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Principles of Natural Hazards Catalogs Compiling and Magnitude Classification

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ABSTRACT

A systematic inventory of natural hazard (NH) events over the Georgia is valuable for estimating expected hazard and risk, human and economic losses, quantifying the relationship between NH occurrences and climate variations and for evaluating prediction new efforts. Therefore, it is planned to compile the catalogs of the 5 types of NHs (landslide, debris flow, flash flood, hurricane wind and hail) causing significant economic losses and casualties in Georgia throughout the historical time, drawing upon old and new reports, scholarly articles and other hazard databases. This article develops a principles of NH data collection, the basics of magnitude classification of NH events, which will be used in the process of cataloging and magnitude harmonization of these events.

Keywords: *Extreme natural event, natural hazard, natural disaster, natural disaster risk, magnitude, parametric catalog.*

1 Introduction

Georgia is prone to the natural disasters. In the last 30 years here, more than 700 people died and the economic losses amounted to $6.6 billion; this whole country is within the category of medium and high risk [16]. For example, only in the Georgian capital Tbilisi in 2002 occurred earthquake during which 5 people died and economic damage amounted to $350 million, and in 2015, as a result of a landslide in the Vere river-bed and then a flash flood and debris flow was inflicted severe damage to the Tbilisi, more than 20 people died, and estimated damage cost were more than $50 million. By UNDP, Georgia relates to the countries with medium and high level risk. In addition, in the 90s of the last century, in Georgia due to political, economic and environmental problems was increased urbanization at large towns and the associated increase in population density. As a result, urban elements prone to NHs have appeared with ever-increasing risks, which accordingly contribute to the transition from hazards to disasters.

An extreme natural event is simply an unusual event; it does not necessarily cause harm. If a natural event does not pose any risk to human property or lives, it is simply a natural event.

A NH is distinguished from an extreme event. A NH is a threat of a naturally occurring event will have a negative effect on humans. NHs (and the resulting disasters) are the result of naturally occurring processes that have operated throughout Earth's history [12]. Hazard assessment is when scientists study natural events to determine characteristics of various hazards. Hazard Assessment consists of determining the following:

- When and where hazardous processes have occurred in the past.
- The magnitude of past hazardous processes.

- The frequency of occurrence of hazardous processes.
- Probable effects of different hazardous processes depending upon the magnitude.

A NH escalates into a natural disaster when an extreme event caused harm in significant amounts and overwhelms the capability of people to cope and respond. A natural disaster is a hazard that has already occurred. A natural disaster has severe adverse impacts on human lives and livelihoods. Such events result from natural processes in the geospher, hydrosphere or atmosphere [7].

Natural disaster risk assessment involves not only the assessment of hazards from a scientific point of view, but also the socio-economic impacts of a hazardous event. Risk is a statement of probability that an event will cause a statement of the economic loss in monetary terms.

The global sequence of natural disasters is irregular, but it shows a trend toward increases in the number and size of events of all kinds (Fig. 1). Preliminary studies related to the occurred and spread of natural disasters in Georgia [16] showed that the most common are 12 types of natural disasters: earthquake, landslide, snow avalanche, flash flood, debris flow, drought, hurricane wind, lightning, hail, freezing, frost, fog. But the most significant economic losses and casualties are related with six types of this disasters: earthquake, landslide, flash flood, debris flow, hurricane wind and hail. As a result, the natural disasters in Georgia have to be considered as a standing negative factor for the development process of the country. As a result, the natural disasters in Georgia have to be considered as a standing negative factor for the development process of the country. The importance and relevance of the issues discussed above stimulates an active investigation of the parameters of NHs that induce natural disasters. It was revealed that various effects caused by different natural disasters, their complex interaction with the environment, and geophysical, geological and other processes, cause some deficits in the current knowledge. The assessment of vulnerability of the element at risk to hazards is very important for an effective and proper assessment of risk. In order to assess hazard information about its parameters, such as magnitude and intensity of an event, the size of the exposed area and information of damages to elements at risk caused by theses hazards are necessary. It was still unclear what should be considered as the magnitude or recurrence period of the event of a given magnitude, and how these parameters could be estimated [16]. Hence, it was impossible to establish trends change in number of all and separate types recorded natural disasters events in Georgia. Since, on a global scale, the rise in the number of natural disasters is predominantly attributable to weather-related events, and while global warming will continue in the coming decades, its contribution to increasing natural disasters number and losses will become more prominent [8].

