Disaster Impact Assessment: A Holistic Framework

Ana Laugé
Tecnun – University of Navarra
alauge@tecnun.es

Josune Hernantes
Tecnun – University of Navarra
jhernantes@tecnun.es

Jose M. Sarriegi
Tecnun – University of Navarra
jmsarriegi@tecnun.es

ABSTRACT

One of the important aspects of the crisis management consists in a comprehensive analysis of the impacts generated and their associated cost. The capacity to carry out an efficient holistic management, through the development of preventive measures and response programs relies on a proper estimation of impacts which helps to mitigate the harshness or can even avoid impacts in face of future crises. The aim of this paper is to analyse existing methodologies for natural disasters' impact evaluation, the identification of the different impact categories as well as the explanation of a natural disasters impact framework, which includes a list of indicators for a correct impact assessment. The framework also analyses the evolution of impacts, that is, how immediate impacts can also generate delayed impacts.

Keywords

Natural disaster, Impact assessment, Impact analysis, Holistic framework

INTRODUCTION

A comprehensive analysis of the potential impacts that may result as a consequence of a natural disaster has to be conducted to facilitate crisis management. In case crisis managers can not make decisions about how to prevent or respond to a crisis being unaware of their consequences, as their management will result inefficient. Furthermore, a proper assessment of natural disasters' impacts helps evaluating the efficiency of prevention and preparedness measures implemented to prevent or reduce the impact of such events.

Actually, impact analysis can help improving crisis management throughout the overall crisis lifecycle. During *prevention phase*, impact analysis will be useful for risk analysis which relies on the likelihood of an event and its consequences. Through risk assessment preventive measures such as changes in building processes or in land use planning could be implemented. In the *preparation phase*, the analysis of past disasters' impacts lead to the improvement of response programmes assigning priorities, allocating resources and training responders. Furthermore, in the *response phase* all previously developed programmes and training improves managers learning about the consequences of a natural disaster over time reducing indirect impacts' generation. Finally, in the *recovery phase* impact generation has to be taken into account. For example the reconstruction process can still generate new impacts on welfare or extend the existing ones. Therefore, a holistic impact estimation has to be carried out in order to improve preventive measures and response programs which can help to mitigate harshness and may even prevent future crises.

The research presented through this paper is part of a PhD thesis in progress. The aim of the PhD thesis is to develop a natural disasters' impact framework to assist crisis management with natural disasters impact assessment. The natural disasters' impact framework will have a holistic perspective including all sectors affected by natural disasters with a special focus on critical infrastructures as the welfare of society is dependent on their proper functioning (Collier and Lakoff, 2008; Croope and McNeil, 2011). Furthermore, the framework will also have a dynamic perspective as impact evolution over time will also be analysed.

IMPACT ASSESSMENTS ANALYSIS

A review and analysis of the dimensions that are currently used in the literature for the identification,

classification and evaluation of the impacts of natural disasters has been conducted (Laugé, Hernantes, Labaka and Sarriegi, 2012). For this purpose, classifications used by international agencies and organizations from different countries (Australian Government, 2011; Benson and Twigg, 2004; Bureau of Transport Economics 2001; Calderón Patier, Fernández-Ardavín Martínez and Martínez Torre-Enciso, 2003; ECLAC, 2003; FEMA, 2002; Hallegatte and Przyluski, 2010; Middelmann, 2007; National Research Council 1999; Pelling, Özerdem and Barakat, 2002; Rose, 2009; SCARM, 2000; U.S. General Accounting Office, 2002) and the ones used in several research projects funded by the European Union were analyzed (DOMINO, 2011; EUMASS, 2011).

The most internationally recognised impact assessment methodologies are ECLAC and HAZUS (ECLAC, 2003; FEMA, 2002). The Economic Commission for Latin-America and the Caribbean (ECLAC) developed its first version of the handbook for estimating the socio-economic and environmental effects of disasters in 1991 and in 2003 they published the current version. On the other hand, HAZUS is a software tool for natural disasters loss estimation created by the Federal Emergency Management Agency (FEMA) of the United States; the first version was launched in 1997 and is being periodically updated.

