), 20^0-45^0 (medium steep), 45^0 <(very steep). The area of slopes with different average inclination angles were measured on the map, counted, increasing area and number were calculated, the density of geomorphosystems with different average inclination angles were calculated, tables and histograms were constructed. Very inclined geomorphosystems (6^0-12^0) in terms of their number (330547; 25.45%) and straight geomorphosystems (0^0-1.5^0) in terms of area (8274.28 sq. km; 41.74%) predominate in the above-mentioned area, notwithstanding, very steep geomorphosystems differ in the least number (68551; 5.28%) and smallest area (174.28 sq. km; 0.88%). If we take into account that straight (0^0-$1{,}5^0$), weakly inclined ($1{,}5^0$-3^0), moderately inclined (3^0-6^0), very inclined (6^0-12^0) geomorphosystems are convenient for economic activity, then it can be said that the main part of the studied area is suitable for economic activities. In general, as the average angle of inclination increases, the number and density of geomorphosystems initially decrease, then they increase again, and the average value of the area and total area decreases. This is explained by the unequal tectonic activity of geomorphosystems.

Depth of slope fragmentation. The depth of slope fragmentation was determined based on a known methodology. Slopes are classified according to the depth of fragmentation: 0-250 m - very

[2] Nikolaevskaya, E. Methodical instructions on the design and composition of complex scientific-reference atlases. Morphometric relief maps / E. Nikolaevskaya.-Moscow: MSU, -1966, (In Russian).

weakly fragmented, 250-500 m - weakly fragmented, 500-750 m - moderately fragmented, 750-1000 m - strongly fragmented, 1000 m <very strongly fragmented. The slope depth map of the study area was compiled using the cartogram method at a scale of 1: 100 000. The number of slopes with different splitting depths was counted on the map, and their area, increasing area and their number, average value and density of the area were calculated, tables were drawn and histograms were constructed.

The slopes with the smallest area (2250.99 sq. km; 13.70%) in the study area are strongly fragmented. Very weakly fragmented (h = 0-250 m) and weakly fragmented (h = 250-500 m) slopes are considered more favourable for economic activities and they cover 46.29% of the surveyed area.

Very strongly fragmented (h = 1000m <) slopes are not proper for agriculture and capital construction. They can be used for summer pasture, hayfield and other purposes. This area can be used for mountaineering, hiking, skiing and adventure tourism, and such slopes cover 23.10% of the surveyed area.

Strongly fragmented slopes (h = 750 -1000 m) occupy 13.70% of the study area. It is unthinkable to engage in agriculture here, construction work requires additional costs and special equip-ment, for this reason, such slopes are suitable for skiing and hiking.

Moderately fragmented slopes (h = 500-750 m) cover 16.91% of the study area. Such slopes are generally convenient for the construction of engineering installations and related facilities. However, they are unsuitable for agricultural activities. This area especially can be used for hiking, skiing, mountain tourism, in some cases, in this area, people may engage in alpinism.

Slopes with a fragmentation depth of up to h = 500 m (very weak and poorly fragmented) cover 46.29% of the study area. Such slopes are opportune for almost all sectors of the economy.

When the value of vertical fragmentation rises, initially, the number, area and the density of slopes goes up, nonetheless, before rising again, it declines. This is explained by the uneven and intensive fragmentation of the area under the influence of tectonic forces.

The density of horizontal fragmentation of slopes. The den-sity of horizontal fragmentation influences the organization of agri-cultural-related activities, construction of tourism-recreation faci-lities, selection of tourist routes, ecogeomorphological stress of geo-morphosis and others. The density of horizontal fragmentation was calculated based on known methods, the classification of slopes according to the density of horizontal splits is given on the following scale: 0-1 km./sq.km (weakly fragmented), 1-2 km./sq.km (moderately fragmented), 2-3 km./sq.km (strongly fragmented), 3 km./sq.km <very strongly fragmented. A 1: 100000 scale map of the study area was compiled using the slope relief fragmentation density. The area of slopes with different fractional densities was measured and counted on the map, the increasing area and number, the average value of the area, the density of slopes with different fragmentation were calculated. The results of this work are presented in the form of tables and histograms.

Slightly fragmented slopes predominate in the study area in terms of their number (2798; 70.66%) and their area (11141.05 sq. km; 67.82%). Then consecutively moderately fragmented (1044; 26.36%, 4831.13 sq.km.; 29.41%), strongly fragmented (104; 2.63%, 407.11 sq. km .; 2, 48%) and very strongly fragmented (14; 0.35%, 48.46 sq. km; 0.29%) slopes can be noted. The average value of the area of moderately fragmented slopes is the highest - 4.63 sq. km.

The density of horizontal fragmentation depends on the lithology of the rocks, the nature of the soil, the slope of the surface, the amount and nature of precipitation, the height of the area, the exposition of the slopes, the direction of watersheds, vegetation, human activities and other factors.

The highest value of horizontal fragmentation in the study area is observed in the southern part of the area, especially in the Gobustan-Absheron physical-geographical region.

In the middle mountainous zone, where the amount of rainfall is higher, the horizontal splitting is caused by rivers, and in the highlands, they form owing to tectonics. In high mountainous areas, the frequency of horizontal fragmentation is comperatively lower in

areas where rocks are widespread and are difficult to dissolve in water, and in forested areas,

Exposition of the slopes. The exposition map was compiled based on a DEM file using eight cartons (north, northeast, east, south, southeast, west, northwest) of the study area at a scale of 1: 100,000. The number of slopes with different exposition was counted on the map, the area was measured, the increasing area and number, the average value of the area, the density of slopes with different expositions were calculated tables were drawn, histograms were constructed.

In the studied area horizontal (11909; 1.70%, 3396.09 sq. km.; 17.13%) and inclined (689442; 98.30%, 16427.75 sq.km; 82.87%) areas were separated by computer. South-east (87233; 12.44%) and north-east (2917.99 sq.km, 14.73%) geomorphosystems predominate in terms of their number. Northern-facing geomor-phosystems are characterized by the highest density (7.16). Nor-mally, geomorphosystem assessment is based on northern (northern, northeastern, northwestern) and southern (southern, southwestern, southeastern) slopes. Southern slopes cover 32.36% of the study area, while northern slopes cover 30.54%. Therefore, the studied area is convenient for various areas of economic activity.

Thus, in the Azerbaijani part of the Greater Caucasus, the southern exposition (32.36%), straight (41.74%), weakly vertical (30.05%) and weakly horizontal (67.82%) fragmented slopes occupy the largest area. Slopes with density ($a = 6^0$-12^0; K = 16.67), weakly fragmented (h = 250-500m, K = 0.060, K = 0-1km. / sq.km.; K = 0.170) and northern slopes dominate. A comprehensive analysis of a large number of morphometric indicators shows that the area is dominated by south-facing, weakly fragmented, low-slope slopes. Based on these morphometric indicators, the study area is almost entirely suitable for economic activity.

The morphometric analysis of the map of the slope exposition by the cartographic-mathematical method. In the example of the southern slope of the Greater Caucasus of the research area(S=10142,08 sq.km),a 1:100 000 scale exposition map of the slopes was morphometrically analyzed by mathematical-statistical

and information(data) methods.The investigation of the cartometric and morphometric indicators,tables,flower diagrams, histograms and maps indicate that western-slope exsposition predominate in the studied area in terms of number(474;18,50%) and area (2008,17 sq.km;19,80%).

