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Residential and Non-Residential Building Damage and Loss Assessment in Georgia

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Abstract
This paper responds to the necessity for the creation of a unified disaster damage and loss assessment method for residential and non-residential buildings in Georgia. The objective of this study is to elaborate on an improved standardized formula for damage assessment in the residential and non-residential sector. The formula provides additional clarity to the various worldwide methodologies and frameworks presently used in the damage assessment of buildings and structures. The paper itself provides four key findings: 1) that each assessment approach and the amount of damage and loss calculated for the residential sector are based on various subjective opinions (non-systematic/standardized damage assessment approaches), derived from the best knowledge from commissions created at the municipal level; 2) a review of global methodologies and frameworks revealed a clear gap in the provision of formulas for calculating economic losses in the residential and non-residential sector; 3) the need for a comprehensive explanation of the unit cost of construction in the UNISDR methodology was identified; and 4) the necessity to collect detailed and specific data for the damage and loss calculation, alongside a requirement for frequent renewals of the integrated database (associated with the need for additional resources) – without which it often leads many countries, including Georgia, to use ineffective methodologies (e.g., HAZUS). Therefore, the study offers a new and original approach for assessing damaged buildings and provides an alternative method to fill the gap in the damage assessment of particular types of buildings and structures. Moreover, the paper proposes a building damage assessment formula that does not require specific databases to be frequently updated or integrated within the GIS system.

Keywords Disaster Assessment, Residential and Non-residential Sector, Disaster Resilience, Applied Approach, Damage and Loss, Georgia

1. Introduction

In response to the various problems and challenges caused by both natural and man-made hazards, the Government of Georgia elaborated its Disaster Risk Reduction (DRR) Strategy and Action Plan in 2017.[1] One key aspect of the DRR is the development of a unified system for the assessment of damage and loss caused by natural and man-made hazards.

Despite the proposed strategy, an assessment tool has not been proposed thus far. The regulative framework in Georgia as well as the technical capabilities of stakeholders, at both the central and municipal level, are limited to the sound assessment of the damage and losses associated with disasters. The creation of databases for disaster-related damage

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[1] http://gov.ge/files/469_59429_120118_4.pdf

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and loss, the collection of relevant information from stakeholders, as well as the transparency of the methodologies used each highlight areas for significant improvement. The relevant authorized government agencies presently have no unified system for disaster damage assessment to improve the management of risk. Therefore, private organizations (especially research institutes and insurance companies) have little or no information to provide informed decisions for preventive measures that could help avoid or minimize the negative effects of natural and man-made hazards, improve risk management, and promote the development of the respective insurance market.

Under common practice in Georgia, the damage and loss caused by natural and man-made hazards are assessed and registered by commissions established at the municipal level.[2] As there is no systematic or standardized approach regarding how a commission should assess the damage caused by a hazard, each assessment act and the amount of damage and loss calculated are currently grounded on mostly subjective opinions, visions, and the inadequate knowledge of municipality commission members.

The aim of this research is to create a unified assessment method for damage and loss caused by natural and man-made hazards in the residential and non-residential sector. This would help provide full and comparable reporting of the required information on loss, improve the reliability of the data, and lessen any subjective factors during assessment. The theoretical and practical findings of the research can thereafter be used by the legislative and executive bodies of government, insurance companies, and practitioners to address various relevant issues within the field.

The proposed standardized method would also improve the management of certain issues, such as: the validity and reliability of related data, accounting-standardization, and comparability with international databases. Furthermore, it would help fulfill certain obligations under the EU-Georgia Association Agreement and SENDAI framework.[3]

Moreover, the systemic collection of disaster-based damage and loss data would enable relevant government agencies, private insurance companies, and research institutes to develop and calibrate damage and loss assessment models. These models could be used to assess both short- and long-term economic shocks alongside various sustainability aspects. The collected data could also be used to calculate compensation for the victims of a disaster. Therefore, this defined compensation in turn would help establish a fair and effective state aid mechanism, facilitate cooperation with local communities, the private sector, and the international community, and enable insurance market development. As a result, the proposed method would contribute profoundly towards bridging the gaps and resolving the challenges highlighted above.

