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NATURAL DISASTERS IN ITALY: EVOLUTION AND ECONOMIC IMPACT

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NATURAL DISASTERS IN ITALY: EVOLUTION AND ECONOMIC IMPACT

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ABSTRACT

The interest for the dynamics of natural disasters has significantly expanded during the last decades, from natural sciences to other fields, including economic research, due to the global increase in frequency and socio-economic impact of such events. Economic evaluation of natural disasters nevertheless constitutes a complex and multidisciplinary field. This note presents the Natural Disasters Database for Italy (NDDI), a data set obtained by combining different data sources and describing the evolution of natural disasters and their impact on public spending starting from the Second World War.

* Pietro Lazzaretto ha curato questo lavoro durante uno stage presso Prometeia Associazione.

INTRODUCTION

In the last few decades, general awareness about natural disasters has significantly increased worldwide: the widespread coverage of media, broadcasts ever more frequently warning calls on deaths, infrastructural and economic damages due to natural disasters, mainly in densely-populated hazard-exposed areas, in industrializing and industrialized countries. Alongside this, climate and environmental-related issues, which used to be faced as long-term problems, are turning out having considerable implications even within shorter timeframes. Indeed, natural disasters appear to be spreading in several directions: on one hand, regions historically exposed to extreme events (storms, cyclones or heavy rains), seem to be affected harder and within shortened return periods than in the past (World Bank and United Nations 2010); on the other, the incidence of phenomena, which are not specific to certain climatic regions, are significantly rising (Field et al. 2012) (e.g. "off-season" heat waves, protracted droughts, frequent storms, …). In addition, the occurrence of other non-climate deterministic shocks, as earthquakes, volcanic eruptions or natural floods, is increasingly amplified by global population rising and urban density growth in highly hazard-exposed areas. By their nature, this kind of events still results in even more catastrophic disasters than the aforementioned ones, in terms of immediate capital stock destruction and human casualties they produce (*§1.5; §2.2*).
Risk evaluation of disasters is a complex task for policy-makers, as it is determined by the concurrence of multiple factors (UNDRR 2019, pp.18-19) (*fig.1)*: *Disaster Risk* can be defined as "the potential loss of life, injury or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time", and can be expressed as a probabilistic function of, on one side, *hazard* (the phenomenon itself), *exposure* ("the localization of people, infrastructure, housing, production capacities and other tangible human assets […]") and *vulnerability* ("conditions related to physical, social, economic and environmental factors or processes which determine or increase the susceptibility of a community or a set of assets […] "); on the other of *coping capacity* ("the ability of people, organizations and systems, using available skills and resources, to manage adverse conditions […]") and *resilience* ("the ability of a system, community or society that is exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner […]"). In terms of damages and losses, a disaster might be larger or smaller depending on the frequency of *hazards*, the width of *exposure*, the level of *vulnerability* (Ratti 2017, p.7). It is then clear that potential damages arising from natural disasters, are not only determined by the contingent nature of hazards, but are heterogeneous, region-specific and determined by a

range of different influences, among which local economic structures and development, together with political and social conditions, play a primary role.

In this articulated framework, figures show the number of natural disasters worldwide having more than doubled from the late-eighties, but economic damages having almost tripled (Ritchie and Roser 2019). Therefore, it is not surprising that the perception of the relevance of economic and social damages arising from natural disasters has significantly grown (Blaikie et al. 2014, see Marin and Modica 2017, p.57).

However, as pointed out by Kim (2010, p.2), the economics of natural disasters is still a nascent field: economic research on the consequences of natural disasters is still fairly limited, particularly with respect to natural sciences field.

In this context, this work aims at undertaking a country-level analysis, focusing on natural disasters evolution and economic impact in Italy, one of the European countries which suffered major losses from natural disasters in the last forty years (European Environment Agency 2019). If research has already been carried out on mapping socio-economic exposure to natural hazards from an *ex-ante* perspective, even at a municipal level (Marin and Modica 2017), the objective here is to contribute from an *ex-post* angle, to refine the drafting of a complete database of natural disasters occurred in Italy from the Second World War to present, and to establish a unitary analysis of their impact on public finances.

In the first part, after a general contextualization of the concept of natural disaster and its economic consequences, an analysis of natural disasters evolution in Italy will be undertaken. The second part, will sum up the research work carried out in reconstructing how disasters-related public spending evolved, with a final focus on the interventions that followed the three major disasters (earthquakes) in recent Italian history*: Abruzzo (2009), Emilia (2012), Central Italy (2016)*. The last part will start from the analysis developed in the previous chapters, to trace potential scenarios in the evolution and spending for natural disasters.

1. NATURAL DISASTERS: CONCEPTS, *ECONOMICS* AND EVOLUTION IN ITALY

1.1 CONCEPTS

It might be useful to start with some terminological clarification on natural disasters concept. From a qualitative point of view, it is difficult to formulate one exhaustive definition, as the perception of events as natural disasters may be influenced by the socio-economic context in which they occur: concurrence of natural hazards and human actions, spatial and temporal extent, kind and magnitude of damages might be diversely conceived in different settings (Ratti 2017). A qualitative characterization has therefore to transcend precise definitions of causes or kind of damages, but might rather establish the broad nature of disruption induced by shocks. In this context, it is possible to place UNISDR's definition (see Ratti 2017 p.6), according to which a (natural) hazard turns into a disaster if it results in "serious disruptive effects" on the life of affected communities, considering human, material, environmental and economic losses, such that they are not able to recover through their own resources only. If the effects end up being unrecoverable as to pre-existing conditions, the disaster might turn into a *catastrophe* (Posner 2004, see Ratti 2017, p.6). From an economic point of view, Hallegatte and Przyluski (2010, p.2) define natural disasters as any natural shock affecting an economic system, resulting in significantly negative consequences for firms' assets and production factors, for consumption dynamics and labor market conditions. Alternatively, or complementarily, natural disasters might be defined in terms of quantitative thresholds (deaths, injured people, direct damages, …). This alternative, although it might result restricting or might still lead to conflicting results depending on thresholds choice, provides a more objective basis, making it more suitable for empirical analyses. This methodology is therefore the one that will be mainly adopted in the continuation of this chapter.