Geometric features of slopes. In this chapter, the geometric features of slopes are also inquired. A classification of slopes by shape has been developed. It has been established that morphometric indicators have a great influence on the geometric shape (configuration) of slopes. The study of geometric features of slopes is of great importance in the effective use of the resources of mountain geomorphoses.

The principal problems and prospects of morphometric research and utilisation for the application of mountain geomorphosystems. It should be noted that there are specific challenges and prospects for morphometric research and utilisation of mountain geomorphosystems for application. In our opinion, it is impossible to use geomorphosystems effectively without identifying these problems and prospects. The geomorphosystem has several features, the essential of which is morphometry. A geomorphosystem is a more stable component of the geographical landscape and it forms its ecological basis, is an abiotic factor and has a bioecological function. For this reason, there are numerous problems in the morphometric study of geomorphosystems for ecological purposes. The fundamental problem of applied morphometric research is the application of unmanned aerial vehicles, aviation systems, differential interferometry, digital modelling and others can be noted as a perspective on the development of a unified theoretical and methodological basis of this research. The main problem of the efficient use of mountain geomorphosystems is natural and anthropogenic factors, and the prospects are to organize its use on the most contemporary scientific basis.

In the fourth chapter, "The interaction of morphometric indicators of mountain geomorphosystems in different ways" was examined.

Graphoana-lytic analysis of the interaction between the morphometric indicators of slopes. Without a thorough study of the relationship between morphometric parameters, it is infeasible to assess the application of the geomorphosystem, to understand the geomorphological laws.

The interaction was studied the interaction of rivers of different degrees and slopes of different views with different stages (steps) and the study of geographical proximity with graphoanalytic method on the basis of a topographic map at a scale of 1: 100 000.

The relationship between the morphometric indicators of the slopes were studied graphically by graphoanalytic method in the south-eastern part of the Greater Caucasus - in the basins of the rivers Agsu, Pirsaat, Gozluchay, Chigilchay and Jeyrankechmez (S = 2780.97 sq. km.) and there are 572 slopes here. The average angle of inclination, horizontal and vertical splitting, exposition, average length, maximum, minimum, average height and extreme height inequality of each of them were calculated. Thus, 5148 morphometric indicators of slopes were scrutinized.

Based on a complex morphometric study, we proposed a no-vel morphometric indicator called the inequality of the extreme height of the slopes. This figure can be considered an analogue of vertical splitting.

The correlation was investigated using graphs constructed between morphometric indicators. It was found that there is no functional relationship between morphometric indicators or it is rarely observed. Especially, the coorrelation relationship is widespread. Provided that we do not factor in the areas of rock, rock and soil avalanche there is a close relationship between the angle of inclination and the density of the split. The relationship between morphometric indicators is mainly lost in the area around the watershed and the southern arid part of the area and sometimes becomes fairly complex.

Morphometric method of separating morphotypes of slopes with various exposition based on the relationship between morphometric indicators. Separation of morphotypes of slopes was carried out in the south-eastern part of the Greater Caucasus (the area between the Pirsaat and Chigilchay rivers). The total area of this region is 2393.33 sq. km. 425 slopes were categorized as their exposition, average inclination angle, horizontal and vertical fragmentation, and typical (background, predominant) morphometric indicators and their range were determined. During coding, the first digit indicates the angle of inclination, the second digit indicates the depth of fragmentation, and the third digit indicates the density of horizontal fragmentation. For example, 011, where 0 is the angle of inclination. It is less than the typical value (6^0), 1-fragmentation depth, It is typical. That is, more than 250m is less than 500m. 1 is the density of horizontal fragmentation. İt is typical. That is, it is more than 0.5 km.kv./km, less than 1 km./sq.km. 000, 111, 222- means that the angle of inclination, horizontal and vertical splitting are correlated with each other. The small value of the inclination angle corresponds to the small value of the horizontal and vertical fragmentation (000), the large value of the inclination angle corresponds to the large value of the horizontal and vertical fragmentation (222), and so on.

The relationship between the exposition and the morpho-metric parameters mentioned above has also been studied. It was found that a closer connection is typical for south-west, west, south-east slopes, and a weaker connection is typical for north, north-east and north-west slopes.

Based on this research, a 1: 100 000 slope morphotype map was compiled using a quality background method. There are 21 morphotypes of slopes on the map. Of the 425 slopes, 130 (30.59%) have the most closely related morphometric indicators, with 105 (24.71%) slopes having a background. The relationship between the morphometric values of the remaining slopes (190; 44.71%) is weak.

Investigation of the interaction between the rivers with different degrees and slopes with various exposition at the hierarchical level. This relationship has been explored based on a 1: 100 000 scale topographic map. The study was conducted on the example of

the area between the Damiraparanchay and Chigilchay rivers. The area of this field is 5467.17 sq.km. There are 2633 rivers and 1130 slopes with different grades.

For comparative analysis, the number of rivers and slopes with different grades was counted, their differences were found, relevant tables were drawn up, graphs were made. The combined analysis of rivers and slopes with different grades indicates that the number of low-grade (especially grade I) slopes are several times less than the number of rivers of the same grade. The difference between the intermediate degrees (II and III) is not large. At high levels (IV, V, VI) the number of slopes is several times greater than the number of rivers.The combined analysis of morphometric indi-cators and graphs shows that as the rate of slopes and rivers increa-ses, their number decreases.

Methodology of mapping the neighbourhood of slopes with different exposition and its morphometric analysis. Neighbourhood research is one of the main problems of modern geomorphology. To map the neighbourhood of slopes with different exposition, a map of the neighbourhood of the slopes is made. It is a synthetic estimation map of slopes and allows us to bring to light their genetic rela-tionship, similarity, diversity and other features.

The neighbourhood of slopes with the various exposition was studied on the example of Shamakhi research area on the basis of the methodology of "Y.G.Simonov (1970)"[3]. The area of the research zone is 277.64 sq. km. There are 39 slopes with 86 neighbours. The number of slopes is calculated on the map of slope exposition, the area, the average value of the area, the density of the slopes, the total length of the border, the length of the adjacent borders and other indicators were calculated. The results of this work are given in the tables.

The interdependence (interconnection, connection) in the stu-dy area varies from 6.25% to 33.33%. Slope neighborhood map was

[3] Simonov, Y. Geographical community and methods of its measurement // - Mos-cow: Bulletin of Moscow State University, Geography series, -1970.№4, -p.13-18, (In Russian).

compiled using the cartogram method on a scale of 1: 100000 with this scale (in%): 0-5; 5-10; 10-15; 15-20; 20-25; 25-30; 30-35. This map visually shows the horizontal division of the area, the characteristics of the statistical distribution of neighbourhood indicators.

The neighbour connection of exposition has also been stu-died. For example, slopes with a northern exposition are always adjacent to slopes with the same exposition (west, east). As a result of scrutinisation it was found that there is no such connection. Due to tectonic movements, the formation, appearance and neighbourhood of the slopes are chaotic.

The fifth chapter is devoted to "The morphometric study of mountain geomorphosystems for engineering purposes".