The importance of creating unified and standardized approach to assess residential and non-residential sector is also proved by need of assessment and compensation of disaster victims during events. For the last 30 years, several catastrophic events of severe human loss and economic damage have been recorded in Georgia. According to different data, during 1991-2021, due to natural disasters 200 to 350 persons died and 1.7 - 3.7 billion

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[2] Order of the Governor of the Lagodekhi Municipality – "On the Establishment of a Standing Commission to Investigate the Consequences of Disaster in Lagodekhi Municipality". http://www.lagodekhi.gov.ge/sites/default/files/596.pdf

[3] United Nations (UN). Sendai Framework for Disaster Risk Reduction 2015–2030. https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

GEL[4] of economic damage and losses was recorded (The World Bank (2017); Rukhadze etc., (2014)). For example:

- In 1991, 7.0 magnitude earthquake was registered in Racha (north-west part of Georgia), during which 114-270 persons died (exact number is unknown); 46,000 buildings were damaged (the earthquake spread to 700 villages) and the economic loss amounted to about 100 million Russian Manat (744 million USD) [5];
- In 2014-2015 the Devdoraki landslide caused the death of 14 persons, delayed the only operating transit route to the Russian Federation for a month and the economic loss reached to 120 million GEL (68.6 mln USD)[6];
- In 2015, during Tbilisi flooding 19 persons died (3 persons are missing), 67 persons were displaced and 700 persons were directly affected; 40 units of roads, various homes and a variety of urban infrastructure and communication systems were damaged; Tbilisi Zoo was completely destroyed (most of the animals died) and the economic loss amounted to 268 million GEL (118 mln USD)[7].

Due to the fact that there was no systematic or standardized damage assessment approach, every assessment act, and the amount of damage and loss calculated, was based on the subjective opinions and visions of the commission members on an ad hoc basis. Consequently, the proposed method would improve the reliability of calculations, the comparability with international databases, and the ability to exchange information and accuracy. The damage assessment formula proposed for Georgia could also be used by authorities in other countries, as all the variables used within the formula have clear definitions and can be readily collected (not requiring GIS or other integrated systems), while the method itself can be easily implemented in practice.

2. Literature Review

The existing literature on the assessment of damage and loss caused by natural and man-made hazards can be divided into three groups. The first group of studies assesses the specific types of impact; in particular, short-term and long-term, direct and indirect, and the economic impact on a particular sector. The second group includes damage assessments as a result of specific natural events or catastrophes (e.g., earthquakes (Cardona et al., 2008; Erdik et al., 2011), drought (Nagarajan, 2010; Ding et al., 2011; Cui et al., 2019), and floods (Dutta et al., 2003; Jonkman et al., 2008; The World Meteorological Organization (WMO), 2013; Ruiz et al., 2017)). Finally, the third group relates to the comprehensive multisectoral methodologies for assessing damage and loss caused by natural and man-made hazards (Moore et al., 2014).[8]

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[4] Due to different GEL/USD exchange rates (1991-2021 years), we can’t estimate economic losses in USD.

[5] https://ghn.ge/news/234360-sakartvelos-istoriashi-qvelaze-dzlieri-7-magnitudis-mitsisdzvra-rachashi-kalak-ambrolaurtan-mokhda

[6] The ministry of Economy and Sustainable Development of Georgia;

[7] Tbilisi Needs Assessment (2015) https://www.ge.undp.org/content/georgia/en/home/library/environment_energy/tbilisi-disaster-needs-assessment--2015.html;

[8] APEC Workshop on Damage Assessment Techniques. Guidelines and best practices for post-disaster damage and loss assessment. Yogyakarta, 3-6 August, pp 21-37, 2009.

