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Reconstruction, recovery and socio-economic development of the Basilicata region, southern Italy: lessons and experience after the 1980 earthquake

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ABSTRACT In the present paper, a critical analysis of the 1980 Irpinia-Basilicata (southern Italy) post-earthquake phase has been carried out, with particular attention to the Basilicata region. Post-earthquake policies were mainly addressed towards the physical reconstruction and socio-economic development of the affected areas. As for the development process, the expected results from the industrialisation and infrastructure works have been rather poor or indeed not achieved, mainly as a consequence of red tape, inefficiency and sometimes corruption events. On the other hand, impressive steps ahead have been made in terms of knowledge advancement concerning the assessment and reduction of seismic risk, with the creation of important education and research institutions in Basilicata. Furthermore, the relationship between earthquake disaster and territorial development has been examined, starting from some prominent studies proposed in the literature. The evolution of vulnerability levels to earthquakes of some countries around the world have been evaluated. Specifically, considering a time span of about 40 years (1980-2020), the data related to the number of deaths caused by earthquakes with respect to the population exposed has been analysed and some comparisons have been carried out. Although limited, since referring to a single risk indicator, the results confirm the close link between seismic consequences and socio-economic characteristics of the affected communities, as a poignant lesson for planning effective risk mitigation strategies.

Key words: Irpinia-Basilicata earthquake, post-earthquake reconstruction, socio-economic development, seismic rehabilitation, disaster prevention.

1. Introduction

Italy has suffered numerous strong earthquakes that have caused profound changes in the natural, urban and socio-economic environment. The 23 November 1980 Irpinia-Basilicata (southern Italy) earthquake was the most devastating seismic event occurred in Italy in the last 100 years in terms of loss of human life and destruction of cultural heritage. A large area of Campania and Basilicata was severely affected, especially the provinces of Avellino, Potenza, and Salerno (Moscaritolo, 2020). According to data from the National Institute of Geophysics and Volcanology (Rovida *et al.*, 2021), the magnitude M_w 6.9 earthquake destroyed dozens of towns, killed about 3,000 people, injured about 9,000, and left about 300,000 homeless. The disastrous consequences of this earthquake were exacerbated by the local and central governments' unpreparedness in the management of relief efforts.

In May 1981, the Italian government passed the Law 219/81, which, unlike other reconstruction laws issued after past earthquakes, aimed not only at carrying out a physical reconstruction of the areas affected, but also at defining socio-economic development plans for the communities and territories involved. The socio-economic development process was based on three major 'pillars': i) industrialisation of the territory; ii) infrastructures, and iii) education. On one hand, post-earthquake policies did not produce the expected results on the industrialisation and infrastructure works mainly as a consequence of red tape, inefficiency, and sometimes corruption events during the reconstruction phase. On the other hand, some important investments were made in education, including the founding of the University of Basilicata (UniBas), long overdue. Establishing higher education and research centres, in relation to the implementation of the development process, was one of the main goals of Law 219/81, also in view of providing the bases for better planning of natural disaster prevention and preparedness.

The analysis of the consequences of the 1980 Irpinia-Basilicata earthquake, and the impact of the measures promoted by Law 219/81, highlights the significant role of the socio-economic characteristics of the affected territories and communities in the prevention and management of natural disasters. The strong relationship between disaster prevention and territorial development has been extensively addressed in literature studies. In the report "Reducing Disaster Risk: a challenge for development" by the United Nations Development Programme (UNDP/BCPR, 2004), the potential links between vulnerability to natural hazards and levels of development for the period 1980-2000 have been analysed. In this context, the United Nations Office for Disaster Risk Reduction (UNDRR) supports the implementation of the Sendai Framework for Disaster Risk Reduction 2015-2030 (UNISDR, 2015), which also recognises the close relationship between disaster risk management and socio-economic activities. At the European level, the link between the objectives of the new Union Civil Protection Mechanism (European Union, 2019) and those of the new European cohesion policy 2021-2027 (EU Cohesion Policy, 2020) points out that the safety of the building and infrastructural heritage must interact positively with the growth objectives of the European Union.

In this framework, in order to facilitate the application of seismic risk mitigation actions, the consequences of future earthquakes, as well as the advantages deriving from implementing rehabilitation plans to reduce the social and economic impact, should be clearly assessed (Tanner *et al*., 2016). While requiring huge resources, seismic rehabilitation plans can also contribute to economic growth, especially for the recovery of territories with negative demographic trends (e.g. Masi *et al*., 2021b). In order to guarantee the safety of the building stock and improve its performance, seismic rehabilitation should consider modern functional requirements and new safety standards through integrated and sustainable interventions (e.g. Manfredi and Masi, 2018). In the field of the assessment and reduction of seismic risk, the scientific and technological advancements obtained by the network of the University Laboratories of Seismic and Structural Engineering (ReLUIS) are fundamental in the activities of the Italian Department of Civil Protection (DPC). ReLUIS contributes to post-earthquake emergency management activities through *in situ* technical surveys for usability and damage assessment of buildings, with particular emphasis on schools, hospitals, churches, and strategic infrastructures (e.g. Di Ludovico *et al*., 2017). Further, the research activities carried out by ReLUIS deal with the evaluation of expected seismic consequences to define effective mitigation strategies (e.g. Dolce *et al*., 2021; Masi *et al*., 2021a). ReLUIS also participates in the activities of the so-called non-structural prevention, in particular with the communication campaign "Io Non Rischio - I Do Not Take Risks (INR)" (Postiglione *et al*., 2016).

In this paper, some activities related to the physical reconstruction program and the socio-economic development process after the 1980 Irpinia-Basilicata earthquake, focusing on the Basilicata region, are reported and discussed. The main results have been examined to highlight the positive and negative effects of post-earthquake policies. Subsequently, starting from the review of the UNDP/BCPR (2004) report, the relationship between disaster and socio-economic development has been analysed, in particular for earthquakes. Specifically, the number of people killed by earthquakes with respect to the total population has been selected as a significant indicator, and the values for some countries affected by earthquakes in the past have been compared.

2. Reconstruction and socio-economic development in Basilicata region

On 23 November 1980, at 18:34:52 UTC, a strong earthquake, commonly known as the Irpinia-Basilicata earthquake, occurred in the southern Apennines. It was one of the most disastrous seismic events in recent Italian history. The magnitude M_w 6.9 earthquake affected a large area of southern Italy involving three regions: Basilicata, Campania, and Puglia. Fig. 1 shows the isoseismical map of the earthquake (Postpischl *et al*., 1985). The maximum value of macroseismic intensity was equal to X MCS (Mercalli Cancani Sieberg scale) in the municipalities of Sant'Angelo dei Lombardi and Conza della Campania (province of Avellino) (Braga *et al*., 1982; Guidoboni *et al*., 2018). According to the final report of the Government Committee (1991), 687 municipalities were affected, including 37 declared devastated, 314 severely damaged and 336 damaged, in which there were about 3,000 victims, 9,000 injured, and 300,000 homeless. These disastrous consequences were also due to the interruption of transport roads and communication lines, the