Morphometric study and engineering-geomorphological assessment of mountain geomorphosystems. Almost any construction begins with a morphometric evaluation of the geomorphosystem for engineering purposes. Studies show that each morphometric indicator has its own engineering characteristics. Morphometric indicators can change the geomorphosystem over time, determine the size, shape, direction, height and other characteristics of the structure. Depending on the type of engineering work, either this or that morphometric indicator may play a more important role. For example, fragmentation and inclination have a greater effect on the passage of territory. Exodynamic processes cause great damage to construction sites. The speed and destructive power of floods, avalanches, rock avalanche, landslides and other exodynamic processes depend on the angle of inclination.

The construction and operation of engineering facilities affect the ecogeomorphological conditions of the area. Therefore, a complex engineering-geomorphological study of the geomorphosystem, along with other work, is necessary for the efficient use and protection of geomorphosystems, long-term operation of engineering facilities.

The essence of engineering-geomorphological research is that based on morphometric, geomorphological and other researches the areas which are more or less suitable for engineering works are

allocated. Construction in these areas requires less labour and material costs and is long-lasting.

As a result of engineering-geomorphological research, a large number of interconnected maps are compiled. Examples are a zoning map based on morphometric indicators, a morphometric assessment map of construction conditions, and an engineering geomorphological map based on the degree of suitability of the engineer for mountain geomorphosystems.

Engineer of geomorphosystems compiled a zoning map based on morphometric indicators on the degree of suitability for work on the example of the study area (S = 19823.84 sq. km, about 22.89% of the territory of Azerbaijan) at a scale of 1: 100000 has been. To compile the map, the average angle of inclination, exposition, horizontal and vertical fragmentation of each slope was evaluated on a five-point scale. Point is a total (synthetic) indicator that combines all morphometric indicators. The development of a scale and evaluation of points is one of the most responsible stages of mapping. When preparing this scale, the scale, purpose and task of the map, the nature of the study area, the size of the morphometric indicator, etc. factors must be taken into account. A five-point scale will be used in our research.

Based on a five-point scale, the slopes are classified ac-cording to the degree of suitability for engineering work: 1 point (relatively useful), 2 points (less useful), 3 points (good), 4 points (more useful), 5 points (most useful). Following this scale, a zoning map based on morphometric indicators according to the degree of suitability of geomorphosystems of the Azerbaijani part of the Greater Caucasus for engineering works was compiled using the cartog-raphic method at a scale of 1: 100 000. This map is of great engineering importance. It can be called a morphometric assessment map of construction conditions. On the map, the number of areas suitable for engineering work to various degrees was counted, the area was calculated, tables were compiled and analyzed.

As the value of point in the study area increases, before decreasing, the number and density of slopes increase and the average value of the area increases.

It should be noted that in addition to morphometric indi-cators, the engineer is responsible for the construction and operation of facilities, geological (especially tectonics and lithology), geomorphological, hydrogeological, etc. features are affected. Therefore, the necessary information of engineering importance was transferred from the thematic maps to the morphometric assessment map of the construction conditions. The map based on this method is called the engineering geomorphological map (EGM). Such a map was compiled on a 1: 100,000 scale on the example of the Pirsaat River research area.

Morphometric study of geodynamic activity of mountain geomorphosystems. The geomorphosystem has several features. One of them is its dynamism. Its evaluation is one of the most responsible tasks in the organization of economic activities. Morphometric indicators also have a great impact on the dynamics of the geomorphosystem. Monitoring of the geomorphosystem should be carried out regularly for long-term uninterrupted and accident-free operation of engineering facilities. Taking into consideration the geodynamic activity of the geomorphosystem allows the engineer to place objects efficiently. This, in turn, allows them to operate for a long time, efficiently, without accidents and safely.

One of the engineering maps is a map of the geodynamic activity of the geomorphosystem. It is based on a 1: 100 000 scale topographic map of the study area. The average length, horizontal and vertical splits of the slopes, the average angle of inclination, the average height, and the exposition were assessed on a five-point scale.

According to the degree of geodynamic activity of geomorphosystems of the Greater Caucasus (within Azerbaijan), the zoning map based on morphometric indicators was compiled by cartogram on a scale of 1: 100,000 on the following scale: K = 0-0.2 (1 point, very weak, most favourable), K = 0.2-0.4 (2 points, weak, favorable), K = 0.4-0.6 (3 points, medium, relatively favorable), K = 0.6-0.8 (4 points, strong, very unfavorable), K = 0.8-1.0 (5 points, very strong, unfavourable).

Influence of morphometric indicators of mountain geomorphosystems on the location of habitats. Morphometric indicators have a significant impact on the location of all engineering facilities, especially settlements. The effect of morphometric indicators on the location of settlements was studied based on a topographic map at a scale of 1: 25000 on the example of the study area of the southern slope of the Greater Caucasus. The area of the research zone is 10142.08 sq. km. There are 476 settlements (S) here.

The location of each settlement, the average angle of inclination, the average height, the configuration and planning of the settlement, the number of settlements within each altitude zone, their percentage and density were determined. Factoring in the inclination and exposition of the altitude zones, the settlements were grouped, histograms and flower diagrams were drawn up. The lowest (80; 16.81%) settlements are located in the middle mountainous zone. There are no settlements in the high mountain and nival-glacial zone and the subnival semi-zone. 216 (45.38%) settlements are located in the lowlands.

The highest settlement in the study area is the village of Kanaa. This village is located at an altitude of 1760 m, in the basin of Girdimanchay.

Based on the above research, the settlements were divided into two groups: 1. Lowland settlements (200-500 m), 2. Highland settlements (500 m <).

Depending on their location, settlements on slopes, water-sheds and ravines can be distinguished. Lowland settlements predo-minate in this area (416; 87.39%). Then the settlements located in the watershed (41; 8.61%) and the valley (19; 3.99%) can be mentioned.

The location of settlements on different expositions has also been studied. 119 (25.00%) settlements in the study area are located on the slopes of the southwest, 4 (0.84%) on the northwest, 18 (3.78%) on the northeast slopes.

The settlements in the study area have fairly various layouts. Irregular planning is predominant. Regular planning is typical for Russian settlements. Almost all settlements have irregular planning. In recent years, the scattered form is typical for settlements. Separate

houses were built around the settlement. This is explained by the desire of the population to use the relief effectively. There is no radial planning in the study area.

The configuration of the settlements was also studied. Unlike cities, rural settlements, especially in mountainous areas, are characterized by a very complex configuration. The difference in the configuration of the settlement from the shape of the geometric figure is due to local conditions (coastal zone, relief features, water supply, land use, etc.).

The sixth chapter is devoted to "The morphometric study of mountain geomorphosystems for agricultural purposes".

Methodology of compiling a map of heat supply of mountain geomorphosystems based on morphometric research. It is extremely essential to know the degree of heat supply of the area for the effective organization of agricultural activities. A novel methodology has been developed for mapping the heat supply of the geomorphosystem. Average elevation, average inclination angle, and viscosity were assessed on a five-point scale, and the geomorphosystem was classified as very well-supplied (5 points), well-supplied (4 points), moderately supplied (3 points), poorly supplied (2 points), very poorly provided (1 point). According to the degree of heat supply of geomorphosystems of the Azerbaijani part of the Greater Caucasus, a zoning map based on morphometric indicators was compiled using the cartogram method at a scale of 1: 100 000 (Figure).

