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ИЗВЕСТИЯ

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MORPHOMETRİC ANALYSIS IN GIS BASED OF RELIEF PARAMETERS MUDFLOW BASINS

Abstract. On based SRTM DEM using GIS technology morphometric analysis of relief Shinchay-Damira-paranchay mudflow basins was performed. With this purpose there were built maps of hypsometry, slopes, aspec, range relief and drainage density, indices, dissection and ruggedness, surface curvature. Also it was analyzed the areal distribution of these parameters by grade.

Now, in connection with development of digital technologies and broad availability of data of remote sensing, detailed assessment of a relief became possible. Application of the digital models of a relief (DMR) considerably simplified the morphometric analysis of a relief.

Obtaining morphometric data in a form and structure of a surface of a relief serves the initial procedure.

Key words: GIS, DEM, morphometric analysis, range relief, SRTM.

Introduction. The drainage basin is the fundamental unit in fluvial geomorphology within which the relationships between landforms and the processes that modify them have been studied. The study of the geometry of the basin and the way in which it changes in response to processes has become a major part of modern geomorphology. Morphometric analysis of a drainage basin is a quantitative description of a basin and an important aspect to know the character of the basin [5].

In geomorphology long ago gained the development "geometrical approach" in studying of a relief. In foreign literature this direction gained development under the name "geomorphometry" [7, 8]. There are also synonyms of this term such as "quantative morphology" (the quantitative morphology), "quantative terrain analysis" (the quantitative analysis of a relief).

The explored region consists of central and east parts of the southern slope of Greater Caucasus and adjacent territories. The area of the explored region is 3220 sq.km (figure 1).

Methodology. As input data for the GIS-analysis of morphometric indexes of relief materials of satellite photos of SRTM are used.

Data of SRTM (Shuttle Radar Topographic Mission) represent the processed results of radar survey of the surface of the globe made from the board of the American Shuttle space ship by the method of radar interferometry, in February 2015. This survey was conducted out almost in all territory and the water area of Earth between 60 ° north lat., 54 ° south lat. by means of the radar SIR-C and X-SAR.

A mathematical basis of the data is the referents-ellipsoid WGS-84 and a projection of GCS_WGS_1984. For SRTM data processing we used the ArcGIS 10.2.1 software package (ESRI, Inc., the USA), the application – Hydro Tools and DEM Tools [1, 9].

The main operations were carried out in the ArcGIS - spatial Analyst applications, 3D analyst and geostatistical Analyst. The Hydro Tools tool model operations of watersheds, reservoirs and drainage network perform functions of processing and preparation of the digital models of a relief (DMR). The DEM Tools applications which contain a number of functions, for calculation of some morphometric indexes was useful to realization in some of operations [3]. The scheme of creation the morphometric maps on the basis of digital models of a relief on ArcGIS (figure 2).

