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Natural hydrometeorological disasters, their causes and prevention measures

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Abstract

Modern global climate change and anthropogenic activities mismanagement led to a sharp intensification of natural disasters. This problem is especially urgent for Georgia where high waters and continuous floods are preconditioned by the landscape-climatic state. On each spring season mountainous rivers and dry gaps run in strong flows toward to the lowlands. Based on the joint statistical analysis of natural river floods and 1936-2008 period climatic grid data their classification according to genesis has been performed. Natural floods trend in western and eastern Georgia has growth tendency. The risk map has been constructed that allows identifying risk areas within the danger zone and developing preventive measures for infrastructure protection against floods.

Keywords*: Climate change, flooding zone, gridded data set, interpolation*

Georgia is one of most problematic country by natural and anthropogenic disasters. The natural flooding and damages have been observed on each month. For sustainable development one of the most significant social-economic and ecological problems is the protection of population and infrastructure from natural phenomena. The 58% of natural disasters goes to the flooding. It covers 52% of whole territory thus the losses are enormous. In Georgia there are more than 26 000 big and small rivers. Most of them are Mountain Rivers and are characterized by large inclination and hydro potential. Besides because of glacier feeding they are also characterized by long-term flood regime till August and low-land rivers by floods regime during whole year. The first place holds hydro resources from energy-characters. The theoretical energy of all river runoffs is 229 bill. kl.wat.hr. power-26,1 mln.kl.wat.hr. For present only 25% of hydro resources is utilized. Most perspective is the construction of small hydro powers that successfully resolve regional and state economic problems. The flooding problem became more urgent from the second half of the 20-th century when natural phenomena were intensified (table1).

Table.1. Damages (mln. GEL) caused by natural flooding on the territory of Georgia

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Number of natural flooding	2	4	16	6	10	20	8	7	16	20	18
Damage (mln. GEL)	2.0	4.1	78.7	4.2	20.5	80.0	15.0	40.3	38.0	30.0	20.7

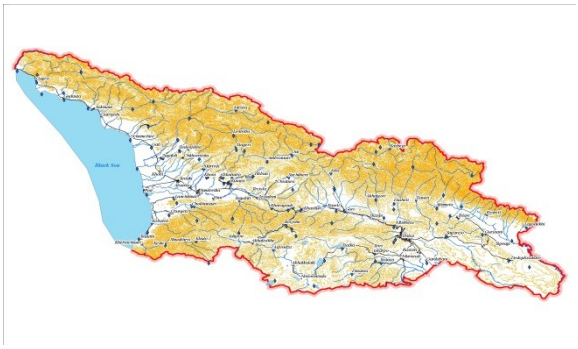
As the criteria of catastrophic flooding the 0.01-10% provision of daily maximal river water discharge has been taken representing danger for population and infrastructure. The flooding is intensive rising of river water level in short period in any year period and is characterized by significant destruction and losses. Because of relief and climate vertical zoning the regime and genesis of catastrophic flooding is different. The flooding by its genesis is natural and anthropogenic. Natural catastrophic flooding is caused by sharp rising of air temperature revealing in intensive snow melting and heavy showers. The statistical analysis of detected flooding reveals that from total number 34% is caused by snow-rain and 66% by continuous rain.

Catastrophic flooding and intensive rain comparative analysis revealed that on Black Seaside the natural flooding are caused by daily rains more than 100mm, on Kolkheti Plateau more than 80mm, on Guria, Ajara region more than 120mm. IN mountain zones because of big slope the natural flooding are caused more than 50mm rains, in flood hit river basins more than 30-40mm rains. The flooding on small basin rivers almost concur with intense rains date and on big basin rivers the flooding is late on 12 hour or 1-2 day and is connected with basin regulation capacities and on the location of intense rain center in the basin. Based on the analysis of natural and catastrophic flooding inter-annual frequency their zoning by season has been realized pic.1

