AVALANCHE DANGER ON ROADS İN MOUNTAİNOUS REGİONS OF GEORGİA USİNG THE EXAMPLE OF RACHA-LECHKHUMİ KVEMO SVANETİ REGİON

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Abstract

Natural hazards, such as avalanches, are common in the mountainous regions of Georgia. They pose a great danger to the population, cause destruction, paralyze sections of roads, and often cause casualties.

Racha-Lechkhumi Kvemo Svaneti region of Georgia belongs to the high mountain region (400-4000 m. above sea level). The region is characterized by steep slopes and abundant snowfall. Therefore, avalanches are not a rare event in the region. Snow avalanches especially damage the road infrastructure that connects the municipalities of the region. In winter, the blocking of road sections by avalanches from the slopes threatens the surrounding populated areas, causes ecological problems and human casualties are frequent.

Meteorological elements: air temperature, snow cover, precipitation are studied on the research sections of the highways of the region. The data is processed according to the data of two weather stations in the region (Oni, Mamison Pass) and covers the last 60 years. Based on the results of the research. A geo-informational map of avalanche hazards of road sections of the Racha-Lechkhumi Kvemo Svaneti region has been compiled.

The conducted research will significantly contribute to the implementation of correct and effective anti-avalanche measures, reducing the economic losses of the country.

Keywords: natural disaster, avalanche, climate, road infrastructure, geoinformation map

I. Introduction

Snow avalanches are one of the most important natural disasters. The purpose of the study is to investigate the avalanche danger of the Racha-Lechkhumi and Kvemo Svaneti highways in the mountainous region of Georgia, the smooth operation of which is important for the sustainable development of the country.

Based on long-term (>60 years) data from meteorological stations and checkpoints in Georgia, regions with little snow, medium snow, no snow, and especially no snow are distinguished according to the amount of snow. The maximum height of the snow cover in the area with little

snow varies from 30-50 cm to 140-160 cm in the area with average snow. The maximum height of the snow cover increases with the increase in the absolute altitude of the place and is from 60-100 cm to 450-500 cm in the area without snow the maximum height increases from 100–120 cm to 550–600 cm, and the maximum height of the snow cover changes from 100–120 cm to 700–750 cm in a particularly snowless area [1].

Therefore, it is logical that 56% of the territory of Georgia is covered with avalanche-prone slopes, catastrophic avalanches spread over 36% of the territory, avalanches occur annually on 20% of the territory, and sporadic, rare avalanches occur on 36% of the territory, which are possible to repeat once a year or several decades [2].

According to the data of the National Environmental Agency, there are more than 5,000 identified avalanche traps in Georgia [3].

Avalanche risk in mountainous regions of Georgia depends on topography (orography, hypsometry, and slope inclination), climate (air temperature, atmospheric precipitation, and snow cover), and vegetation cover. Evaluation of the above-mentioned elements allows for the determination of the origin, mode, and distribution characteristics of avalanches [4-6}.

Four main quantitative characteristics determine the degree of avalanche danger in the territory of Georgia:

- avalanche activity of the area (active area in terms of avalanche formation);
- Avalanche distribution frequency (number of avalanches per area unit);
- frequency of arrival of avalanches (the number of arrivals of avalanches from the avalanche reservoir in one winter);
- Duration of the avalanche period (number of avalanche days in one winter) [7,8]

On the territory of Georgia, especially strong, strong, medium, weak, and non-avalanche-prone areas are distinguished (Fig. 1) [9]. The percentage of their sea hazards is presented in Fig.2.