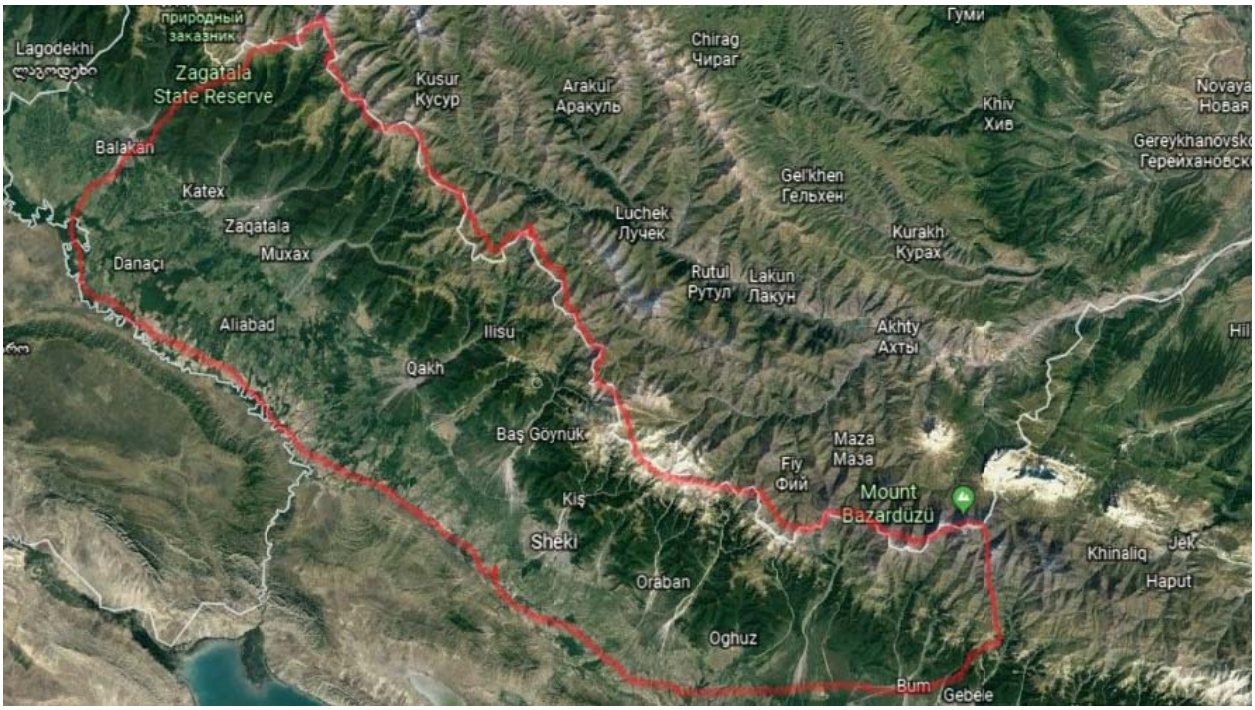


Figure 1 – A geographical location of the explored region

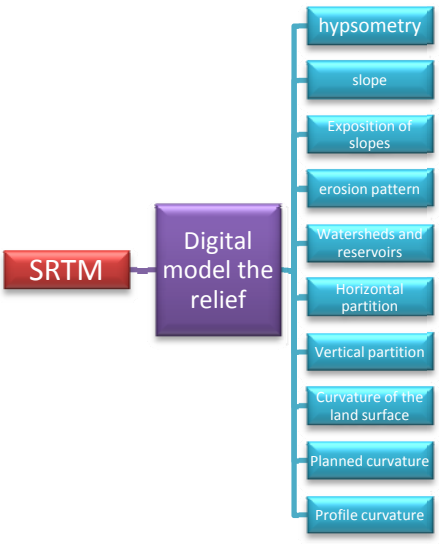


Figure 2 – Scheme of creation of morphometric maps

Discussion of results. For the analysis, we used such classical parameters of morphometry as hypsometry, a surface bias, an exposition of slopes, horizontal and vertical partition, curvature and also, such parameters as the index of partition (dissection index) and the index of ruggedness (ruggedness index).

Hypsometry. The analysis of the Digital model of relief (DMR) shows that absolute heights fluctuate here at 175 to 4147 m. The analysis of the hypsometric map (figure 3) shows that the largest space (54% in the explored region) is occupied by the range of height 175-1000 m (table 1).

Biases of a surface (steepness) and exposition of slopes. Calculations of the biases of a surface it is necessary at assessment of slope processes, in soil erosion calculations, assessment of lands, etc. According to the calculations received from the map (figure 4) slopes with the 10° occupy 49.5% of the total area (table 2). Slopes of more than 10° where slope processes proceed more intensively, is occupied 50.5% of the territory, at the same time the large territory is covered with the slopes by the steepness more than 40°.

