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ASSESSMENT OF CLIMATIC RISKS FROM HAZARDOUS WEATHER PHENOMENA

*** Elizbarashvili E.Sh., ** Elizbarashvili M.E., * Elizbarashvili Sh.E., ** Elizbarashvili I.Sh.**

[*] *Institute of Hydrometeorology of Georgian Technical University, Tbilisi, Georgia*
[**] *Ivane Javakhishvili Tbilisi State University, Tbilisi, Georgia*
eelizbar@hotmail.com

Summary: *Droughts, strong winds, hurricanes, torrential rains, hail, floods, floods, blizzards, extreme temperatures, and other similar disasters cause more severe economic losses than volcanic eruptions, tsunamis, and earthquakes, and these hazards pose climate risks. The main factors of the process of occurrence of climatic risk of dangerous meteorological phenomena are considered. The article describes a methodology for assessing the vulnerability of objects (risk recipients) exposed to hazardous phenomena. On the example of two points located in different geographical conditions - Tbilisi and Dmanisi, possible social and economic risks associated with these phenomena are identified. The greatest climatic danger is represented by fog and strong winds, and in summer, Tbilisi is very hot with concomitant soil, atmospheric drought, and extreme fire hazards. To a lesser extent, the area is damaged by heavy rainfall and hail.*

Key Words: *hazardous phenomenon, probability, vulnerability, social and economic risk.*

Introduction

According to the United Nations, more than a million people have died due to natural disasters over the past five decades. At the same time, about 90% of the most severe economic losses are accounted for not by such natural phenomena as volcanic eruptions, tsunamis, and earthquakes but by hydrometeorological phenomena. Droughts, strong winds, hurricanes, heavy rains, hail, floods, floods, blizzards, extreme temperatures, and other similar disasters result from climate change and become more powerful. Thus, we can discuss climatic risk if dangerous or unfavorable meteorological phenomena are observed in a given territory and a particular object (risk recipient) is under their probable influence.
In order to mitigate the expected negative consequences of hazardous phenomena and unfavorable weather conditions, the associated potential risks should be assessed and compared with the value of the acceptable risk, and then adaptation decisions should be made.

Materials and methods

Climate risk is a combination of the likelihood and consequences of a hazardous or adverse event occurring. Risk is defined as the product of the probability of a specific meteorological hazard by the conditional probability of the vulnerability of the recipient who may be exposed to this hazard [1]:

$$R=pU \quad (1)$$

where: **p**- is the probability of an event; **U**- is the consequences of an event or the vulnerability of an object exposed to a hazardous phenomenon, which is determined by the formula:

$$U = (s/S)\cdot m\cdot t\cdot K \quad (2)$$

s — average area of impact of this phenomenon (sq. km),
S — area of the region (sq. km),
m — population of the administrative region (people),
t — time of action of a dangerous meteorological phenomenon or unfavorable weather conditions (day);
K — coefficient of aggressiveness of the phenomenon.

Climate risk is usually called social risk, i.e., the risk of social damage to the territory under consideration since it determines the size of the population affected by this phenomenon. The general formula of social risk or the likelihood of injury to a particular recipient is as follows [1,2]:

$$Rc=p(s/S)\ (si/S)\cdot m\cdot t\cdot K \quad (3)$$

where **si** - recipient area, sq. km.

The basis of the economic risk management mechanism is the definition of economic damage caused by a hazardous event. The cumulative damage in a given area is called economic risk. Economic risk is the product of the probability of a meteorological hazard by the amount of damage; expressed in monetary units [1,2]:

$$Re= ARc=p(s/S)\ (si/S)\cdot m\cdot t\cdot K\cdot A \quad (4)$$

Where **A**- is the share of gross domestic product per day per inhabitant of a given administrative unit. In the conditions of Georgia, emergencies mainly create the following weather phenomena:

• Hot days (**SU25** when the maximum air temperature exceeds 250).
• Strong wind (**W**, when the wind speed is not less than 15m / s).
• Heavy precipitation (**R30**, when the daily precipitation is at least 30 mm).
• Mist (**F**).
• Hail (**Ha**).
• Blizzard (**B**).