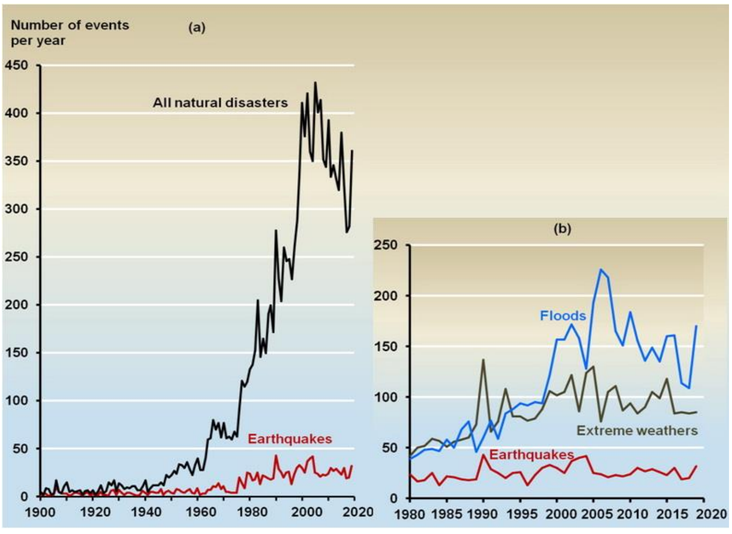

Fig. 1. Trends in number of recorded natural disaster events worldwide: (a) All natural disasters; (b) Earthquake versus hydrological and meteorological disasters ([6], [14], [15]).

The importance of the described issues requires studying the trends and characteristics of the factors of most common and destructive NHs in Georgia, which will be based on the most completeness parametric catalogs of these NHs, homogenized with the appropriate magnitude classification.

2 Principles of natural hazards cataloging

Assessment of NH, investigation of their regularities and many other related issues are mainly based on input data. Along with the development of the field of science of NH, the requirements for source information are increasing. This is especially true for tasks that require statistical approaches.

Thus, it is necessary to create NH parametric catalogs of events occurring in the territory of Georgia. It should be noted that in the reality of Georgia, there is no printed or electronic published parametric catalog for any type of NH events other than earthquakes.

To solve this task, first of all, the principles of compiling catalogs should be established:

- Only unified parameters should be included in the NH catalogs, i.e. the catalogs should include all searched historical events, starting from ancient times to the present day. All events must be classified in a single system, while the main parameters are defined for events of different magnitudes and different times.
- Magnitude classification should be performed for each type of NH events and corresponding catalogs should be harmonized according to one type of magnitude.
- For each event of NH, the most probable values of the main parameters, determined from the set of all available data, should be selected. Main parameter values should have error estimates.
- In the preparation of NH catalogs for each event, it is necessary to use all the available information (bulletins of various types, publications and manuscripts, articles and researches dedicated to individual strong events, extracts from geographical descriptions of travelers and local experts, reports from newspapers and journals, etc.). In this process, we should not limit ourselves to using the main, well-known sources. It is necessary to search for additional data, to conduct search works in print and electronic mass media in various archives, etc., which will allow us to significantly increase the amount of information and discover many new events.
- The preparation of materials for NH catalogs should be carried out in several stages: in the first stage, the data will be collected and systematized, then the initial processing of the existing data will be carried out, the preparation of the materials ends with the compilation of a chronological basis, in which all the prepared data must be entered in a strict order, as well as the results of their initial processing. Then the work will begin - analysis of the collected data, parametrization of NH events and assessment of the accuracy of the obtained values of NH main parameters.

The type and list of the unified main parameters of NH have been established. They will be listed in the catalogs. Each event will have two column allocated in the catalogs (except for the "Comments " and "Sources" columns). In the first column, the values of the main parameters will be placed, in the second column - actual error. Brackets in all graphs mean approximate values of given parameters.

The main parameters are: date (year, month, day), time of occurrence (hour), coordinates of the epicenter (latitude, longitude), magnitude, intensity, damage area (in terms of km^2), scale of natural disaster (number of killed, loss in terms of thousands USA dollars). In addition, there will be "Comments" and "Sources" columns.