Pic1. Catastrophic flooding regime of Georgian rivers

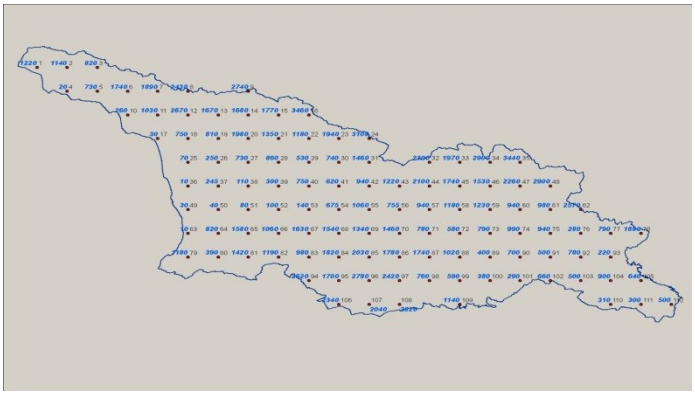
Exp: 1. River flooding propagation from the Black Sea. 2. Rivers with annual flooding. 3. Rivers with summer flooding. 4. Rivers with summer-autumn flooding. 5. Rivers with spring-autumn flooding.

To identify flooding zones the 1936-2008 year period temperature and precipitation gridded data set was used.The created temperature and precipitation database for each station has been transformed in data set for each year for 1936-2008 periods, to investigate their special distribution for concrete year and month.200 000 scale topographic map of Georgia with WGS-84 UTM projection was used.



Pic.2. Meteostation and posts over Georgian Territory

Using ARC GIS V.10 gives possibility to interpolate data with different procedures such as IDW, Kriging, Spline, Spline with Barriers and etc. For Georgian conditions Spline with Barriers was selected. Physical geographical barriers existed in the landscape such are cliffs, rivers present difficulties when trying to model surface using interpolation. The barriers represent a sudden interruption in the landscape and also the values are different on either side of barrier [2,3]. The whole territory of Georgia was divided by 25 km. grid so that the territory have to be covered as many points as possible. So the 112 pointed 25 km. grid was created. Such grid with corresponding elevations has been presented on the pic.5.

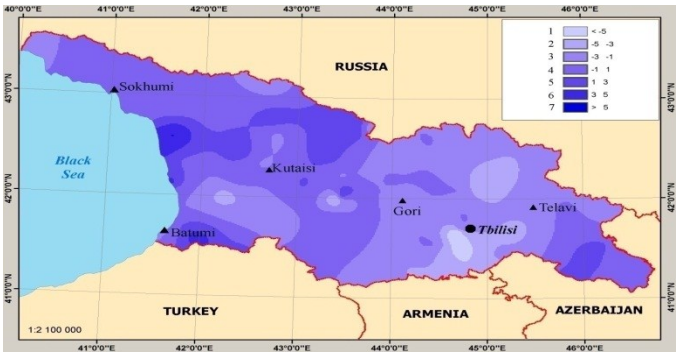


Pic.3. Grid points with elevation

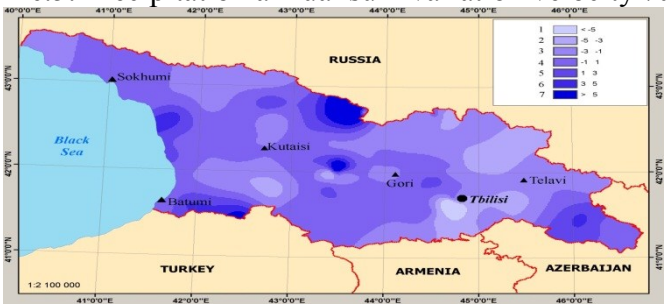
Temperature change velocities during 10 year period for January, July and annual indices for all 87 meteorological stations were used for construction of monthly and annual temperature change GIS maps (Pic4).

Pic.4. Annual mean temperature change rate during 10 years

As it is evident from maps the temperature change in Georgia has heterogeneous- mosaic type under global warming conditions, that is preconditioned by complex physical-geographical especially orographic and landscape- climatic conditions of territory. The biggest areas of severe warming in west Georgia were detected in Gudamakhari and Kharuli Ridges, Southern Part of Kakheti Ridge and Javakheti Plateau. Middle and weak warming areas are in west Georgia, especially in Svaneti, Lechkhumi and Egrisi Ridges. On the small part of Georgian territory temperature was insignificantly varied. And cooling was detected basically in west Georgia. Intense cooling has taken place in most territories of Adjara and near Sokhumi. The warming and cooling central regions and areas were retained on individual months but the seasonal peculiarities have been also revealed. Namely on January intense cooling was detected in Central Parts of Western and Eastern Caucasus, and on July the severe warming area was fixed in northern part of Shida kartli. GIS maps of precipitation annual and seasonal sum variation have been constructed under global warming conditions (Pic. 5-6).