In the calculations, the coefficients of aggressiveness of the phenomena were taken in accordance with [1], and the areas of influence of this phenomenon were taken from our previous studies [3-9] (Table 1).

Table 1. The coefficient of aggressiveness (K) and the average area of influence (s) of the phenomenon.

Characteristics	**Meteorological phenomena**					
	SU25	**R30**	**Ha**	**F**	**W**	**B**
K	0.02	0.03	3	0.5	1.0	0.8
s кв. км	10000	3000	7	6000	4000	5

The discussion of the results. Table 2 provides some information on hazardous weather damage taken from a catalog compiled by us at the Institute of Hydrometeorology of Georgia.

Table 2. Damage from some hazardous weather phenomena.

Phenomenon	**Year**	**Month**	**Day**	**Damage million US dollars**	**District (center highest intensity)**
Shower	1972	June	7	Human casualties	Tbilisi
Strong wind	1961	November	16-17	2	Tbilisi
Strong wind	1962	October	26	0.5	Tetri-Tskaro
Hurricane	1973	March	4	5	Tbilisi-Bolnisi
Intense heat and drought	1997	April-May	-	20	Tbilisi
Intense heat and drought	2000	April-May	-	150	Tbilisi
Hail	1978	M	28	22	Kakheti (Sighnaghi)
Hail	1987	M	9	26	Kakheti (Udabno, Nukriani)
Hail and hurricane	2012	July	19	30	Kakheti (Telavi)
Fog	1966	March	5	0.1	Kvemo-Kartli (Tetri-Tskaro)

Noteworthy is the catastrophic downpour observed on June 7, 1972 in Tbilisi, when over a short time (245 minutes), more than 100 mm of precipitation fell. The downpour caused significant material damage to industrial enterprises, communications, transport, utilities and municipal

services, and the city's population. More than 200 individual houses were destroyed, in which more than 1000 families lived, factories were stopped, there were human casualties. According to Table 2, material damage from strong winds on November 16-17, 1961, amounted to USD 2 million, and on March 4, 1973, damage from a hurricane wind in the Tbilisi-Bolnisi region amounted to USD 5 million. The intense heat and drought in the city of Tbilisi and its environs in April-May 1997 caused losses of 20 million, and in June 2001 - 10 million US dollars, on March 5, 1966, heavy fog caused damage to the Kvemo-Kartli region of 10,000 US dollars, etc.

Tables 3 and 4 present data on social and economic risks from hazardous weather phenomena in two different geographic conditions - in Tbilisi and Dmanisi, calculated according to formulas (3) and (4). When calculating the economic risk, the gross domestic product (GDP) was assumed to be $ 26 (in 2015 prices).

Table 3. Social (Rs people) and economic (Re US dollars in 2019 prices) risks from a single phenomenon in Tbilisi.

Weather phenomenon	**Season**							
	Winter		**spring**		**Summer**		**Autumn**	
	Rc	**Re**	**Rc**	**Re**	**Rc**	**Re**	**Rc**	**Re**
SU25	0	0	5347	160410	18492	554760	8466	253980
W	66840	2005200	89120	2673600	44560	1336800	44560	1336800
R30	0	0	668	20040	668	20040	334	10020
F	122540	3676200	11140	334200	0	0	77980	2339400
Ha	0	0	322	9660	322	9660	0	0
B	1.2	36	0	0	0	0	0	0

Table 4. Social (Rc people) and economic (Re USD in prices of 2019) risks from one phenomenon in Dmanisi.