From this study, two different classification types for identification and evaluation of crisis impact are inferred. The first type classifies impact according to their nature differentiating between tangible versus intangible and direct versus indirect impacts. Tangible impacts are the impacts that can be measured in monetary terms as there is market for them, such as destruction of vehicles, buildings or infrastructure, the changes in income or increasing of costs. Thus, their cost estimation results much easier. On the other hand intangible impacts are difficult to estimate, as there is no systematic or agreed method available to measure them (Bureau of Transport Economics 2001; ECLAC, 2003; Hallegatte and Przyluski, 2010; Middelmann, 2007). Examples of intangible impacts are deaths, injured people, human suffering, cultural artefacts, losses of memorabilia, environmental impacts and psychological effects. Both tangible and intangible impacts can also be positive such as income increase in not affected industry or development of community and solidarity.

Furthermore, direct impacts represent the partial or complete physical destruction caused by the natural disaster to human beings, buildings, infrastructure, vehicles, capital and on stock. Direct impacts will occur over different periods of time depending on the type and magnitude of the disaster. On the other hand, indirect impacts are consequence of direct impacts caused by the hazard. Indirect impacts are more difficult to identify and furthermore, are harder to estimate (ECLAC, 2003; National Research Council 1999). Examples of indirect impacts are changes in income or flows of goods and services that will not be produced and that may extend throughout the rehabilitation and reconstruction periods and increase of the unemployment rate (Calderón Patier et al., 2003; ECLAC, 2003; FEMA, 2002; National Research Council 1999). Indirect impacts can also be positive, generating benefits to society such as increasing income of the construction sector due to reconstruction activities.

The second classification distinguishes impacts based on the affected sector. The analysed impact assessments differentiate three to five sectors. For instance, the ECLAC (ECLAC, 2003) apart from categorising impacts into direct and indirect also divides impacts by social, infrastructure, economic and overall effects. On the other hand, HAZUS (FEMA, 2002), which focuses on indirect impacts, estimates physical, economic and social sectors excluding, for example, the environmental impact.

IMPACT ASSESSMENT PROBLEM STATEMENT

After completing the analysis of the methodologies currently used for the classification of impacts several barriers and limitations have been identified. It is likely that crises have a greater long-term impact on quality of life, livelihoods, economic and environmental conditions than what is currently being evaluated. That is why the official estimation of the impacts does not convey the whole story of how crises affect people and their environment (Logar and van den Bergh, 2011). Thus, the evaluation of impacts that is currently developed today is often incomplete and inaccurate (Mckenzie, Prasad and Kaloumaira, 2005).

Usually, impact analysis is carried out immediately after the critical event to prioritize the needs of relief and rehabilitation. This involves the accomplishment of the analysis in situations of great stress for those managing the crisis. So generally, the analysis focuses on quantifying direct physical damage in infrastructure and estimating the number of deaths and injuries. Indirect impacts, such as the effects on the productive capacity of the affected region, are rarely monitored as months or years are needed to properly estimate them (Lequeux and Ciavola, 2011; Pfurtscheller, Lochner and Thieken, 2011). Furthermore, adopting a holistic perspective on temporal and spatial aspects when analyzing existing classifications, would allow observing all the impacts generated also including the ones that in many cases are excluded such as the social effects.

A challenge in estimating the impacts of a crisis is to know what should be included. For example, if an earthquake destroys a road there is no doubt about including the reconstruction of this road among the impacts.

But issues such as economic losses of businesses that are accessed by this road, their customers and suppliers' losses and the discomfort caused to those who need to use longer alternate routes with a consequent increase in fuel consumption should also be included. Therefore, a dynamic perspective analysing cause and effect relationship among impacts should be developed.

The lack of consistency among methodologies concerning the definition of various concepts is another barrier when analyzing impact estimation methodologies (Logar and van den Bergh, 2011). Each organization uses similar terms in which they group different kind of impacts so that the results of these estimations result divergent.

Finally, critical infrastructures play an important role in impact generation. Society is highly dependent on the correct functioning of critical infrastructures. Therefore, if one or more critical infrastructures result to be damaged by a natural disaster they will generate important consequences affecting the whole society. However, current impact assessment methodologies such as ECLAC and HAZUS (ECLAC, 2003; FEMA, 2002) do not make special focus on critical infrastructures.

The detection of currently existing barriers and limitations highlights the need of developing a holistic natural disasters impact evaluation framework including a dynamic perspective that enables to analyze the cause and effects of impacts as well as with special attention on critical infrastructures due to their important role on impact generation.

NATURAL DISASTERS' IMPACT FRAMEWORK

In this section, a first draft of the framework for natural disasters' impact evaluation is presented. The objective of the framework relays on helping crisis managers to estimate disasters' impacts in different sectors.