According to D. Eckhardt et al, (2019) there are 12 methodologies and 11 general frameworks for assessing the damage caused by a natural disaster or catastrophe. Some of which include:

- The Handbook for Estimating the Socio-economic and Environmental Effects of Disasters, devised by the United Nations (UN) Economic Commission for Latin America and the Caribbean (ECLAC- DaLA).[9] This methodology (guide) is one of the most widely used around the world (many other methodologies and guidelines also utilize its approach and calculation formulas). Nevertheless, each state significantly adapts the methodology based on their respective needs.
- HAZUS – the Risk Assessment Methodology developed by the US Federal Emergency Management Agency (FEMA),[10] used to assess flood, tornado, and earthquake damage. The greatest advantage of the methodology is that it is based around the Geographic Information System (GIS) and contains comprehensive information, such as the layout and classification of buildings, populations, communication maps, river flood heights, rainfall in geographical areas, among other details. However, the necessity to incorporate detailed and specific data for damage and loss calculations leads to ineffectiveness of the HAZUS methodology in many countries, including Georgia itself. Additionally, the system and its integrated database require constant updating, which is associated with significant financing and research.
- IDEA[11] – uses cost-benefit analyses to assess damage caused by disasters. The purpose of this approach is to employ newly developed methods for analysis and to improve data collection, specifically:
    - Assist relevant state agencies in effectively managing the process of recording and repairing damage caused by disaster;
    - Facilitate improvements to the risk assessment process for future events.

  The IDEA approach is a general framework to assess disaster-related damage and does not provide specific formulas to calculate economic losses.
- MIRA[12] – the Multi-Sectoral Pre-Assessment Methodology/Framework was developed by an interagency working group, NGOs, educational institutions, donor organizations, and United Nation's experts. It uses both current and historical data to evaluate the damage caused by disasters. This assessment methodology is predominantly used by humanitarian aid organizations for the in-depth assessment of disaster damage and for effectively planning any response phases.

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[9] ECLAC. Handbook for Estimating the Socio-economic and Environmental Effects of Disasters. LC/MEX/G.5. LC/L.1874, 2003. https://repositorio.cepal.org/handle/11362/2782

[10] https://www.fema.gov/flood-maps/products-tools/hazus

[11] Improving Damage Assessments to Enhance Cost-benefit Analyses. http://www.ideaproject.polimi.it/?page_id=11

[12] MIRA. Multi-Cluster/Sector Initial Rapid Assessment Guidance. Revision July 2015, IASC - Inter-Agency Standing Committee, pp. 2, 2015.

- IRA[13] – this Preliminary Rapid Assessment Methodology is used to assess the aftermath of a natural disaster and to identify the immediate needs of the affected population. It also aids the prioritization of humanitarian aid and future measures.
- EMA – the Disaster Assessment Guidelines developed by the Australian Emergency Management Agency.[14] Among the other methodologies and frameworks listed above, these guidelines are the simplest in terms of application, and they show how to apply economic analysis to derive the total cost of assessed losses in a specific area. It is important to note that the EMA methodology uses an approximate estimate of the damage caused by a disaster and that there are no formulas for how initial calculations are compiled before being averaged (which causes potential bias). The EMA uses three approaches (one of the needs) to assess loss – averaging, synthetic-comprehensive, and surveys:
    - Averaging approach – economic losses are estimated by averaging the losses incurred during a certain capacity natural disaster;
    - Synthetic-comprehensive approach – pre-created databases (types of buildings, averaged furniture, appliances and other inventory, etc.) and computer programs are used to assess damage;
    - Survey approach – the damage caused by an event is estimated in detail and is not based on historical data.
- The DaLA methodology is used to assess socio-economic and environmental damage. Its loss assessment is based on a calculation of the resources required to recover a damaged asset (recoverable amount), and it classifies loss as direct, indirect, or macroeconomic. Because the methodology is multi-sectoral (assessing the damage to buildings, agriculture, education, health, manufacturing and commerce, tourism, and the environment) it is quite complex. For the purposes of the study, a few findings a worth highlighting, in particular:
    - The methodology was developed in 2003 and needs significant renewal;
    - Loss assessments are not standardized (standard forms of evaluation have not been developed), therefore it is difficult to compare losses from different events;
    - The building damage assessment[15] section indicates the primary information (data) required for collection and the secondary data to be calculated. The definitions of computable variables are also given, but no formulas are provided, consequently offering space for different interpretations of the calculation. Additionally, only three levels of damage to buildings are proposed (demolished, semi-damaged, and undamaged), which is a significant gap in damage assessment;