Weather phenomenon	**Season**							
	Winter		**spring**		**Summer**		**Autumn**	
	Rc	Re	Rc	Re	Rc	Re	Rc	Re
W	725	18850	4359	113334	1453	37778	2421	62946
R30	0	0	6	156	12	312	5	130
F	8035	208910	8035	208910	2556	66436	8035	208910
Ha	0	0	4	104	5	130	1	26
B	2	52	1	26	0	0	0	0

Social risk indicates the number of people affected at a certain level, and it characterizes the severity of the consequences (catastrophic) of the implementation of hazards.

Table 3 shows that the distribution of social risks is seasonal. Fog and strong winds pose the most significant risk. In particular, the greatest risk from fog is expected mainly in the autumn-winter period; in summer, it is absent. The social risk from strong winds is most remarkable in spring, although the risk is also significant for other seasons.

The economic risk is also most significant from fog and strong winds. For example, in Tbilisi in winter, the economic risk from the fog in one case may amount to more than USD 3.6 million, in autumn - more than USD 2.3 million. The economic risk from strong winds in spring exceeds $ 2.6 million and exceeds $ 2 million in winter.

Conclusion

The main factors of the process of occurrence of climatic risk of dangerous meteorological phenomena are considered. The article describes a methodology for assessing the vulnerability of objects

(risk recipients) exposed to hazardous phenomena. On the example of two points in different geographic conditions - Tbilisi and Dmanisi - the possible social and economic risks associated with these phenomena have been identified. The greatest climatic danger is represented by fog and strong winds, and in summer, Tbilisi is very hot with concomitant soil, atmospheric drought, and extreme fire hazards. To a lesser extent, the area is damaged by heavy rainfall and hail.

References

1. Kobysheva N.V, Akentieva E. M, Galyuk L.P. Climate risks and adaptation to climate change and variability in the technical sphere. // St. Petersburg, 2015, 144 p., (in Russian).
2. Kobysheva N.V, Galyuk LP, Panfutova Yu. A. Methodology for calculating social and economic risks created by dangerous weather phenomena.// Proceedings of the MGO, vol. 558, 2008, pp. 162-172, (in Russian)
3. Elizbarashvili E.Sh., Varazanashvili O.Sh., Tsereteli NS, Elizbarashvili M.E. Hurricane winds in the territory of Georgia. // Meteorology and Hydrology, No. 3, 2013, pp. 43-46, (in Russian)
4. Elizbarashvili E.Sh., Varazanashvili O.Sh., Tsereteli NS, Elizbarashvili M.E., Elizbarashvili Sh.E . Dangerous fogs on the territory of Georgia. // Meteorology and Hydrogy, No. 2, 2012, p. 52-59, (in Russian)
5. Elizbarashvili E.Sh., Elizbarashvili M.E. Natural meteorological phenomena on the territory of Georgia. // Zeon. Tbilisi, 2012, 104 p., (in Russian)
6. Elizbarashvili E. Sh., Elizbarashvili M.E., Elizbarashvili Sh.E. Investigation of the frequency of occurrence of the most dangerous meteorological phenomena for Georgia. // Meteorology and Hydrology, No. 10, 2020, p. 82-89, (in Russian)
7. Elizbarashvili E. Sh., Elizbarashvili M.E., Elizbarashvili Sh.E., Pipia M.G., Kartvelishvili L.G. Snowstorms in the mountainous regions of Georgia. // Meteorology and Hydrology, No. 1, 2020, p. 58-62, (in Russian).
8. Elizbarashvili E. Sh., Elizbarashvili M.E., Elizbarashvili Sh.E., Pipia M.G., Chelidze N.Z. Catastrophic Precipitation in Georgia. // European Geographical Studies, 6(1), 2019, pp. 50-60.
9. Varazanashvili O, Tsereteli N, Amiranashvili A, Tsereteli E, Elizbarashvili E, Dolidze J, Qaldani L, Saluqvadze M, Adamia S, Arevadze N, Gventcadze A. Vulnerability, hazards and multiple risk assessment for Georgia. // Natural Hazards, vol.64, 2012, pp. 2021-2056.