Assessing social vulnerability to earthquake hazard: from statistical to spatial analysis

Ivan Frigerio[1], Daniele Strigaro[1], Matteo Mattavelli[1], Silvia Mugnano[2]
Mattia De Amicis[1]

[1] Geomatic Laboratory, DISAT Department, University of Milano-Bicocca

[2] Sociology and Social Research Department, University of Milano-Bicocca

Abstract

In the framework of classical natural hazard, multi-hazard and risk assessment the concept of vulnerability is referred to the fraction of the total risk value that could be loss after a specific adverse event (Mazzocchi et al., 2009). However, over the last few years the term 'Vulnerability' has been frequently cited in scientific literature in regard to different context, focusing particularly to social-economic aspects that influence societal conditions such as exposure, sensitivity, coping, adaptive capacity and social capital (Adger, 2006; Gallopin, 2006).
Indeed, the natural hazards does not have a random effect on the local community and generally the most affected groups are the more vulnerable ones, already marginalized by class, race, ethnicity and gender (Blaikie et al., 1994). Therefore, natural hazards can be more or less devastating according to vulnerability, which depends on the time and place where the event happens and the socioeconomic conditions of the population affected (Cutter et. al., 2003).
Within this framework, the main purpose of this work is to assess social vulnerability indicator (SVindex) toward earthquake hazard for Italian country in order to identify hot-spot areas: zones with high seismic levels and at the same time high social vulnerability levels. The methodological approach consist in four different steps:

1. the first is the development of a spatial database using Spatialite with different tables coming from 2001 ISTAT population census. The database is used to increase data management and to create several socioeconomic indicators (e.g. age, education, gender) as proxy variables that better explain the Italian population socio-economic conditions that influence the capacity of a community to prepare for, respond to, and recover from hazards and disasters;
2. the second step is to apply on the proxy variables a multivariate statistical analysis. Through different **R** packages (e.g. vegan, princomp, outliers) principal component analysis (PCA) is performed to reduce dataset. At the end of the PCA, the interpretation of the component matrix generated 4 main factors that explain the relationship between

variables unfolding the 74.6 % of the variance in the entire dataset. These components are interpreted as the follow: **age**, **employment**, **education** and **anthropization**;

3. the third step consist in the aggregation of the 4 components through an additive model to create SVIndex and mapping it using QGIS software;
4. the last step is to produce an exposure map, combining SVIndex with earthquake hazard map, developed by INGV (National Institute of Geophysics and Volcanology) (Gruppo di Lavoro MPS, 2004) to assess the spatial relationship between social vulnerability and seismic hazards.

The exposure map can be integrate in the emergency plans in order to better allocate resources such as people, materials and financial founds, in response to improve emergency management against disaster events.
This study allows also to identify appropriate cost-effective risk reduction measures to be implemented at a local level; to help territorial planners in managing the relationship between natural processes and human communities using FOSS softwares. Finally, the lack of social studies in the hazard and risk assessment highlights the need to better integrate social science research concerning social vulnerability into emergency and risk management decision-making.

References

- ✔ Marzocchi, W., Mastellone, M.L., Di Ruocco, A., Novelli, P., Romeo, E., Gasparini, P. (2009). Principles of multi-risk assessment: interaction amongst natural and man-induced risks (Project report). Office for Official Publications of the European Communities, Luxembourg.
- ✔ Adger, W. N. (2006). Vulnerability. Global environmental change, 16(3), 268-281.
- ✔ Gallopín, G. C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. Global environmental change, 16(3), 293-303.
- ✔ Blaikie, P., Cannon, T., Davis, I., & Wisner, B. (2014). At Risk II-: Natural Hazards, People's Vulnerability and Disasters. Routledge.
- ✔ Cutter, S., Boruff, B., & Shirley, L. (2003). Social Vulnerability to Environmental Hazards. Social Science Quarterly, 242-261
- ✔ Gruppo di Lavoro MPS (2004). Redazione della mappa di pericolosità sismica prevista dalla Ordinanza PCM del 20 marzo 2003 n. 3274, All. 1. Rapporto conclusivo per il Dipartimento della Protezione Civile, aprile 2004, Istituto Nazionale di Geofisica e Vulcanologia (INGV), Milano-Roma, Italy, 163 pp. Retrieved from http://zonesismiche.mi.ingv.it/