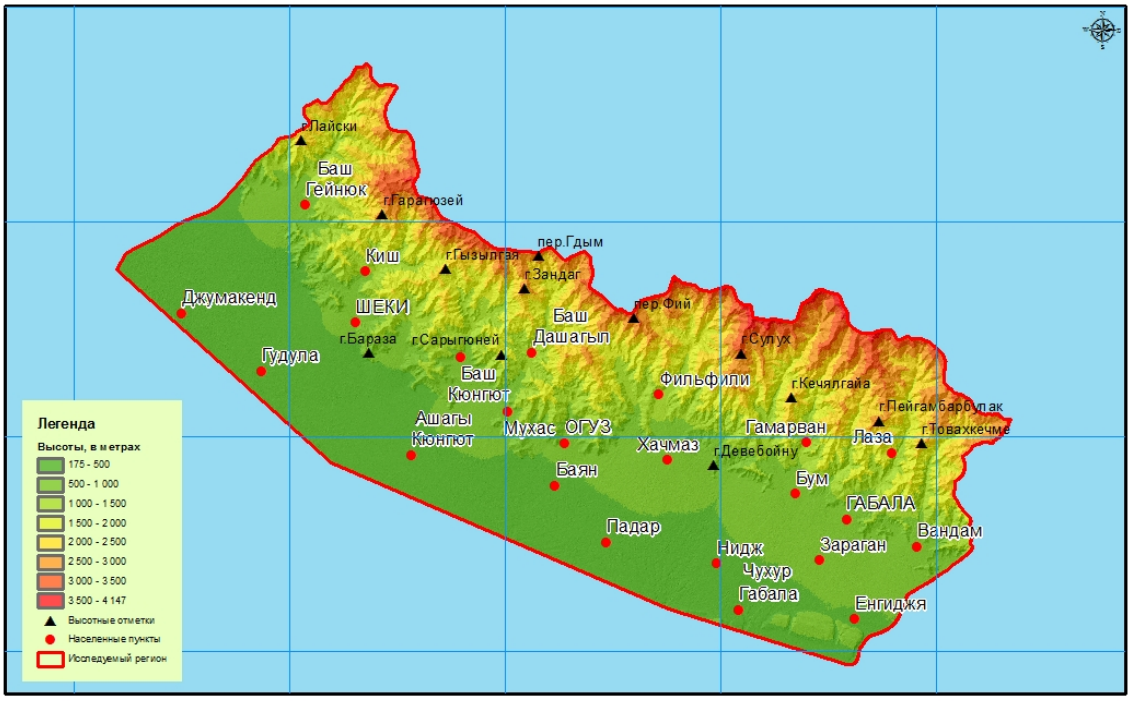
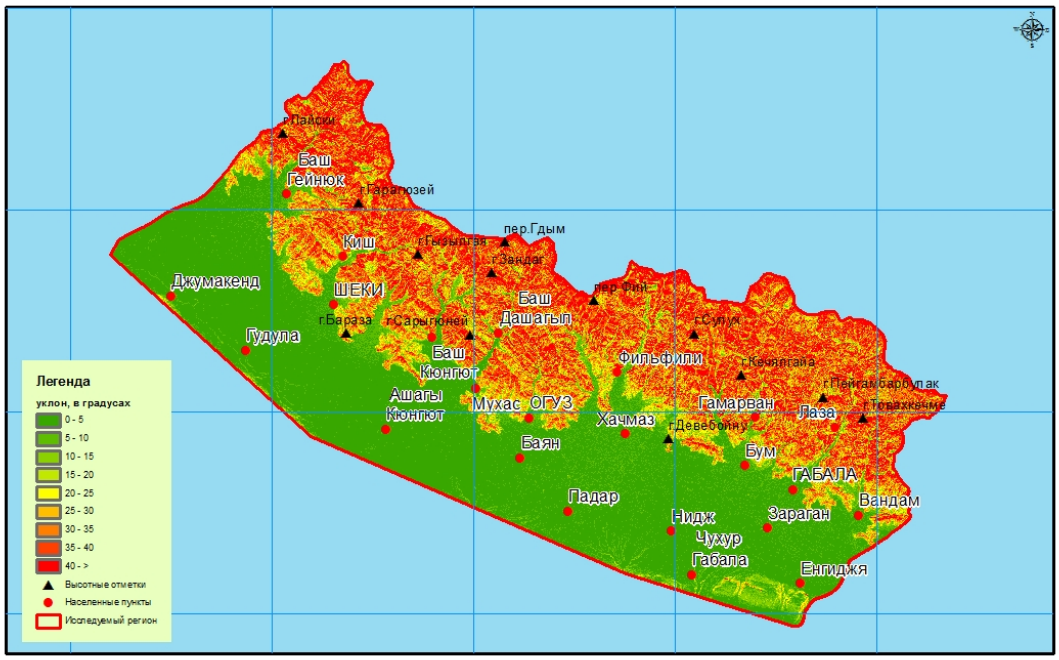