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[13] IASC. Initial Rapid Assessment (IRA) Tool: Guidance Notes. http://www.who.int/hac/network/global_health_cluster/ira_guidance_note_june_2009.pdf

[14] EMA. Australian Disaster Resilience Manual 27: Disaster Loss Assessment Guidelines, 2002. Australian Institute for Disaster Resilience CC BY-NC, 2002. https://knowledge.aidr.org.au/media/1967/manual-27-disaster-loss-assessment-guidelines.pdf

[15] ECLAC. Handbook for Estimating the Socio-economic and Environmental Effects of Disasters. LC/MEX/G.5. LC/L.1874, pp 75-91, 2003. https://repositorio.cepal.org/handle/11362/2782

- According to the methodology, if a real estate owner is reluctant to assess their loss, then data on the damaged building will not be recorded, thus making this approach incomplete;
- Comparable to the other loss assessment methodologies and guidelines, the DaLA methodology does not offer a standardized approach for assessing damage to cultural heritage sites or works of art, rather it suggests individual damage assessments.

To facilitate fulfillment of obligations under the SENDAI Framework, the United Nations Disaster Risk Reduction Service Agency has simplified its guidelines[16] to better estimate the Socio-economic and Environmental Effects of Disasters (DaLA), as established by the UN Economic Commission for Latin America and the Caribbean.

After a detailed study of the UNISDR methodology, the need for a comprehensive explanation of the variable (unit cost of construction) given in the formula for estimating damage to the residential sector was identified. The definition of unit cost of construction should highlight that, it includes uplift costs as well. Beyond which, the assessment formula is incorrect. In addition, the damage assessment formula for residential properties does not include regional construction costs or other elements that were considered in the proposed approach for Georgia.

Based on the existing methodologies and the frameworks reviewed, there is clear gap in the provision of formulas for the calculation of economic losses. Therefore, the method proposed (formula) is an attempt to fill this gap and provide additional clarity to building damage assessment.

3. Residential and Non-residential Damage and Loss Assessment

Disasters principally cause notable damaged to residential and non-residential buildings and structures. Considering the significant interdependence of economic sectors, damage to buildings can also lead to delays in economic activities and deterioration of common standards of living; typically ongoing until buildings are rehabilitated or rebuilt. Therefore, it is vital to consider all the details that affect the calculation of damage and loss attained during assessment.

The proposed method for judging damage caused by a natural or man-made hazard to the residential and non-residential sector is based on the repair or replacement cost approach for direct cost analysis. There are many damage-related costs (direct and indirect) to residential and non-residential structures, such as shelter operations, renting houses or apartments, removing rubble, cleanup and mud removal (in the case of flooding), and damage to utility connections (water, sewage, electricity, and gas), latter of which are not considered here as they fall under public services.

The proposed calculation formulas and parameters are intended for different types of buildings located in Georgian territory, and by determining their technical condition or

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[16] United Nations Office for Disaster Risk Reduction (UNISDR). Technical guidance for monitoring and reporting on progress in achieving Sendai Framework global targets for Disaster Risk Reduction, 2018.

general suitability index, the damage is calculated. However, the formula, with certain adjustments, could also be used for damage assessment by authorities in other countries.

Under the proposed approach and calculation, damage to a building is considered to be damage of individual structures, elements, or as a whole loss of its primary (design) technical-economic characteristics (sustainability, strength, safety, etc.) caused by external factors.

Damage is assessed by visual or instrumental (tools) examination to ascertain the degree of destruction during the building inspection period. The degree of damage is determined by the assessment of measures and works needed to restore the building and its elements.

