Can effects of a seismic disaster be assessed by demography? A multidisciplinary approach for Italian earthquakes

Maddalena De Lucia[1], Federico Benassi[2], Fabrizio Meroni[3], Gemma Musacchio[3], Nicola Alessandro Pino[1], Salvatore Strozza[6]

[1] Istituto Nazionale di Geofisica e Vulcanologia, Osservatorio Vesuviano, Napoli, Italy, maddalena.delucia@ingv.it
[2]Italian National Institute of Statistics (Istat), Roma, Italy, benassi@istat.it
[3]Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Milano, Milano, Italy, fabrizio.meroni@ingv.it
[4]University of Naples Federico II, Department of Political Sciences, Napoli, Italy strozza@unina.it

Abstract: We investigated the demographic impact of past earthquakes on local communities, coupling damage, assessed by MCS Macroseismic intensities, with long term demographic parameters. We started with two case studies, both from Southern Italy and occurring several decades ago. The results of this work depict a general framework of demographic distress in the areas most affected by the seismic events, that might have enhanced the impact of earthquakes. It also points out how demographic evolution across seismic disasters may follow not easily predictable dynamics. This approach to the study of the earthquakes' effects can be easily extended to other cases, given the availability of detailed territorial statistical data in a sufficiently long period of time.

Keywords: seismic disaster, demography, macroseismic intensity.

1. Introduction

According to the UN definition, a disaster is "a serious disruption of the functioning of a community or a society, involving widespread human, material, economic or environmental losses and impacts, which exceed the ability of affected community or society to cope using its own resources" (UNISDR, 2009). It causes damage, losses, widespread and long-term effects that are not straightforward to assess.

A more comprehensive assessment of a disaster impact adds to the physical damage the human and environmental dimensions, accounting for disease, patterns of population, socioeconomic development and other effects. In other words, impact, not just damage, of disasters can provide key knowledge regarding several types of failures and indirect loss and effects.

We discuss about some of the most significant parameters that could describe seismic disasters' impact, including the long lasting social effects. We developed a methodology to better delineate the relationship among seismic disasters and their effects on the demography and on urban structure of distressed land and communities. However, we pointed out that demographic parameters are not just affected by the disasters themselves: socio-economic factors, policies and programs implemented before, after and during the event are also relevant (De Lucia et al., 2020).

We analyze in details the long term dynamics and structure of population within a long time period across a seismic disaster, putting demographic parameters in relation to different grades of macroseismic intensities assessed in affected areas. Case studies to test our analytical approach were two seismic disasters occurred in southern Italy: the Belice (1968) and the Irpinia-Basilicata (1980) earthquakes. The choice is supported by the availability of strong and robust datasets both for macroseismic intensities and for demographic data and indicators, compiled respectively by Istituto Nazionale di Geofisica e Vulcanologia (INGV) and Italian National Institute of Statistics (ISTAT).

The methodology and parameters used are described in De Lucia et al. (2020). Here we highlight some aspects that allow to derive a more comprehensive picture of disasters' impact.

Here and in the following chapters, only values of macroseismic intensity according to the Mercalli-Cancani-Sieberg scale (MCS) are used (Sieberg, 1930). From now on, Intensity IMCS will be indicated in a short form using I.

2. Belice (1968) and Irpinia-Basilicata (1980) seismic disasters

The Belice (1968) and Irpinia-Basilicata (1980) seismic sequences mostly affected areas that could be considered homogeneous from a socioeconomic and cultural point of view. They both belong to southern Italy and are internal areas, with small cities and villages.

2.1. Belice area

The Belice area is in western Sicily and is characterized by a low-to-moderate seismicity; only few earthquakes and with very few sources are listed in historical catalogues for this area (CPTI15, Rovida et al., 2016). The region has not suffered strong earthquakes in history except for 1968 earthquake. Recent seismicity is sporadic and of low energy, with very few M>3 seismic events recorded from 1985 until today.

The 1968 Belice earthquake seismic sequence began on January 14, 1968. Afterwards, the main event (M_W=6.41; I_0=10) occurred at 2:01 GMT, in the night between 14 and 15 January, and was felt throughout central and western Sicily, and also in Messina and Catania, located at about 200 km. In the following days and months other damaging seismic shocks stroke. The official number of victims was 231 and displaced people were more than 30,000 (Guidoboni and Valensise, 2011)

Some municipalities were completely destroyed (I=10); others suffered a total devastation (I=9) (Figure 1).