1.2 THE *ECONOMICS*

To complete the theoretical framework, the main economic concepts in natural disasters analysis will be explored further; the work of Hallegatte and Przyluski (2010) provides an exhaustive overview. Essentially, natural disasters tend to affect the economic system in several ways (*§1.1*). However, damages can be traced back into two broad macro-categories: direct and indirect losses. The former comprehends all immediate physical consequences, and can be divided into market losses (such as the destruction of tangible assets), referring to losses of tradable goods easily computable from market prices, and non-market losses (as damages to ecosystems or life losses) which cannot be traded or replaced, posing wider problems in terms of monetary quantification. The latter refers to secondary effects, not caused by the disaster itself, but by its consequences (as increases in unemployment, business failures, tourists' flows reduction, …). In principle, indirect losses should include all those costs that transcend temporal and spatial boundaries of the disaster itself, or that derive from losses in economic sectors different from those directly damaged. It is important to point out that indirect losses can generate "negative costs" as well (e.g. relative "gains"). That is, for example, any stimulus created by reconstruction activities.

Having identified potential sources of economic losses, it is fundamental, to conduct any economic evaluation, to define a proper counterfactual (*what would the economic trajectory have been, if the disaster did not happen?*). Estimates of economic costs can get furthermore complicated if post-disaster economy does not return to the hypothesized baseline-scenario, in case of permanent negative, or even positive effects. This might be the case when reconstruction enhances the expansion of certain economic sectors, or the adoption of more advanced technologies.

Depending on the *flexibility* of production systems, output losses might be compensated or not by the reconstruction process in the short-term. In a system with no flexibility (i.e. where the production level is saturated) part of the unaffected capital in production has to be diverted to reconstruction, thus observable output reduction might not be cushioned. Contrarily, if it is possible to increase the productivity of unaffected capital (i.e. increasing hours worked) for reconstruction processes, there might then be a limited diversion of resources from production. As a result, output losses might be reduced, or even more than compensated by the reconstruction stimulus.

Among available global natural disasters databases, Hallegatte and Przyluski (2010) indicate the *Emergency Events Database*, EM-DAT, (Université Catholique de Louvain-CRED 2019), as an important source of publicly available data.

1.3 THE EMERGENCY EVENTS DATABASE

The *Emergency Events Database,* created in 1988 to support the World Health Organization in disaster risk management and prevention, records over 22,000 natural disasters worldwide from 1900 to present days. Major sources are UN agencies, NGOs, research institutions, insurance companies and press agencies. The database contains both natural (*tab.1*) and technological disasters, classified as follows:

NATURAL DISASTERS (tab.1)

disaster soubgroup	*description*	*Dysasters main types*
Geophysical	A hazard originating from solid earth. This term is used interchangeably with the term geological hazard	Earthquake Mass Movement (dry) Volcanic activity
Meteorological	A hazard caused by short-lived, micro- to meso-scale extreme weather and atmospheric conditions that last from minutes to days.	Extreme Temperature Fog Storm
Hydrological	A hazard caused by the occurrence, movement, and distribution of surface and subsurface freshwater and saltwater.	Flood Landslide Wave action
Climatological	A hazard caused by long-lived, meso- to macro-scale atmospheric processes ranging from intra-seasonal to multi-decadal climate variability.	Drought Glacial Lake Outburst WIldfire
Biological	A hazard caused by the exposure to living organisms and their toxic substances (e.g. venom, mold) or vector-borne diseases that they may carry. Examples are venomous wildlife and insects, poisonous plants, and mosquitoes carrying disease-causing agents such as parasites, bacteria, or viruses (e.g. malaria).	Epidemic Insect Infestation Animal Accident
Extraterrestrial	A hazard caused by asteroids, meteoroids, and comets as they pass near-earth, enter the Earth's atmosphere, and/or strike the Earth, and by changes in interplanetary conditions that effect the Earth's magnetosphere, ionosphere, and thermosphere	Impact Space weather

(source: UNIVERSITE CATHOLIQUE DE LOUVAIN– CRED, 2019. *Em-Dat: The Emergency Events Database*)

Technological disasters include: Industrial Accidents, Transport Accidents and Miscellaneous Accidents. For a disaster to be entered into the database at least one of the following criteria must be fulfilled:

- Ten or more people reported killed;
- Hundred or more people reported affected;
- Declaration of a state of emergency;
- Call for international assistance.

1.4 The NATURAL DISASTERS DATABASE FOR ITALY (1944 – 2018)

From the *Emergency Events Database* (EM-DAT) it is possible to extract data for disasters occurred in the Italian territory. Only natural disasters are included in this analysis (excluding technological ones), for an initial total of 152 events.

However, some events are excluded:

- Observation between 1905 and 1943: very few (eight) events, not precisely specified and with no possibility of cross-checking information;
- *Biological disasters*: only account for two registrations in the early '00 in Southern Italy (no other significant information available);

- *Wildfires*: seven events recorded only in recent years. However, it was not possible to discriminate between man-initiated arsons and real wildfires;
- Two other events were excluded because of the impossibility to find any information on them; database providers were not able to supply additional relevant details ("*1999-0022*": landslide in January, "*1997-0278*": storm in November);
- For *Emilia* (2012) earthquake, two separate registrations (*2012-0142* and *2012-0162*) were included for two tremors on the 20th and 26th of May. Information were aggregated under one single code (*2012-0142*).