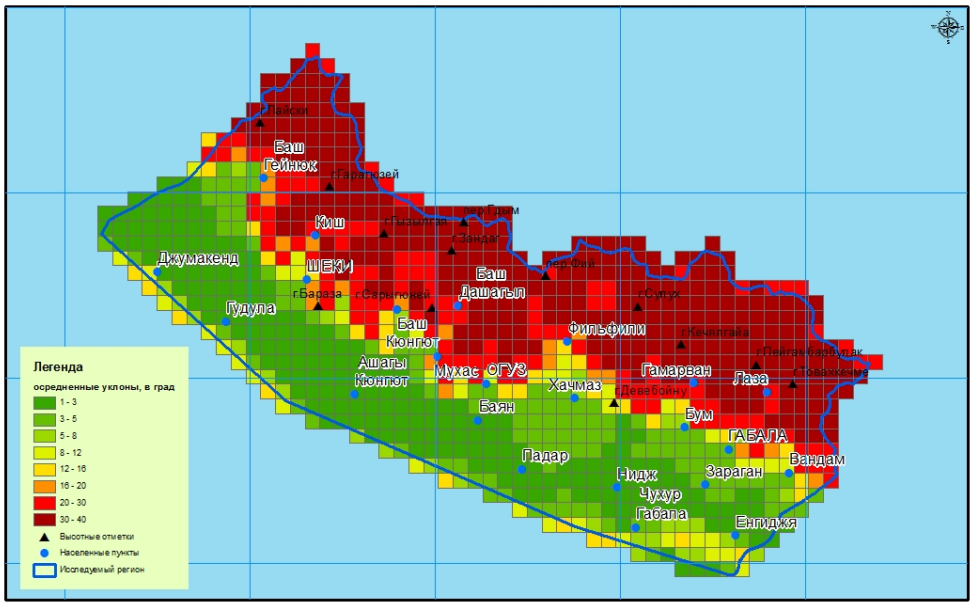
Figure 3 – The hypsometric map of the explored region

Table 1 – Distribution of the total areas on a hypsometry

Hypsometry, m	175–500	500–1000	1000–1500	1500–2000	2000–2500	2500–3000	3000–3500	3500–4147
Area, km^2	1003,385	760,8604	406,5572	391,5357	324,7913	219,8148	100,4427	14,8772
Area, %	31,14	23,61	12,62	12,15	10,08	6,82	3,12	0,46



a)



b)

Figure 4 – The map of slope angles of the explored region received by reference by method (a) and the card of average slope angles received by method of Zone statistics (b)

Table 2 – Distribution of the total areas on slope angles

Angles	0-5°	5-10°	10-15°	15-20°	20-25°	25-30°	30-35°	35-40°	40°->
Area, km^2	1363,24	232,92	103,78	114,93	161,31	233,97	299,97	310,37	399,80
Area, %	42,33	7,23	3,22	3,57	5,01	7,27	9,32	9,64	12,41

The exposition of a slope is one of morphometric characteristics of a relief, characterizing dimensional orientation of the elementary slope (figure 5). It characterizes the slope relation to the multi-scale processes (insolation, gravitation, circulation etc).The exposition can be considered as the direction of a bias [2, 4, 11].