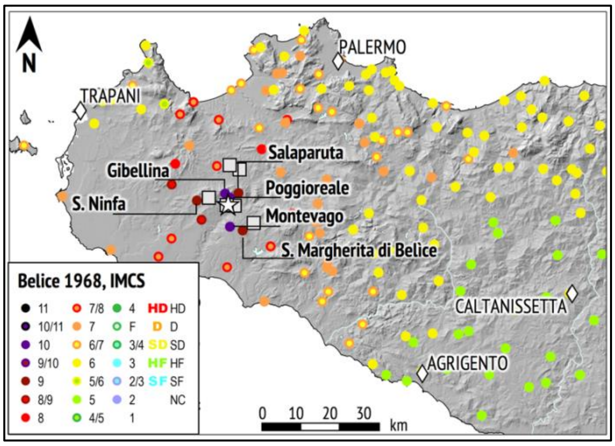

Figure 1 - Color coded Macroseismic Data Points (MDP) for localities affected by the January 15, 1968 Belice earthquake (Locati et al., 2016). White diamonds are provincial capital cities. The white star is the epicenter of the 1968 Belice earthquake and labeled are most damaged localities (I≥9). Light grey squares are major earthquakes' epicenters of the 1968 Belice seismic sequence

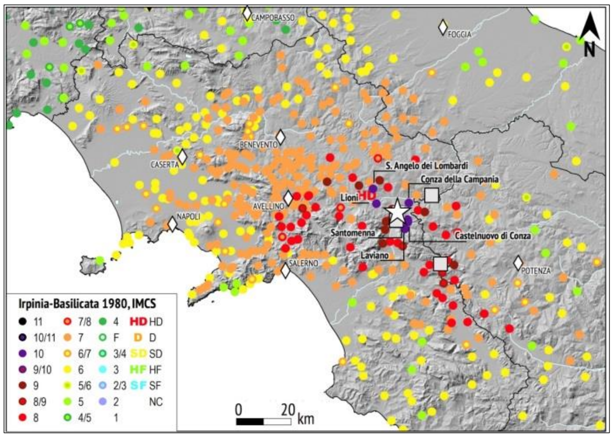

Figure 2 - Color coded Macroseismic Data Points (MDP) for localities affected by the November 23, 1980 earthquake (Locati et al., 2016). White diamonds are provincial capital cities. The white star is the epicenter of the 1980 Irpinia-Basilicata earthquake and labelled are most damaged localities (I=10). Light grey squares are the major earthquakes' epicenters of the 1980 seismic sequence

The prevailing traditional building construction practice, in masonry and with poor quality sealants and insufficient foundations, contributed largely to destruction in a poor economic context based mainly on agriculture. The first rescue operations organized by the government arrived five days after the main shock. There was a general non-rational and ineffective allocation of government aid. Government measures increased the emigration of the Belice population, already under way before the earthquake. In Gibellina, Montevago, Poggioreale and Salaparuta, the original historic centers were abandoned and new urban centers were built.

2.2. Irpinia-Basilicata area

Irpinia and Basilicata areas are located along the southern Apennines where seismicity is made up of frequent events with Magnitude larger than 6. In the last centuries more than ten events with M_W≥6.5 occurred in the area and had a level of damage I_0≥9. The last strong earthquakes before the 1980 Irpinia-Basilicata seismic disaster occurred in 1930 (M_W=6.67, I_0=10) and in 1962 (M_W=6.15, I_0=9), within a lifetime from the 1980 event.

In the Irpinia–Basilicata area recent seismicity is more frequent and has a larger magnitude than in the Belice area. Within last decades several events with magnitude larger than 4.0 occurred.

The 1980 November 23 Irpinia-Basilicata earthquake occurred at 6:34 GMT. This event consisted of at least three main rupture episodes. It was felt all over Italy: southwards down to eastern Sicily, and northwards up to the Po Plain. The most damaging effects were spread over a large area, including the Avellino, Salerno and Potenza provinces, in the Campania and in the Basilicata regions. Total casualties were 2,735, injured were about 9,000, and homeless were 394,000 (Guidoboni e Valensise, 2011). The seismic sequence went on for several months and was followed also by large seismic events.