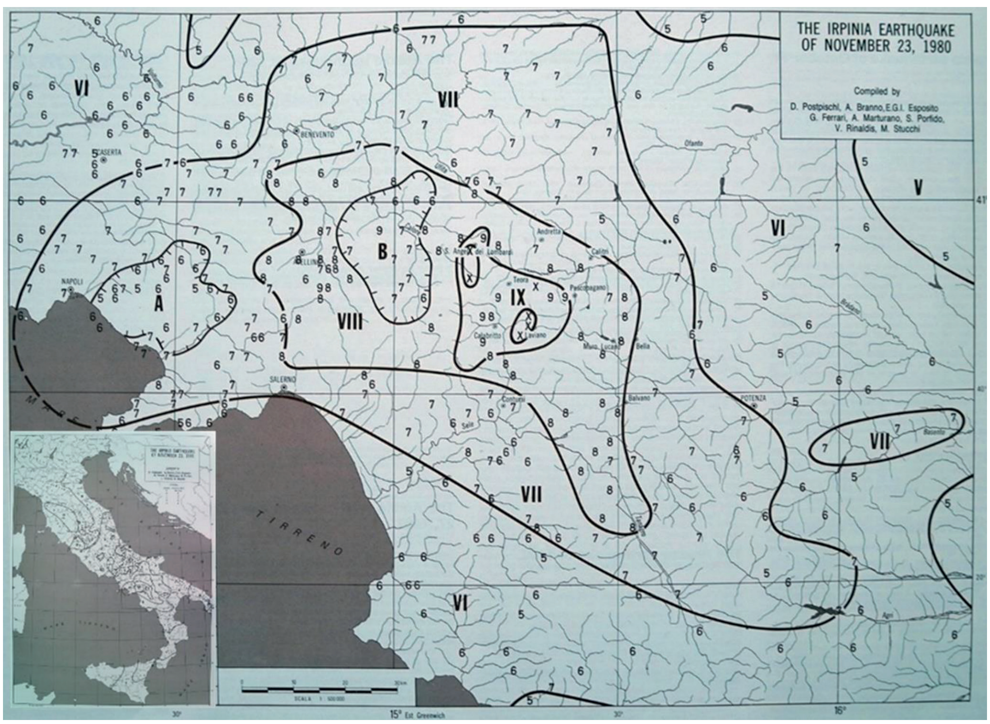


Fig. 1 - Isoseismal map of the 23 November 1980 Irpinia-Basilicata earthquake (from Postpischl *et al*. 1985).

delay in the arrival of rescue teams and the absence of civil protection plans. On 10 December 1980, in the lecture "Difendersi dai terremoti: la lezione dell'Irpinia" addressed to the representatives appointed by Italian Senate committees, professors Barberi and Grandori provided a first analysis of the causes of the very heavy impact of the 1980 earthquake and of future perspectives. Barberi and Grandori particularly underlined that "The chronic inability of public institutions to plan and organise, together with the lack of sensitivity of the scientific community to social problems, has meant that the earthquake defence objective was practically ignored in the last 50 years." It is worth noting that the "chronic inability of public institutions" should be understood as a lack of wide and effective prevention measures adopted before disaster events, and specifically earthquakes. In the same lecture, some results obtained in the Progetto Finalizzato Geodinamica (PFG) of the National Council of Research of Italy (CNR), the first major Italian project on seismic risk assessment, were also presented. Project activities also contributed to surveys of damage/usability of the building stock and potential risks to the affected towns. Also under these premises, on 14 May 1981, the Government issued the Law 219/81, based on two key issues: 'reconstruction' and 'development'. Thanks to the possibilities offered by the huge amount of funds allocated, the goal was not only to rebuild but also to modernise the affected areas, still in a state of backwardness. Specifically, pursuant to article 27, Law 219/81 allowed both the reconstruction in the areas of the existing settlements and also expansions or new constructions deemed necessary for the reorganisation of a territory and for its economic and social development.

2.1. Physical reconstruction program

This section focuses on the physical reconstruction program in the Basilicata region. According to the Law 219/81, all 131 municipalities of the region were affected by the 1980 earthquake although with different severity and, specifically, 8 were classified as devastated, 63 severely damaged, 59 damaged and 1 (Potenza) severely damaged with devastation of its historic centre (Fig. 2). As can be seen in Fig. 2, the damage severity in the province of Potenza was higher

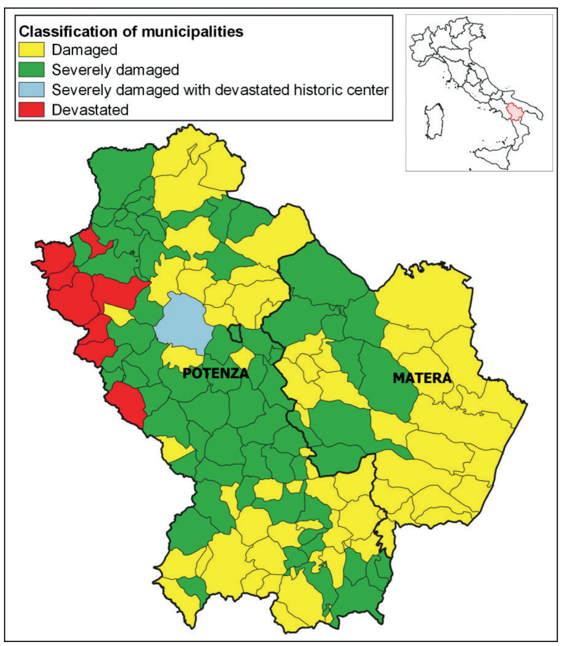


Fig. 2 - Classification of Basilicata municipalities according to the damage observed after the 1980 earthquake.

than that in the province of Matera mostly due to the distance from the epicentral area of the earthquake (located on the NW side of the region).

As regards physical reconstruction data, large sums of money (about 2.5 billion euros) were used to carry out about 27,500 interventions on the residential building stock (data updated to 2010 but not modified in recent years). The data related to the physical reconstruction program were made available by the Civil Protection office of the Basilicata Region and key data can be found at the institutional website of the Region (see Basilicata Region, 2010). It is worth noting that public buildings, and particularly schools, were less involved in the post-earthquake retrofit program.

According to the Ministerial Decree on 2 July 1981, the seismic rehabilitation program included three possible intervention types, namely repair, strengthening or demolition and reconstruction. In particular, repair works aimed at removing unsafe conditions and restoring the original seismic safety by repairing damaged structural and non-structural elements. The strengthening interventions were designed to remove the main structural deficiencies that can determine unfavourable seismic behaviour and increase the seismic capacity of one or more structural members, either without affecting the overall behaviour of the structure (local interventions) or to increase the strength and/or deformation capacity of the entire structure (global interventions). Different intervention techniques aimed at repairing and/or strengthening reinforced concrete (RC) and masonry buildings were considered by practitioners. Specifically, for RC buildings, the most commonly used strengthening techniques have been (Fig. 3):

- concrete or steel jacketing of single structural members to increase their shear and flexural capacity and their deformation capacity in the critical zones (Figs. 3a and 3b);
- insertion of RC shear walls (Fig. 3c).