The proposed formula includes certain variables, parameters, and assessment criteria that are not considered within any international organization, research institute, or private company approach, framework, or damage assessment methodology, which thus highlights an important value addition of this paper. In particular this encompasses:

- Rather than the internationally defined damage categories (completely destroyed, partially destroyed, and unaffected) (Cepal, 2014), which can increase the level of bias in damage assessment, we propose eight categories to minimize assessment bias (Table 1). Damage categories are determined by examining assessed buildings visually. Visual examination, using simple tools, is performed to detect any physical or special conditions of a building; geometric invariance or rigidity; visible damage to the building or its individual structural elements; defects or deformations; and the degree of destruction. The total degree of destruction is calculated as a weighted average of all the damage assigned to structural elements. The criteria and their definitions for detecting the extent of destruction to structural elements are highlighted by Modebadze (2021).

***Table 1**. Damage categories and degree of destruction*

Damage categories / building conditions		***Degree of destruction in %***
I.	*Good*	*10*
II.	*Normal*	*20*
III.	*Satisfactory*	*30*
IV.	*Quite satisfactory*	*40*
V.	*Less satisfactory*	*50*
VI.	*Unsatisfactory*	*60*
VII.	*Very damaged*	*70*
VIII.	*Completely destroyed*	*80*

Source: Proposed by author

- Different types of buildings located within the territory of Georgia have been grouped, classified, and based on their exploitation duration (age), and an amortization coefficient for buildings has been introduced.[17] The exploitation duration of a building is extremely important for residential and non-residential building assessment, as the amortization of a structure and its individual elements

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[17] Elaborated in close collaboration with a representative of the Construction Assessment Association, Marina Khoperia.

implies a loss of the original physical-mechanical and technical-operational properties over time.

- Correction coefficients of transportation costs between primary zones[18] and regions have been estimated.

In order to gauge the damage to residential and non-residential structures, it is critical that the nation-wide average unit cost of construction is not employed, rather the unit cost utilized relates solely to the disaster zone. The unit cost of construction (m^2) is defined for the primary base zones (Zone I: Tbilisi, Batumi, and Kutaisi), where the construction input resources are gathered. Therefore, for different regions of Georgia, construction correction coefficients have been introduced (Table 2). The coefficients represented in Table 2 are based on the distance and the different geographical relief from the primary base zones, as obtained from the Construction Assessment Association of Georgia.

Table 2. Construction correction coefficients based on distance from the base zones

Transport zones	Administrative units (municipalities) and cities	Construction correction coefficients
I (Base)	*Tbilisi, Batumi and Kutaisi*	*1.0*
II	*Mtskheta, Ozurgeti, Zestafoni, Vani and other municipalities and cities located in the same geographically area*	*1.03*
III	*Borjomi, Baghdadi, Akhaltsikhe and other municipalities and cities located in the same geographically area*	*1.042*
IV	*Tsageri, Tsalka, Ambrolauri and other municipalities and cities located in the same geographically area*	*1.06*
V	*Stepantsminda, Ninotsminda and other municipalities and cities located in the same geographically area*	*1.078*
VI	*Mestia*	*1.085*

Source: Author calculation

In essence, damage to the residential and non-residential sector is not only directly related to buildings, it also affects furniture, appliances, and other items (e.g., personal belongings) within a structure. It should be noted that the value of furniture, appliances, machinery, equipment, and other types of property differ for each socioeconomic stratum and business activity. Consequently, it is useful to determine all the assets for each stratum and their corresponding monetary value. When calculating the replacement value for equipment, inventories, and furniture, the respective data can be obtained from commercial price lists. However, at present in Georgia we cannot yet differentiate the

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[18] Large regional centers/cities.

uplift costs based on socioeconomic stratum or business activity. Therefore, following international practice, as the value of equipment, inventory, and furniture are considered a part of the value of the whole building (known as the uplift cost), we can use different uplift cost coefficients based on the building type (instead of the proposed 25% of construction unit cost (Cepal, 2014) identified in many internationally recognized studies). We apply calibrated data derived from the Middlesex (London) Hazard Centre, where a database of the ratio between building fabric costs and inventory costs has been developed for different types of residential and non-residential properties across 40 years.