A preliminary analysis of data posed concerns about the precision of records farther in time: older observations are in fact much less precisely recorded (as to location, date and size), as other authors also pointed out (e.g. Ratti 2017; Hallegatte and Przyluski 2010). According to this consideration, EM-DAT observation were therefore cross-checked with information contained in an Italian report, jointly redacted by the *National Builders Association* (ANCE) and the *Center of Socio-Economic Research in Construction* (CRESME) in 2012, published by the Italian Chamber of Deputies, which contains a detailed list of natural events occurred in Italy between 1944 and 1990 (pp.145–150). From this document, it was possible to extract seventeen more natural disasters, aligned to EM-DAT criteria, but not included in it: seven earthquakes, six floods, three landslides and one storm.

Additional information on the precise spatial and temporal coordinates of disasters came from multiple sources:

- National Centers for Environmental Information (NOAA s.d.);
- *Sistema Informativo sulle Catastrofi Idrogeologiche* (IRPI s.d.)*;*
- *Bollettino Siccità* (ISPRA s.d.);

The final list comprising the Natural Disasters Database for Italy (NDDI), available on Prometeia website, contains 149 natural disasters occurred between 1944 and 2018, divided by macro-areas (North, Center, South-Islands). Data were also organized on a regional (380 data points) and, when possible, provincial basis (459).

1.5 EVOLUTION OF NATURAL DISASTERS IN ITALY

From World War II onward, 149 ascertained natural disasters took place. Among these, almost one-half (sixty-nine) are hydrological (floods, landslides), geophysical ones (earthquakes, volcanic activities) account for forty-two, while Meteorological-climatological (storms, extreme temperatures, drought) are thirty-eight.

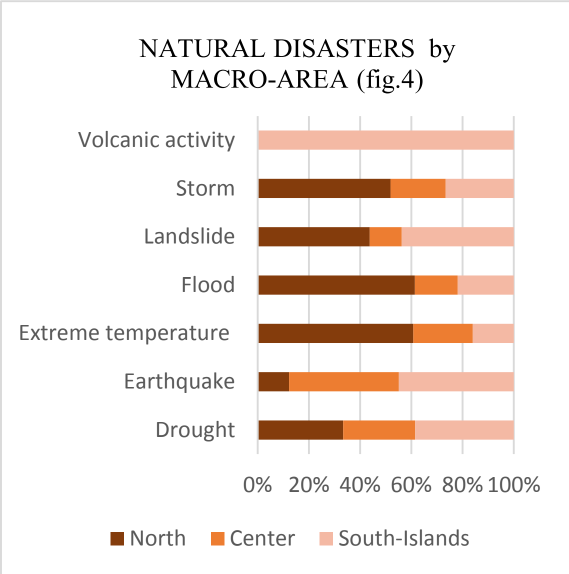
Floods are the most frequent disasters (*fig.3*), accounting for 35% of total, with particular incidence in Northern areas (*fig.4*), affecting almost three million people and causing around one-thousand deaths. This kind of disasters is particularly calamitous when it happens to hit major cities, as happened in Florence (1966) or Genova (1970).

Second in terms of frequency (25%), but first in terms of deaths, are earthquakes, killing 7400 people over the last seventy-five years. Among these, the ones in Belice (1968), Friuli (1976), Irpinia (1980), Abruzzo (2009), Central Italy (2016) were the most catastrophic as to deaths, accounting for 87% of total earthquakes victims.

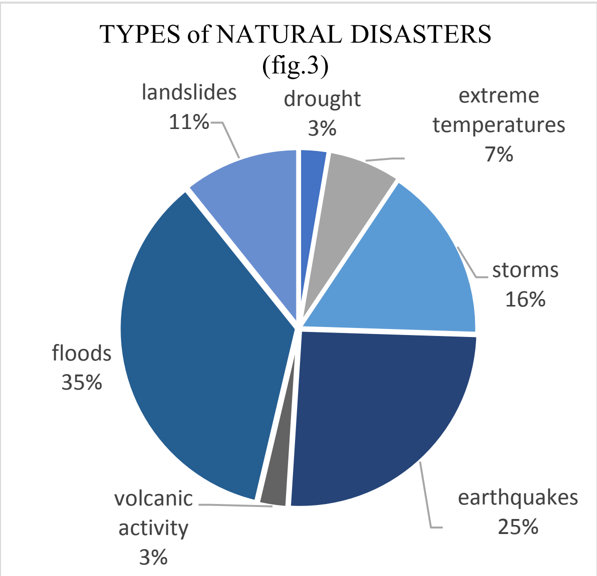
Earthquakes hit mainly Central-Southern areas, with a particular concentration in Apennine regions (rarer, but not less harmful, are earthquakes in the North).

The third cause of natural disasters are storms, with an incidence of 16%, affecting indistinctly from North to South.

Contrarily to earthquakes or floods, which tend to be localized events, storms usually have a vast extension covering frequently more than one region: in the last ten years, six disastrous storms involved on average the surface of more than five regions. In contrast, only three storms were registered over the decade before.