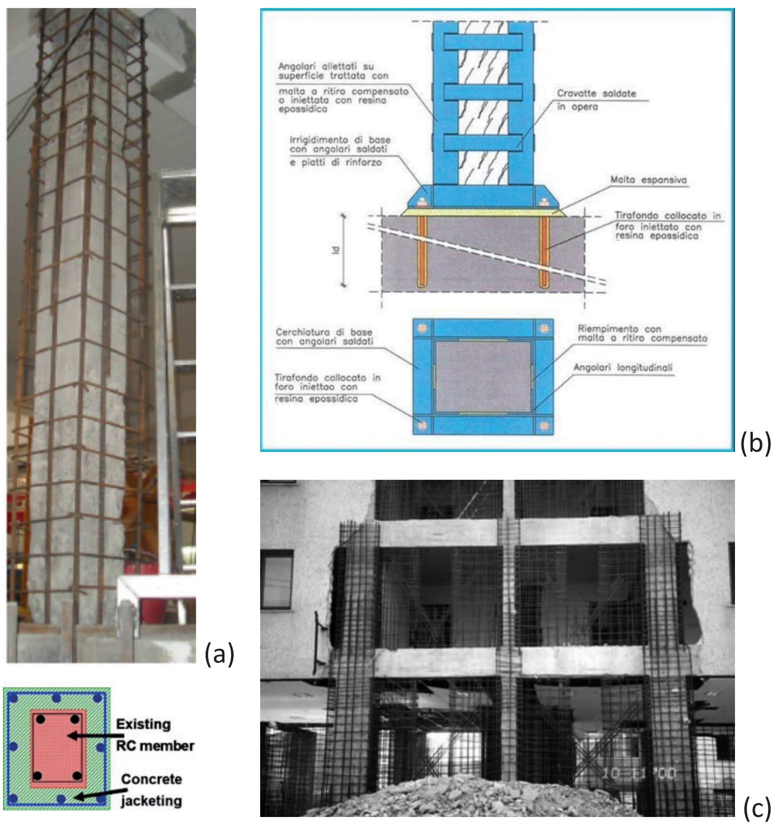


Fig. 3 - Strengthening techniques commonly used for RC buildings: a) concrete jacketing, b) steel jacketing, c) insertion of RC shear walls.

Concerning masonry buildings, the most widely used strengthening techniques have been:

- in-plane strengthening of masonry walls by means of RC plaster with internal steel grids;
- insertion of tie rods to avoid out-of-plane failure of walls and to increase the effectiveness of the connections;
- stiffening of wooden floors with RC slabs and replacement of heavy roofs to eliminate the horizontal thrusts on masonry walls.

The repair works involved the repair of cracks by injections with or without application of a steel grid bonded with a cement-based mortar or local dismantling and rebuilding method (known as 'cuci-scuci').

Fig. 4 shows the number of interventions (percentage on the total number of buildings) carried out in each municipality affected by the earthquake. As observed in Fig. 2 for damage classification, Fig. 4 indicates an increasing share of the percentage of interventions in the NW zone of the region. In addition to the reason described above, this trend mainly depends on the amount of funds at the disposal of each municipality in the post-earthquake rehabilitation program. It is worth noting that 9 municipalities have a percentage of interventions higher than 60%, and an average value equal to 19% is computed for the entire region.

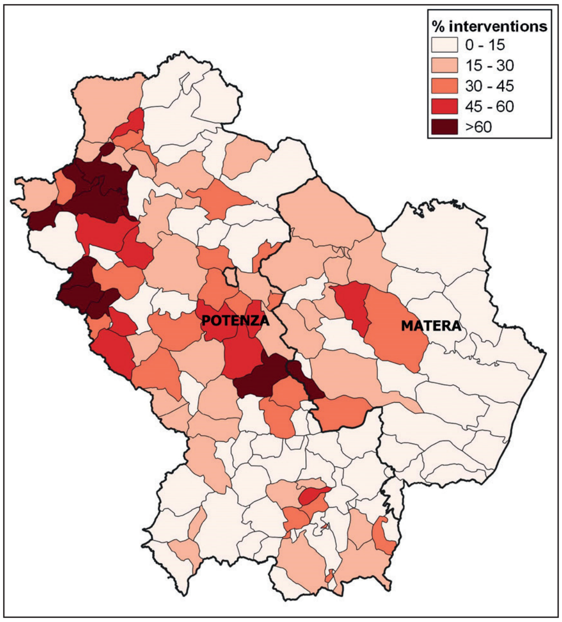


Fig. 4 - Percentage of interventions with respect to the number of buildings of each municipality.

2.2. Socio-economic development process

As clearly stated in article 2 of Law 219/81, in addition to physical reconstruction, promoting the socio-economic development process was a fundamental objective for an effective recovery of the affected areas in order to make them more resilient against future potentially disastrous events. The development process outlined in Law 219/81 was based on three main 'pillars':

- industrialisation of the territory;
- construction of new infrastructures;
- education.

As regards the industrialisation of the most affected areas of Basilicata and Campania regions, pursuant to article 32 of Law 219/81 ("Areas to be allocated to industrial facilities"), one of the objectives was to promote medium and small-sized industrial facilities to increase the employment of the local inhabitants. Some results of the industrialisation process are reported in Simonetti and Ventura (2011) in which the forecast of the expected companies and their employees is compared with the actual data (updated to 2011 but non modified in the last ten years) for the industrial areas located in the provinces of Avellino, Salerno (Campania region), and Potenza (Basilicata region). Table 1 shows the results relating to each of the industrial areas realised in the province of Potenza and the total values. As can be seen, 168 companies out of 255 (about 65%) have been set up and about 6,800 people out of 13,805 (about 50%) have been employed (2011 values). For the province of Potenza, the same percentage in terms of companies is observed, while the percentage in terms of employees decreases (about 30%). This difference is mainly due to the data related to the industrial areas of Baragiano (122 employees out of 1555) and Nerico (0 out of 344). On the contrary, a positive result is recorded for the industrial area of Balvano (450 out of 463).

Table 1 - Industrial areas - Article 32 of Law 219/81 (adapted from Simonetti and Ventura, 2011).

Industrial areas (Article 32 of Law 219/81)				
Localities	**Companies (expected number)**	**Companies (2011 number)**	**Employees (expected values)**	**Employees (2011 values)**
Balvano	6	3	463	450
Baragiano	23	13	1555	122
Isca Pantanelle	7	4	287	141
Melfi	16	12	990	121
Nerico	6	0	344	0
Tito	23	17	1091	411
Viggiano	10	8	387	345
Valle di Vitalba	16	10	945	256
Total (Potenza province)	**107**	**67**	**6062**	**1846**
Total (Avellino, Salerno, and Potenza)	**255**	**168**	**13,805**	**6,804**

As regards the construction of new infrastructures, the development process envisaged implementing infrastructural works (article 8 of Law 219/81). According to the final report of the Government Committee (1991), a wide set of external infrastructural works for the industrial areas in Campania and Basilicata was planned, that is:

- 20 roads for a total length of about 170 km;
- about 210 km of aqueducts;
- about 490 km of power lines and 15 electrical substations;
- about 61 km of wastewater pipelines.

Regarding the Basilicata region, Fig. 5 shows the industrial areas and the main roads envisaged by the development process. It should be noted that, in some cases, the construction of these roads was completed with considerable delay, e.g. the road connecting the industrial areas of Nerico and Baragiano was completed in 2019, namely about 40 years after the earthquake. This unacceptable delay, mainly due to red tape, inefficiency and sometimes corruption, actually made such investment practically futile to promote the economic development of the involved territories.