Cartometric and morphometric works were performed on the map, tables were compiled, histograms were constructed. Their analysis shows that geomorphosystems with very good heat supply dominate in the studied area in terms of area (8334.93 sq. km; 42.04%), number (92; 37.10%), density (0.0046). Poor heat with the smallest area (127.45 sq. km; 0.64%), number (12; 4.84%), density (0.0006) and average area (10.62 sq. km) provided geomorphosystems differ. Medium, good and very well supplied geomorphosystems occupy the primary part of the studied area. This hot climate is explained by a large number of slopes in the southern part

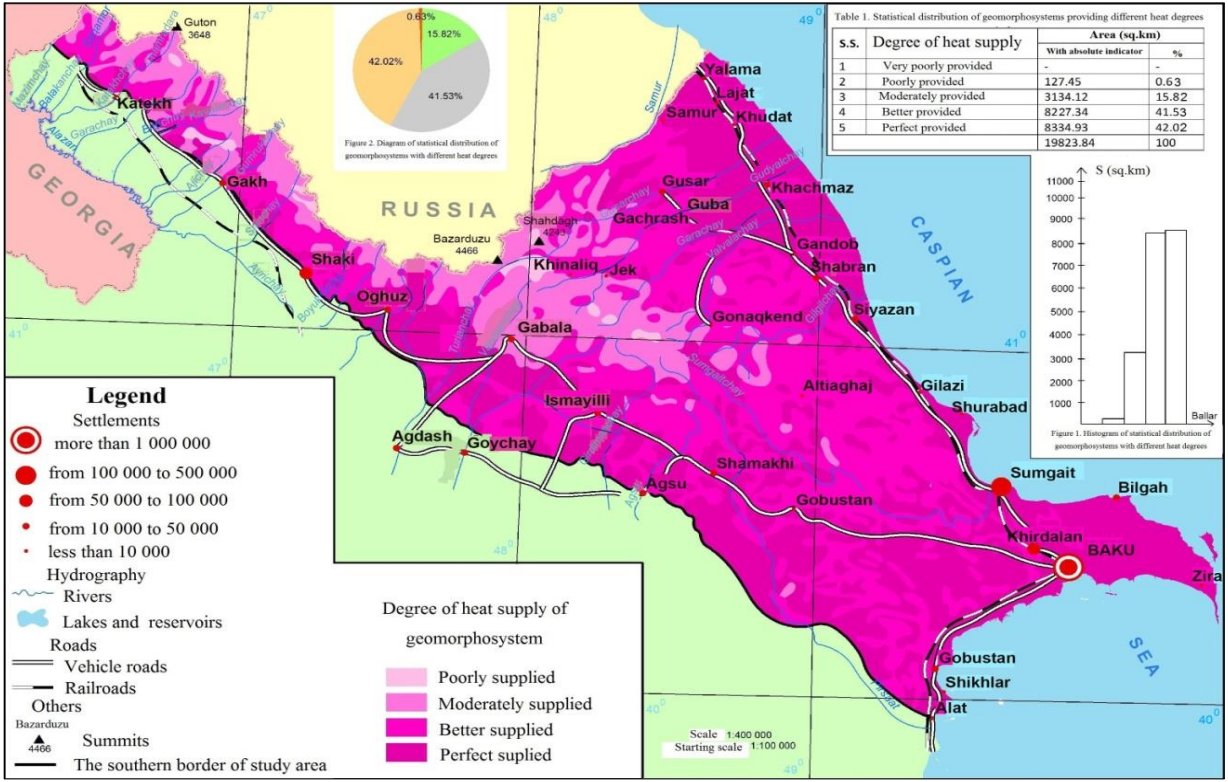

Figure. Map-scheme of regionalization by the degree of heat supply of geomorphosystems on morphometric indicators of the Azerbaijani part of the Greater Caucasus

of the country and the low altitude ($H_{max.}$ = 4466 m, Bazarduzu peak). As the value of the heat supply of a geomorphosystem increase, its area, number, and density increase, and the average value of the area first increases and then decreases. Based on the analysis of these indicators, it can be said that the studied area is suitable for agricultural activities, especially for the cultivation of heat-tolerant plants.

The heat supply map of the slopes is a synthetic assessment map. The heat supply is one of the most important factors in the selection of slopes for agricultural purposes.

Development of the content and methodology of compiling the energy map of the relief of the slopes of mountain geomorphosystems. One of the agricultural maps is the energy map of the relief of the slopes. The energy map of the relief has its own history. Its scientific-theoretical and practical significance has long been accepted. Unfortunately, its content and methodology have not been sufficiently developed.The term relief energy has been used in geomorphology for nearly a century.

It was first used by "Partch"[4] in 1914. İn our research, the proposed methodology for compilinq relief enerfy maps for the last 100 years has been analyzed, and a completely new methodology for compiling relief energy maps on the example of the south-eastern part of the Greater Caucasus (between Pirsaat and Chigilchay rivers) has been developed. This method also takes into account the potential energy of the relief. The energy map of the relief of the slopes of the area between Pirsaat and Chigilchay is compiled on a scale of 1: 100,000 on the following scale: 0-0.3 (very weak energy does not interfere with exogenous processes), 0.3-0.6 (weak energy, very weakly inhibits exogenous processes) 0.6-0.9 (moderately strong energy, creates weak conditions for exogenous processes), 0.9-1.2 (moderately strong energy, creates moderate conditions for exogenous processes), 1,2-1,5 (strong energy, creates strong

[4] Spirodonov A.I. The energy of relief//-Moscow: Geomorphology,-1994. №2,-p.71-74.(In Russian)

conditions for exogenous processes), 1,5-1,8 (very strong energy, creates very strong conditions for exogenous processes).

Tables and histograms were constructed based on cartometric and morphometric works. Based on them, it was determined that as the energy index increases, the number and area of slopes decreases, and the average cost of the field increases. Slopes with an energy potential of 0-0.30 are predominant in terms of number (70.12%) and area (61.69%). They are distributed in the southern part of the study area. As the average height of the slopes, the depth of the split, the angle of inclination, and the volume increase to the north in the studied area, the energy of the relief increases.

For comparative analysis, the energy of the sloping relief was calculated in absolute and point values. Calculations show that 40 slopes have the same value. The amplitude is 0.23. In more than 90% of slopes, this figure is ± 0.05. The maps are similar. In our opinion, this is explained by the features of the evaluation of morphometric indicators in points.

Compilation and morphometric analysis of agrogeomorphological maps of slopes**.**

The primary part of the land fund is located on the slopes. Their morphometric indicators are one of the criteria in assessing the quality of soils. Simultaneous consideration of morphometric indicators provides great agricultural benefits and opens up opportunities for development in a market economy.

2. Individual approach to each slope on the basis of morphometric indicators enables to distinguish different agro-industrial areas within it and to determine the methods of agricultural activities.

3. Morphometric indicators are widely utilized in land allocation, selection of raw and permanently uncultivated land, design of soil protection strips, the water supply of the area, selection of areas for field and the mechanization of agricultural labour. They have a great impact on the distribution of arable land resources, the timing of planting and harvesting, the process of plant development, the spread of agricultural pests and other indicators.

