Chapter 35
Application of a Disaster Economic Assessment Framework Through an Illustrative Example

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Abstract This paper provides an illustrative example of the application of a unified disaster economic assessment framework. The results aim to highlight the primary targets of the proposed framework as its replicability, usability, comparison, capability and generality (applicability to different disaster types).

Keywords Economic assessment · Disasters · Natural hazard · Framework

35.1 Introduction

According to Guha-Sapir et al. [8], the worldwide estimates of natural disaster economic damages in 2016 were US$ 154 billion, 12% above the 2006–2015 annual average. It is estimated that in the next 50 years natural and human-made disasters will increase fivefold in number and severity—both in rural and in urban areas, because of factors such as population increase and land occupation, associated with the historical process of urbanization and industrialization [12]. Several episodes of high magnitude have demonstrated the vulnerability of modern society (earthquakes in Haiti and Chile in 2010; Fukushima nuclear accident in 2011), therefore evidencing the need for differentiated management for these events.

Disasters are divided into sudden onset (earthquakes, tsunamis, terrorist attacks) and slow onset (hungry, poverty or extreme drought) and are characterized by four main phases: mitigation, preparation, response and rehabilitation or reconstruction [14]. These phases are divided into pre-disaster and post-disaster stages, where the first is responsible for: (i) mitigation, encompassed activities, projects or actions aimed at preventing or reducing the impacts of a disaster, and (ii) preparation that involves the possible activities to be performed for a response

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before the disaster occurs [5, 14]. The post-disaster stage is composed by (i) response and reactive phase, given that entities, government and population act directly to save lives and preserve the human and financial resources of the affected region, and (ii) reconstruction that focuses on the financial, social and patrimonial restoration of the affected region [5, 14].

It is a common understanding in the literature that there is no way of neutralizing all negative impacts resulted from disasters, but efforts can be made to reduce their impacts [11]. One of these actions is related to provide a disaster economic assessment to quantify, qualify and support the event phases (mitigation, preparation, response and recovery). One of the primary sources of uncertainty in the estimation of the costs of natural hazards is the lack of enough, comparable and reliable data [10].

According to UNISDR - United Nations International Strategy for Disaster Reduction [13], one of Sendai's framework recommendation is to promote real-time access to reliable data and use information and communications technology innovations to enhance measurement tools and the collection, analysis and dissemination of disaster data. Following this statement, based on a systematic literature review of disaster economic assessment methodologies, Eckhardt et al. [7] proposed a modular, replicable and user-friendly framework capable of providing an economic assessment of different disaster types.

This paper provides an illustrative example of the framework proposed by Eckhardt et al. [7], with an application in a disaster in the mountain region of Rio de Janeiro in 2011. Through this application, we aim to validate some characteristics of the proposed framework, such as replicability (can be used by different users), modularity (to evaluate only specific and pre-defined costs), usability and generality (applicability to different disaster types).

This research is based on secondary sources, as peer-reviewed papers and gray literature (assessment reports and congress papers), related to the 2011's disaster in Rio de Janeiro. The information collected about the disaster in the mountain region of Rio de Janeiro in 2011 was, then, classified according to the economic assessment framework proposed by Eckhardt et al. [7].

The structure of this paper is as follows: Sect. 35.1 gives an overview of disasters. Section 35.2 presents the economic assessment framework proposed by Eckhardt et al. [7]. Section 35.3 details the illustrative example. Section 35.4 presents the research conclusions.

35.2 Economic Assessment Framework

Based on a systematic literature review, Eckhardt et al. [7] proposed a framework (as present in Fig. 35.1) to assess the economic costs of a disaster based on six major stages: (1) pre-event; (2) disaster event; (3) scope; (4) post-event; (5) coordination; and (6) technical data source. According to the authors, the four first stages are considered cyclic (one stage feeds the other), whereas coordination and technical data source are timeless supporting stages for all elements of the framework.

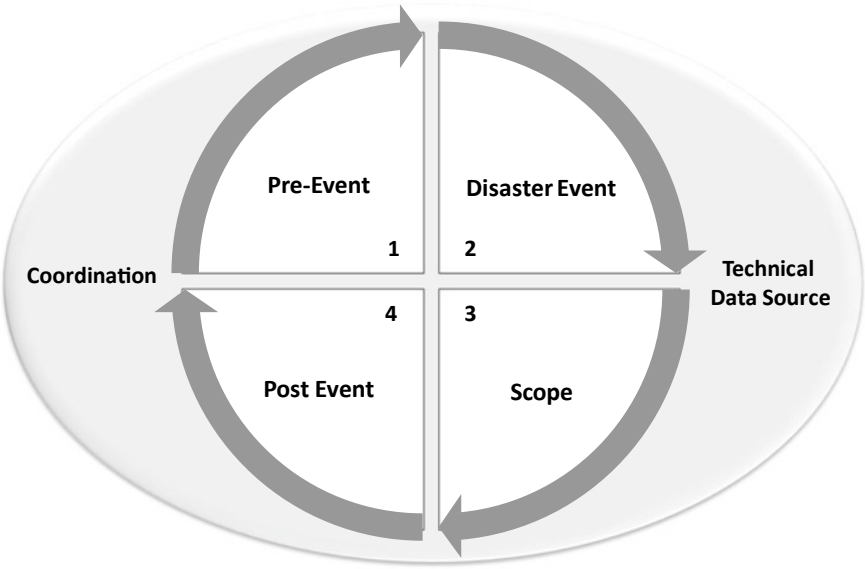

Fig. 35.1 Economic assessment framework. *Source* adapted Eckhardt et al. [7]