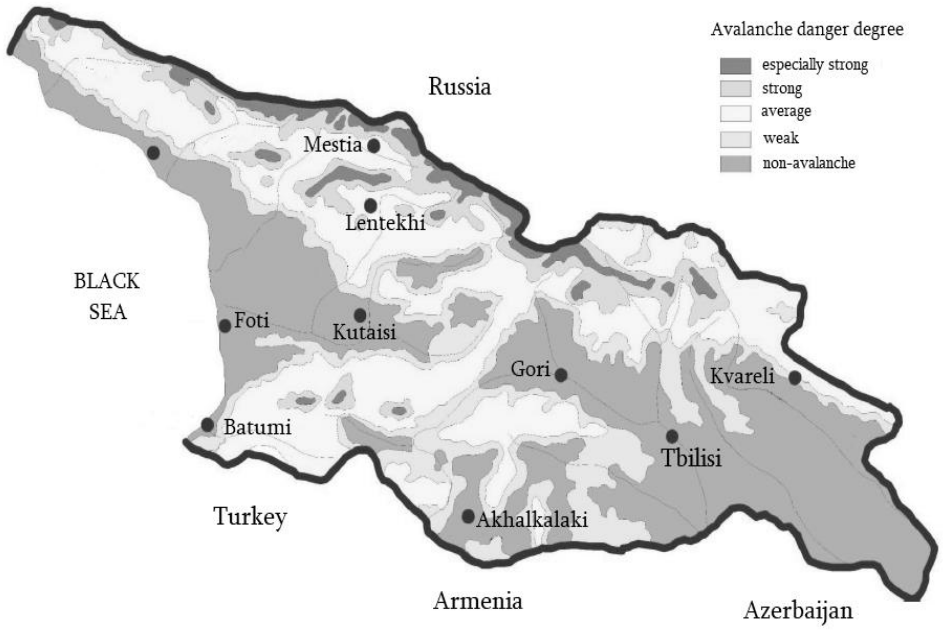

Figure 1: *Schematic map of Georgia's avalanche hazard quality. Source: Saluqvadze, M. (2018)*

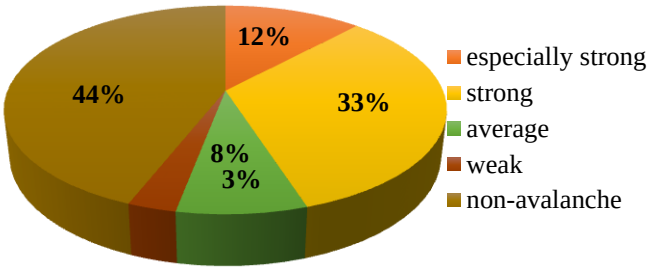

Figure 2: *The percentage of the degree of avalanche danger in Georgia.*

II. Methods

Area under study

The object of our research is one of the regions of Georgia, Racha-Lechkhumi and Kvemo Svaneti (Fig. 3). It is located on the southern slopes of the Central Caucasus and belongs to the high mountain zone (400–4000 m) [10].

Figure 3: *Racha-Lechkhumi and Kvemo Svaneti region. Source: http://rachalechkhumi.blogspot.com/2014/ [11]*

The region is rich in mountain resorts: Shovi, Usira, Lashichala, Veshwake, Muashi, Sortuan, Bugeuli, Khidikar. There are many types of healing mineral or sulphurous waters in the region. From the point of view of tourism, it is distinguished by the abundance of attractive objects.

On the territory of the region, we can find the oldest churches: Nikortsminda, Barakoni, Khonchiori, Mootdzali, Patara Oni, Ghe, Kviriketsminda, Laila, Chazhashi complex, Minda-tsikhe, Kvaratsikhe, the oldest complexes of castles - "Dakhdi", "Dahkari", "Arr Latsa", Oni Synagogue, Shaor and Lajan reservoirs, etc. [12]. All of the above emphasizes the need for proper functioning of the road infrastructure in the region.

Racha has humid weather up to 2000 m above sea level, winter is cold and long, summer is short and warm, absolute minimum temperature is -27 °, and the maximum is 36°. Precipitation ranges from 1000–1500 mm to 1600–1800 mm.

As for the maximum height of the snow cover, in general, it ranges from 127 cm to 535 cm in

Racha-Lechkhumi and Kvemo Svaneti (Table 1).