Table 3: Uplift cost coefficient for residential and non-residential sector with 4% std

Housing[19]	14%	Brick Warehouse	181%	Library	35%
Supermarket	178%	Hotel	11%	Fire Police Station	10%
Hypermarket	169%	Large Hotel	33%	Hospital	12%
Showroom	200%	Theatre	17%	Large Hospital	13%
Kiosk	16%	Playing Field	7%	Church	128%
Public House	19%	Sport Center	6%	Starter Unit	5%
Café-Restaurant	27%	Marina	15%	Sewage works	4%
Small Office	18%	Sport Stadium	17%	Car Park	0%
Large Office	16%	School	14%	Large Storage depot	200%
Bank Building	14%	University	18%	Office Block	17%
Wearhouse	200%	Surgery	12%	Large Office Block	23%
Traditional retail (small)	31%	Community Center	4%		
Traditional retail (large)	41%				

For Example: A small retail (shop) will have a 31% uplift on Building costs to reflect moveable, fixed equipment and stock. Uplift is capped at double Building costs (200%)

Source: Middlesex (London) Hazard Centre.

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[19] Uplift coefficients are derived from the Middlesex (London) Hazard Centre where a database of the ratio between Building Fabric costs and Inventory costs has been developed for 34 residential properties (Type and age).

Damage received from building destruction can be calculated with the following formula:

$$\boldsymbol{D = DB + UP}$$

where,

- DB – damage value of damaged residential and non-residential building
- UP – Uplift cost.[20]

$$\mathbf{DB} = \left(\sum_{\mathbf{i}}^{\mathbf{n}} \mathbf{V_0} * \mathbf{P_i} * \mathbf{S_0} * \mathbf{DD_i}\right) * \boldsymbol{k_j} * \mathbf{r}$$

$$\mathbf{UP} = \boldsymbol{V_0} * \boldsymbol{S_0} * \boldsymbol{U_e} * \boldsymbol{DI}$$

where,

$$\boldsymbol{S_0 = F \times f}$$

$$\boldsymbol{k_j} = \mathbf{100 - (70*n/N)}^{21}$$

V_0 – Construction unit cost (m^2) in current prices[22] for different type of buildings [23].

P_i – Share of construction element i (floor, wall, roof etc.) value in to construction unit cost (m^2) (%).

For illustration, Table 4 presents shares of construction elements values in to construction unit cost for several type of buildings[24] located on the territory of Georgia.

We could use average values instead of construction unit costs and shares of construction elements values in to construction unit cost for different type of buildings, but our approach reduces biasness unlike other methodologies / guidelines and increases precision.

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[20] Equipment, inventory, appliances and furniture values as certain part of the value of the whole building

[21] Calculation of an amortization coefficient is intended for various types of buildings located in Georgia, and by determining their technical condition the damage is calculated. Therefore, based on practice and Construction Assessment Association experts' assessments, even in case if actual age of the building (n) reaches official exploitation duration (N) only 70% of actual amortization is assigned.

[22] Construction unit costs for different type of building are presented in G., Modebadze, Assessment and administration of damage caused by natural and man-made hazards (theoretical-methodological aspects). PhD thesis, Annex 22, 2021

[23] Elaborated in close collaboration with representative of Construction Assessment Association – Marina Khoperia

[24] 42 type of residential and non-residential buildings were studied and their data are presented in G., Modebadze, Assessment and administration of damage caused by natural and man-made hazards (theoretical-methodological aspects). PhD thesis, Annex 22, 2021

Table 4. Share of construction elements value in to construction unit cost for different types of buildings in (%)