It is necessary to have profitable maps for efficient selection of sown areas of crops and organization of agriculture. One of them is the agrogeomorphological map. In our opinion, the agrogeomorphological map is a synthetic assessment map of the relief, which contains all the information necessary for agricultural activities.

To compile an agrogeomorphological map, first of all, a morphometric assessment map of agro-geomorphological characteristics of slopes is compiled. Such a map was compiled based on a 1: 100000 topographic map for the mountainous part of the Gozluchay river basin. There are 91 slopes. The average angle of inclination, average height, average length, horizontal and vertical splitting were evaluated on a five-point scale and the slopes were classified as: relatively favourable (1 point), less favourable (2 points), favourable (3 points), more favourable (4 points), the most favourable (5 points). This classification is the basis for compiling a map of the morphometric assessment of the agrogeomorphological characteristics of the slopes on a scale of 1: 100000.

Agrogeomorphological map is compiled by transferring all the information necessary for agriculture on the map of mor-phometric assessment of agrogeomorphological characteristics of slopes.

Agrogeomorphological map of slopes was compiled for the mountainous part of the Gozluchay river basin (S = 500.14 sq. km) on a scale of 1: 100000. Data from the map of ecological assessment of Azerbaijani lands compiled by "G.S.Mammadov (2003)"[5] were transferred to the map of morphometric assessment of agrogeo-morphological characteristics of slopes. All cartographic sources were brought to a single scale (1: 100000). In addition, the map shows dunes, ridges, cliffs, ravines, sediments, karsts, landslides, rocks, rockslides, terraces, depressions, shallow ravines, gullies, river valleys, glaciers, etc. factors that hinder the mechanical cultivation of soils are also transferred.

[5] Mamedov G.S. Ecological assessment of the soil of Azerbaijan [Map] / 1: 600 000 / - Baku: State Committee for Land and Cartography, -2003.-1l, (In Russian).

The analysis of the work done shows that as the value of point in the study area increases, the number, area and density of slopes first increase and then decrease. The river basin as a whole is favourable for agricultural activities.

Morphometric analysis and assessment of erosion hazards and erosion fragmentation of mountain geomorphosystems.

To prohibit erosion the comprehensive research should be conducted. An integral part of this study is morphometric research. Morphometric indicators have a significant impact on the speed and destructive power of surface flows.

The threat of erosion leads to a decrease in the area of arable land resources, soil fertility, and an increase in the cost of agricultural labours.

The study of erosion hazard based on morphometric indi-cators was carried out on the example of the area between Pirsaat and Chigilchay rivers (S = 2393.33 sq. km).

Horizontal and vertical splitting of slopes, average inclination angle, average length, morphology and visibility were assessed on a five-point scale, and slopes were classified according to erosion hazard: very weak (1 point), weak (2 points), moderate (3 points), strong (4 points), very strong (5 points). Morphometric assessment map of erosion risk of slopes was made by cartographic method at a scale of 1: 100000.

A joint analysis of the morphometric and cartometric work performed on the map indicates that with a minimum number (27; 6.35%), area (88.86 sq. km; 3.71%) and density (3.29) weak slopes are characterized by dangerous slopes. Very weak and very strong erosion-dangerous slopes are not found in the study area. Erosion-prone slopes are widespread in Gobustan. This arid climate is due to the lack of vegetation (especially forest).

For the morphometric study of erosion fragmentation of geomorphosystems of the study area, horizontal and vertical fragmentation of slopes, average inclination angle, average length, average height and visibility were evaluated on a five-point scale and geomorphosystems were classified according to erosion fragmentation (1 very weak), weakly fragmented (2 points), moderately

fragmented (3 points), strongly fragmented (4 points), very strongly fragmented (5 points). Based on it, the map of zoning based on morphometric indicators according to the degree of erosion fragmentation of geomorphosystems of the Azerbaijani part of the Greater Caucasus was compiled by the cartogram method on a scale of 1: 100000.

Based on the morphometric indicators of this map, it was determined that geomorphosystems with moderate fragmentation predominate in terms of the number (110; 41.51%), area (8578.51 sq. km; 43.27%) and density (0.0055). Very strongly fragmented geomorphosystems are characterized by the smallest number (2; 0.75%), area (19.78 sq. km; 0.10%) and density (0.0001).

Thus, moderately fragmented geomorphosystems predominate in their numbers, areas and densities in the investigation area. The density of slopes within a certain area depends on their area, the density of the ravine network. The geomerphosystems are strongly raptured with the ravine and stream network in the tectonically active areas (the northern part of the research area) and arid-denudation regions (southeastern part of the research area). The disintegration degree of geomorphosystems depends on the height of the erosion base, the verticality of the slope, the lithology of the rocks, vegetation, the amount and intensity of atmospheric precipitation and other factors.

Tectonic activity in the study area decreases from the watershed to the Kura-Araz lowland, Alazan-Ayrichay valley and the Caspian coast. In this direction, the number of morphological indicators and the point given to it decreases. The tectonic uplift zone corresponds to the high value of morphometric indicators and, accordingly, the high value of points, and the subsidence zone corresponds to the low value of morphometric indicators, and therefore the low value of points.

The seventh chapter is devoted to "The morphometric study of mountain geomorphosystems for recreation, tourism and ecological purposes".

Morphometric study of the recreational potential of mountain geomorphosystems. Geomorphosystems have an effect on the

recreational characteristics of the area and the recreational activities of people, for this reason, they can be considered as a recreational resource. Geomorphosystems are the basis of the geographical landscape. Therefore, their study and protection of them are fairly essential. The recreational potential of a geomorphosystem depends mainly on morphometric parameters. They affect the territorial organization of recreational activities, the formation of recreational areas, allow the creation of a morphometric cadastre and quantify the exoticness of the geomorphosystem. Without morphometric indicators, it is impossible to objectively assess the recreational potential of the geomorphosystem and conduct recreational zoning.

Morphometric indicators affect all areas of tourism. It acts as a factor of recreation and tourism and determines the specialization of the area. Analysis of the table based on the literature indicates that each morphometric indicator affects tourism activity. Based on the analysis of this table, it can be believed that a complex and accurate morphometric analysis of the geomor-phosystem is necessary for the effective organization of tourism.

Owing to the great recreational importance of the geomor-phosystem, a novel direction in the science of geomorphology - recreational geomorphology has emerged. Geomorphosystems affect the recreational characteristics of the area and the recreational activities of people. The recreational significance of the hemor-rho-phystem is determined by its morphometric parameters.

Vertical fragmentation determines the variation of the recrea-tional potential of a geomorphosystem at heights.

Total (general) fragmentation (vertical and horizontal) deter-mines the contrast, dynamics and other characteristics of geomor-phosystems.

The angle of inclination has a significant impact on almost all recreational features of the geomorphosystem, the organization of recreational activities.

Depending on the heat supply of the exposition geomor-phosystem, the appearance of recreational objects, etc. affects the properties.

The average height determines the visible area of the geomorphosystem. The cleanliness, pressure, humidity and other features of the area are closely related to the average altitude.