Table. 1: *The maximum height of the snow cover in Racha-Lechkhumi and Kvemo Svaneti*

Weather station	Altitude of weather station	Years of observation	Maximum height, cm	Recurrence of snow cover height of more than 50 cm, (cm/year)				
				>50-100	101-200	201-300	301-400	>400
Ambrolauri	544	1932-2021	165	25	6	-	-	-
Oni	788	1932-1998	127	21	3	-	-	-
Shaori	1145	1948-1988	255	21	19	4	-	-
Uravi	1150	1939-1990	230	19	6	1	-	-
Shovi	1507	1935-2021	365	24	30	4	1	-
Mamison Pass	2854	1935-1992	535	31	11	6	-	1

The Table 1., presents the height of meteorological stations and checkpoints, the years of observations, the maximum snow height, and the recurrence of the snow cover height of more than 50 cm by year [13].

As it can be seen from the presented material, in the territory of Racha-Lechkhumi and Kvemo Svaneti regions, according to the indicators of avalanche danger (Fig. 1.), especially strong, strong, and average avalanche-risk areas are separated.

The detection of avalanche-prone sections on the highways of the Racha-Lechkhumi and Kvemo Svaneti regions was based on the existing materials of many years of field studies, the databases of the National Environment Agency, information and publications published in literary sources, and the fundamental studies of the Shota Rustaveli National Science Foundation (grant FR 21-1677). Materials and data from field expeditions carried out in 2022 During the field work, the avalanche hazard of each research road section of Racha-Lechkhumi and Kvemo Svaneti region was studied. In particular, a drone (dji mavic 3) was used to describe the locations of avalanche arrivals on road sections, the location of avalanche collectors, and collect photo and video material in areas of avalanche danger where it is impossible to reach on foot.

III. Results

The morphometric (beginning and end height, length, focal area, surface slope) and dynamic characteristics of the avalanche (maximum speed and impact force, cone volume, and maximum height of the moving avalanche) of the area avalanche on the highways of Racha-Lechkhumi and Kvemo Svaneti region are presented in Table 2.

Table 2: *Morphometric and dynamic characteristics of dangerous avalanches of Racha-Lechkhumi and Kvemo Svaneti highways*

N	Altitude, m		Length, m		Total		Avalanche area, ha	Tilt angle, degree	Speed, m/s	Impact strength, t/m^2	Volume 1000 m^3	Avalanche height, m	Length, m	Suspension height
	Absolute	Relative	Horizontal	Factual	Horizontal	Factual								
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
1	Lentekhi municipality, village Nagomari. Right slope of river Tskhenistskali													
	550	35	80	85	2450	2695	4,8	24	0	0	92	24	2650	530
	The avalanche cross the road, pass by the buildings, cross the river and stop on the opposite slope													
2	Lentekhi municipality, village Nagomari. Left slope of river Tskhenistskali													
	545	5	140	140	600	720	0.2	2	0	0	3	17	680	544
	Crosses the road, passes by the buildings, stops in the river													
3	Lentekhi municipality, village Kvedrishi. Right slope of river Tskhenistskali													
	555	100	200	200	1040	1155	0.3	3	0	0	4	18	1060	560
	Cross the road, passes by the buildings, stops in the river													

4	Lentekhi municipality, village Mazashi. Right slope of river Tskhenistskali													
	620	15	120	120	830	980	0.2	7	11	6	3	18	930	615
	pass by the buildings, cross the road, the river and stop on the opposite slope													
5	Lentekhi municipality, village Tskhumaldi. Left slope of river Kheledula													
	1350	35	270	270	1470	1625	2.4	7	0	0	58	30	1500	1360
	Cross the road, pass by the buildings													
6	Lentekhi municipality, village Bavari. Left slope of river Kheledula													
	1220	150	1000	1010	3620	3880	12.0	8	0	0	331	35	2910	1360
	Pass by the buildings, cross the road, stop in the river													
7	Lentekhi municipality, village Bavari. Left slope of river Kheledula													
	1205	60	400	400	2490	2680	1.2	8	0	0	30	32	2570	1215
	Crosses the road, passes by the buildings, stops in the river													