The pre-event stage is characterized by pre-disaster activities such as definition of the nomenclatures and units to be used; definition of resilience indicators; definition of indicators to be used during the assessment (number of deaths, number of injured people, number of residential units destroyed); and authorization and access to the necessary data (census, financial, socioeconomic information).

The disaster event stage aims to characterize and scale the impacts caused by the disaster. Disaster characteristics are understood as type (earthquake, flood, strong winds, drought); intensity scale; affected region; duration; and start date. The initial information usually defines the impacts after the occurrence of the event, such as the number of impacted people; confirmation of the affected regions; derivation of other disasters (e.g., an earthquake can generate tsunami); and initial damage estimates (e.g., the percentage of residential units destroyed).

According to Eckhardt et al. [7], the scope stage is considered the most complex one since it defines the scope to be carried out through the entire assessment cycle. This phase defines the costs to be evaluated, the reports, the type of evaluation (measuring positive impacts, potential impacts or only back to normality), the covered disaster phases, assessment priorities and sectors. According to ECLAC—Economic Commission for Latin America and the Caribbean [3]—there are three main sectors to be evaluated in this stage: social sectors (housing, education, health); productive sectors (agriculture, livestock, fishery, mining, industry, trade, tourism); and infrastructure sectors (water and sanitation, electricity, transport and communications). In addition, for each sector, the decision-makers should define which costs will be evaluated: direct costs (damages to property), business interruption costs (local inter-

ruption of economic processes), indirect costs (induced losses in local or regional levels), intangible costs (damages to goods and services which are not measurable) and risk mitigation costs (risk reduction costs).

The last stage of the internal cycle of the framework, post-event, is responsible for the publication of the performed assessment. At this stage, decision-makers should document lessons learned and if necessary define new indicators for future evaluations (feed the pre-event stage).

In order to support the execution of the internal cycle stages, the coordination stage is designed to define the assessment stakeholders; to create a communication plan; to list, mitigate and prioritize risks and issue; to define quality metrics; and to define the assessment budget. Finally, the technical data source (TDS) stage aims to create all infrastructures to operate the framework, for instance, the creation of a centralized database, definition of software and tools to be used, listing of methods according to the defined scope.

35.3 Illustrative Example

According to Bandeira et al. [1], the natural disaster that occurred in 2011 in 20 cities in Rio de Janeiro is considered the biggest natural disaster in Brazil, where 916 people died, and 90,000 were directly affected. The causes of this storm, described by the authors, were: geology of the region, irregular occupation (on slopes and alluvial plains) and intense precipitation (in periods of 15 min).

The phase of response to this disaster showed several problems, described by Bandeira et al. [1], such as: (i) logistics problems due to highways and interrupted roads; (ii) low level of planning and efficiency in the use of available resources (e.g., helicopters stopped in the field); (iii) lack of aid kits (doctors, food and water); (iv) removal of deaths; and (v) problems in distributing aid (for instance, no planning for allocation of medical kits and medications). Besides these problems, Costa et al. [2] have identified: (vi) lack of information on the actual size of the disaster; (vii) looting and insecurity in some affected places; (iv) lack of adequate transportation; (x) difficulties in using the available communication system due to the topography of the region; and (xi) poor quality of maps available.

Through the framework proposed by Eckhardt et al. [7], this study focuses on two major impacted sectors, housing and tourism. The first directly affected the local population; the second, directly and indirectly, impacted the economy, since most of the gross domestic product (GDP) of the region's municipalities is generated by tourism.

The overall input information to the framework was based on post-disaster data sources (assessments, case studies and methodologies). For indicators and resilience scores, two sources were selected, World Bank [16] that describes the Post-Disaster Needs and Assessment (PDNA) methodology, and ECLAC [3] that describes the Damage and Loss Assessment (DaLA) methodology. For disaster parameters and overall information (size, type, impacts), three sources were selected, the World

Bank [15] that applied DaLA, Bandeira et al. [1] that present a case study and ENAP—National School of Public Administration [4] —that tries to find answers to the disaster.

Table 35.1 shows the result of the internal cycle of the proposed framework. The first stage of the framework, pre-event, is defined before the disaster occurs. For this stage, we used the information presented in the World Bank [16] in order to define the indicators to be measured. The authors proposed the International System of Units as adopted by Brazil since 1962 [9]. The resilience score is based on the ECLAC [3].