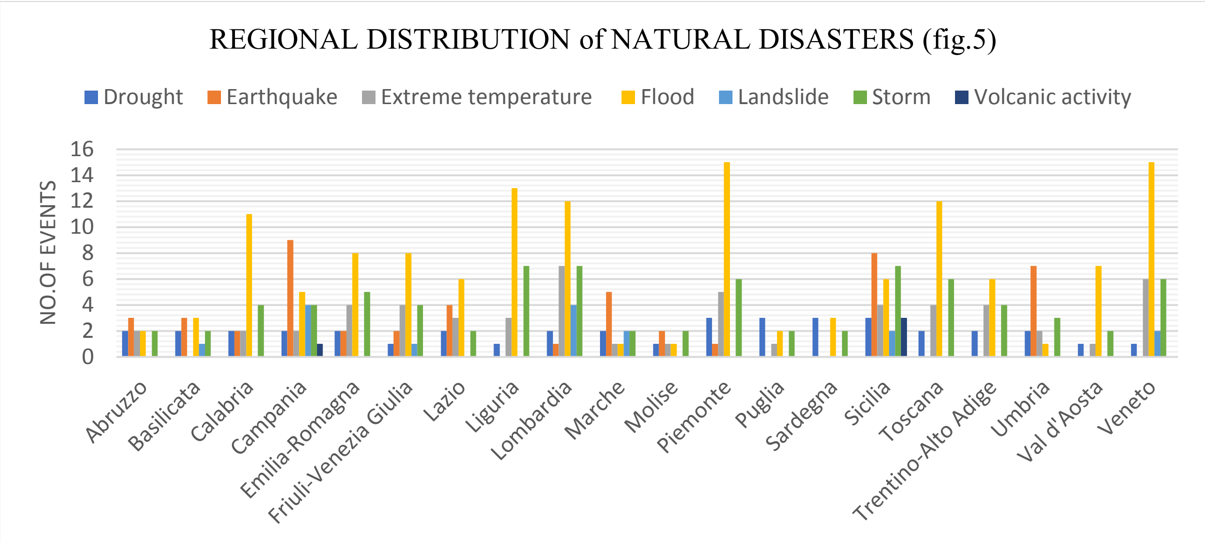


Landslides account for 11% and, as extreme temperatures (7%), tend to cover the entire national soil. If landslides mirror the historical fragility of the Italian territory, dreadful waves of extreme temperatures (both hot and cold) are quite a recent phenomenon: the first registration is in fact in the late-nineties. Since then, extreme-temperature events have increased in their frequency and in their extension. Residual fractions are represented by droughts and volcanic activity, both at 3%. As extreme temperatures, extreme droughts have been registered only from the late-nineties and the last two events covered almost all the National territory.



A low frequency of events, such as extreme temperatures or intense drought periods, should not lead to and underestimation of the weight of this kind of hazards. Leaving aside the awareness of this kind of events farther in time (and therefore registrations precision), they would seem here to have abated. This might be attributable to the threshold choice by EM-DAT (*§1.3*) which, although crucial to conduct an objective categorization of events (*§1.1*), results in concealing *under the radar* events that, although strictly speaking are not disasters in the short-run, might potentially assume catastrophic connotations over medium-long terms.
A last note on volcanic activity: registrations are not frequent (3%) and homogenously distributed. These events, that affect Southern Italy only (Etna and Vesuvio Volcanoes) are of concern mainly because of the steady urbanization of wide areas exposed to volcanic risk. Over 700,000 people live in the "red zone" of mt. Vesuvio: unforeseen violent eruptions, although very unlikely, would provoke unimaginable consequences.

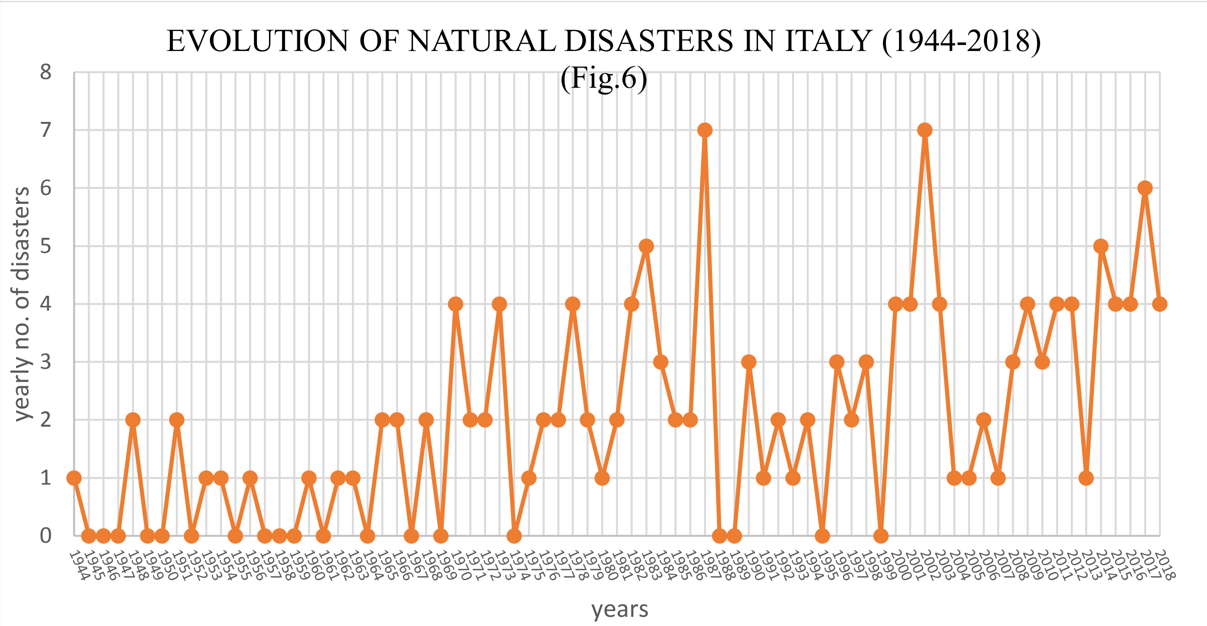
At a regional level (*fig.5*), Lombardy and Sicily were the most affected areas with 33 natural disasters, followed at 30 by Veneto and Piemonte. If Sicily was mainly stricken by earthquakes, all northern regions suffered instead from a higher incidence of floods, which roughly accounted for one half of total disasters.