N	Altitude, m		Length, m		Total		Avalanche area, ha	Tilt angle, degrees	Speed, m/s	Impact strength, t/m^2	Volume 1000 m^3	Avalanche height, m	Length, m	Suspension height
	Absolute	Relative	Horizontal	Factual	Horizontal	Factual								
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
8	Lentekhi municipality, village Bavari. Left slope of river Kheledula. The peak 1794 m. to the south-west													
	1190	30	200	200	1410	1525	0,4	8	0	0	9	27	1470	1200
	Crosses the road, passes by the buildings, stops in the river													
9	Lentekhi municipality, village Mananuri. Left slope of river Kheledula. The peak 1677 m. To the south-east													
	1110	20	200	200	530	595	0,1	6	0	0	2	22	540	1115
	Crosses the road, passes by the buildings, stops in the river													
10	Lentekhi municipality, village Khacheshi. Rght slope of river Kheledula. The peak Bachgeti 2272 m. to the north-east													
	1040	10	180	180	3510	3755	4.0	3	0	0	107	34	3670	1045
	Passes by the buildings and stops on the road													
11	Lentekhi municipality, village Khacheshi. Rght slope of river Kheledula. The peak 1902 m. to the north-east													
	1020	0	80	80	1410	1565	0.3	0	0	0	6	26	1530	1020
	Pass by the buildings, cross the road, stop in the river													
12	Lentekhi municipality, village Khacheshi. Left slope of river Kheledula. The peak 2379 m. to the south-west.													
	1005	5	190	190	2860	3130	9,8	2	0	0	247	32	3030	1008
	Pass by the buildings, cross the road, stop in the river													
13	Lentekhi municipality, village Khacheshi. Left slope of river Kheledula. The peak 1499 m. to the south-west.													
	1010	15	140	140	620	675	0,2	6	0	0	3	21	610	1015
	Passes by the buildings and stops on the road													
14	Lentekhi municipality, village Khacheshi. Left slope of river Kheledula. The peak 1499 m. to the south-west.													
	1001	3	180	180	1420	1520	3,0	1	0	0	56	24	1430	1004
	Passes by the buildings and stops on the road													
15	Lentekhi municipality, village Khacheshi. Left slope of river Kheledula. The peak 1499 m. to the south-west.													
	1005	15	150	150	850	950	0,2	6	0	0	4	23	890	1010
	Passes by the buildings and stops on the road													
16	Lentekhi municipality, village Kheledi. Left slope of river Kheledula. The peak 1365 m. to the south-west.													
	940	5	90	90	350	400	0.1	3	0	0	2	19	370	942
	Crosses the road and stops at the buildings													
17	Lentekhi municipality, village Tsinashi. Left slope of river Kheledula. The peak 1286 m. to the south.													
	815	15	300	300	1070	1150	0.2	3	0	0	3	20	1040	820
	Pass by the buildings, cross the road, the ravine and stop in the river bed													