The technical data source stage aims to support the operation of the stages present in the internal cycle of the framework. In this illustrative example, we can cite the use of a central Excel database for compiling and storing the data. The evaluation methods (e.g., repair/replacement, econometric, input–output) were obtained from Eckhardt et al. [6] and Meyer et al. [10]. The framework allows and highlights the use of sophisticated tools and methods, such as stage–damage curves (SDCs). However, since it is an illustrative example that occurred in 2011, such complexity would need to obtain the necessary information in the pre-event phase (for instance, the definition of river level and velocity indicators) and, consequently, would not make possible the framework operation. On the other hand, the framework is flexible in allowing the use of less complicated tools according to the result defined and expected in the scope stage. The coordination stage was not validated in this example since it is based on secondary data sources, and it had an academic purpose (stakeholders from the academy) and carried out a long time after the disaster.

35.4 Conclusions

This study sought, through an illustrative example, to analyze the economic assessment framework for disasters proposed by Eckhardt et al. [7]. The example showed the modularity of the related framework, where the scope was clearly defined and published through the following elements: sectors to be evaluated (tourism and housing), type of costs (direct and indirect), phase (response and recovery), methods (repair/replacement and econometrics).

The replicability of the framework can be done by a process to store the data and their respective data sources. However, the need for a detailed methodology (including processes and flows) is transparent to guarantee the expected result regarding replicability. Once applied to a different type of disaster from the earthquake example presented by Eckhardt et al. [7], the proposed framework shows that it can be applied to different sudden onset disaster types. On the other hand, it is necessary for additional applications in a slow onset disaster such as drought and hunger.

The technical data source stage needs additional efforts to map the methods to be used in the different assessment costs, and according to the scope defined it can also be enhanced with an execution duration of each type of method and cost according to the disaster scale. Finally, the coordination stage seems to be adequate and well

Table 35.1 Economic assessment framework applied to housing and tourism sectors

	Description	Housing	Tourism	Reference
Pre-event	Pre-define measurable indicators	• Number of residential units affected divided by: (i) location (rural, industrial, commercial); (ii) construction type (wood, concrete); (iii) year of construction; and (iv) damage level • Number of people impacted divided by (i) death, (ii) injured, (iii) homeless • Average quantity of people per family • Average temporary shelter needs • Total cost to repair or replace • Total cost for social rent • Definition of house sizes • Total furniture cost	• Number of historic buildings affected by (i) year of construction and (ii) type • Number of hotels and restaurants affected by: (i) location; (ii) construction type; and (iii) activity type • Revenue loss	World Bank [16], ECLAC [3]
	Define units and nomenclature standards	International System of Units and Brazilian reais currency Nomenclature: Not applied		–

(continued)

Table 35.1 (continued)

	Description	Housing	Tourism	Reference
	Provide data authorization and accessibility	• Population census • Household survey • Affected area maps • Finance reports • Poverty maps • Construction materials used in the affected areas • Typical household goods and equipment • Average monthly rentals • Construction costs for each house type	• Total number of tourists by: (i) visitation place/location; (ii) month; and (iii) special dates • Average reais spent by each tourist per day • Total revenue by tourism place	Adapted ECLAC [3]
	Resilience score	• Construction capacity per month • Time to release financial resources	• Construction capacity per month • Time to release financial resources	Adapted ECLAC [3]
	Description	Housing	Tourism	Source
Impacts	Disaster specification	• Disaster type: floods and landslides • Date: January 10–12, 2011 • Duration: 3 days • Most critical cities affected: Nova Friburgo, Teresópolis, Petrópolis, Sumidouro, São José do Vale do Rio Preto, Bom Jardim e Areal • Number of deaths: 916 • Number of impacted people: 90,000 • Number of homeless people: 35,000 • Several cultural heritages destroyed: Friburgo Downtown Church + Chair Lift and Petrópolis (Vale do Cuiabá region was destroyed) • Hotels and marketplaces were • In the seven municipalities, 6.13% of the properties were impacted, and 3.34% were destroyed		Bandeira et al. [1], World Bank [15], ENAP [4]
	Impact analysis			

(continued)

Table 35.1 (continued)

	Description	Housing	Tourism	Source
Scope	Define which disaster phases will be covered	Response and recovery	Recovery	–
	Decide whether to count 'potential' or 'back to normality' costs in the assessment	Back to normality costs	Potential	–
	Define the costs to be evaluated	Direct costs	Indirect costs	–
	Define which sectors will be covered	Housing and human settlements	Tourism	–
	Measure the positive aspects of the disaster	No	Yes	–
	Define overall priorities per disaster phases	No	No	
	Define deliverables (full and partial reports)	Total direct costs by house type	Total indirect costs by total loss revenue.	–
	Check for previous disaster assessments	Not applicable	Not applicable	–
Post-event	Reports	Results of this research	Results of this research	–
	Lessons and learn	Results of this research	Results of this research	
	Report publication	Not applicable	Not applicable	–

referenced, but a future work, based on a real-time disaster application, is needed to prove its effectiveness.

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