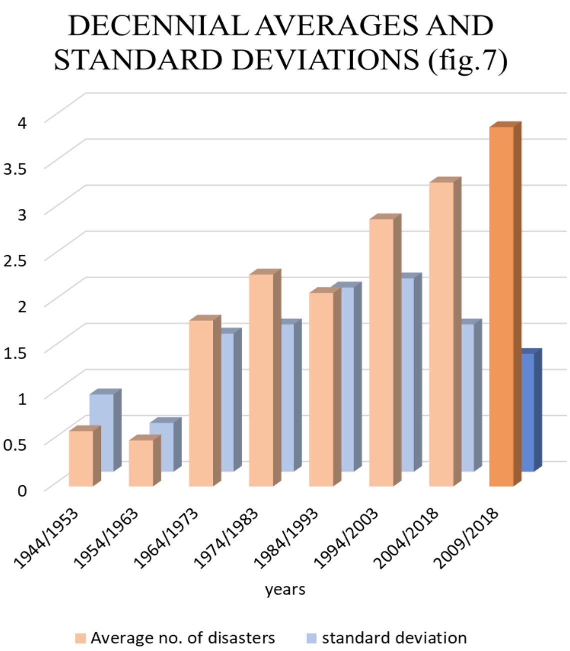


However, normalizing the number of events for regional extensions, Liguria results being the most affected region, with 4.43 disasters per thousand squared-kilometers, where floods and storms accounted for more than 80% of disasters. In terms of deaths, 86 every 100,000 inhabitants were killed in northern regions, while figures are lower in Southern-Insular and Central Italy with respectively 66 and 11 deaths per 100,000 inhabitants. As to regional patterns, northern regions are mainly subject to hydrological events while central ones to earthquakes, southern regions have instead more heterogeneous patterns: Sicily and Campania, for example, were indistinctly hit by all disaster categories considered, while Calabria mainly by hydrological ones, similarly to the North.

At a provincial level, some territories tended to be hit more repetitively than others: most affected areas were also those where large metropolitan cities are: Naples and Venice (12 events), Genova (11), Turin (10), Milan (9), Rome (8), thus highlighting how population density in restricted areas plays a non-negligible role in making a natural hazard a disaster.

An overview of the complete series (*fig.6*), leads to a conclusive question: what was the evolution of natural disasters over time?

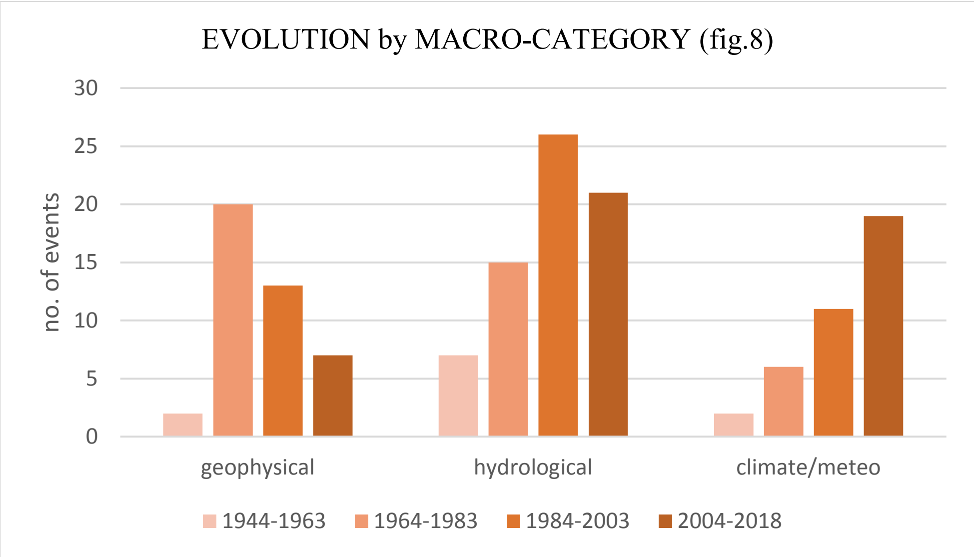




A first look at the chart does not seem to suggest any clear trend, but data present wide variability. As also pointed out by Hallegatte and Przyluski (2010), data on large natural disasters are scarce, because of their nature of, fortunately, rare events. If this does not allow for a large sample necessary for econometric analysis, it is still possible to look at some descriptive statistics to extract valuable insights. In fact, looking at ten-year means (*fig.7*), from 1944 to the mid-sixties around one natural disaster every two years occurred. During the sixties figures grew at

1.8 disaster per year, remaining then stable between 2.3 and 2.1 for the two following decades. Between the late-nineties and the beginning of the new century, figures underwent a steep rise to 2.9 per year, attesting at an even higher yearly average level of 3.9 from 2009 to present days. This growing trend is not immediately identifiable due to high annual variability, which indeed is not constant during the period. In terms of decennial standard deviations, this is relatively low during initial decades (0.84 in the period 1944-1953, 0.53 for 1954-1963), increasing then from the late sixties to the late nineties to more than 2.1, decreasing then to 1.28 over the last decade. That is, if after the WW II data were rather stable around low values, after a period of higher variability at the end of the century, figures seem having settled around higher levels in recent years.

In terms of macro-categories (*fig.8*), geophysical disasters grew between the sixties and early-eighties falling afterwards (thanks probably to the establishment of an anti-seismic legislation in the construction sector*, §2.2*), whereas hydrological ones grew until the end of the century and stabilized thereafter. Climate-meteorological disasters showed, instead, a continuous growth: only two were registered until 1963, growing at 6 during the following twenty years, 11 between 1984 and 2003, 19 in the last 15 fifteen years.



Although, as stated before, no aim of inference or forecast would make sense in this context, it is worthwhile to highlight that, due to the manifold possible contributory causes described in the previous paragraphs, the frequency of natural disasters, despite annual variability, seems to be stabilizing around higher average levels than in the past. Among the macro-categories analyzed, climate/meteorological disasters seem to be growing faster than others in recent years.

2. NATURAL DISASTERS AND PUBLIC SPENDING IN ITALY

When it comes to the economic impact of natural disasters, this might differ significantly among categories, and over time. The following analysis aims at investigating how overall public expenditures evolved, and whether it is possible to identify any common ground with the frequency evolution (*§1.5*).

