DEBRIS FLOWS: Disasters, Risk, Forecast, Protection

Proceedings
of the 5th International Conference

Tbilisi, Georgia, 1-5 October 2018

Editors
S.S. Chernomorets, G.V. Gavardashvili

Publishing House “Universal”
Tbilisi 2018

СЕЛЕВЫЕ ПОТОКИ: катастрофы, риск, прогноз, защита

Труды
5-й Международной конференции

Тбилиси, Грузия, 1-5 октября 2018 г.

Ответственные редакторы
С.С. Черноморец, Г.В. Гавардашвили

Издательство Универсал
Тбилиси 2018

ღვარცოფები: კატასტროფები, რისკი, პროგნოზი, დაცვა

მე–5 საერთაშორისო კონფერენციის მასალები

თბილისი, საქართველო, 1–5 ოქტომბერი, 2018

რედაქტორები
ს.ს. ჩერნომორეც, გ.ვ. გავარდაშვილი

გამომცემლობა "უნივერსალი"
თბილისი 2018

УДК 551.311.8
ББК 26.823

Селевые потоки: катастрофы, риск, прогноз, защита. Труды 5-й Международной конференции. Тбилиси, Грузия, 1-5 октября 2018 г. – Отв. ред. С.С. Черноморец, Г.В. Гавардашвили. – Тбилиси: Универсал, 2018, 671 с.

Debris Flows: Disasters, Risk, Forecast, Protection. Proceedings of the 5th International Conference. Tbilisi, Georgia, 1-5 October 2018. – Ed. by S.S. Chernomorets, G.V. Gavardashvili. – Tbilisi: Publishing House “Universal”, 2018, 671 p.

ღვარცოფები: კატასტროფები, რისკი, პროგნოზი, დაცვა. მე–5 საერთაშორისო კონფერენციის მასალები. თბილისი, საქართველო, 1–5 ოქტომბერი, 2018. გამომცემლობა "უნივერსალი", თბილისი 2018, 671 გვ. პასუხისმგებელი რედაქტორები ს.ს. ჩერნომორეც, გ.ვ. გავარდაშვილი.

Ответственные редакторы С.С. Черноморец, Г.В. Гавардашвили
Edited by S.S. Chernomorets, G.V. Gavardashvili

Верстка: С.С. Черноморец, К.С. Висхаджиева, Е.А. Савернюк
Page-proofs: S.S. Chernomorets, K.S. Viskhadzhieva, E.A. Savernyuk

При создании логотипа конференции использован рисунок из книги С.М. Флейшмана «Селевые потоки» (Москва: Географгиз, 1951, с. 51).
Conference logo is based on a figure from S.M. Fleishman’s book on Debris Flows (Moscow: Geografgiz, 1951, p. 51).

ISBN 978-9941-26-283-8

Forecasting colloidal fractions value transported by floods on the example of Duruji Basin

T. Supatashvili[1,2], Sh. Kupreishvili[3], P. Sichinava[3], M. Shavlakadze[3], K. Dadiani[3], K. Kiknadze[3], l. Maisaia[3]

[1]University of Georgia, Tbilisi, Georgia

[2]Ecocenter for Environmental Protection, Tbilisi, Georgia

[3]Tsotne Mirtskhulava Water Management Institute of Georgian Technical University, Tbilisi, Georgia

The Duruji River considered as one of the most debris flow dangerous river of Georgia, which no one create danger for town Kvareli. For Kvareli danger is debris flow formed in river basin, that difficult is inert mass which is accumulated in the river bed. In article is considered modern condition of river Duruji basin and is provided recommendation about river bed cleaning necessity. The anthrophogenic impact on the environment often became cause formation of the anomalies, particularly, debris flow, the result is dramatically changing the existing situation and ecological balance. Currently the most effective measure performed for debris flow prevention in Kvareli is a river embankment. After its construction, debris flows have taken place for several times, but the town was not affected.

debris flow, Duruji, hazards, protection

Прогнозирование количества коллоидных фракций, переносимых паводками (на примере бассейна Дуруджи)

Т. Супаташвили[1,2], Ш. Купреишвили[3], П. Сичинава[3], М. Шавлакадзе[3], К. Дадиани[3], К. Кикнадзе[3], И. Маисая[3]

[1]Университет Грузии, Тбилиси, Грузия

[2]Экоцентр окружающей среды, Тбилиси, Грузия

[3]ТИнститут водного хозяйства имени Цотне Мирцхулава Грузинского технического университета, Тбилиси, Грузия