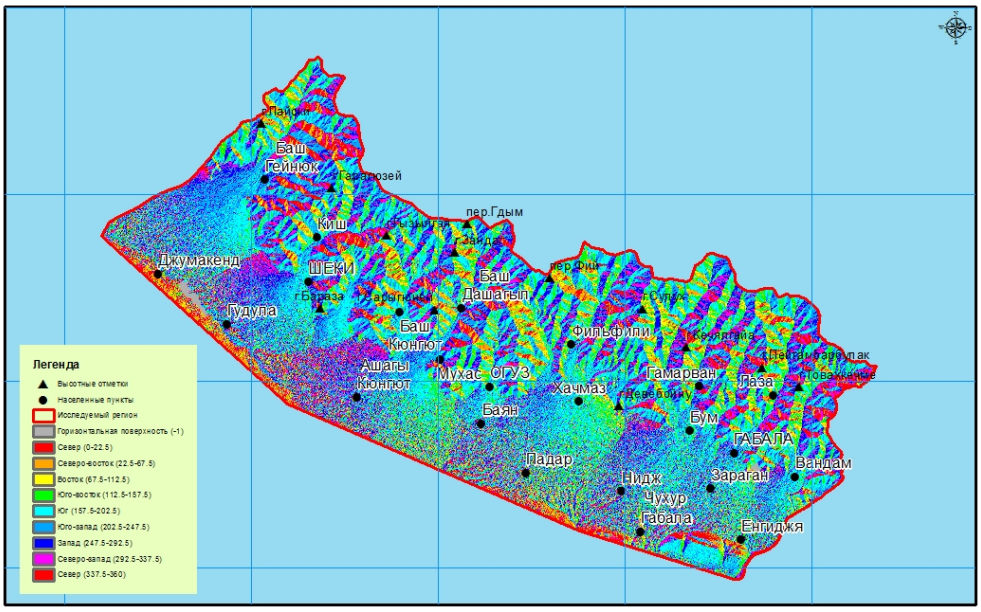


Figure 5 – The map of an exposition of slopes of the explored region

Table 3 – Distribution of the total areas on an exposition of slopes

Exposition	Flatness	North	North-East	East	South-East	South	South-west	West	North-west
Area, km^2	47,29	231,07	193,76	200,83	383,37	762,79	672,10	419,73	309,23
Area, %	1,47	7,18	6,02	6,24	11,91	23,69	20,87	13,03	9,60

As seen from the table, the southern exposition slopes (southern, southern, western, southern and eastern) is composed of half a total of 56.5%. The slopes with anti-polar orientation (northern, southern-western and northern-western) have more than twenty-eight percent of the total area.

Vertical and horizontal partition. Calculates vertical scattering by using a cartogram, which is a tool used by ArcGIS (Spatial Analyst Tools → Zonal Statistics), which calculates the amplitude (in meters) of the DMR values in the calculable cells (figure 6). The vertical clearance, more than 350 m, was discovered in the main section of the Caucasus Quarter and in the high-altitude zone.