Morphometric study of the geomorphosystem for tourism, recreation and ecology was also implemented based on a topographic map at a scale of 1: 100 000. Morphometric study of the recreational potential of the geomorphosystem was carried out on the example of the Greater Caucasus (within Azerbaijan). Average inclination angle, exposition, horizontal and vertical splitting, average height were assessed on a five-point scale, the geomorphosystem was classified according to its suitability for recreational activities: relatively favourable (1 point), less favourable (2 points), favourable (3 points), more favourable (4 points), the most favourable (5 points). Based on this classification, a recreational zoning map of the Greater Caucasus (within Azerbaijan) based on morphometric indicators of geomorphosis temples was compiled using the cartogram method on a scale of 1: 100000. Analysis of the map shows that the studied area as a whole is suitable for recreational activities in terms of morphometric indicators.

The general geographical issues of geotourism. Tourism is one of the contemporary and fast- developing areas of the economy of Azerbaijan,and owing to its effective arrangement,the analysis of its geographical issues is fairly essential.The geographical issue of tourism can be divided into two great groups:1.Natural(tectonics, geomorphology,morphometry,hidrography,climate and others); 2.Social-economic(economic-geographical position,the accessibility of transportation, the settlement of population and others). In the research, Each of these issues was considered and investigated shortly.

Development of methodology and content of geotourism map of mountain geomorphosystems. One of the types of tourism in Azerbaijan is geomorphological tourism (GT). Even though Azerbai-jan is the republic with the best opportunity for the development of geotourism in the Southern Caucasus, these resources are still not used effectively. Geotourism resources are one of the most valuable natural resources of our republic.

A map of geotourism resources should be developed for efficient use of geotourism (geomorphological tourism) resources and proper organization of tourism activities.

In our research, a 1: 600 000 geotourism map of Azerbaijan was compiled based on literature and cartographic sources. This map describes the different forms of relief, their complexity, the objects of tourist importance associated with them. Based on this map, it is feasible to analyze the opportunities of geotourism, the country's prospects in this area and the effective selection of tourist routes.

Investigation of morphometric features of regions with caves. One of the rarest types of geotourism in Azerbaijan is cave tourism. We consider the caves as an object of geotourism. From our point of view, such research can be a starting point for fundamental research in the field of cave tourism.

Taking into account the current state of tourism in Azerbaijan (especially cave tourism), it can be concluded that our Republic is a country with quite favourable opportunities and related problems for the development of this area of tourism.

Taking into account the great scientific-theoretical and practical significance of the caves, 10 caves were declared reserves. Caves are one of the rare archeological and natural-historical monuments. They are of great scientific, theoretical and practical importance. In our research, caves are studied as a tourist object.

To effectively use the tourist resources of the caves, it is necessary to collect a plethora of information about it. The best tool for collecting such data is GIS technology. Geographic Information System (GIS) is an invaluable tool for operational collection, systematization, protection, updating and other information about caves. GIS technology allows us to display the obtained data in parts, maps in layers. Thus, GIS technology opens up new opportunities for the study and use of tourism resources.

Azerbaijani caves are characterized by their very complex geological - geomorphological and morphometric features. They have not yet been studied at the modern level of science and technology. Khashi, Galaalti, Sudur and other caves are of great tourist importance in the study area.

The morphometric indicators of the area where the caves are located and the effect of morphometric indicators on the distribution of caves was examined in the research paper. Based on literature and cartographic sources, a map of cave tourism of the Republic of Azerbaijan and a map of the distribution of caves by altitude zones were compiled on a scale of 1: 600000. Analysis of the maps shows that morphometric indicators have a significant impact on the formation and spread of caves. Thus, as the angle of inclination increases, the karst process weakens. Karst formation weakens at an inclination of 12^0-15^0. At the same time, the formation of caves is greatly influenced by the horizontal and vertical splitting of the slopes.

The caves are unevenly distributed in the study area. They are more widespread in mountainous areas with high tectonic activity, where the rocks are very fragmented and the depth of fragmentation is high.

The made up map allows analyzing the regularities of the distribution of caves which is completely useful for the organization of cave tourism (selection of effective tourist routes, the opening of new routes, selection of efficient places for cave tourism) and zoning.

Morphometric study of the slopes of mountain geomorphosystems for winter tourism. Winter tourism is one of the rapidly developing areas of tourism in our country in recent years. The morphometric study of the geomorphosystem for winter tourism was carried out on the example of the Khinalig research area. The study area is located above the forest belt. Its northern border reaches the watershed of the Greater Caucasus. It has several natural resources for winter tourism. Factors affecting winter tourism can be divided into the following groups: 1. Geomorphological-morphometry and morphology of the geomorphosystem, 2. Topographic, 3. Climate, 4. Landscape (especially vegetation), 5.Labour resources, 6.Infra-structure. All these factors were considered in the investigation. Since morphometric indicators affect each of these factors, it has been more thoroughly studied.

The area of the research zone is 1761.05 sq. km. The mountainous parts of the basins of the Samur, Gusarchay, Gudialchay, Garachay and Valvalachay rivers are located here. There are 504 slopes. The average inclination angle, horizontal and vertical splitting, average height, average length and exposition were assessed on a five-point scale and the slopes were classified according to their suitability for winter tourism: 1 point (unfavourable), 2 points (less favourable), 3 points (relatively favourable), 4 points (favourable), 5 points (very favourable). Based on the score, a map of the slopes of the Khinalig research area for winter tourism was compiled using a cartogram at a scale of 1: 100000.Cartometric and morphometric works were done on the map, a table was compiled. Based on a comprehensive analysis of these works, it was determined that 68.11% of the surveyed area is suitable for winter tourism. Along with this map, a map of the primary objects of winter tourism of Khinalig research area was compiled on a scale of 1: 100000. The map shows ski routes, tourist bases, hotels, travel agencies, settlements where winter tourism can be developed (Shyub, Garavulustu, Gonagkend, Firik and Sudur), cableways, airports, etc. The maps are an invaluable tool for organizing and managing winter tourism in the field of research. The method can be applied to any mountainous area. As a result of the research, a package of proposals consisting of 37 items necessary for the efficient use of winter tourism resources and its development in a market economy was developed, and 12 ski routes were proposed.

Morphometric study of mud volcanoes for tourism purposes. One of the areas of geotourism is mud volcano tourism.

Although Azerbaijan has great potential for the development of mud volcano tourism, they have not yet been studied for tourism purposes, the necessary maps have not been compiled, and mud volcano tourism and mud volcano treatment have not been organized worldwide.

The Gobustan-Absheron physical-geographical region of Azerbaijan is one of the most widespread regions of mud volcanoes in the world. The study considers the mud volcano as a tourist destination. There are two directions of tourism importance of mud

volcanoes: a) it is an object of observation and is of great importance for tourists, b) the therapeutic value of mud volcanoes allows to create of a sanatorium in the areas where they are spread. Taking into account the great scientific-theoretical and practical significance of mud volcanoes, an order was signed on August 15, 2007, to protect 52 volcanoesim[6].

Morphometric study of the regions where mud volcanoes and other geomorphological objects are spread remains one of the unresolved problems of tourism in Azerbaijan.

This morphometric study was performed for the effective organization of mud volcano tourism (selection of efficient routes, protection of mud volcano landscape, creation of perfect infrastructure, etc.).