3 Magnitude classification of natural hazards

In spite of the substantial differences between the different types of NHs, they require at last three main characteristics for a scientific assessment. First, it has to be principally possible to identify the specific geographical coordinates. Second, it has to be possible to identify the recurrence period for each type of hazard and third, the magnitude of an event has to be reliably estimated.

The magnitude of a NH event is related to the energy released by the event. It is distinguished from intensity which is related to the effects at a specific location or area. The magnitude of a NH event varies in its frequency of occurrence over time in an inverse power relationship, or in other words, the larger and the more energetic the event, the rarer it is in time [11].

Landslides have become one of the most deadly natural disasters on earth, not only due to a significant increase in extreme climate change caused by global warming, but also rapid economic development in topographic relief areas [10].

Landslide magnitude is the measure of the landslide size. It may be quantitatively described by its volume or (indirectly) by its area. The latter descriptors may refer to the landslide scar, the landslide deposit, or both [2].

Taking into account the available data on landslides in Georgia, we believe that its volume V_{LL} (the mass that has been moved along the main scarp) is the most suitable measure of the landslide size in terms of m^3. And considering that this volume sometimes reaches millions of m^3, it is better to take the logarithm of the landslide volume (in term of m^3) as the landslide magnitude (M_{LL}).

$$M_{LL}=\mathrm{Log}V_{LL} \qquad (1)$$

Debris flows represent an important NH process in mountain areas. The main elements required for a practical hazard assessment include the following steps: (i) estimation of potential initiation zones and sediment sources, (ii) establishment of a relation between the magnitude and frequency of expected future debris-flow events, and (iii) assessment of the flow behavior and delineation of areas potentially endangered by flowing debris [13].

A catalogue of past events is an important basis for the hazard assessment. The magnitude of an estimated debris flow event is typically assessed based both on information about magnitude of past events and on geomorphological investigations in the catchment [13].

The estimation of debris flow size, i.e. the maximum volume of debris material discharged during a single event, is a basic step toward the assessment of debris flow hazard [3].

Debris flow magnitude is a measure of the debris flow size, which can be quantified determined by the logarithm of the maximum volume in terms of m^3 of debris material discharged during a single event.

$$M_{\mathbf{DF}}=\mathrm{Log}V_{\mathbf{DF}} \qquad (2)$$

Flash floods cause some of the most severe natural disasters around the world. In Georgia, intense snowmelt and rainfalls in the comparatively small catchments of many rivers, especially in the mountainous regions, cause flash floods.

Flash floods are basically extreme form of hydrological phenomena and it generated by the natural or anthropogenic causes [4].

Flash floods likely to result in significant geomorphic change are those that produce discharges many times above that normally experienced by the river, that is, those with high maximum peak discharge to mean annual discharge [9].

Flash flood magnitude **is** a measure of the flash flood size, which can be quantified determined by the logarithm logarithm of the maximum water discharge in terms of m^3/sec.

$$M_{\mathbf{FF}}=\mathrm{Log}W_{\mathbf{FF}} \qquad (3)$$

By hurricane wind is considered an extreme meteorological event, during which the wind speed exceeds 30 m/s. Hurricane winds can cause catastrophic damage to its distribution area. Moving or airborne debris can break windows and doors and allow high winds and rain inside a home or business. In some hurricane winds, wind alone can cause extensive damage such as downed trees and power lines, collapsing weak areas of homes, businesses or other buildings. Additionally, hurricane winds can create storm surges along the coast and cause extensive damage from heavy rainfall. Floods and flying debris from the excessive winds are often the deadly and destructive results of these weather events.

On the territory of Georgia, hurricane winds are mainly western or eastern direction. Hurricane winds can have a moderate negative impact in the central part of the Colchis lowland with adjacent sub-mountainous and mountainous areas, as well as the South Georgian Highlands and Kvemo Kartli. Here the maximum wind speed can be 43-49 m/s. The zone of significant impact of hurricane wind occupies small areas of the territory of the South Georgian Highlands and Kvemo Kartli. In these areas, the maximum hurricane wind speed can exceed 50 m/s [5].