Italy, contrarily to other European countries (Boccard 2008), does not have an insurance scheme for natural hazards. It follows that a very small risk portion is covered by private insurance, and insurance penetration in this field is among the lowest in the industrialized countries (SwissRe 2018). As a result, the Italian Government has always acted as an "insurer of last resort", fully financing rebuilding programs and supporting interrupted economic activities. That said, it seems justified to choose public spending as an indicator for overall economic costs.

2.1 DATA COLLECTION

A detailed analysis of public spending in Italy, requires the integration of data from different sources, covering different time periods. The objective is to identify the evolution of budgetary allocations from 1944 to present days. The two main sources are:

- *Primo Rapporto ANCE/CRESME – Lo stato del territorio italiano* (2012);
- Italian Government Budget Documents.

The first document covers all provisions from 1944 to 2009. Specifically included are geophysical (earthquakes, volcanic activity) and hydrogeological events (floods, landslides). General references regarding expenses for *all other disastrous events* are also given.

Total expenses (expressed in € at 2011 ISTAT price index) attested at around 222 billion: 168 of which were devoted to earthquakes, 54 to hydrogeological disasters. As pointed out in the report (ANCE and CRESME 2012, p.141), these sums account for short-term emergency aids, long-term public and private reconstruction funds, tax cuts and tax credits, support grants for interrupted economic activities.

Of the €168 billion earmarked for geophysical calamities, 99 billion refer to the period from 1944 to 1990. Considering instead those for hydrological events, 31 billion over 54 were allocated up to 1990, 23 billion from 1991 onward. Estimated €2 more billion, are added to these sums, including all other disastrous events.

Allocations from 1944 to 1990 are catalogued thanks to the work of Catenacci (see ANCE and CRESME 2012, pp.145-150), a geologist who filled a detailed listing of natural disasters

ordered by category, date and place of occurrence, together with amounts and durations of all the corresponding funding instalments from the Central Government. Reported data from 1991 to 2009 refer, instead, to a publication of the National Council of Geologists (CNG 2010).
These two sets of data were reorganized shifting from an event-based classification to a yearly amortization (as they would appear in yearly Government Budgets). Public funds from 1944 to 1990 were easily handed out, as starting years and length of each instalment was explicitly indicated. Allocations covering more than one year, when specific indications were absent, were assumed to be equally distributed over the funding period. Funds from 1991 to 2009 were precisely amortized whenever reference to specific provisions of law were available (CNG 2010, ch.7 pp.15 e ss.). Residual funds, were equally distributed over the period.
To complete the series from 2007 to present, official publicly available documents from the Italian Government Budget were examined. From these documents it is possible to secure detailed data on expenditures for natural disasters. The cost items selected from these documents were the same as those included in ANCE and CRESME Report (2012), summarized in the previous page. National Budget documents are organized according to *Missions, Programs and Actions* (in ascending order of disaggregation). *Missions* represent principal expenditure functions and strategic objectives pursued; *Programs* are homogeneous expenditure aggregates for the achievement of objectives defined by *Missions* in which they are included; *Actions* are budget aggregates underlying expenditure programs, specified for a better understanding and verifiability of funding allocations (Ragioneria Generale dello Stato 2019).

Documents from 2007 to 2010 are available at a disaggregated level up to *Programs* (but not *Actions*) (Ragioneria Generale dello Stato 2018). The considered mission for this period is *Civil Rescue* which includes appropriations from the Ministry of Economic Affairs and Finance for the programs *Interventions for Public Calamities* and *Civil Defense* and from the Ministry of the Interior for the program *Risk Prevention and Public Aid*. As no other mission includes relevant expenditure items for this period, Civil Rescue is assumed to be in this case a good proxy of the overall economic impact on public finances. From 2011 onward, expenditure items are distributed also within other missions and/or ministries. However, from the same year, *Technical Annexes* to the State Financial Budget ("*Allegato Tecnico – Disegno di Legge di Bilancio*") are available for every single Ministry (Ragioneria Generale dello Stato 2011; 2012; 2013; 2014; 2015; 2016; 2017; 2018b; 2019b). In these documents, expenditure items are disaggregated up to every single *Action*. It is therefore possible to extract, year by year, Ministry by Ministry, allocations of competence just for natural disasters.

Budget allocations to *Civil Rescue* mission fall between 2010 and 2011 (from around €5.7 billion to €4.2 billion at current prices, gradually increasing thereafter up to €6 billion in 2019). In parallel, this decrease is compensated by growth in other missions. At the Ministry of Economic Affairs and Finance, which holds the majority of total allocations, other relevant programs emerge: *Support measures through the tax system* account for €5.14 billion allocated from 2011 to 2019, €1.7 billion are allocated for *Reimbursements to local authorities*, €4.1 billion for *Residential constructions*, and €1.24 billion for *Debt burdens* arising from natural disasters not already included in *Civil Rescue* mission. At current prices, the Ministry of Economic Affairs has allocated between 2007 and 2019 (including expenditure forecasts for 2020 and 2021) a total of €54.23 billion, followed by the Ministry of the Interior with €32.7 billion. Within the latter, the majority (€32.3 billion) refer to *Civil Rescue,* whereas €0.4 residual billion are allocated to multiple specific actions. The Ministry of Infrastructures accounts for €3.7 billion from 2011 onward; the largest part of these funds was allocated to floods prevention in the Venice area (almost €3 billion). Allocations at the Ministry of Economic Development account for €1.35 billion, (mostly concentrated in one expenditure item, in 2014, for the earthquake occurred in Abruzzo (2009), for €0.91 billion) and for €1.73 billion at the Ministry of the Environment and Territory Protection. The latter, mainly refer to prevention interventions and are allocated for more than one billion from 2017 onward. Residual funds pertain to the Ministry of Labor and Ministry of Cultural Heritage, for €0.15 billion in total.