18	Lentekhi municipality, village Tsinashi. Left slope of river Kheledula. The peak 1286 m. to the south.													
	815	15	300	300	990	1065	0,2	3	0	0	3	19	950	820
	Pass by the buildings, cross the road, the ravine and stop in the river													
19	Lentekhi municipality, village Faki. Left slope of river Kheledula. The peak 1848 m. to the Tsanashi													
	830	30	190	190	2560	2730	0.6	9	0	0	13	27	2620	850
	will pass the village near the buildings of Faki, crosses the road, ravine, stops at village in Nash													
20	Lentekhi municipality, village Faki. Left slope of river Kheledula. The peak 1848 m. to the south.													
	830	30	190	190	1860	1995	0.4	9	0	0	8	24	1900	845
	Pass the village near the buildings of Faki, crosses the road, ravine, stops at village in Tsanashi													
N	Altitude, m		Length, m		Total		Avalanche area, ha	Tilt angle, degree	Speed, m/s	Impact strength, t/m^2	Volume 1000 m^3	Avalanche height, m	Length, m	Suspension height
	Absolute	Relative	Horizontal	Factual	Horizontal	Factual								
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
21	Lentekhi municipality, village Lesema. Right slope of river Kheledula. The peak 1848 m. to the north-east.													
	800	35	60	70	1020	1170	0,6	30	0	0	10	22	1130	670
	Crosses the road, buildings, river and stops on the opposite slope.													
22	Lentekhi municipality, village Lesema. Right slope of river Kheledula. The peak 1590 m. to the north-east.													
	800	-35	60	70	1020	1170	0,6	30	0	0	10	22	1130	670
	Crosses the road, buildings, river and stops on the opposite slope.													
23	Lentekhi municipality, village Lesema. Left slope of river Kheledula. The peak 1917 m. to the South-west.													
	770	15	240	240	890	980	0,8	4	0	0	12	19	900	765
	Pass by the buildings, cross the river and rise to the road.													
24	Lentekhi municipality, town Lentekhi. Right slope of river Kheledula. The peak 1410 m. to the north-east													
	725	10	80	80	520	630	0.1	7	0	0	1	18	600	730
	Pass by the buildings, cross the road and stop in the river													
25	Lentekhi municipality, town Lentekhi. Right slope of river Kheledula. The peak 1410 m. to the north-east													
	750	20	20	30	960	1115	1.2	45	0	0	20	21	1110	740
	Pass by the buildings, cross the road, the river and stop on the opposite slope.													
26	Lentekhi Municipality, the right slope of the Lascadura River, The peak 971 m. to the east													
	755	10	50	50	340	425	0.1	-11	0	0	1	17	400	750
	Pass by the buildings, cross the river and stop on the road													
27	Lentekhi Municipality, the left slope of Lascadura River, Mt.1175 m. to the south-west.													
	745	10	130	130	590	680	0.6	4	0	0	9	19	630	750
	Crosses the road, passes the buildings, stops in the river													
28	Lentekhi Municipality, the right slope of Tskhenistskali River, Mt.1175 m. to the south.													
	725	10	130	130	410	460	0.2	4	0	0	3	17	400	730
	Cross the road, pass by the buildings													
29	Lentekhi Municipality, the left slope of the Tskhenistskali River, Mt.1299 m. to the north.													
	745	25	230	230	920	1015	0,3	6	0	0	5	19	960	750
	Crosses the road, passes the buildings, stops in the river													
30	Lentekhi Municipality, the left slope of Tskhenistskali River, village Babili, Mt.1177 m. to the north.													
	775	15	90	90	1810	1985	1.5	9	0	0	29	24	1955	770
	Pass near the village Babili buildings, crosses the road, the river and stops on the road													
31	Lentekhi Municipality, the left slope of the Tskhenistskali River, village Babili, Mt.2759 m. to the south-east.													
	880	-100	300	310	4040	4520	48.0	19	0	0	134	35	4300	810
	Pass the village near the Babil buildings, crosses the road, the river and stops on the opposite slope													
32	Lentekhi Municipality, the right slope of Tskhenistskali River, village Shtvili, Mt.1952 m. to the south-west.													

	1000	-35	140	145	1860	2105	6.0	14	0	0	134	28	2020	980
	Pass by the buildings of Shtvili village, cross the river and come up on the road													
33	Lentekhi Municipality, the right slope of Tskhenistskali River, village Buleshi, Mt.1952 m. to the south-east.													
	1030	-50	110	120	1190	1325	0.4	8	0	0	7	24	1260	1000
	Crosses the road, passes the buildings, crosses the river and stops opposite on the slope													
34	Lentekhi Municipality, the right slope of Tskhenistskali River, village Mami. Mt.2116 m. to the south													
	1025	-10	50	50	2970	3275	9.5	11	0	0	25	35	3250	1020
	Crosses the road, passes the buildings, crosses the river and stops oppositeon the slope road													