Река Дуруджи считается одной из самых селеопасных рек Грузии. Селевые потоки по Дуруджи неоднократно создавали опасность для города Кварели. Для Кварели опасными являются сели, зарождающиеся в бассейне и приводящие к отложению селевой массы в русле. В статье рассматривается современное состояние бассейна Дуруджи и даются рекомендации о необходимости очистки русла от селевых отложений. Антропогенное воздействие на окружающую среду часто становилось причиной возникновения аномалий: в частности, пселевые потоки резко меняют существующую ситуацию и экологический баланс. В настоящее время наиболее эффективной мерой для защиты города Кварели является береговая селезащитная дамба. После ее строительства селевые потоки происходили несколько раз, но город не пострадал.

сель, Дуруджи, опасность, защита

Introduction

In Caucasus, particularly in Georgia, on the background of the global warming and high energetic class tectonic processes importance disrupted gravitas stability of the high mountain zones. From the natural disasters distributed on the Georgia territory one main is debris flow, which has placed approximately every mountain region. Debris flows damages many fields of industry, also decrease agricultural lands.

Recently, on our planet is not such mountain country, which had not had disasters caused by debris flow. In the World annually lose 50-70 thousand cubic kilometers of the agricultural lands. From these 14 thousand cubic kilometers loses caused by debris flow.

The Duruji River can be considered as one of the most active rivers with debris flow processes among the mountain rivers comprising the catchment basin of the Southern Caucasus.In the sources of the river Duruji intensively accumulated million cubic meter rock clastic. In the basin periodically developing destructive force of debris flow processes, it threatens Kvareli city and surrounding areas.

The catchment basin of the Duruji River is subdivided into two geographical parts: the Main Caucasian Range and Alazani Valley [*Gavardashvili, 2003*]. In accordance with the lithological section, the catchment basin of the Duruji River is subdivided into the following parts: 1. shale stratum; 2. strata with inclusions of clay-shales and sand-stones, and: 3. quaternary sediments.

It is well known that the bed of Shavi Duruji is eroded because of the Shavi Mountain (2200 m above sea level), and the bed of Tetri Duruji is eroded because of the Southern range of the Pokhalo. The total area of the catchment basin of the Duruji river including its debris flow cone is equal to 116 km^2, among which the area of debris flow cone by itself is equal to - 36 km^2 [*Gavardashvili, Chakhaia, 2002*].

According to the special engineering researches and stationary observations performed by the “Sakgeologia” in the Duruji River basin, on the average, over 1 hectare area about 1000-3500 tons of solid mass is moved out from the unstable slopes of the catchment basin annually. The amount of solid mass accumulated in the source area reaches up to 1.0-1.5 million of cubic meters. A total, anticipated reserve of solid mass exceeds 500 million of cubic meters.

Fig. 1. River Duruji basin

During last 100 years in the river Duruji basin fixed approximately 40 disaster by debris flow, which caused 200 human victims. First in 1832 river Duruji destroyed town Kvareli. Next tragedy was 1904. In 1906 was built protectable walls, but in 1949 again was terrible tragedy by debris flow, which took ca. 250 victims.

According to assessment of specialist, stone-mud flows in the river Duruji basin forms by 12-14 years period. These flows move with high speed and with 20-25 m height, due to high Specific weight (2,0-2,3 $tone/m^3$) easily destroyed any resistance.

Fig. 2. The embankement of river Duruji.

Recently, scales of disaster debris flow phenomena activate on the Katheti territory. The indicators of disasters processes activation from the 2004 is high, with extreme explosion in some years. Such was 2009 and 2010. The one from the main factors of activation of natural disasters is excess atmospheric precipitates, among them heavy rains. By the observations has been istablished, that in the East Georgia start traspormation of the debris flow up to 30 mm precipiates in the 24 hours [*Gavardashvili, Bilal Ayub, 2011*].

Fig. 3. River Duruji basin at the rain.

After 1990 the basin of the river Duruji has not cleaned. During last 20 years sediments accumulated and completely covered protectable walls. For these moment river Duruji is up to town Kvereli territory. In case of small flood is possible river overcome damaged embankment and threatens the town Kvareli.

The main part

For forecast colloidal fractions transported by floods formed in the river Duruji basin has been implemented field-monitoring works [*Supatashvili, 2014a,b*], when has been taken water sample when implemented chemical analysis and received data is given in the Table 1.