Pic.5. Precipitation annual sum variation velocity % in decade.



Pic 6. Precipitation sum variation velocity % in decade of cold period.

As it is evident from maps the precipitation change has heterogeneous type under global warming conditions. On the most territories of east Georgia precipitation annual sum reduced in decade by 1-3% velocity. The biggest velocities of precipitation reduction were detected in Kvemo Kartli and it was more than 5% in decade. The essential changes of precipitations on the east most part of east Georgia which is characterized by steppe and semi-arid landscapes, also on the most part of west Georgia hasn't been detected. The precipitation growth was fixed in some regions of west Georgia – on Lechkhumi and Egrisi Ridges, Central Part of Kolkheti Lowland, East Adjara also in east part of Iori Plateau, where precipitation annual sums in each decade have been increased by 1-3%, and in Mountain Adjara and in some regions of Black Sea Shore velocity reaches 5%.

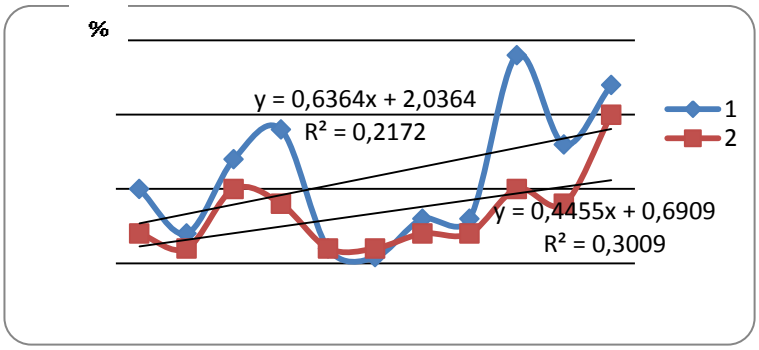
Such precipitation trends were maintained during warm and cold periods of year. During warm period the precipitation reduction zone in Kvemo Kartli was significantly enlarged. During cold period on east and west parts of Caucasus the precipitation reduction zone and velocity have been increased, but on Central part of Caucasus on Mamisoni Passing region cold period precipitations were increased by 5% velocity in decade. The flooding probability by seasons is presented in table 2.

Table 2. Natural and catastrophic flooding probability (%) by seasons for 1936-2010 year period on Georgian rivers

Periods	West Georgia	East Georgia
Winter	7.8	0.3
Spring	25.8	56.1
Summer	47.8	38.3
Autumn	18.6	5.5

From the table it has been revealed that natural flooding maximal frequency comes on summer in west Georgia-47.6%, that is connected with intense rains on that season and in west Georgia on spring that is connected with combined action of snow intense melting and intense rains, the minimal frequency is in winter that is connected with snow accumulation in mountain and high mountain zone and with small frequency of heavy rains in lowland.

The catastrophic flooding most frequency is in May-August in west Georgia and in east on April-June. The natural and catastrophic flooding regime is different on Georgian rivers because of 60% of river basins is located in mountain and high mountain zones and 40% on lowlands and foothills. The natural and catastrophic flooding frequency multiyear step over 1936-2010 year period is given on pic.7.



Pic 7. The natural and catastrophic flooding frequency multiyear step over 1936-2010 year period in West (1) and East (2) Georgia

As it is evident from the chart flooding trend has increasing tendency in West and East Georgia. The catastrophic flooding risk was defined according spatial-temporal distribution of losses, frequency, precipitation and temperature. 5 different risk zones have been selected on the Georgian territory pic.8.

Pic.8. Flooding risk zones on the Georgian territory

1. Very big risk 16%, 2. Big risk 10-16%. 3. Average risk 4-10%, 4. Small risk 2-4%, 5 Very small risk <2%

The constructed map gives possibility to reveal settlements in dangerous zones and elaborate preventive measures. For river water regulation the most effective are reservoirs, because they can retain high water flows and mitigate catastrophic processes. Thus for mountainous rivers the construction of small reservoirs would be useful. Also the elimination of deforestation and forest degradation will significantly reduce flooding damages.

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