The methodology to develop the framework has been based on literature review and real natural disaster's analysis. The developed framework includes the four categories that impact assessment methodologies use for impact categorisation (tangible, intangible, direct and indirect). Furthermore, the sectors included are also based on the assessment methodologies analysed including critical infrastructure sector due to their important role in impact generation. In addition, impact indicators have been identified from impact assessment methodologies and recent natural disasters. The framework does not include impact indicators related to macroeconomic effects (for example GDP) as including them could entail double counting. Finally, the indicators have been defined at an aggregated level and therefore, specific indicators such as impact on special groups (for example women) have not been included.

The current version of the framework clusters impacts by sectors including: critical infrastructure, economic, social and environmental. In each sector several families have been listed comprising a total of 23 families. Into each family a number of impact indicators have been identified with 152 impact indicators in total. In addition, these indicators have been classified according to their nature, differentiating direct impacts from indirect ones and also tangible from intangibles. Direct impacts occur in a short period of time whereas indirect impacts, being consequence of the direct ones, spread over time. Hence, as the time goes by; indirect impacts' evaluation becomes more and more complex. Thus, dynamic aspects of crises impacts are also being studied into this framework but are not currently implemented.

Critical Infrastructures sector

This sector comprises impacts suffered by critical infrastructures. The included critical infrastructures correspond to the indicative list of the Green paper on a European Programme for Critical Infrastructure Protection (Commission of the European Communities, 2005) which considers the following infrastructures as critical: Energy, Information and Communication Technologies (ICT), Water, Food, Health, Financial, Public & Legal Order and Safety, Civil Administration, Transport, Chemical and Nuclear Industry, and Space and Research.

The direct impacts' indicators included into this sector correspond to the physical damage suffered by all critical infrastructures including damage to infrastructure, equipment and supply comprising a total of 24 indicators. On the other hand, indirect impacts' indicators are referred to the increase in operating costs or loss of income for each critical infrastructure (33 indicators). For example, Energy critical infrastructure can suffer several different impacts when a natural disaster strikes. In the framework the following direct indicator impacts have been listed: a)Damage to energy infrastructure, and b)Damage to equipment and supplies. Furthermore, identified indirect indicators are: a)Increase in energy operating costs, b)Inadequate access to Critical Infrastructures' services, and c)Costs of demolition and debris removal.

Economic sector

This sector excludes businesses already included in critical infrastructure sector. Into the economic sector we have included impacts over primary (production of raw material and basic foods), secondary (trade and industry) and tertiary (services) sectors. Direct economic impacts are related to the physical damage of each on the three sectors (10 indicators). Furthermore, indirect impact examples are unemployment and businesses loss of income or increase in their operating costs among others (19 indicators). Taking the Primary Economic sector as example, the direct indicators are: a)Damage to infrastructure (excluding the ones included into Critical Infrastructures sector), b)Damage to machinery and equipment (excluding the ones included into Critical Infrastructures sector), and c)Loss of stock. Indicators for indirect impacts are: a)Increase in operating costs, b)Loss of income, c)Income increase in surrounding not affected activities, d)Cost of demolition and debris removal, e)Inadequate access to Critical Infrastructures' services, and f)Unemployment.

Environmental sector

The environmental sector include impacts on soil contamination, soil movements, air emissions, surface or ground water contamination, fauna, flora, sensitive areas and natural resources impacts (18 direct and 11 indirect indicators). Soil contamination direct indicators are listed as: a)Earthworks/movements, b)Contamination, c)Changes to visual attributes of area, and e)Cost to rehabilitate land. Additionally, indirect indicators are: a)Erosion around collapsed area, b)Contamination, and c)Fertile soil from volcanic eruption.

Social sector

Social impacts are effects of disasters over population, culture, education, and property including direct impacts such as physical destruction or affected people (9 indicators) whereas indirect impacts are related to people displacement, secondary health effects, demographic changes, insecurity or humanitarian aid (28 indicators). Into this sector Culture direct indicators impact are: a)Damage to cultural infrastructure, b) Damage to contents (works of art, archaeological findings and archives), and f) Damage to Works of art, Archaeological findings and Archives which are irreparable. As indirect indicators we have identified: a)Increase in cultural services operating costs, and b)Costs of demolition and debris removal.