In general, the process of economic growth and development was not fully realised due to various critical factors (Viesti, 2011):

i) poor efficiency of the Public Administration;
ii) poor quality of infrastructure services;
iii) small size businesses;
iv) lack of relationships with research and innovation.

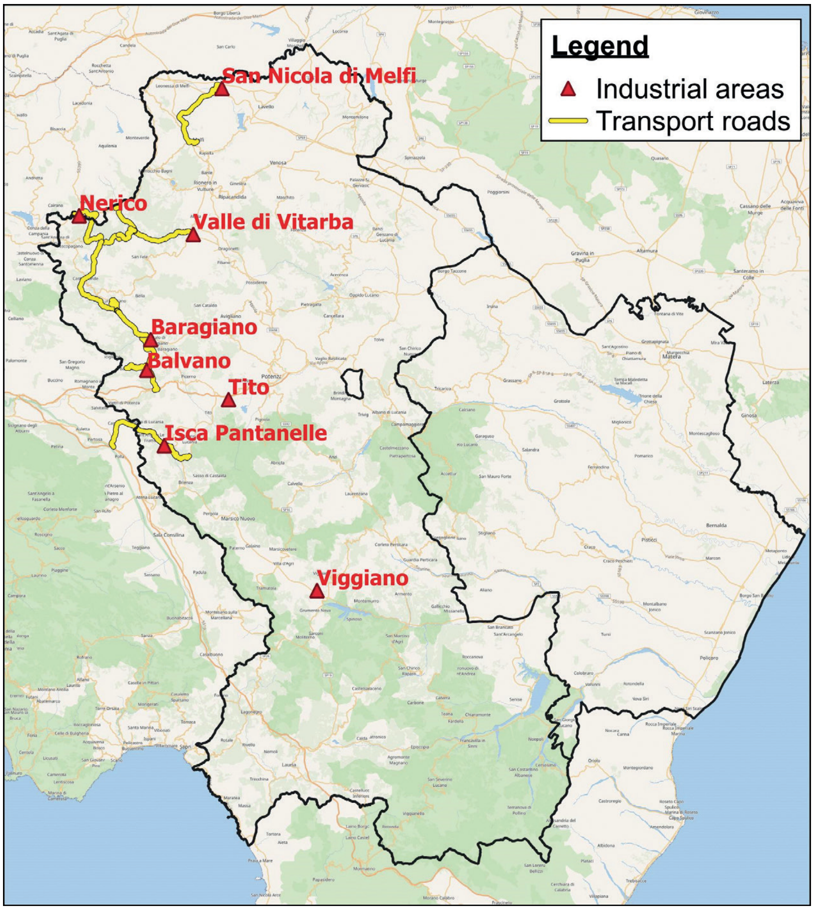
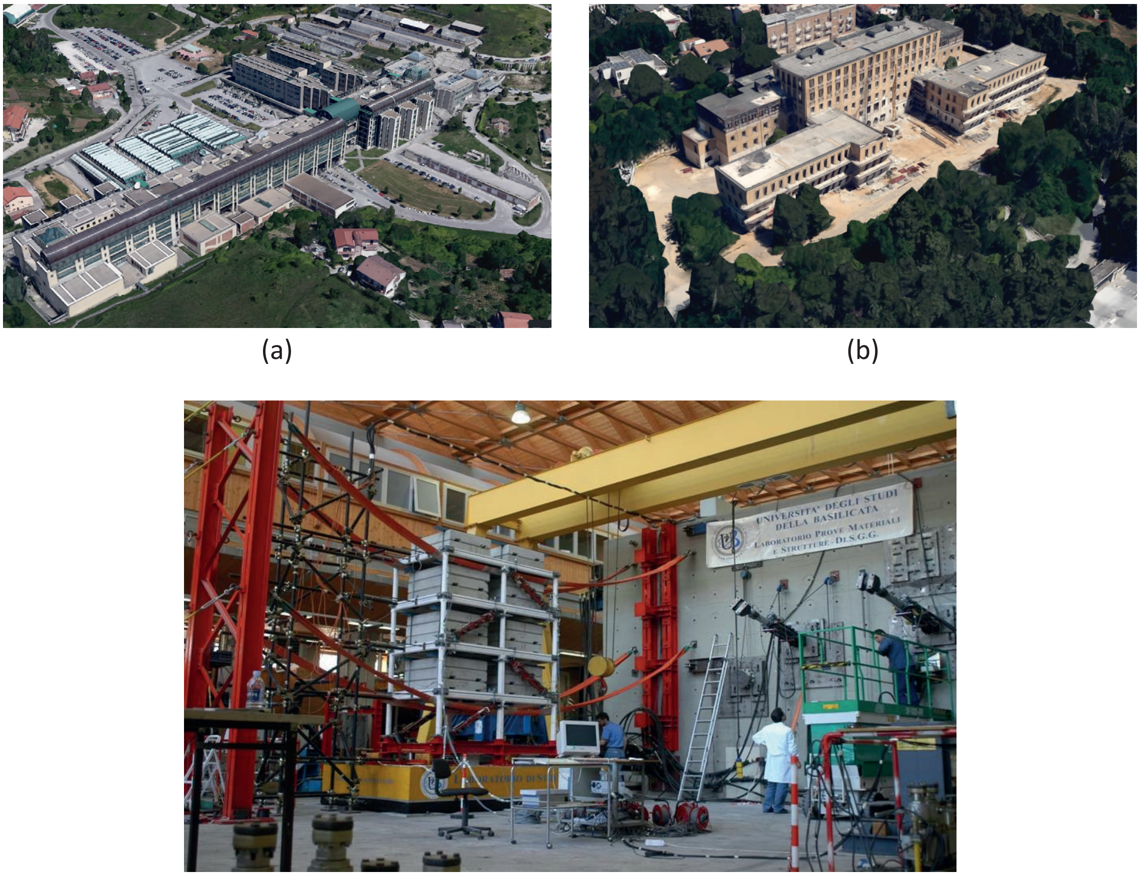


Fig. 5 - Industrial areas and transport roads in Basilicata region.

As regards the third pillar, namely 'education', one of the most important investments was the foundation of UniBas (Fig. 6). Law 219/81, in fact, finally provided the grounds for the establishment of a university in the Basilicata region, even if the project of establishing it dates back to the previous decade. However, it was only after the 1980 earthquake with the determining impulse of the post-earthquake legislation, that the project became a reality. The embryo of the University, in fact, is included under the articles 39-45 of the Law 219/81. Specifically, article 39 virtually lays its foundation stone, stating: "Effective from the academic year 1982-1983, the State University of Basilicata, based in Potenza, shall be established".



(a) (b)

(c)

Fig. 6 - Campuses of UniBas located at Potenza (a) and at Matera (b), Laboratory of seismic and structural engineering in Potenza (c).