	Two -storey concrete brick house	Single -storey concrete brick house	Two -storey: Stone first floor and wooden second floor	Single -storey wooden spools
Foundation	5	14	7	5
Frame (frame elements: columns, railings), Walls, Partitions	8	7	0	0
Roofing and staircase	16	17	22	29
Floor	13	5	6	6
Windows / Doors	3	8	4	7
Partitions, interior facing	7	16	12	15
Plumbing work	12	9	9	8
Wiring and supply	16	12	15	14
Miscellaneous works	8	4	6	5
Foundation	6	2	5	4
Frame (frame elements: columns, railings), Walls, Partitions	6	6	14	7

Source: G., Modebadze, Assessment and administration of damage caused by natural and man-made hazards (theoretical-methodological aspects). PhD thesis, 2021. Elaborated in close collaboration with representative of Construction Assessment Association – Marina Khoperia

DD_i – Degree of destruction of construction element i (%)

The value of the variable depends on the decision of the evaluator, which is based on comparing the post-catastrophic condition of the building with the hypothetical, pre-catastrophic condition of the same building (Table 1, and G., Modebadze (2021) annex 19).

DI – Degree of destruction of inventory, equipment and furniture (%).

S_0 – area of damaged building (m^2).

F - The area of the plot occupied by the building (m^2).

f – Number of floors.

k_j – Amortization coefficient of the building j (%).

r - Construction correction coefficients based on distance from the base zone (Table 2)

U_e – Uplift coefficient.

N – Exploitation duration (age)

n – Actual age of the building.

The variables given in the formula for calculating the damage and loss caused by natural and man-made hazards are divided into two categories:

Pre-defined / integrated data:

- Construction unit cost (m^2) in current prices[25] for different type of buildings [26];
- Share of construction element i (floor, wall, roof etc.) value in to construction unit cost (m^2)[27] (%);
- Construction correction coefficients based on distance from the base zone.
- Uplift coefficient;
- Exploitation period/duration (age).

The data that will be determined on the spot during the evaluation process:

- Degree of destruction of construction element i (%);
- Degree of destruction of inventory, equipment and furniture (%);
- area of damaged building (m2);
- The area of the plot occupied by the building (m2);
- Number of floors;
- Amortization coefficient of the building j (%);
- Actual age of the building.

4. Case study

On 9th October of 2021, in Batumi, considerable part of seven-floor residential building completely collapsed. Construction and renovation work in violation of safety rules at ground floor space led collapse of some part of the building. As a result, whole building became a subject to dismantling. Nine persons, including three minors, have died following the collapse. 54 families (160 person) were displaced.

The assessment of damage can be divided into two parts: first, we should assess totally destroyed part of the building, where furniture, appliances and other movable inventory has been totally destroyed and second, assess the rest of the building, where furniture, appliances and other movable property were not damaged. Damage of inventories and furniture is reflected in uplift cost calculations.

If we apply proposed damage assessment formula, estimated damage will be:

$\mathrm{DB} = (\sum_{\mathrm{i}}^{\mathrm{n}} \mathrm{V}_0 * \mathrm{P}_{\mathrm{i}} * \mathrm{S}_0 * \mathrm{DD}_{\mathrm{i}}) * k_j * \mathrm{r} = 1200 * 1 * 3220 * 1 * 0.417 * 1 = 3{,}864{,}000$ GEL (USD 1,400,000) [28]

Uplift cost for destroyed area - $UP_1 = V_0 * S_0 * U_e * DI = 1200 * 805 * 0.14 * 1 = 135{,}240$ GEL (USD 49,178) and uplift cost for dismantling area - $UP_1 = V_0 * S_0 * U_e * DI = 0$

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[25] Construction unit costs for different type of building are presented in G., Modebadze, Assessment and administration of damage caused by natural and man-made hazards (theoretical-methodological aspects). PhD thesis, Annex 22, 2021

[26] Elaborated in close collaboration with representative of Construction Assessment Association – Marina Khoperia

[27] Construction unit costs for different type of building are presented in G., Modebadze, Assessment and administration of damage caused by natural and man-made hazards (theoretical-methodological aspects). PhD thesis, Annex 22, 2021