In the epicentral area I=10 was reached in six municipalities (Figure 2); around the epicentral area, 9 municipalities were classified with I=9. Forty-five localities were classified as I=8-9 and I=8. In the Campania region alone, more than 50% of buildings were damaged and 5% collapsed. Masonry buildings, cultural heritage (i.e., churches, monasteries, defense walls of ancient buildings) and even reinforced concrete buildings in the surrounding area were damaged also heavily.

The economic asset was that of a rural area, mostly standing on agriculture and small farms. Building stocks were ancient and poor conditions masonry, some of which had been already damaged by previous earthquakes. At that time, villages, traditionally affected by emigration, were starting a slow developing process thanks to emigrants investments. The seismic disaster heavily impacted this process, and resumed emigration. About 300,000 people were displaced.

3. Conclusive remarks

The post-disaster picture, retrieved by mapping population inter censual growth rates (Livi Bacci, 1981) between time-zero (disaster occurrence) and the year 2011 (i.e., last census collected data), suggests a negative population growth (Fig. 3.b and 3.d) in heavily damaged areas.

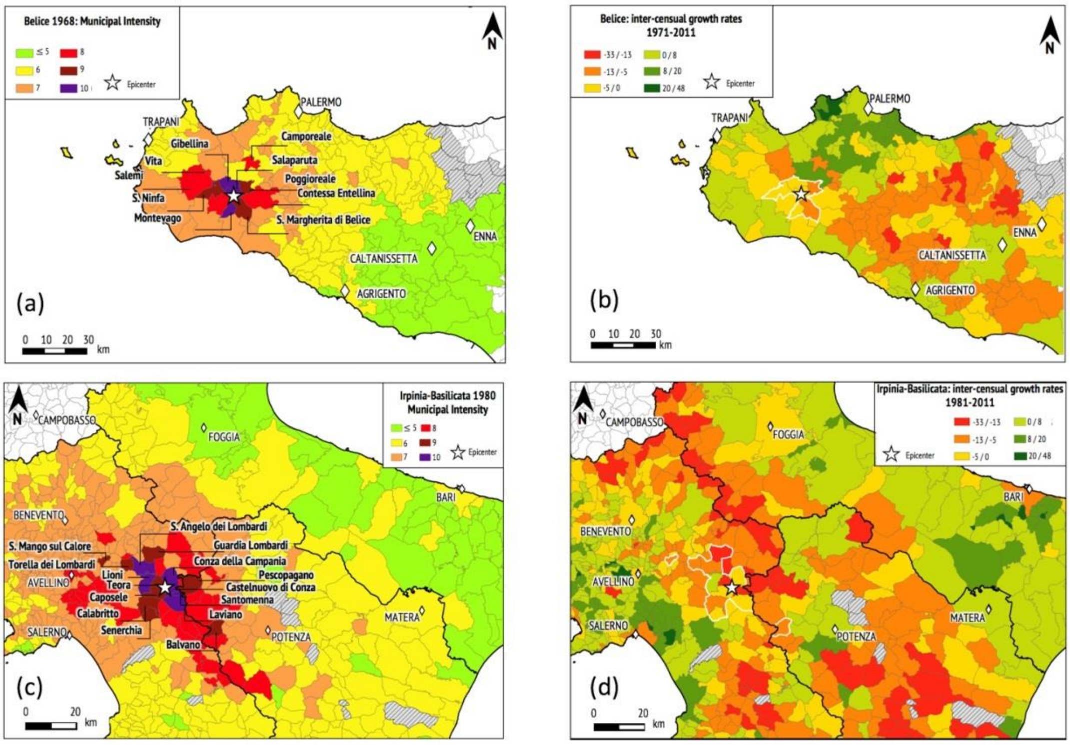

Figure 3 – Post-seismic disaster observations: Inter censual growth rates maps (b and d) compared to the municipal intensity maps (a and c) for the Belice (upper panel) in the time span 1971-2011, and the Irpinia-Basilicata (lower panel) in the time span 1981-2011. White diamonds are provincial capital cities. Hatched areas are municipalities excluded from the analysis. (a), (c): Municipal macroseismic Intensities map representations; villages classified as I=8, I=9 and I=10, for the Belice, and I=9 and I=10, for the Irpinia-Basilicata, are labelled; (b), (d): growth rates difference

over time; villages with I=9 and I=10, for the Belice area (b), for the Irpinia-Basilicata area (d), are white contoured