FUTURE RESEARCH

Currently, we are working to identify the cause and effect relations that exist among impacts. Cause and effect means, for example, that as long as direct impacts persist there will be more indirect impacts generated. These causal influences help crisis managers understand their evolution over time. It is therefore recommended a more dynamic evaluation of impacts which takes into account relationships among them and their evolution over time under different conditions. The study of these cause and effect influences is very relevant as they are the reason why a natural disaster can still create impacts years after the occurrence of the triggering event. Thus, analysing disasters and impacts evolution over time crisis managers could learn how their decisions affect the final impact of disasters .

CONCLUSION

In this research we have explained the need of developing a holistic natural disaster impact framework. This framework can improve natural disasters impact evaluation which helps crisis managers improving all phases of crisis management. However, further research on real natural disasters' impact cause and effect relationship is needed to implement the dynamic aspect of the impact assessment framework.

REFERENCES

1. Australian Government. Risk and impact analysis. 2011 [cited February 13 2013]. Available from http://www.ga.gov.au/hazards/risk-and-impact-analysis.html.
2. Benson, C. and Twigg, J. (2004) 'Measuring mitigation' methodologies for assessing natural hazard risks and the net benefits of mitigation – A scoping study, Switzerland.
3. Bureau of Transport Economics. (2001) Economic costs of natural disasters in australia, Bureau of Transport Economics, Paragon Printers, Camberra, Australia.

4. Calderón Patier, C., Fernández-Ardavín Martínez, A. and Martínez Torre-Enciso, M. I. (2003) La valoración económica de los desastres: Una aproximación metodológica a través de las tablas input-output, *Anales de economía aplicada*, Almería, Spain.
5. Collier, S. and Lakoff, A. (2008) The vulnerability of vital systems: How 'critical infrastructure' became a security problem, The politics of securing the homeland: critical infrastructure, risk and securitisation, Routledge.
6. Commission of the European Communities. (2005) Green paper on a european programme for critical infrastructure protection, Brussels.
7. Croope, S. V., and S. McNeil. 2011. Improving resilience of critical infrastructure systems postdisaster. *Transportation Research Record: Journal of the Transportation Research Board* 2234, (1): 3-13.
8. DOMINO. DOMINO european project webpage. 2011 [cited February 13 2013]. Available from http://www.dominoproject.eu/.
9. ECLAC. (2003) Handbook for estimating the socio-economic and environmental effects of disasters, Mexico.
10. EUMASS. EUMASS - european mass-transit system security risk assessment and audit methodology. 2011 [cited February 13 2013]. Available from http://88.32.124.85/EUMASS/index.html#.
11. FEMA. (2002) HAZUS-MH MR5, Washington D. C.
12. Hallegatte, S. and Przyluski, V. (2010) The economics of natural disasters: Concepts and methods, 5507, Chief Economist of the Sustainable Development Network, The World Bank, France.
13. Laugé, A., J. Hernantes, L. Labaka, and J. M. Sarriegi. 2012. Análisis y clasificación de los impactos en situaciones de crisis. *Revista Internacional De Desastres Naturales, Accidentes E Infraestructura Civil* 12, (2): 179-86.
14. Lequeux, Q. and Ciavola, P. (2011) Methods for estimating the costs of coastal hazards, Final report WP7, Project CONHAZ, Cost of natural hazards.
15. Logar, I. and van den Bergh, J. C. J. M. (2011) Methods for assessment of the costs of droughts, CONHAZ Report, .
16. Mckenzie, E., Prasad, B. and Kaloumaira, A. (2005) Guidelines for estimating the economic impact of natural disasters on development in the pacific, Australian Agency for International Development, Australia.
17. Middelmann, M. H. (2007) Impact of natural disasters, Natural Hazards in Australia. Identifying Risk Analysis Requirements, Geoscience Australia.
18. National Research Council. (1999) The impacts of natural disasters: A framework for loss estimation, National Academy Press, Washington, D. C.
19. Pelling, M., A. Özerdem, and S. Barakat. 2002. The macro-economic impact of disasters. *Progress in Development Studies* 2, (4): 283-305.
20. Pfurtscheller, P., Lochner, B. and Thieken, A. H. (2011) Costs of alpine hazards, CONHAZ Report, Cost of Natural Hazards.
21. Rose, A. 2009. A framework for analyzing the total economic impacts of terrorist attacks and natural disasters. *Journal of Loss Prevention in the Process Industries* 6, (1).
22. SCARM. (2000) Floodplain management in australia— best practice principles and guidelines, 73, CSIRO Publishing, Collingwood, Victoria.
23. U.S. General Accounting Office. (2002) Review of studies of the economic impact of the september 11, 2001, terrorist attacks on the world trade center, Washington.