N	Altitude, m		Length, m		Total		Avalanche area, ha	Tilt angle, degree	Speed, m/s	Impact strength, t/m^2	Volume 1000 m^3	Avalanche height, m	Length, m	Suspension height
	Absolute	Relative	Horizontal	Factual	Horizontal	Factual								
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
35	Lentekhi Municipality, the right slope of the Tskhenistskali River, village Mami. The peak 1948 m. to the south-west													
	1050	-25	80	85	1100	1210	0.7	17	0	0	13	24	1170	1040
	Pass by the buildings, cross the river and stop on the opposite slope road													
36	Lentekhi Municipality, the right slope of Tskhenistskali River, village Makhashi. The peak Airashi 3189 m. to the south-east													
	1325	0	20	20	3880	4355	160.0	0	0	0	448	35	4350	1325
	Pass by the buildings, cross the road, stop in the river													
37	Lentekhi Municipality, the left slope of Koruldashi River, village Tsana. The peak 2302 m. to the south-east													
	1710	-20	100	100	540	615	0.1	-11	0	0	2	30	570	1700
	Pass by the buildings, cross the river and rise to the road of the second slope													
38	Lentekhi Municipality, the left slope of Koruldashi River, village Tsana. The peak 2339 m. to the west													
	1670	-15	90	90	800	900	0.2	-9	5	1	5	32	920	1665
	Crosses the road, crosses the river and stops at the buildings													
39	Lentekhi Municipality, the left slope of Koruldashi River, village Tsana. The peak 2339 m. to the west													
	1690	-20	60	65	560	670	0.1	18	0	0	2	30	640	1680
	Crosses the road, crosses the river and stops at the buildings													
40	Lentekhi Municipality, the left slope of the Tskhenistskali River, village Cvelieri. The peak 2936m. to the north													
	1000	-20	60	65	3470	3840	19.0	-18	0	0	53	35	382	995
	Pass by the buildings, cross the road, the river. Horseshoe and stops													
41	Lentekhi Municipality, the left slope of the Khopuri River, village Nanari. The peak 1373m. to the north-west													
	950	20	220	220	890	970	0.3	5	0	0	5	21	800	960
	Pass by the buildings, cross the road													
42	Lentekhi Municipality, the right slope of the Khopuri River, village Khofuri. The peak 1213m. to the south-west													
	660	15	170	170	415	475	0.1	5	0	0	1	16	405	667
	Crosses the road, passes by the buildings and stops at the river in Khopuri													
43	Lentekhi Municipality, the right slope of the Khopuri River, village Khofuri. The peak 1213m. to the south-west													
	700	-10	80	80	710	815	0.2	-7	0	0	3	18	775	695
	Cross the road, pass by the buildings, cross the river Khofuri. stops on the opposite slope													
44	Lentekhi Municipality, the left slope of Tskhenistskali River, village Khopuri. Mt.1351 m. to the wets													
	595	5	200	200	780	900	0.2	1	0	0	3	17	920	598
	Pass by the buildings, cross the road and stop at the river Tskhenistskali													
45	Lentekhi Municipality, the right slope of Gobishuri River, village Ghobi. The peak 1723 m. to the south-wets													
	1450	-35	110	115	880	965	1.7	-18	0	0	36	26	880	1425
	Pass by the buildings, cross the river Gobishuri and stops on the opposite slope													