Hurricane wind magnitude is a measure of the hurricane wind size which can be quantified determined by the hurricane wind speed (in terms of m/s) divided by 10.

$$M_{\mathbf{HR}}=S_{\mathbf{HR}}/10 \qquad (4)$$

The severity of hail events range based on the size of hail, winds, and structures in the path of a hailstorm. Storms that produce high winds in addition to hail are most damaging and can result in numerous broken windows and damaged siding. Hailstorms can cause extensive property damage affecting both urban and rural landscapes. Fortunately, most hailstorms produce marble-size or smaller hailstones. These can cause damage to crops, but they normally do not damage buildings or automobiles. Larger hailstones can destroy crops, livestock and wildlife and can cause extensive damage to buildings. A major hailstorm can easily cause damage amounting into the of millions monetary units.

Georgia is one of the most hail-hazardous countries in the world. Therefore, the problem of hail in this country is devoted to numerous works covering a wide range of studies, such as climatology of hail, radar observation on hail processes, theoretical and experimental studies of the mechanisms of hail formation, methods of impact on hail processes, analysis of impact results, etc. [1].

Hail magnitude is a measure of the hail size which can be quantified determined by the hail grain size in terms of mm.

$$M_{\mathbf{HL}}=D_{\mathbf{HL}}/10 \qquad (5)$$

4 Conclusions

The studies related to the occurred and spread of natural disasters in Georgia showed that the most common are 12 types of natural disasters. But the most significant economic losses and casualties are related with six types of this disasters: earthquake, landslide, flash flood, debris flow, hurricane wind and hail. Thus, is required studying the trends and characteristics of the factors of most common and destructive NH in Georgia, which will be based on the most completeness parametric catalogs of these NHs, homogenized with the appropriate magnitude classification. It should be noted that in Georgia there is no published parametric catalog for any type of NH events, other than earthquakes.

In this article, the principles of compiling NH catalogs are established, which will become the basis for the inventory of NH recorded in the historical past in Georgia, as well as their parameterization and magnitude classification. To implement the latter, the concept of magnitude and the possibility of its quantitative calculation for all considered types of BS were defined.

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References

[1] Amiranashvili A. G., Bolashvili, N. R., Gulashvili Z. M., Jamrishvili N. K., Suknidze N. E., Tavidashvili K. Z. Modeling the distribution of hailstones by mean max sizes on the territory of Kakheti (Georgia) using data of the freezing level in the atmosphere and radar measurements. Journal of the Georgian Geophysical Society, ISSN: 1512-1127, Physics of Solid Earth, Atmosphere, Ocean and Space Plasma, v. 24(1), 2021, pp. 25-36.

[2] Corominas J., Van Westen C., Frattini P., Cascini L., Malet J.-P., Fotopoulou S., Catani F., Van Den Eeckhaut M., Mavrouli O., Agliardi F., Pitilakis K., Winter M. G., Pastor M., Ferlisi S., Tofani V., Herva´s J., Smith J. T. Recommendations for the quantitative analysis of landslide risk. Bull Eng Geol Environ 73, 2014, pp. 209–263 DOI: 10.1007/s10064-013-0538-8

[3] D'Agostino V., March L. Debris flow magnitude in the Eastern Italian Alps: data collection and analysis. Phys. Chem. Earth (C), Vol. 26, No. 9, 2001, pp. 657-663.

[4] Dhar O.N., Nandargi S. Hydrometeorological aspects of floods. Natural Hazards, 28, 2003, pp. 1-33.

[5] Elizbarashvili E. Sh., Varazanashvili O. Sh., Tsereteli N. S., Elizbarashvili M. E. Hurricane winds on the territory of Georgia. Russian Meteorology and Hydrology, vol. 38, no. 3, 2013, pp. 168-170.

[6] EMDAT. OFDA/CRED International Disaster Database, Université catholique de Louvain, Brussel, Belgium, 2020.

[7] Gladel T., Alexander D. E. Classification of natural disasters. In book: Encyclopedia of Natural Hazards, Ed. by P.T. Bobrovsky, 2013, pp. 78-82. DOI: 10.1007/978-1-4020-4399-4_61 https://www.researchgate.net/publication/299725165

[8] Hoeppe P. Trends in weather related disasters – Consequences for insurers and society. Weather and Climate Extremes, 11, 2016, pp. 70-79

[9] Kochel R.C. Geomorphic impact of large floods: review and new perspectives on magnitude and frequency. In: Baker, V., Kochel, R. and Patton, P., Eds., Flood Geomorphology, Wiley, New York, 1988, pp. 169-187.