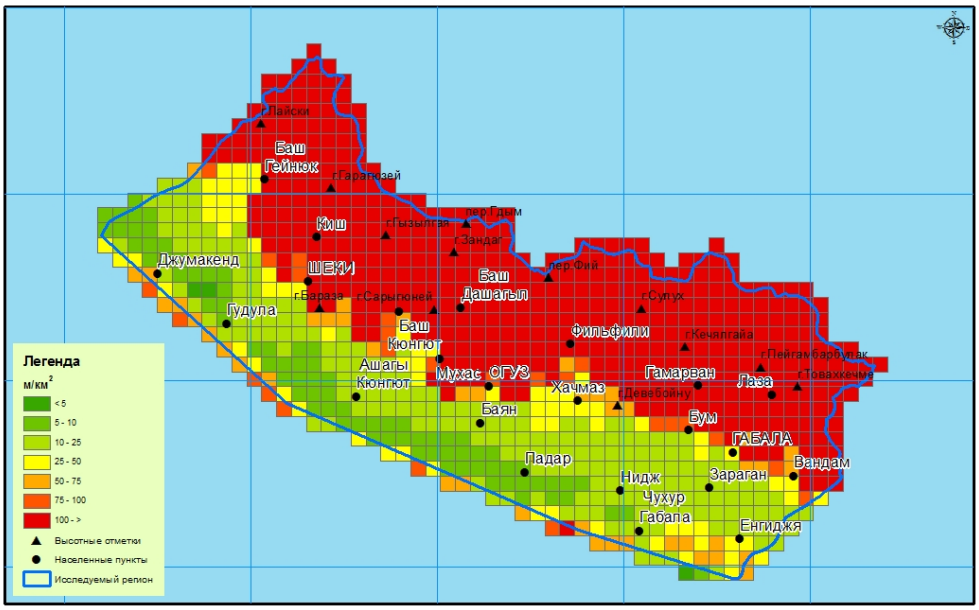


Figure 6 – Map of vertical spreading relief of the region

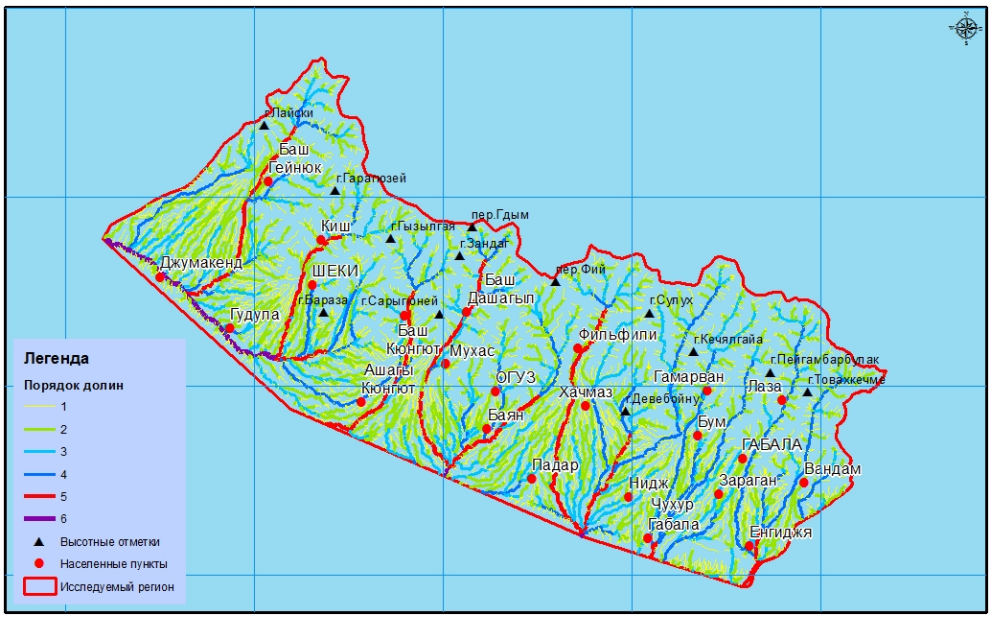
For horizontal computing, there has been used the Hydrology Tool (Spatial Analyst) to create all erosion network (figure 7).

The erosion network was the base for the calculation horizontally partition. The analysis of the map (figure 7 b) shows that the maximum marks of horizontal partition are found for the Qanix-Ayrichay plain, the least – for water separate zones.

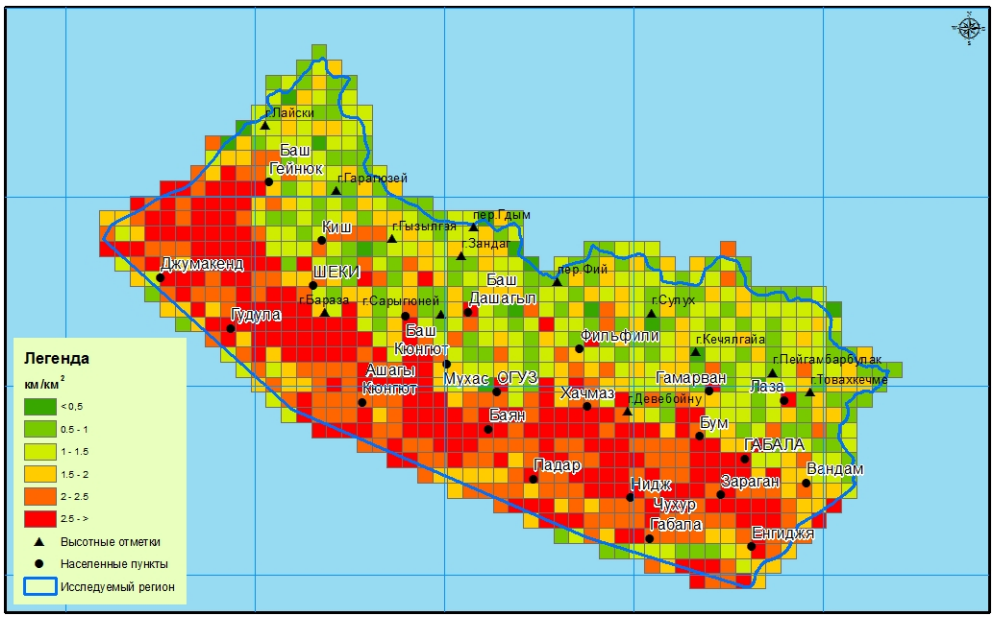
DI, dissection index. This index expresses a ratio of the relative relief (in this case vertical partition) to an absolute relief (i.e. to the maximum indicators of a relief, so-called topmost surfaces).

$$DI = \frac{Zmax - Zmin}{Zmax}.$$

He is an important index of partition of a surface and indicates a vertical partition. The high value of the index indicates the orogeny, low value corresponds to stable areas.The analysis of literary data and morphometric features of the explored territory allows us to choose on the basis of this index five class scale system - such as, very low DI (<0,1), low DI (0,1-0,2), temperate DI (0,2-0,3), high DI (0,3-0,4) and very high DI (>0,4) (figure 8). More detailed characteristics of this index are given in table 4.