Table 1. The relative volume values of the sediment transported by floods formed in the river Duruji basin

#	Year	Debris flow discharge, Q max (m^3/sec)	The volume of sediment, S_i (kg)	The relative value of sediment, (S_i/S_{max})	[(S_i/S_{max} – $S_{aver.}$)]	[(S_i/S_{max} – $S_{aver.}$)]^2
1	1899	434.8	1826.16	0.21	0.03	0.0009
2	1906	2000	8400	1	0.82	0.67
3	1947	1666.6	6999.72	0.83	0.65	0.42
4	1949	370.4	1555.68	0.18	1	1
5	1956	253.2	1063.44	0.13	0.05	0.0025
6	1957	199.2	836.6	0.09	0.09	0.0081
7	1961	159.6	670.3	0.079	-0.101	0.01
8	1961	210	882	0.105	-0.075	0.005
9	1961	740	3108	0.369	0.129	0.035
10	1961	250	1050	0.125	-0.055	0.003
11	1963	172	722.4	0.086	-0.094	0.0088
12	1963	132	554.4	0.066	-0.114	0.0129
13	1963	703	2950.5	0.35	0.17	0.0289
14	1963	144	604.8	0.072	-0.108	0.011
15	1963	73	306.6	0.0365	-0.14	0.0196
16	1963	470	1974	0.235	0.055	0.003
17	1963	103	432.6	0.05	-0.13	0.0169
18	1963	1244	5224.8	0.622	0.442	0.195
19	1963	443	1860.6	0.22	0.04	0.0016
20	1963	288	1209.6	0.144	-0.036	0.00129
21	1963	150	630	0.075	-0.105	0.011
22	1963	262	1100.4	0.13	-0.05	0.0025
23	1963	446	1873.2	0.222	0.042	0.0017
24	1963	205	848.4	0.101	-0.079	0.006
25	1963	82	344.4	0.041	-0.139	0.019
26	1963	62	260.4	0.031	-0.149	0.022
27	1973	200.6	842.52	0.1	-0.08	0.064
28	1976	240.2	1008.84	0.12	-0.06	0.036
29	1977	167.6	703.92	0.08	-0.1	0.01
30	1981	264	1108.8	0.132	-0.048	0.0023
31	1982	458	1923.6	0.229	0.049	0.0024
32	1983	229	961.8	0.114	-0.066	0.004
33	1984	162	680.4	0.081	-0.099	0.0098
34	1986	282	1184.4	0.141	-0.039	0.0015
35	1986	160	672	0.08	-0.1	0.01

#	Year	Debris flow discharge, Q max (m^3/sec)	The volume of sediment, S_i (kg)	The relative value of sediment, (S_i/S_{max})	[(S_i/S_{max} – $S_{aver.}$)]	[(S_i/S_{max} – $S_{aver.}$)]^2
36	1986	321	1348.2	0.16	-0.02	0.0004
37	1990	114	478.8	0.05	-0.13	0.0169
38	1992	330.2	1386.84	0.16	-0.02	0.0004
39	1997	221.1	928.62	0.11	-0.07	0.0049
40	1999	333.3	1399.86	0.16	-0.02	0.0004

The average relative values of the colloidal sediment is equal:

$$\left(S_i \bar{/} S_{\max}\right) = \frac{\sum_{i=1}^{40}\left(S_i \bar{/} S\right)}{N} \qquad (1)$$

The squared derivation of relative values of colloidal fractions is equal:

$$\sigma = \sqrt{\frac{\sum \left(S_i / S_{\max}\right) - \left(S_i \bar{/} S\right)}{N}} = 0{,}258; \qquad (2)$$

The relative values of colloidal volume as a result of flood in the suitable interval is given in the table 2.

Table 2. The frequencies of the relative volume of the colloid al fraction volume in the suitable interval

Interval	**0-0.25**	**0.25-0.5**	**0.5-0.75**	**0.75-1.0**
Friquency mi	35	2	1	2
f(Si/Smax)	0.7	0.175	0.1	0.025

For draw histogram we use table 2 data and draw its graph (Fig. 4.)