Negative population growth is accompanied by an increasing level of ageing and a decrease of child/woman ratio (Livi Bacci, 1981; Caselli et al., 2006), as well as a low spatial concentration, assessed by Gini index (Mc Kibben and Faust, 2004), already before the earthquakes.

In general, analysis and observations depict a general framework of demographic distress of the areas most affected by the seismic events. This might have enhanced the impact of earthquakes: depopulation processes might be associated in fact with an increase in building vulnerability. It is indeed conceivable that the demographic dynamics observed in these areas could result in little or even no maintenance of buildings. In some cases (i.e., Belice) land abandoning was also reinforced by a general strategy endorsed by the government within the emergency phase (Guidoboni and Valensise, 2011). Thus demographic distress appears to be a factor negatively affecting the seismic vulnerability. It may counterbalance the expectation for which damaging past earthquakes should trigger proper reconstruction and reduce building vulnerability, fostering changes in the individual risk perception.

From a different perspective, depopulation of more seismic areas could also have the positive effect to move population in safer areas, with a gain in terms of security and even from an economic point of view.

Demographic data describe the dynamics of the population in an area, even though their interpretation is not straightforward, for the multiplicity and the complexity of the contributing factors. Natural disasters are among these. Our analysis highlights that demographic evolution across seismic disasters follow not easily predictable dynamics. However, the distinct trends among the different intensity classes within each area – and between the two areas themselves –resulting from our study represent relevant issues for debate and further deepening. Additional information of the internal variability of the demographic groups and more detailed data, also on the role of the components of the demographic dynamics, could help to better delineate the whole picture.

Acknowledgements

The opinions expressed here are those of the authors and do not necessary reflect the ones of their Institutions.

References

De Lucia, M., Benassi, F., Meroni, F., Musacchio G., Pino N.A., Strozza, S. (2020). Seismic disasters and the demographic perspective: 1968, Belice and 1980, Irpinia-Basilicata (southern Italy) case studies. *Ann. Geoph.,* 63, https://doi.org/10.4401/ag-8298

Guidoboni, E., Valensise, G. (2011). *Il peso economico e sociale dei disastri sismici in Italia negli ultimi 150 anni (1861-2011)*. Centro EEDIS-INGV, Bononia University Press, Bologna (*in Italian*).

Livi Bacci, M. (1981). *Introduzione alla demografia*. Loescher Editore, Torino (*in Italian*).

Caselli, G., Vallin, J., Wunsch, G., (Eds.) (2006), *Demography: Analysis and Synthesis, A Treatise in Population*, Academic Press, New York.

Locati, M., R. Camassi, A. Rovida, E. Ercolani, F. Bernardini, V. Castelli, C. H. Caracciolo, A. Tertulliani, A. Rossi, R. Azzaro, S. D'Amico, S. Conte and E. Rocchetti (2016). *DBMI15, the 2015 version of the Italian Macroseismic Database.* Istituto Nazionale di Geofisica e Vulcanologia.

McKibben, J.N., Faust K.A. (2004). Population Distribution-Classification of Residence. In: *The Methods and Materials of Demography*, J.S. Siegel and D.A. Swanson (eds). Elsevier Academic Press, San Diego, California, 105-124.

Rovida, A., M. Locati, R. Camassi, B. Lolli and P. Gasperini (eds), (2016). *CPTI15, the 2015 version of the Parametric Catalogue of Italian Earthquakes.* Istituto Nazionale di Geofisica e Vulcanologia.

Sieberg, A. (1930). Geologie der Erdbeben, *Handbuch der Geophysik*, 2(4), 552–555.

UNISDR (United Nations International Strategy for Disaster Reduction), 2009. *Terminology on disaster risk reduction*. United Nations.