2.2 THE COMPLETE SERIES

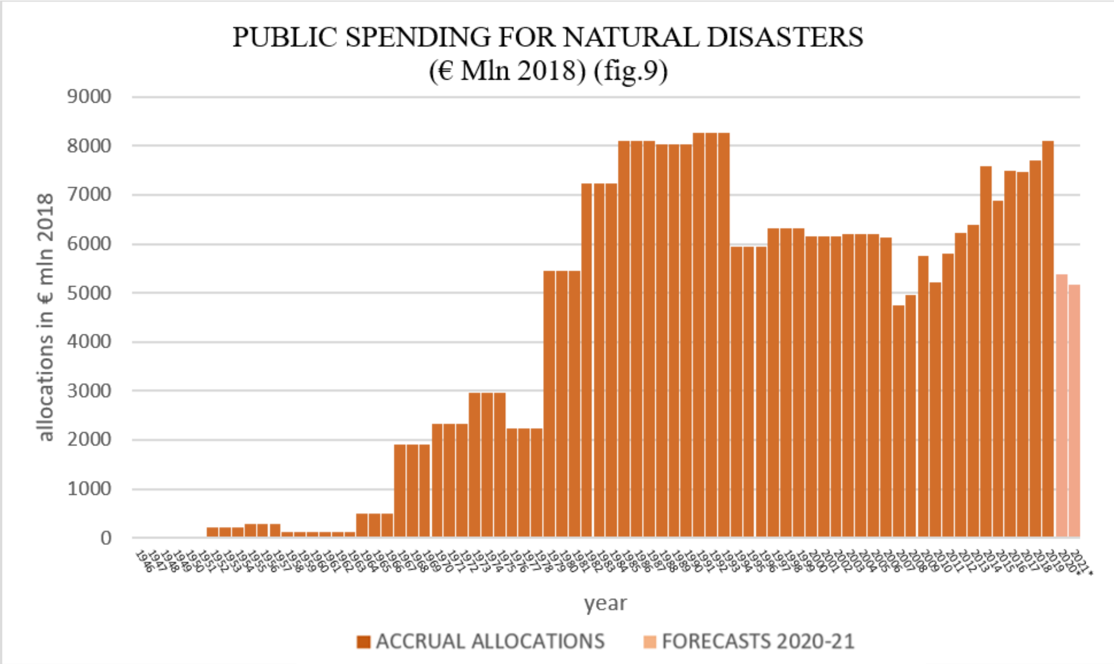
In order to harmonize data from the different sources analyzed and provide a final picture, total estimated yearly expenditures are reassessed based on 2018 ISTAT price indexes. Moreover, the two estimated series, (the one based on ANCE and CRESME Report from 1944 to 2009 and the other on official Budget Documents covering from 2007 onward), overlapped for three years. What can be seen from (*tab.2*) is that, despite different sources, total estimated expenditures (in real terms) don't seem to differ substantially.

OVERLAPPING YEARS in the TWO SERIES (2018 € billion) (tab.2)

	1944-2009 series	2007-2019 series
2007	5.1	**4.75**
2008	4.95	**4.95**
2009	4.7	**5.75**

The last figure is significantly higher from Budget Documents, as the tail of the first series (1944-2009) is a projection of average allocations earmarked in previous years, not accounting for the earthquake occurred in Abruzzo (2009). In the two previous years errors are instead much narrower. For these three years, figures from official Budget Documents are included in the data set because of their greater precision.

For a matter of graphical representation, total allocations from 1946 (first allocation) to 2005, are expressed here as an average of subsequent three-year periods (*fig.9*).



PUBLIC SPENDING FOR NATURAL DISASTERS (€ Mln 2018) (fig.9)

Overall total public allocations amount at around €307.85 billion (at 2018 prices). Forecasts for 2020 and 2021 (€10.55 billion overall) show much lower figures with respect to previous years. Sums allocated from the EU Solidarity Fund (since 2002) are also included (European Commission 2019): disbursements in aid to Italy amount to €2.8 billion (more than one half of total allocations from the Fund equal to €5.54 billion).

Total resources devoted to natural hazards and disasters appear to be very low in the first twenty years of the series, accounting for just €3.9 billion until 1966. Thereafter, allocations start growing, experiencing a steep rise from the mid-seventies to the nineties. After flattening and decreasing during the nineties and the early 2000s, earmarked public funds start rising gradually from 2007 up to present days.

Some considerations can be made comparing the series of total appropriations to the one of the frequencies of natural disasters presented in the previous chapter: while the number of natural disasters, despite its intrinsic yearly variability, showed an average increase during the last seventy-five years, the dynamics of public allocations seem to follow a different pattern. In fact, the maximum level of yearly appropriations was reached between the mid-eighties and early-nineties, when figures reached on average the equivalent of €8 billion each year, a level never reached thereafter until 2019 when, according to the last Budget Law, a total of approximately €8.11 billion was allocated, following a positive trend during the last twelve years. On the whole, a major determinant in the evolution of public spending related to natural disasters seem to be attributable, more than to the yearly number of disasters, to the magnitude of those more catastrophic, namely earthquakes. Surely, a non-negligible role is also played by investments for hydrological hazards, that were absent just after the WW II but started growing during the sixties continuing up to present days. The economic impact of climate-meteorological events, and of relative allocations, is instead almost null up to now.

A deeper look into data, sheds light on the fact that the first rise in the late-sixties is mainly due to Belice earthquake (1968), which accounted alone for the equivalent of almost € 9.4 billion, followed within twelve years by two other major earthquakes in Friuli (1976, overall impact of almost €21 billion) and Irpinia (1980, €65 billion). The accumulation of appropriations for these three events is the first responsible for the steep rise between the seventies and the early-nineties. Annual allocations tend to flatten between the nineties and the early ‘00 Just one major earthquake hit Italy in the late-nineties (Marche, 1997) allowing for public finances to dispose of allocations from the previous events. Then, from 2009 onward, three earthquakes occurred in seven years: Abruzzo (2009), Emilia (2012), Central Italy (2016) impacting significantly on expenditures over the last decade (approximately €40 billion). All together, these seven events, which represent just 4.7% of total natural disasters (*§1.5*), accounted for 50% of the overall economic impact.