Four faculties were then created (Agriculture, Engineering, Science, and Humanities), offering 9 degree courses, two of which (i.e. Hydraulic Engineering, and Environmental and Land Planning Engineering) were hailed as being an academic innovation in that scientific field. From 2010-2012, legislative reforms brought about a change in the University's overall organisation and location (Figs. 6a and 6b) leading to the establishment of six new Academic Divisions (four Departments: DiCEM - Department of European and Mediterranean Cultures, Environment, and Cultural Heritage (located at Matera); DiMIE - Department of Mathematics, Computer Science, and Economics; DiS - Department of Science; DiSU - Department of Humanities and two Schools: SAFE - School of Agricultural, Forest, Food, and Environmental Sciences, and SI - School of Engineering where the Laboratory for Seismic and Structural Engineering is located, see Fig. 6c).

UniBas is currently a small, but young and dynamic academic institution with about 6,500 students, 320 researchers and professors, and 280 units of technical administrative. Since the beginning, higher education, research and technology transfer, particularly as regards natural and environmental risk mitigation, have been and are part of its mission[1].

[1] *"This is why we celebrate our annual dies academicus every year on 23 November, because this University is, to the people of Basilicata, a sign of rebirth and resurrection, of glorious return to life, of conscious hope for a brighter future"* (from the opening address of the then Rector Fonseca on the occasion of Pope John Paul II's 1991 visit to UniBas).

In this context, several studies and projects have been, and still are, dedicated to natural and environmental risk mitigation, also involving other research topics with strategic value for the Basilicata region (e.g. urban and regional planning, control of anthropic activities).

The analysis and impact of urban and regional planning choices has been a highly debated topic for some time. For this reason, defining strategies for the sustainable and resilient development of the Basilicata region is one of the main challenges in UniBas research activities (e.g. see Amato *et al*., 2015; Dastoli and Pontrandolfi, 2021). Specifically, Amato *et al*. (2015) focused on the land use variations to determine soil consumption and predict future changes, while Dastoli and Pontrandolfi (2021) proposed an integrated strategy to increase the resilience of inland areas of the Basilicata territory.

In the field of seismic risk studies to support effective urban planning and land use optimisation, a significant step forwards in Italy has been the implementation of seismic microzonation (SM) analyses able to assess local seismic hazard (Moscatelli *et al*., 2020). Further, it is worth citing the studies carried out to define a soil amplification map of the urban area of Potenza town used to calculate earthquake damage scenarios for the residential building stock (see Chiauzzi *et al*., 2012; Strollo *et al*., 2012).

With regard to the control of anthropic activities, in particular related to oil fields, many studies focused on the area along the valley of the Agri River located in the SW of the Basilicata region. This area hosts one of the largest onshore oil fields in continental Europe. The geological, geophysical, and environmental aspects have been, and still are, widely analysed (e.g. see Bucci *et al*., 2012; Prosser *et al*., 2021). Furthermore, studies on the seismic risk of the Agri Valley area were conducted also in relation to the debate on the seismicity induced or triggered by the oil extraction process. In this context, considering the large resources deriving from royalties, Masi *et al*. (2021b) proposed an action plan for the seismic risk mitigation of the residential building stock of 18 villages located in the Agri Valley, specifically applied to the small town of Viggiano. These studies are also aimed at providing specific support to the choices and activities of local authorities.

Finally, an important aspect for critically analysing post-earthquake policies is the link between earthquake disaster and its effects on demography (De Lucia *et al*., 2020). To this end, an analysis of the demographic trend for the eight municipalities declared devastated by Law 219/81 has been carried out for the period 1971-2011. The data have been extrapolated from the Istituto Nazionale di Statistica (ISTAT, see www.istat.it), which released a census of the Italian population every 10 years in the period considered. Specifically, Fig. 7 shows the percentage variation of the population related to the 1971 census with respect to other censuses considered (i.e. 1981, 1991, 2001, and 2011). The variation for the provinces of Matera and Potenza and for Basilicata region is also reported. Despite the great efforts made in post-earthquake policies, all municipalities show a mostly negative demographic trend over the 40 years considered. It is worth underlining that the negative trend was already present before the 1980 earthquake, as can be seen observing the variation between the 1971 and 1981 census, however it was exacerbated by the earthquake effects. The highest reduction is found for the municipality of Ruvo del Monte equal to about 42% (from about 1880 inhabitants in 1971 to about 1100 in 2011). It should be noted that negative values are also observed for Potenza province (about -8% for 2011) and the whole Basilicata region (about -4%), while a positive trend is observed for Matera province (about +3%). This difference could be due to the fact that Potenza province was more severely affected by the earthquake, as shown at section 2.1.

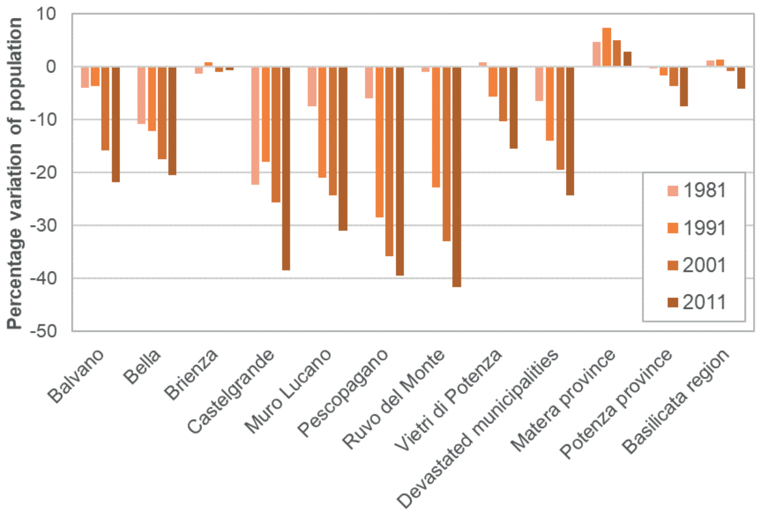


Fig. 7 - Percentage variation of the population (from 1971 to 2011).

3. Relationship between disaster and development

The critical analysis of the reconstruction program and development process after the 1980 Irpinia-Basilicata earthquake, described in the previous section, underlined the significant role of the socio-economic characteristics of the communities in the prevention and management process of natural disasters. Natural disaster risk is connected to human development processes. Disasters put development at risk but, at the same time, human development conditions and strategies can significantly contribute to the impact of natural hazards. In the global report "Reducing disaster risk: a challenge for development" prepared for the United Nations Development Programme (UNDP/BCPR, 2004), the potential links between disaster risk and development level of countries affected by natural hazards were analysed. By setting reference values for the period 1980-2000, the role of the local development conditions on the consequences of four natural hazards (earthquakes, tropical cyclones, floods, and droughts) was identified and studied, showing the strong relationship between impact of disasters and level of development of many countries worldwide. Specifically, this relationship was mainly demonstrated referring to the higher number of deaths generally observed in low human development countries. After this study, the relationship between disaster prevention and territorial development has also been recognised in other national and international initiatives and programs, the most significant of which is undoubtedly the Sendai Framework for Disaster Risk Reduction 2015-2030 (UNISDR, 2015), where the role of social and economic aspects on disaster risk reduction is fully recognised. It is also worth mentioning the Opinion "A European policy on the seismic requalification of buildings and infrastructure" proposed by the European Committee of the Regions (EU Opinion, 2017). Underlining the link between mitigation of natural risks and cohesion funds, the Opinion points out that "*comprehensive seismic risk prevention measures are a primary requirement for the EU, in order to protect the safety of its citizens, conserve its historical and cultural heritage, limit spending arising from harm to people and things and maintain the conditions for territorial development and investment for growth*".