a)



b)

Figure 7 – Resistance to CMS Erosion network (a) and map horizontally-distal relief region of the method zonal statistics (b)

Table 4 – Distribution of the total areas by the index of a partition (DI)

Class	DI	Area, km^2	Area, %
Very low	<0,1	1067,583937	33,17
Very low	0,1-0,2	594,9441697	18,49
Temperate	0,2-0,3	1225,437168	38,08
High	0,3-0,4	312,8245578	9,72
Very high	>0,4	17,44357346	0,54

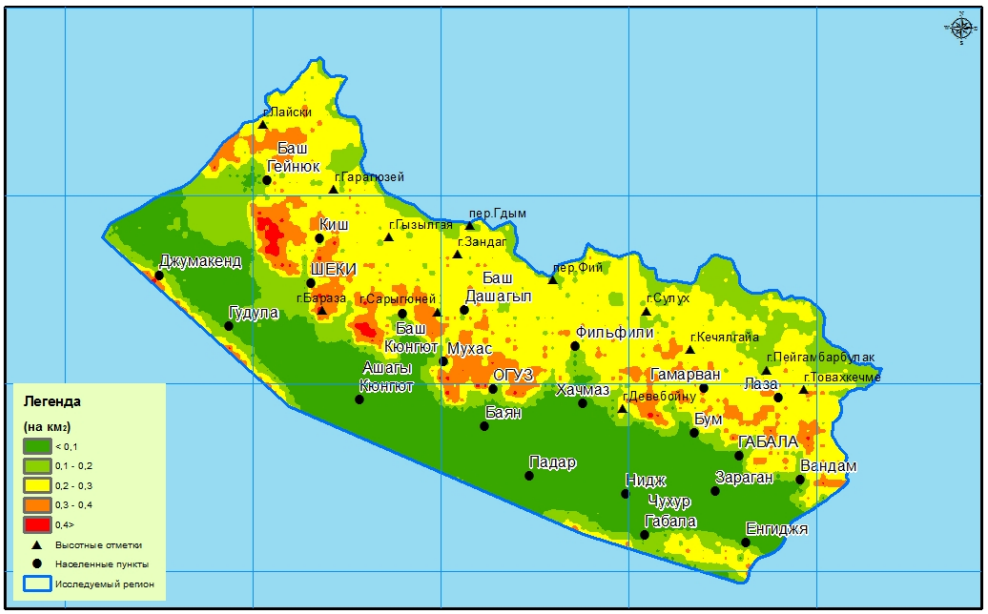


Figure 8 – Distribution of the index of a partition

Ruggedness index. This index describes the complexity and roughness of a land relief. The ruggedness defines extent of crossing of area where the drainage (erosive) network acts as a key parameter. Chorley (1972) developed a formula for this index [9-11]:

$$\frac{Deep\ partition\ (m/km^2)\ *\ horizontal\ partition\ (km/km^2)}{1000}.$$

This index is widely used by scientists in morphological researches for the best comprehension of formation of elements of a relief in the difficult geomorphological conditions [5-8]. Results of the analysis show that the maximum values are partition are observed in mountain and mid-mountain zones of the territory (figure 9).