The mathematic waiting of relative values of colloidal fraction volume is equal:

$$m'_* = \sum_{i=1}^{40}\left(S_i / S_{\max}\right) \cdot f\left(S_i / S_{\max}\right) = 0.125 \cdot 0.875 + 0.25 \cdot 0.05 + 0.625 \cdot 0.025 + 0.875 \cdot 005 = 0.18 \qquad (3)$$

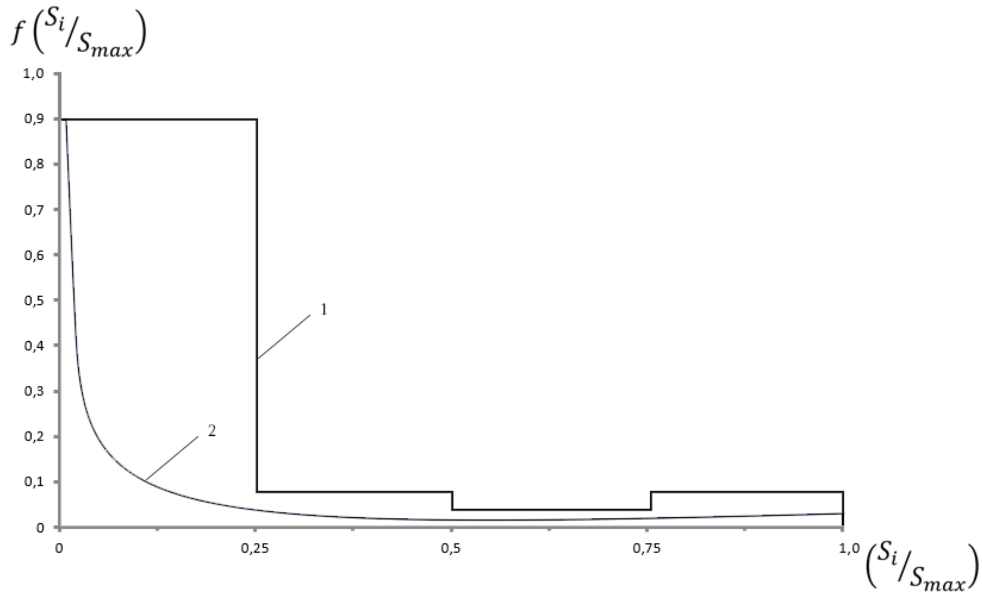

Fig. 4. The histogram of relative values of colloidal fraction volume (1) and suitable distribution curve (2).

The Fig. 4 is suitable the law of Veibull, which is follow:

$$f(S_i/S_{\max}) = 0{,}232(S_i/S_{\max})\cdot\exp\left[-0{,}258(S_i/S_{\max})^{0.18}\right] \quad (4)$$

The reliability of received values calculated by formula (4):

$$\mathrm{P}(S_i/S_{\max}) = \int_0^{1{,}0} f(S_i/S_{\max})\,d(S_i/S_{\max}) = 0{,}78 \quad (5)$$

The risk of this independence (5) is equal:

$$R = 1 - P(S_i/S_{\max}) \quad (6)$$

$$R = 1 - 0.78 = 0.22 \quad (7)$$

The reliability calculated according to our theoretical researches is equal 0.78, which is allowable value [*Morgan, Hann, 2001*].

Conclusion

So, we consider theoretical data about ecological problems of river Duruji and also implemented field-experimental researches and calculated forecast value of colloidal fractions of sediment transported by floods of river Duruji, and also calculated reliability and risk of these received data and finally can say that river Durui basin need suitable debris flow against measures.

For the effective protection of the population of the town of Kvareli in Georgia from debris flow formed on the Duruji River together of river embankment building is necessary to restore of river bed cleaning. Using of debris flow sediment for ceramic industry, building and agriculture increase demand of debris flow sediment and will be restore cleaning of river Duruji bed.

References

Gavardashvili G. (2003). Forecast of erosion-debris flow processes in the river Duruji basin and new engineering-ecological measures against them. Tbilisi. Metsniereba.

Gavardashvili G., Chakhaia G. (2002). Evaluation of Present Ecological Situation of the River Duruji Drainage Basin. Bull. of The Georgian Academy of Sciences. Tbilisi, 166(1): 174 – 177.

Gavardashvili G.б Bilal Ayub (2011). The Field Investigation of Erosion and Debris Flow Processes in Catchment Basin of the Duruji River. Word Debris Flow Associations, Padua University (Italy). 5th International Conference on Debris-Flow Hazards Mitigation, Mechanics, Prediction and Assessment. Padua, Italy, 63-71.

Supatashvili T. (2014a). Evaluation of debris flow sediment and using it in order to increase agricultural lands. XII International Conference of Environmental, biological and ecological sciences. Madrid.

Supatashvili T. (2014b). Evaluation of ecological condition of the river Duruji. 4th International scientific and technical conference, Modern problems of water management, environmental protection, architecture and construction" Georgia, Tbilisi.

Morgan R.P.C., Hann M.J. (2001). Shah Deniz Gas Export Project: erosion risk assessment. Interim Report to BP Kvaerner. Cranfield University, Silsoe, 25 p.