[28] 08.08.2022 - USD/GEL – 2.75

So, total damage is 3,999,240 GEL (USD 1,454,269)

where,
k_j= 100 – (70*n/N) = 100 – (70*50/60) = 41.7%
$S_0 = F \times f = 3220$ m^2
V_0 – Construction unit cost (m^2) in current prices = 1200 GEL (USD 436.36)
P_i – Share of construction element i (floor, wall, roof etc.) value in to construction unit cost (m^2) (%) = 1
r - Construction correction coefficients based on distance from the base zone = 1
U_e – Uplift coefficient = 0.14
DD_i – Degree of destruction of construction element i (%) = 100%
DI – Degree of destruction of inventory, equipment and furniture (%) = 100% and 0%
N – Exploitation duration (age) = 60 years
n – Actual age of the building = 50 years
S_0 – area of damaged building (m^2) = 7x460 = 3220 m^2, totally destroyed 805 m^2
F - The area of the plot occupied by the building (m^2) = 460 m^2
f – Number of floors = 7

5. Conclusion

A review of global methodologies and frameworks revealed a clear gap in the provision of formulas for calculating economic losses in the residential and non-residential sector. As there is clear obstacle in the provision of practical guidelines for assessing damage and loss in the residential and non-residential sector, the proposed standardized method (formula) in the paper offers a solution to fill the current gap in assessment. The formula provides additional clarity to the various worldwide methodologies and frameworks presently used in the damage assessment of buildings and structures.

The standardized method developed for assessing the damage and loss caused by natural and man-made hazards to the residential and non-residential sector would improve the management of issues such as: the reliability and validity of data, accounting-standardization, comparability with international databases, as well as reporting for various purposes. It would also help Georgia comply with the international frameworks under the UN as well as the European Union's development agenda.

After a detailed study of the UNISDR methodology, the need for a comprehensive explanation of the variable (unit cost of construction) given in the formula for estimating damage to the residential sector was identified. The definition of unit cost of construction should highlight that, it includes uplift costs as well. Beyond which, the assessment formula is incorrect.

The necessity to collect detailed and specific data for the damage and loss calculation, alongside a requirement for frequent renewals of the integrated database (associated with the need for additional resources) – without which it often leads many countries, including Georgia, to use ineffective methodologies (e.g., HAZUS). Therefore, the study offers a new and original approach for assessing damaged buildings and provides an alternative method to fill the gap in the damage assessment of particular types of buildings and structures. Moreover, the proposed damage assessment method could be employed by authorities in other countries, as all the variables used within the formula have a clear definition (there is no room for different interpretations of the calculation), and they can be both easily collected (not requiring GIS or other integrated systems) and deployed in practice.

The proposed method differs from other well-regarded methodologies and frameworks (ECLAC- DaLA, UNSDR, HAZUS, EMA, etc.) by clarifying certain aspects and adding relevant variables (such as amortization coefficient of the building and construction correction coefficients based on distance from the base zone). Moreover, rather than the internationally defined damage categories (completely destroyed, partially destroyed, and unaffected) (Cepal, 2014), which can increase the level of bias in damage assessment, the paper propose eight categories to minimize assessment bias.

The suggested method corresponds to a standardized disaster impact assessment in the residential and non-residential sector, and it moreover recognizes Georgia's peculiarities and relevant stakeholder needs. It can additionally be applied in different disaster events and across every region of the country. The proposed method is precise enough to consider the characteristics of all buildings. Furthermore, the method can identify, analyze, and evaluate the impact of natural and man-made hazards on the residential and non-residential sector. Critically, it may also be used as a valuable tool during informed, risk-related policy decision-making and planning.

Furthermore, the systematic collection of data on disaster damage and loss in the residential and non-residential sector would enable the relevant government agencies, private insurance companies, and research institutes to develop (calibrate) damage and loss assessment models. The latter of which could moreover assess short- and long-term economic shocks and sustainability issues. The collected data could thereafter be used to calculate compensation for the victims of a disaster. Therefore, such defined compensation would support the establishment of a fair and effective state aid mechanism, facilitate cooperation with the private sector and local and international communities, and enable development in the insurance market.

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