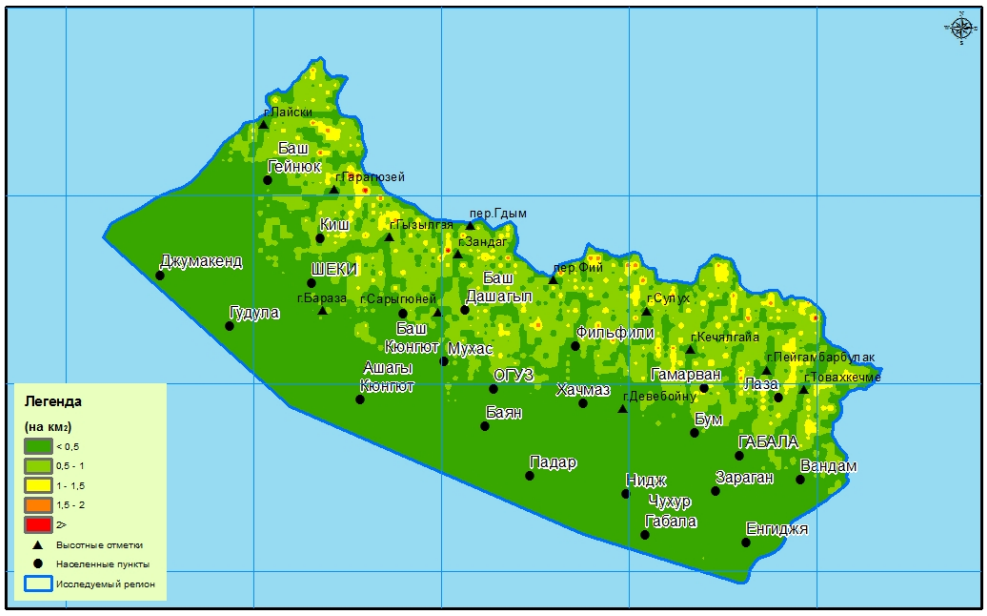


Figure 9 – Distribution of the index of ruggedness

Table 5 – Distribution of the total areas by the index of ruggedness (RI)

Class	RI	Area, km^2	Area, %
Very low	<0,5	2180,205994	67,74
Very low	0,5-1	909,3180482	28,25
Temperate	1-1,5	122,4866082	3,81
High	1,5-2	6,030192299	0,19
Very high	>2	0,481880286	0,01

Conclusions.

1. So, for the first time for the explored territory is carried out the complex morphometric analysis according to the radar interferometric topographic trajectory SRTM, with the software of ArcGIS.
2. On the basis of the created DMR and the modern GIS-technologies are calculated morphometric parameters of a relief. This way allows to carry out the assessment of the modern erosive processes on the quantitative basis and to create a set of geomorphological maps.
3. By means of our research materials is possible to study characteristic of processes of an erosion and accumulation and also assessment of potential stability or tendency to an erosion of various sites of the explored territory.

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ГАҚ НЕГІЗІНДЕ СЕЛ ҚАУІПІ БАР БАССЕЙНДЕРДІҢ БЕДЕР ПАРАМЕТРЛЕРІН МОРФОМЕТРИЯЛЫҚ ТАЛДАУ

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МОРФОМЕТРИЧЕСКИЙ АНАЛИЗ ПАРАМЕТРОВ РЕЛЬЕФА СЕЛЕОПАСНЫХ БАССЕЙНОВ НА ОСНОВЕ ГИС

Аннотация. На основе цифровой модели рельефа SRTM с помощью ГИС-технологий выполнен морфометрический анализ рельефа селеопасных бассейнов междуречья Шинчай-Дамирапаранчай. С этой целью построены карты гипсометрии, углов наклона, экспозиции, горизонтального и вертикального расчленения, индексов расчлененности и пересеченности, кривизны поверхности. Также проанализировано площадное распространение этих параметров по классам.

Рельеф является одним из основных факторов в дифференциации ландшафтов. В настоящее время, в связи с развитием цифровых технологий и широкой доступностью данных дистанционного зондирования, стала возможным детальная оценка рельефа как ландшафтообразующего фактора. Применение цифровых моделей рельефа (ЦМР) значительно упростило морфометрический анализ рельефа. Именно рельеф и его параметры признаются наиболее важными при выделении ландшафтов.

Получение морфометрических сведений о форме и структуре поверхности рельефа служит начальной процедурой, которая предшествует содержательному исследованию генетических, динамических, временных (т.е. общих геоморфологических) аспектов функционирования рельефа. Преимущество такого подхода заключается в возможности абстрагирования от неопределенности и неоднозначности в геоморфологическом отношении, при этом сосредоточиваясь на анализе морфометрических показателей.

В определении рельефа как объекта исследования геоморфологии существуют 2 основных взгляда. Первый из них рассматривает рельеф как некую совокупность форм земной поверхности, которую можно

описать в виде набора пространственно-координированных высотных отметок (в виде XYZ). Т.е. исследованию подлежат геометрические показатели. Такой подход называется геометрическим. Другая трактовка рельефа учитывает и слагающие его геологические тела. Это значительно усложняет и делает субъективным классификацию форм рельефа.

Ключевые слова: ГИС, ЦМР, морфометрический анализ, расчлененность, SRTM.

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