46	Lentekhi Municipality, the left slope of Tskhenistskali River, village Sasashi. The peak 14531 m. to the north-east													
	1143	2	30	30	760	825	0.4	4	0	0	7	23	820	1144
	Passes by the buildings and stops on the road													
47	Lentekhi Municipality, the left slope of Tskhenistskali River, village Leusheri. The peak 2992 m. to the north													
	1035	25	110	110	5970	6325	350	13	0	0	980	35	6325	1025
	Pass by the buildings, cross the road and stop in the river													
N	Altitude, m		Length, m		Total		Avalanche area, ha	Tilt angle, degrees	Speed, m/s	Impact strength, t/m^2	Volume 1000 m^3	Avalanche height, m	Length, m	Suspension height
	Absolute	Relative	Horizontal	Factual	Horizontal	Factual								
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
48	Lentekhi Municipality, the left slope of Tskhenistskali River, village Tekali. The peak Tekali 3044 m. to the north													
	1050	-50	70	85	5050	5485	280.0	35	0	0	7840	35	5440	1025
	Pass by the buildings, cross the road, the river and stop on the slope													
49	Tsageri Municipality, the right slope of Lajanuri River, village Lesindi. Mt. 938 m. to the north-east													
	810	20	100	100	350	370	0.1	11	0	0	1	17	320	820
	Pass by the buildings, cross the road													
50	Tsageri Municipality, the left slope of Lajanuri River, village Lajana. Mt.1252m. to the north-east													
	590	10	100	100	1140	1265	1.4	6	0	0	21	19	1120	595
	Pass by the buildings, cross the road													
51	Ambrolauri Municipality, the right slope of Lekhuni River, village Uravi. The peak 2208m. to the south-east													
	900	-40	120	130	2120	2305	0.6	18	0	0	13	26	2260	880
	P0.6ass by the buildings, cross the road, the river and stop on the slope													
52	Ambrolauri Municipality, the right slope of Lekhuni River, ore of Lekhuni. The peak 2862m. to the south-east													
	1830	25	550	550	2350	1540	85.0	3	0	0	2380	35	2300	1840
	Pass by the buildings, cross the road, stop in the river bed													
53	Ambrolauri Municipality, the left slope of Lekhuni River, ore of Lekhuni. The peak 3076m. to the north-west													
	1855	35	310	310	2540	2875	205.0	6	0	0	5700	35	2260	1880
	Pass by the buildings, cross the road, the river and stop by the buildings													
54	Oni Municipality, the right slope of Chashuri River, village Gona. The peak 2680m. to the south-east													
	1720	30	200	200	690	790	0.1	8	0	0	2	31	700	1735
	Pass by the buildings, cross the road													
55	Oni Municipality, the right slope of Rioni River, village Chiora. The peak 1824m. to the south													
	1280	20	260	260	850	930	0.2	4	0	0	4	25	780	1290
	Pass by the buildings and cross the road													
56	Oni Municipality, the right slope of Chanchakhi River, village Glola. The peak 1926m. to the south													
	1245	5	220	220	1150	1280	0.3	1	0	0	7	27	117	1247
	Pass by the buildings, cross the road and stop in the river													
57	Oni Municipality, the left slope of Chanchakhi River, village Glola. Mt. 2347m. to the north													
	1315	5	80	80	530	600	0.1	4	0	0	2	25	550	1318
	Pass by the buildings and cross the road													

In the table of morphometric and dynamic characteristics of avalanches, columns 2–9 provide data on the absolute and relative height of the avalanche and its separate sections, horizontal and actual length, surface slope, and area of the avalanche center. Columns 10–15 present numerical data on the values of avalanche speed and impact force, avalanche cone volume, moving avalanche snow height, avalanche length, and the absolute height of the avalanche stop on a separate section of the avalanche collector. The last column of each avalanche description indicates the place where the avalanche will stop.

e.g. It will pass by the building, cross the river, cross the road, and stop on the opposite slope. In addition to these numerical data, the location of each avalanche is given (river valley, height of

the mountain, or peak where the avalanche begins). The settlement and the main object of our research are indicated a road where an avalanche can cause damage. A minus sign in front of the number in the third column indicates that the avalanche crossed the road, ravine, or river and stopped on the opposite slope.

By combining the existing basic data and the data of our expeditionary works, we were able to create a modern, large-scale geo-informational maps of the avalanche danger of highways in the Racha-Lechkhumi and Kvemo Svaneti regions (Fig. 4; Fig. 5).

