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A GIS-based approach to identify the spatial variability of social vulnerability to seismic hazard in Italy

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ABSTRACT

This paper argues for a multidisciplinary framework to assess the relationship between environmental processes and social sciences that can be adapted to any geographic location. This includes both physical (earthquake hazard) and human (social vulnerability) dimensions in the context of disaster risk reduction. Disasters varies drastically depending on the local context. Indeed, the probability of a natural disaster having more devastating effects in one place than in another depends on the local vulnerability components of the affected society (cultural, social and economic). Therefore, there is an important correlation between the potential risk and the social resistance and resilience of a specific place, thus the disaster response varies according to the social fabric. In this context, the evaluation of social vulnerability is a crucial point in order to understand the ability of a society (studied at individual, household or community level) to anticipate, cope with, resist and recover from the impact of natural disaster events. Within this framework, the paper discusses how it is possible to integrate social vulnerability into the seismic risk analysis in Italy. Specifically, socioeconomic indicators were used to assess and mapping social vulnerability index. Afterwards, a Geographic Information System (GIS) approach was applied to identify the spatial variability of social vulnerability to seismic hazard. Through the use of a risk matrix, the classes of a social vulnerability index map were combined with those of a seismic hazard map proposed by INGV (National Institute of Geophysics and Volcanology). Finally, a qualitative social vulnerability exposure map to an earthquake hazard was produced, highlighting areas with high seismic and social vulnerability levels. Results suggest the importance of the integration of social vulnerability studies into seismic risk mitigation policies, emergency management and territorial planning to reduce the impact of disasters.

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1. Introduction

In the last decades the impact of natural hazards has increased due to increased population density in hazardous zones, often associated with poor human planning, and to the increase in the frequency and intensity of extreme events as a consequence of climate change (Pachauri et al., 2007). Italy, owing to its intrinsic geological/geomorphological peculiarities and climatic conditions, is characterized by high exposure to natural hazards with potentially severe consequences. A natural hazard only becomes a disaster when it affects a human population that is exposed and vulnerable (Uitto, 1998). Italy is one of the five European Countries with the highest probability of being involved in a disaster and suffering economic losses (Welle, Birkmann, Rhyner, Witting, & Wolfertz, 2012). Table 1 shows the major disasters, caused by poor environmental management and natural hazard events that occurred in Italy from 2000 to 2013, with the deaths, number of people involved and economic losses (Guha-Sapir, Vos, Below, & Ponserre, 2014). In this context, the term disaster is interpreted as a result of the combination of: the exposure to natural hazards, the conditions of vulnerability featured by the place and insufficient ability or measures to reduce or cope with the potential negative consequences (UNISDR, 2016). Natural disasters are not preventable, but vulnerability assessments, hazard mitigation and emergency management planning can reduce the impacts of disaster events and facilitate recovery.

Hydro-geological and earthquakes events are certainly the most relevant natural phenomena for their high diffusion, but many others are far from negligible, for example large active volcanoes close to densely populated areas (e.g. Vesuvius area). According to the study carried out by the Institute for Environmental Protection and Research (ISPRA) in 2008, 70.5% of Italian municipalities are affected by landslides (ISPRA, 2011). Otherwise, on the basis of the seismic hazard map (Fig. 1), by National Institute of Geophysics and Volcanology (INGV), 37.6% of Italian municipalities fall into the two higher classes of earthquake hazard (Zones 1, the most dangerous areas, where major earthquakes may occur and Zone 2, areas that may be affected by rather strong earthquakes) (INGV, 2003).

According to Alexander (1993), a hazard may be assimilated as the pre-disaster situation in which some risks of a disaster event exist, principally because the human population has placed itself and its socio-economic characteristics in an exposed situation with overlaid differential vulnerabilities. The disaster extent varies drastically depending on the local context. Indeed, the probability of a natural disaster having more devastating effects in one place than another depends on the local vulnerability of an affected society, intended as a cultural, social and economic organization (Cutter, Boruff, & Shirley, 2003). In this context, risk assessment and management through appropriate forecasting and prevention measures play a fundamental role in redefining areas prone to natural hazards and in reducing future phenomena at all levels. Several Italian public authorities and research centers are examining these topics to propose efficient methodologies to reduce the impact of hazard events on vulnerable elements. However, these studies converge particularly on the physical side of vulnerability, focusing on the damages and economic losses estimated for buildings and infrastructures, omitting the social component of vulnerability. Natural hazards do not have a random effect on the local community and generally the most affected groups are the more vulnerable ones, already marginalized by socio-economic classes (i. e. people that have the same social, economic, occupation or educational status), race, ethnicity and gender. These marginalization factors are a central component of vulnerability and they can be defined as the susceptibility of social groups to the impact of hazards, influencing economic losses, injuries and fatalities (Blaikie, Cannon, Davis, & Wisner, 2014; Cutter et al., 2003). 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 socio-economic conditions of the population affected. This highlights the need to better integrate social science research concerning social vulnerability into territorial planning and emergency management decision-making. Within this framework, the vulnerability of a place can be modeled by studying the potential hazard of a place on the basis of the interaction between risk (a measure of the potential damages or losses in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period) and mitigation (measures to lessen risks or reduce their impact) (Cutter et al., 2003).

2. Methodology

The method presented in this paper had been applied at national scale and consists in a qualitative and quantitative approach including spatial analysis through Geographic Information System (GIS) and statistical modeling. Effective use of both methods (quantitative and qualitative) and of different tools at one's disposal (geospatial tools, statistical techniques and others) can lead to enhanced research opportunities and, more importantly, for applied geography, a deeper knowledge of the geographic phenomena being studied (Yeager & Steiger, 2013). Following the hazard-of-place model approach proposed by Cutter et al., 2003, the methodological framework for assessing the social vulnerability index (SVI) to seismic hazards for Italy was conducted

Table 1
Major natural disasters occurred in Italy from 2000 to 2013.

Dates	Location	Type	Killed	Total affected	Est. Damage (US$ millions)
04/10/2000	Pimont, Val d'Aoste, Ligurie	Flood	25	43,000	8000
20/11/2000	Tuscan, Lombardy, Friuli, Venezia, Trentino	Flood	5	2000	50
18/07/2001	Nicolosi, Catania province (Sicily)	Volcano			3.1
14/09/2001	Naples (Campania region)	Flood	2		100
04/08/2002	Brescia, Venice, Lombardy, Friuli, Liguria	Flood		20	296
06/09/2002	Sicily, Palermo	Earthquake	2		500
31/10/2002	San Giuliano di Puglia (Campobasso, Molise region)	Earthquake	30	8533	796
11/04/2003	Alessandria (Piemont)	Earthquake		232	561.352
29/08/2003	Udine province, Frioul-Venetie Julienne	Flood	2	350	655
11/12/2008	Rome, Venice, Calabre	Flood		3	278
06/04/2009	Aquila, and the neighboring municipalities	Earthquake	295	56,000	2500
01/10/2009	Messina, (Sicily)	Flood	35	5140	20
20/05/2012	Finale Emilia (Ferrare region)	Earthquake	7	11,050	15,800
11/11/2012	Venice, Rome, Tuscany, Umbria	Flood	4	1200	15
18/11/2013	Olbia, Arzachena (Sardaigne)	Flood	18	2700	780