Based mainly on the approach proposed in the UNDP/BCPR (2004) report, the following section aims at evaluating the vulnerability levels of some countries worldwide to highlight the relationship between disasters and development. Specifically, considering a time period of 41 years (1980-2020), a comparative analysis between the number of deaths caused by earthquakes and the population has been carried out.

3.1. Earthquake disaster risk

Table 2 reports the number of deaths by type of natural disaster for three different time periods: i) 1980-2000, ii) 2001-2020, and iii) 1980-2020. These data have been extrapolated from the International Emergency Events Database (hereafter EM-DAT, see www.emdat.be) compiled by the Centre for Research on the Epidemiology of Disaster (CRED). The database contains the world's most comprehensive data collection on the occurrence and effects of technological and natural hazard-related disasters from 1900 to the present day. EM-DAT provides objective data for assessing communities' vulnerability to disasters and to help policy-makers set priorities. Table 2 shows that a total of 884,668 deaths (33% of total) were caused by earthquakes all over the world between 1980 and 2020. Note that, for the period 1980-2000, the deadliest disaster type was drought (about 42% of total), while, in the subsequent twenty years (2001-2020), earthquakes caused about 54% of total deaths.

The UNDP/BCPR (2004) report proposes several analyses based on population data (in terms of both exposed and total population) and number of deaths from earthquakes in order to measure and compare the relative vulnerability of different countries for the period 1980-2000. A critical aspect of this analysis is the limited time span considered (1980-2000), being too short to derive conclusions with respect to strong earthquakes, which are low frequency/high impact events. In order to partially overcome this limitation, in the following the analyses are updated referring to data available for a wider time period 1980-2020 (41 years).

Table 2 - Deaths caused by natural hazards for three time periods: 1980-2000, 2001-2020, and 1980-2020.

	1980-2000		**2001-2020**		**1980-2020**	
Disaster type	**Deaths**	**% of total**	**Deaths**	**% of total**	**Deaths**	**% of total**
Earthquake	163,574	12%	721,094	54%	884,668	33%
Landslide	15,790	1%	17,328	1%	33,118	1%
Wildfire	1,302	0%	1,533	0%	2,835	0%
Flood	153,065	11%	104,773	8%	257,838	10%
Storm	258,572	19%	200,142	15%	458,714	17%
Volcanic activity	24,976	2%	1,601	0%	26,577	1%
Drought	560,461	42%	21,232	2%	581,693	22%
Extreme temperature	15,592	1%	171,332	13%	186,924	7%
Epidemic	144,820	11%	102,322	8%	247,142	9%
Total	1,338,152		1,341,357		2,679,509	

Specifically, the data related to the number of deaths caused by earthquakes in the period 1980-2020 has been extrapolated from EM-DAT (Fig. 8). The highest values are observed in Haiti with 222,587 people killed in earthquakes (mostly due to the M_w 7.0 event in 2010), and in Indonesia with 184,332 deaths caused mainly by the M_w 9.1-9.3 2004 earthquake.

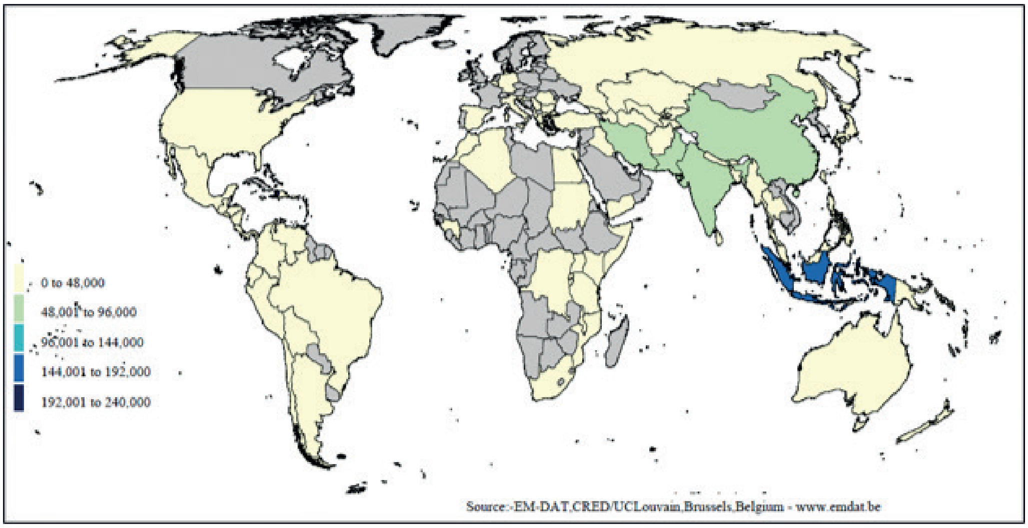


Fig. 8 - Total deaths from earthquakes (1980-2020).

At the same time, population data for the period 1980-2020 has been obtained referring to the information reported in Roser *et al*. (2019). As an example, Fig. 9 shows the distribution of world population for the year 2020. In Italy, for 2020, the total population was equal to 60.5 million. In order to make consistent comparisons between countries for the time periods considered (i.e. 1980-2000; 2001-2020, and 1980-2020), the number of deaths versus total population has been used as risk indicator. It should be noted that this indicator allows considering less populated countries with the same weight of more populated countries, but it fails when considering the impact in absolute terms [the 'weight' of each human being is not the same, see UNDP/BCPR (2004)].

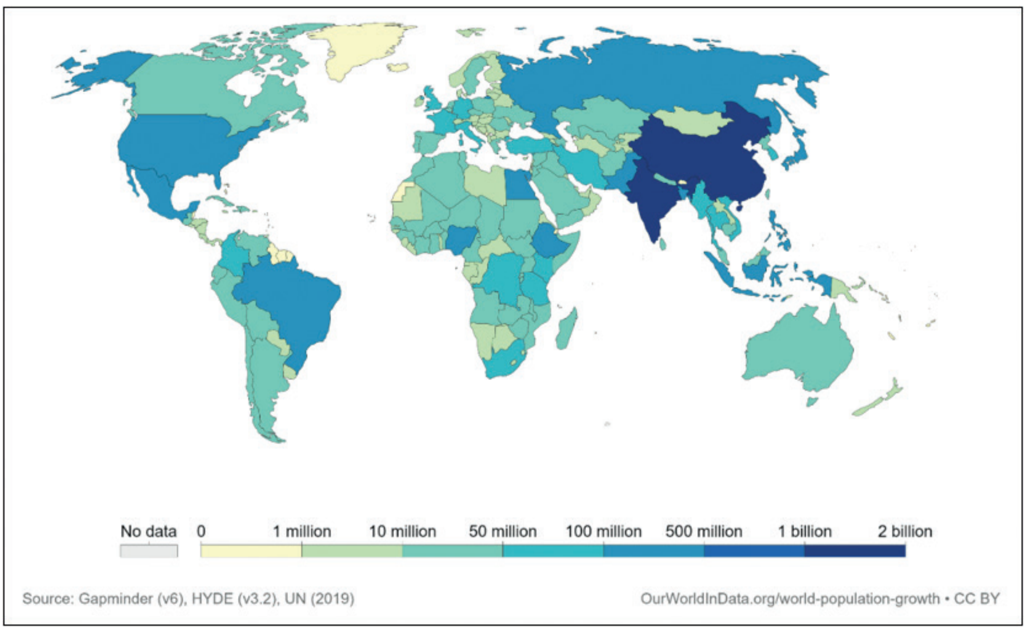
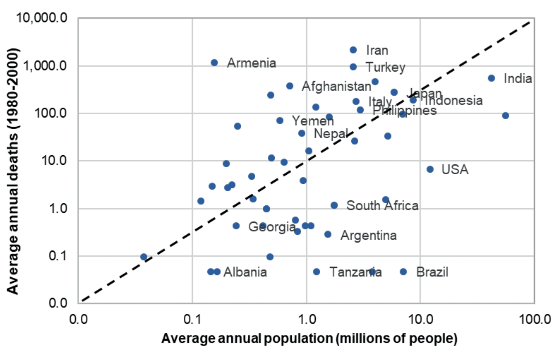