Geomorphosystems of the Gobustan-Absheron physical-geographical region, which is a particular region of the mud volcano, were studied in a complex morphometric way. The area of the physical-geographical region is 5059.75 sq. km. There are 540 slopes here. They have an absolute height and a vertical split, which is not very large, and are sharply divided by a network of ravines and streams. The eastern exposition slopes dominate here. They occupy 20.32% of the territory of the Gobustan-Absheron physical-geographical region and make up 18.14% of all slopes. Northeastern slopes differ in the smallest area (81.60 sq. km; 2.15%) and number (19; 3.52%).

In here the average angle of inclination reaches 20^0 and slopes with a 6^0-12^0 inclination predominate. On such slopes, several construction works become more difficult, and earthworks increase. Special techniques are required to increase productivity. They cover 56.67% of all slopes, occupying 47.15% of the surveyed area.

[6]İ.H Aliyev. Order of the President of the Republic of Azerbaijan "On the Establishment of the Baku and Absheron Peninsula Mud Volcano Group State Nature Reserve" August 15, 2007. №2315. Department of Affairs of the President of the Republic of Azerbaijan. Decrees and orders of the President of the Republic of Azerbaijan.Bibliographic index. №2 (7), - p.28, (In Azerbaijani)

The cost of vertical splitting (splitting depth) reaches 750 m. Slopes up to 250 m deep are predominant. This mud volcano does not significantly affect the organization of tourism. They occupy 52.84% of the surveyed area. Gobustan-Absheron physical-geographical region is characterized by the arid climate. A network of ravines and streams is widespread here.

The density of horizontal fragmentation reaches 3 km./sq.km. The slopes with horizontal fragmentation up to 1 km./sq.km. are prevalent. They occupy 63.12% of the studied area and are quite suitable for the organization of mud volcano tourism. The cones of a mud volcano have a radial horizontal split.

Analysis of the morphometric parameters of the slopes indicate that the geomorphosystems of the study area are generally suitable for the organization of mud volcano tourism.

In our research, the mud volcano tourism map of the Gobustan-Absheron physical-geographical region was compiled on a scale of 1: 300000 based on literature and cartographic sources. This map is of great importance for the organization of mud volcano tourism.

Based on the above research, a 30-item package of proposals on the effective organization of mud volcano tourism and the use of these resources was developed.

Morphometric study and assessment of ecogemorphological tension on the slopes of mountain geomorphosystems.

The whole field of human economic activity is connected with the geomorphosystems of the earth's surface. In the conditions of market economy, along with plains, mountainous areas have been intensively adopted in our republic. As a result, geomorphosystems in mountainous areas lose their original state. This culminates in the loss of its engineering, aesthetic, agricultural and other features. Therefore, there is a need for efficient use and protection of geomorphosystems and this requires the study of their ecological condition. Ecological geomorphology, a relatively young field of applied geomorphology, deals with such research.

It should be noted that inefficient use of relief leads to a violation of its original condition. That is why the study of its

ecological condition is one of the most important issues in geomorphology.

Deterioration of the initial condition of the slopes (its fraction, intensive grazing, landslides, avalanches, etc.) requires a thorough study of the slopes, morphometric monitoring and making up of a novel map. An ecogeomorphological map may be the best example of such a map. An ecogeomorphological map is, first of all, a source of information about the ecological status of a geomorphosystem and can be used for its protection.

Echogeomorphological tension of the slopes was assessed and morphometric analysis was performed on the example of the slope of the area between the Pirsaat and Chigilchay rivers. Its area is 2393.33 sq. km.The purpose of the research is to compile an ecogeomorphological tension map of slopes, to study the distribution of areas with slopes with different ecogeomorphological tensions and their distribution in vertical zones. The ecogeomorphological tension of the area is greatly influenced by the hypsometry, slope, exposition and horizontal and vertical division of the area.

Hypsometry affects ecogeomorphological tension by climatic factors. Thus, as the climate changes, the temperature, pressure and humidity of the atmosphere change as well. This in turn affects the ecogeomorphological tension.

The inclination determines the intensity, energy, the intensity of solar radiation and other properties of all slope processes.

Horizontal fragmentation determines the degree of variability of the ecogeomorphological conditions of the slope. The intensively fragmented geomorphosystem is subject to intensive destruction.

Vertical fragmentation determines the height distribution of the tensions of the ecogeomorphological conditions of the geomorphosystem.

As mentioned above, viscosity affects the heat supply of the geomorphosystem. The slopes of the southern and northern slopes are scattered to varying degrees. The absolute height of the slopes and the physical and geographical conditions also have a great impact on ecogeomorphological tension.

The average angle of inclination, horizontal and vertical splitting of each of the 425 slopes in the study area, visibility was assessed on a five-point scale, classified according to ecogeomorphological stress: 1 point (very weak), 2 points (weak), 3 points (average), 4 points (high), 5 points (very high). Based on these works, the ecogeomorphological stress map of the slopes of the area between the Pirsaat and Chigilchay rivers was compiled by cartographic method on a scale of 1: 100000. Horizontal lines of 200 m, 500 m, 1000 m and 2000 m are drawn on the map. Cartometric and morphometric works were done on this map, tables were compiled and histograms were constructed. Their complex analysis implies that the distribution of slopes with different ecogeomorphological stresses depends on the value of morphometric indicators. There is a vertical zoning in their distribution.

It is typical for the slopes of the area between Pirsaat and Chigilchay: a) Zoning of eco-geomorphological tension of slopes is observed in all river basins, except for the basin of Jeyrankechmez river. Slopes with low ecogeomorphological tension up to the middle mountain zone, slopes with medium eco-geomorphological tension in the middle mountain zone, and slopes with high ecogeomorphological tension in the high mountain zone are observed; b) slopes with very weak and very high ecogeomorphological tension in the high mountain zone is not found in all river basins; c) As the ecogeomorphological tension increases, the number, area and density of slopes in all river basins first increase and then decrease. Slopes with weak ecogeomorphological tension in terms of number (173; 40.71%) and medium area (1008.31 sq. km; 42.13%) predominate. Slopes with very high ecogeomorphological tension is distinguished by the smallest number (4; 0.94%) and area (13.10 sq.km.; 0.55%).

The location of settlements in this area at different ecogeomorphological tensions has also been studied. It was found that the location of habitats is influenced by the ecogeomorphological tension of the slopes. There are 78 settlements here. The settlements are more densely located on slopes with low ecogeomorphological tension and very low ecogeomorphological tension.

RESULTS

1. In the studied area (19823.84 sq.km) weakly inclined by number (330547; 25.45%) and straight (0^0-1.5^0). By area (8274.28 sq.km; 41.74%) geomorphosystems predominate. Very steep (45^0-90^0) geomorphosystems differ in the smallest number (68551; 5.28%) and area (174.28 sq. km; 0.88%). Based on these indicators, it can be said that the studied area is generally suitable for economic activities [48].

Slightly fragmented (250-500 m) slopes predominate in the study area in terms of number (992; 25.05%) and area (4636.15 sq. km; - 30.05%). The minimum number (589; 14, 87%) and area (2667.37 sq. Km ; 16.24%) are characterized by very weakly fragmented (0-250 m) slopes [39].

Weakly horizontally fragmented (0-1 km./sq.km) slopes are more common (2798; 70.66%; 11141.05 sq.km; 67.82%). Very strongly fragmented slopes are characterized by the smallest number (14; 0.35%) and area (48.46 sq. km; 0.29%). As the value of horizontal fragmentation increases, the number and area of slopes decrease [40].