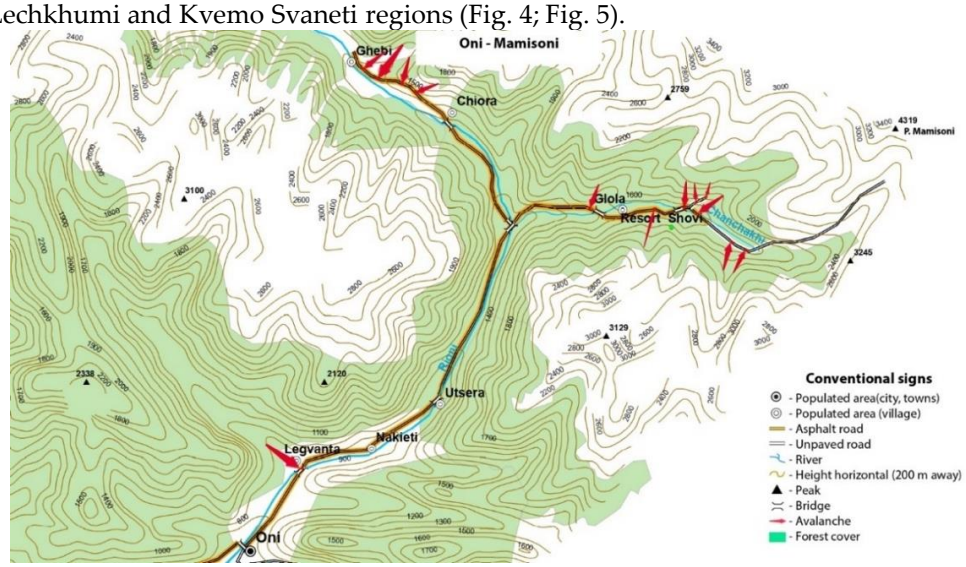

Figure 4: *Avalanche hazard map of Oni-Mamison section of the highway of Racha-Lechkhumi and Kvemo Svaneti region*

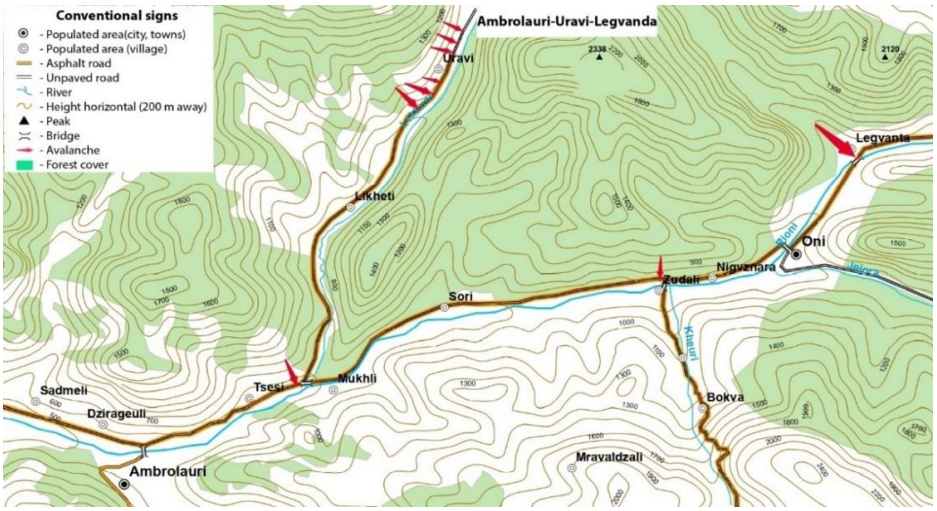

Figure 5: *Avalanche hazard map of Ambrolauri-Uravi-Legvanda section of the highway of Racha-Lechkhumi and Kvemo Svaneti region.*

IV. Discussion

Out of 76 avalanche collection points in the territory of Racha-Lechkhumi and Kvemo Svaneti region [14], 57 were identified, where in the event of an avalanche, a specific section of the highway is included in the area of avalanche arrival, that can cause damage to road infrastructure and, in some cases, human casualties.

The conducted research revealed that there are avalanche-prone areas on the highways of all four municipalities in Racha-Lechkhumi and Kvemo Svaneti region. Among them, Lentekhi municipality (48 sections), Oni municipality (4 sections), Ambrolauri municipality (3 sections), and Tsageri municipality (2 sections) are distinguished by the intensity of avalanche-prone areas. The

slopes of 11 rivers and 31 rural areas of the region fall within the area of the highway's avalanche-prone area (Table 3.).

Table. 3: *Villages and Rivers with avalanche danger of highways section according to municipalities*

Villages with avalanche danger highways section according to municipalities				Rivers with avalanche slopes
Oni	Ambrolauri	Tsageri	Lentekhi	11
4	1	3	24	

V. Conclusions

Based on received data, processing

- Avalanche-risk highways of Racha-Lechkhumi and Kvemo Svaneti region were studied, and their climatic characterization will be done;
- Geo-informational maps were created - a schematic maps of each avalanche-prone road in the region;
- The morphometric and dynamic characteristics of each avalanche were calculated.
- The place of landing and stopping of the avalanche was indicated;
- The frequency of avalanches was determined according to the amount of snow.
- The obtained results will be the basis for the preparation and implementation of anti-avalanche works on the highways of the mountainous regions of Georgia.

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