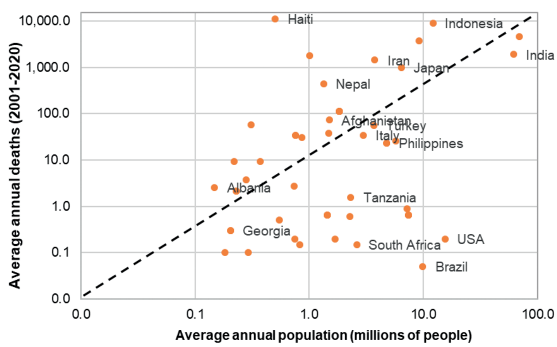
Fig. 9 - Population data for year 2020.

Fig. 10 shows the comparison between the total population size with the number of recorded deaths due to earthquakes for 52 countries related to the three time periods considered: 1980-2000 (Fig. 10a), 2001-2020 (Fig. 10b), and 1980-2020 (Fig. 10c). The number of deaths derived from EM-DAT has been calculated as the average number of deaths per year during the period considered. Since population growth can be sometimes very high in the periods (e.g. for Italy, from 56.3 million of people for 1980 to 60.5 million for 2020), an average value per year has been considered for the three periods. Data displayed in Fig. 10 can be commented as follows: the countries closest to the upper left corner of the graphs show the highest vulnerability to earthquakes (higher number of deaths versus total population). Therefore, drawing an ideal axis from the lower left corner to the upper right corner allows to roughly display the link between consequences (in terms of number of deaths) and exposed population by dividing the 'bad' countries (above the axis: higher number of deaths versus lower exposure) and 'good' countries (below the axis: lower number of deaths versus higher exposure).

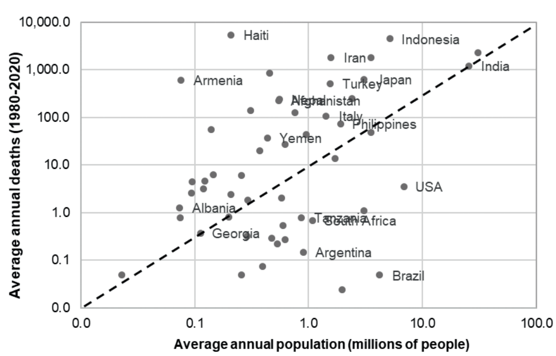
Beyond the intensity of the earthquakes occurring during the considered period, it is reasonable to assume that the separation between 'bad' and 'good' countries is essentially dependent on their vulnerability levels. However, it is worth noting that many countries are placed near the axis thus highlighting that the larger the population, the greater the risk of death. In general, higher exposure (also in terms of infrastructure, production capacities, and other tangible human assets), which is a characteristic of the development process, leads to higher risk.



(a)



(b)



(c)

Fig. 10 - Total population vs. number of recorded deaths for three time periods: 1980-2000 (a); 2001-2020 (b), and 1980-2020 (c).

As can be seen in Fig. 10a, in the period 1980-2000 Armenia was found particularly vulnerable to earthquakes mainly due to a single major catastrophic event (25,000 deaths) that occurred during the reporting period (i.e. in 1988). With respect to the period 2001-2020, Fig. 10b shows that Haiti has the highest value of relative vulnerability due to the strong earthquake occurring on 12 January 2010. Other countries (e.g. Brazil and USA) appear less vulnerable, also because strong earthquakes did not occur during the reporting period. The trend observed in Figs. 10a and 10b is fairly well confirmed in Fig. 10c, related to the total period under examination (1980-2020). Fig. 10 shows that some countries, such as Iran, Turkey, and Indonesia, frequently suffered higher human losses than others, such as the USA, Brazil, and South Africa. In general, the risk of death by earthquake appears correlated with the population and the rate of development of the affected country. It is worth underlining that the adopted approach can lead to overestimating the computed risk for some countries (e.g. Armenia), while underestimating it for others. Indeed, Armenia is an example of a single high impact earthquake in a small-sized country.

In order to compare potentially evolving vulnerability levels, Fig. 11 shows the comparison of the results related to the period 1980-2000 and 2001-2020 for some countries: as an example, the situation worsens for Albania and Nepal, while it improves for the USA and Italy. Specifically, for the period 1980-2000, Italy was among the ‘bad’ countries (above the ideal axis), mainly due to the devastating 1980 earthquake. On the contrary, despite some strong earthquakes (i.e. 2009 L’Aquila and 2016 central Italy), in the period 2001-2020 its position improved (just below the axis), thus suggesting a vulnerability decrease. It should be noted that some countries are not shown in Fig. 11 due to no fatal earthquakes occurring in one of the two periods considered (e.g. Armenia and Haiti).

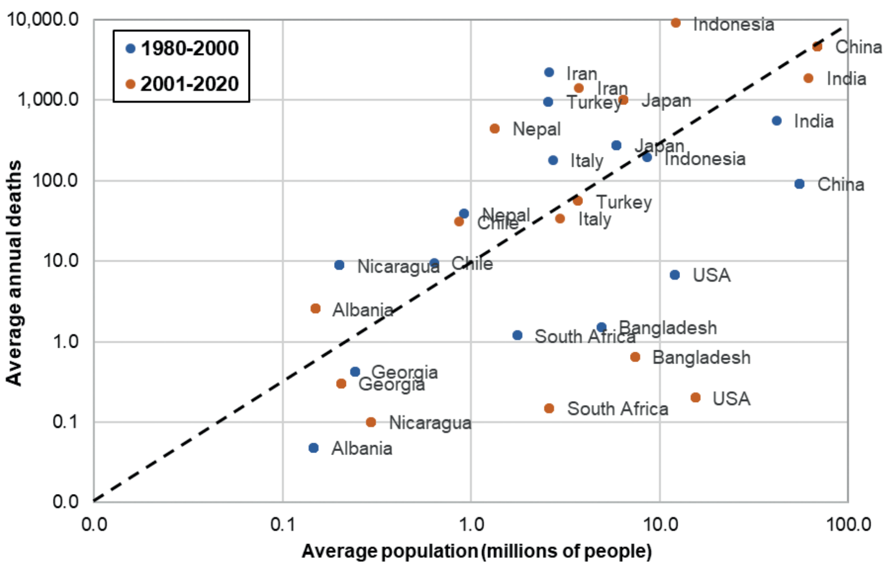


Fig. 11 - Comparison between the vulnerability levels related to the periods 1980-2000 (in blue) and 2001-2020 (in orange).