Northern (north, northwest and northeast) exposition slopes dominate by the numbers (287698; 41.01%). They occupy 30.54% of the surveyed area. However, southern (south, south-west, south-east) exposition slopes dominate by their areas (6414.95 sq. km .; 32.36%). They make up 35.71% of geomorphosystems. The statistical distribution of geomorphosystems of different expositions is very chaotic. There are several different geomorphosystems in highly fragmented regions [34].

2. The complex analysis of morphometric indicators of slopes of the southeastern part of the Greater Caucasus indicates that there is no functional relationship between morphometric indicators of slopes whereas correlation relationship prevails. The area of this zone is 2787.16 sq. km. The basins of the Agsu, Pirsaat, Gozluchay, Chigilchay and Jeyrankechmez rivers are located here. Morphometric indicators are very complex and are formed under the influence of exogenous and endogenous factors and are constantly changing.

An analysis of the interaction of 572 slopes between 5148 morphometric indicators imply that the elevation values (maximum, minimum, average and relative) in the study area as a whole are more closely related to each other and to the angle of inclination than to other morphometric indicators. Exposition does not significantly affect the relationship between morphometric indicators.

A joint analysis of the horizontal fragmentation and exposi-tion map indicates that there is no functional connection between them, nonetheless, the relationship is correlated. The exposition has no direct effect on the intensity of horizontal scattering. Numerous slopes and various expositions are found in the heavily fragmented areas. The lithology of rocks, tectonic activity of the area, atmospheric precipitation, vegetation and other factors have an immense influence on the density of the horizontal fragmentation of the relief.

The relationship between the average angle of inclination of the slopes and their length, relative, extreme and average height is observed everywhere in the study area. The average slope angle of the slopes is more closely related to the height morphometric indicators. The connection between the extreme heights is closer [7, 25].

The study of the neighbourhood of slopes in the Shamakhi research area (S = 277.64 sq. km) points out that there is no connection between the neighbourhood and the exposition. Thus, the exposition of the slopes is mainly the result of tectonic movements, and they have a chaotic character like the slopes.

3. As the point of the morphometric assessment of construction conditions in the study area increases, the area, number and density of slopes first increase and then decrease. The most favourable slopes are 5637.60 sq. km which is 28.44% of the studied area.

Providing that we consider that the suitable, more convenient and most suitable geomorphosystems are favourable for either this or that construction work, then it can be said that the main part of the studied area is morphometrically convenient for construction work. Less favourable slopes can be used for the construction of temporary dwellings [24].

In the Greater Caucasus (within Azerbaijan), moderately geodynamically active areas attract attention in terms of their areas (8870.74 sq. km; 44.75%) and their numbers (109; 37.60%). Thus, the area to be studied is favourable from the point of view of geodynamic activity. As geodynamic activity increases, the number, area and density of slopes first increase and then decrease. This is explained by the unequal division of the area [6].

4. The study area of the southern slope of the Greater Caucasus, 116 (24.367%) of the 476 settlements were located on slopes with an inclination up to 10.5, and 119 (25.00%) were located on the southern exposition slopes. The least (2; 0.42%) settlements are located on slopes with a 20^0-45^0 inclination. On the slopes of any inclination, the settlements are mainly located on the slopes of the southern and southwestern expositions. Settlements have regular, irregular, planned and complex configurations. The maximum density of settlements (0.06) is observed in the lowlands. Sequentially, anterior and middle mountainous (0.03) zones can be noted [9].

5. As the value of point increases in the study area, the area, number and density of geomorphosystems with different degrees of heat supply increase. Geomorphosystems with better heat supply predominate in terms of number (92; 37.10%), area (8334.93 sq. km; 42.04%) and density (0.0046). Geomorphosystems with the smallest area (127.45 sq. km; 0.64%), number (12; 4.84%) and density (0.0006) are characterized by poor heat supply.

Thus, the studied area is entirely suitable for agricultural activities. Very poorly supplied geomorphosystems are not present in the study area. Poorly heated geomorphosystems occupy 127.45 sq. km (0.64%) of the study area [8].

6. On the slopes of the area between the Pirsaat and Chigilchay rivers (S = 2393.33 sq. km.) moderately eroded slopes are predominant by the number (292; 68.71%), area (1623.97 sq. km; 67.86%) and density (0,12) [10, 44].

As the value of erosion fragmentation in the study area increases, the number, area and density of geomorphic systems increase first and then decrease. The average price of the field first decreases then increases and decreases again. Moderately eroded

fragmented geomorphosystems predominate in terms of number (110; 41.51%), area (8578.51 sq. km; 43.27%) and density (0.0055) [37].

7. İn the study area favourable and more favourable geomorphosystems are predominant in terms of their areas (42.27% and 42.22%), numbers (25.41% and 56.56%) and density (0.0035 and 0.0016). Therefore, the morphometric point of view of the studied area is favourable in terms of recreation. As the value of point increases, firstly, the number, area and density of geomorphosystems increase, then decrease. First of all, the average value of the area decreases, then increases, then decreases again. This is explained by the uneven tectonic activity of the study area [31,47].

8. Because of the poor improvement of infrastructure, inaccessibility of some geotourism facilities, weak material base, lack of specialists and other factors geotourism has not developed properly. Natural factors open up wide opportunities for the development of geotourism, nevertheless socio-economic factors are far behind and interfere with its development. The tourism potential of geomorphosystems has not been comprehensively and thoroughly morphometrically analyzed, and their capabilities have not been sufficiently studied.

Climatic conditions are favourable for the development of all types of tourism. When organizing geotourism, the climatic features of the area should be studied, and the weather forecast for the period of tourism activity should be prepared. Winter tourism needs to be studied more thoroughly and comprehensively [28, 29].

9. Along with lithology of rocks, tectonics of the area, climate and other factors, morphometric indicators (slope inclination, horizontal and vertical splitting, exposition) also play an important role in the formation of caves. Thus, it can be said that morphometric indicators have a direct role in the formation of karst caves [16].

The Khinalig research area (S = 1761.05 sq. km) is suitable for winter tourism due to morphometric and climatic indicators. However, socio-economic factors make it difficult to advance such a lucrative industry. In the study area, convenient slopes dominate by their numbers (328; 65.08%), areas (1149.45 sq. km; 68.11%) and

density (0.19). As the value of point increases, the number, area and density of slopes first increase and then decrease. The average value of the area is increasing. In general, the research area is convenient for winter tourism from a morphometric point of view [19].

Mud volcano tourism is one of the less popular but most promising types of tourism. Unfortunately, less attention is still paid to the advancement of mud volcano tourism in our country. The development of this field may create new opportunities for Azerbaijan to enter the world tourism market [42].

10. The increase in ecogeomorphological tension of slopes and the location of settlements in the area between the Pirsaat and Chigilchay rivers generally correspond to the altitude zones. Of the 78 settlements, 42 (53.85%) are on slopes with low eco-geomorphological tension, 22 (28.21%) are moderate, 9 (11.54%) are very weak, and 5 (6.41%) are located on slopes with high ecogeomorphological tension. There are no settlements on the slopes with very high ecogeomorphological tension [49].

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