[10] Lin C.H., Jan J.C., Pu H.C. Tu Y., Chen C.C., Wu Y.M. Landslide seismic magnitude. Earth and Planetary Science Letters, 429, 2015, pp. 122–127.

[11] Lionel E., Jackson Jr. Frequency and Magnitude of Events. Reference work entry, 2016. DOI: https://doi.org/10.1007/978-1-4020-4399-4_147

[12] Nelson S.A. Natural Disasters & Assessing Hazards and Risk. Online Publication, 2018.
http://www.tulane.edu/~sanelson/Natural_Disasters/introduction.htm

[13] Rickenmann D. Debris-flow hazard assessment and methods applied in engineering practice. International Journal of Erosion Control Engineering. Vol. 9, No. 3, 2016, pp. 80-90.

[14] Ritchie H., Roser M. Natural Disasters. Published online at Our World in Data. University of Oxford, 2020. Retrieved from: https://ourworldindata.org/natural-disasters

[15] UNEP/GRID-Arendal. Environment and Poverty Times #3: Disaster issue. Cartographer: Emmanuelle Bournay, 2006. https://www.grida.no/resources/7795

[16] Varazanashvili O., Tsereteli N., Amiranashvili A., Tsereteli E., Elizbarashvili E., Dolidze J., Qaldani L., Saluqvadze M., Arevadze N., Gventsadze A. Vulnerability, hazards and multiple risk assessment for Georgia. J. Natural Hazards, vol. 64, Issue 3, 2012, pp. 2021-2056. DOI: 10.1007/s11069-012-0374-3

ბუნებრივი საშიშროებების კატალოგების შედგენის პრინციპები და მაგნიტუდური კლასიფიკაცია

ო. ვარაზანაშვილი, გ. გაფრინდაშვილი, ე. ელიზბარაშვილი,
ც. ბასილაშვილი, ა. ამირანაშვილი

რეზიუმე

ბუნებრივი საშიშროების (ბს) მოვლენების სისტემატური ინვენტარიზაცია მთელს საქართველოში აუცილებელია მოსალოდნელი საშიშროების და რისკის, ადამიანური და ეკონომიკური ზარალის შესაფასებლად, ბს-ის წარმოქმნასა და კლიმატის ცვლილებას შორის რაოდენობრივი კავშირის დასადგენად და მათი პროგნოზირების ახალი ძალისხმევის შესაფასებლად. ამიტომ დაგეგმილია საქართველოში მნიშვნელოვანი ეკონომიკური ზარალისა და მსხვერპლის მომტანი 5 ტიპის ბუნებრივი საშიშროების: მეწყრის, წყალმოვარდნის, ღვარცოფის, გრიგალური ქარისა და სეტყვის მთელი ისტორიული დროის განმავლობაში მომხდარი მოვლენების კატალოგირება, მოძიებული ძველი და ახალი ანგარიშების, სამეცნიერო სტატიებისა და სხვა საშიშროების მონაცემთა ბაზების საფუძველზე. ამ სტატიაში შემუშავებულია ბს მონაცემების შეგროვებისა პრინციპები, ბს მოვლენების მაგნიტუდური კლასიფიკაციის საფუძვლები, რომელებიც გამოყენებულ იქნება ამ მოვლენების კატალოგების შედგენისა და მაგნიტუდური ჰარმონიზაციის პროცესში.

Принципы составления каталогов природных опасностей и магнитудная классификация

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Резюме

Систематическая инвентаризация природных опасностей (ПО) в Грузии имеет важное значение для оценки ожидаемых опасностей и рисков, человеческих и экономических потерь, количественного определения взаимосвязи между явлениями ПО и изменениями климата, а также для оценки новых усилий по прогнозированию. Поэтому планируется составить каталоги 5 типов ПО (оползень, селевой поток, паводок, ураганный ветер и град), вызвавших значительный экономический ущерб и человеческие жертвы в Грузии на протяжении всего исторического времени, на основе старых и новых отчетов, научных статей и других баз данных об опасностях. В данной статье разработаны принципы сбора данных по ПО, основы магнитудной классификации событий ПО, которые будут использоваться в процессе каталогизации и магнитудной гармонизации этих событий.