Finally, to provide a more concise representation of vulnerability levels and to better compare them, the ratio between the number of deaths per year and the population in millions has been calculated. Fig. 12 shows the values for some countries for the time periods 1980-2000, 2001-

2020, and 1980-2020. Higher vulnerability levels are found in countries such as Iran, Indonesia, and Turkey, even though they have different population sizes and development levels. This comparative analysis shows that the values change significantly with the variation of the time period considered. Specifically, for Italy, the average annual number of deaths per million people is equal to about 1.9 for the period 1980-2020 (from about 3 for 1980-2000 to about 0.6 for 2001-2020). The reduction of losses is significantly affected by the lower magnitude of the earthquakes that occurred in Italy in the period 2000-2020, compared to the magnitude of the 1980-2000 earthquakes, but it is also ascribable to a general reduction of vulnerability in itself, as well as to an improved preparedness of national and local governments in the management of emergencies due to natural disasters.

It should also be underlined that these results are strictly dependent on the risk indicator. In fact, considering the number of deaths with respect to the total population, the earthquake is the most dangerous disaster type while, if alternative risk indicators are considered (e.g. economic losses), higher values can be observed for other disaster types (e.g. storms and floods). Based on data extrapolated from EM-DAT for the period 2000-2019, UNDRR/CRED (2020) show that the economic losses due to storms are higher than those due to other disaster types (1.39 trillion US$), followed by floods (651 billion US$) and earthquakes (636 billion US$).

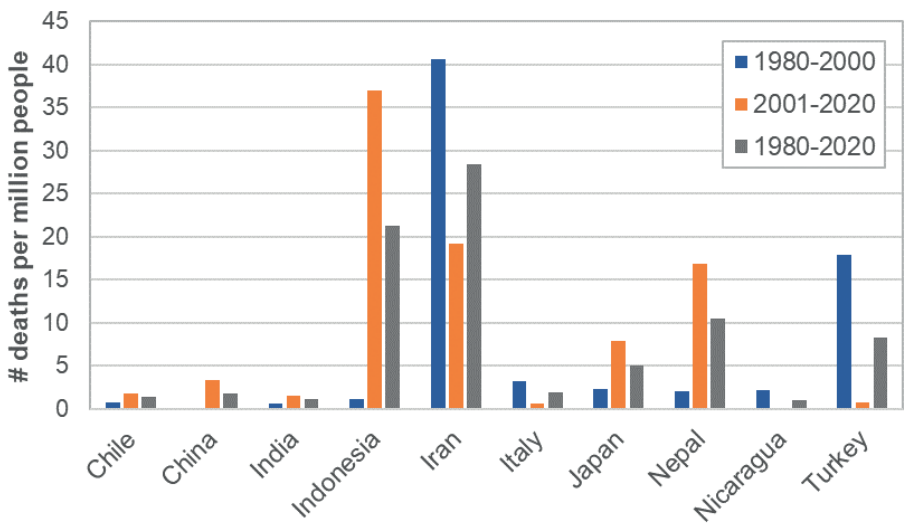


Fig. 12 - Number of deaths (per year) per million people.

4. Closing remarks

The 1980 Irpinia-Basilicata earthquake has been the most devastating seismic event which occurred in Italy in the last 100 years in terms of human and economic losses as well as of the destruction of cultural heritage. The catastrophic consequences due to the role of hazard and vulnerability were further exacerbated by the unpreparedness of the national and local governments in the management of relief efforts. To support the post-earthquake recovery, in May 1981 the Italian Government issued the Law 219/81, addressing two main aspects, namely the physical reconstruction of the damaged built environment and the socio-economic development process of the areas affected by the seismic sequence. Decision makers understood that an effective mitigation from possible future disasters was possible only by combining physical reconstruction programs and development policies.

In the present paper, an overview of the reconstruction program and development process after the 1980 Irpinia-Basilicata earthquake has been first presented, focusing on the Basilicata region. After a short description of the reconstruction data, the main objectives of the development process (i.e. industrialisation of the territory, new infrastructures, and education) have been discussed, highlighting positive and negative outcomes. Furthermore, the effects of the earthquake on the local demography have been analysed, noting that a negative trend for the involved population is found in the period 1971-2011, that is before and after the 1980 earthquake.

The second part of the paper discusses the potential links between risk to natural hazards and development levels. Based on the Report “Reducing disaster risk: a challenge for development” prepared within the United Nations Development Programme (UNDP/BCPR, 2004), the relationship between disaster impact, specifically earthquakes, and development conditions has been analysed with a worldwide perspective. Although the approach adopted in the report allows making comparative analyses between different natural hazards and, for each of them, between different countries, the time span considered (1980-2000) was rather limited to analyse the impact of some natural hazards, especially strong earthquakes, which are low frequency/high impact events. To partially overcome this limitation, additional analyses have been purposely performed, so that data related to a longer period, i.e. 1980-2020, could be considered and discussed in the present paper. To this end, to perform consistent comparisons between different countries, the number of deaths due to earthquakes, with respect to the total population of the country at hand, has been used as an indicator. The comparative analyses have been carried out for three time periods: 1980-2000, 2001-2020, and 1980-2020. Despite the time span is still limited, some clues on the relationship between earthquake disaster and territorial development have been found although, as expected, the results depend closely on the time period considered. Additionally, it should be noted that the results depend on the specific risk indicator adopted in the analyses to measure and compare the consequences. In fact, considering the number of deaths, the earthquake is the most dangerous disaster type while, if alternative risk indicators are considered (e.g. economic impact), higher values are related to other disaster types (i.e. storms).

Returning to the 1980 earthquake, several actions and programs were carried out to mitigate the impact of future events. Among them, the foundation of UniBas can be considered a ‘success story’: since the beginning it has promoted higher education, research, and technology transfer, particularly with regard to natural and environmental risk mitigation. Specifically for seismic risk, the realisation of the structural engineering laboratory has been an important step for knowledge improvement and dissemination. On a national and international level, UniBas is a founding member of the ReLUIS network (www.reluis.it), one of the centres of competence of the Italian DPC. ReLUIS significantly supports the DPC in the post-earthquake emergency management activities, and develops wide research projects for seismic risk assessment and reduction (e.g. Masi *et al*., 2021a), as well as for other structural engineering issues. As far as non-structural prevention is concerned, UniBas and ReLUIS have contributed to establishing and are currently undertaking some prominent initiatives to enhance citizen information and awareness, such as the “Io Non Rischio” (I Do Not Take Risks, www.iononrischio.it) information campaign. The campaign aims to promote a culture of prevention, starting by training volunteers, so that they can help and encourage citizens to effectively deal with natural hazards, making them informed, aware and above all active in reducing risk (Postiglione *et al*., 2016).

Finally, with a view to future research studies, some improvements should be considered in order to further explore the relationship between disaster risk and socio-economic development conditions (both before and after natural disasters), among which: i) using a longer time period for risk analysis; ii) considering effective socio-economic risk indicators, and iii) making comparisons based also on the exposed population.

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