Nowadays, earthquakes, which represent 25% of total natural disasters (*§1.5*) constitute by far the major disaster risk in Italy in terms of overall economic damages (but also of life losses, *§1.5*), accounting alone for more than the appropriations for all other events together. Based on 2012 classification from the Civil Defense Department, 38.5% of Italian municipalities are exposed to high seismic risk (ANCE and CRESME, 2012), accounting for 44% of the total National surface. Moreover, even if an anti-seismic legislation for new constructions was introduced in 1974, 60% of total buildings in Italy were constructed before 1971 and another 16% between 1972 and 1981, thus not following the technical guidelines laid down by law. In addition to this, buildings constructed after 1974 might not comply anyway with current anti-seismic legislation, as the seismicity-risk map was updated several times in recent years. Yet, organic investments for seismic risk prevention were introduced only in 2009, when a €963 million fund was instituted, to be distributed in seven years on a regional basis. Estimates from the *Italian Association of Engineers and Architects (OICE)*, show that approximately €36 billion would be needed to secure building in high-risk areas (Tripodi 2013). Much more than the sums allocated by now, but still less than 20% of total public expenditures for earthquakes in the last seventy-five years.

2.3 FOCUS ON RECENT MAJOR EARTHQUAKES

Three major earthquakes affected Italy during the last ten years: *Abruzzo (2009)*, *Emilia (2012)* and *Central Italy (2016)*.

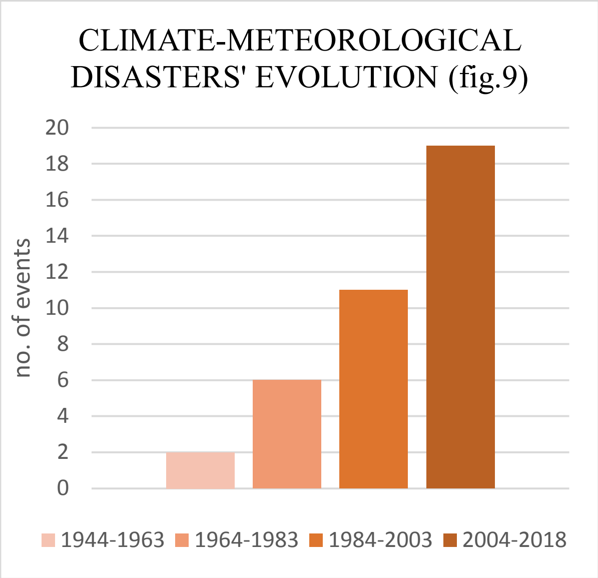
Considering the temporal proximity, no long-term consideration would be possible yet, but a brief overview on the nature of appropriations occurred during the immediately following years, can be conducted. Such a sequence of disasters within just a few years, put considerable pressure on public finances: total appropriations are estimated to be around €40.6 billion overall (UVI 2018): 17.5 billion for the first earthquake, 8.4 for the second, 14.7 for the last one. A detailed insight on appropriations is provided by publications from the Italian Senate, *Ufficio Valutazione Impatto* (UVI 2017; UVI 2018). Allocated funds can be divided in four categories: emergency funds, funds directed to support economic activities, transfers to local authorities and reconstruction funds. While the first three funding categories tend to be entirely allocated in the immediate aftermath of disasters, reconstruction resources tend to be distributed over longer periods of time, showing heterogeneous patterns.

The category breakdown brings to light that the majority of funds (more than €34 billion) are destined to the reconstruction process, while figures are much lower as to support for economic activities which stand at € 3.6 billion. Transfers to local authorities (or similarly reductions in obligations toward central authorities) aimed at generating a financial surplus necessary to face the emergency situation, account for € 1.5 billion, while strictly emergency funds attested at roughly € 1 billion overall (not accounting indeed for expenses occurred in the days immediately subsequent the disasters, as these burdens are usually sustained by the Civil Defense Department or the National Police, which can count on resources already in their balance sheets for such eventualities).

With respect to the most relevant category, namely reconstruction funds, these constitute 90% of total allocation in *Abruzzo,* rising at 93% in *Emilia.* On the contrary, figures are relatively much lower in *Central Italy,* where resources devoted to infrastructural and building reconstruction only account for 75% of the total. Moreover, focusing on the timing of the rebuilding activity in the year of the event and in the year after it, what we can see is that in *Abruzzo* 7.75% of total reconstruction funds were allocated the same year of the disaster, 15.7% within the following year, constituting 44% of total resources appropriated within that period. In *Emilia*, immediate reconstruction funds accounted for 11.6%, while by the following year almost 27% were already allocated. In this case, during the first two years, the weight of resources devoted to reconstruction, represented indeed 81.2% of total allocations. Considering the last earthquake (2016) instead, reconstruction resources only accounted for 0.3% immediately, and 9.24% within the following year. Although it has to be considered that this event occurred in the second half of the year, contrarily to the previous ones, more resources were in this case devolved to support economic activities and financial needs of the population, accounting for some €1.36 billion the year of the disasters, versus almost null (€33 million) reconstruction allocations (UVI 2018).

While the different composition of total allocations might reflect the different nature of these events and therefore the heterogeneous financial needs arisen from them, it emerges that in each of the cases considered reconstruction needs have a predominant weight. Reconstruction timing plays indeed a fundamental role in terms of multiplicative effects on consumption and investments (Codogno 2016). From this starting point, further research might therefore be conducted to explore how the recovery of local economies varies depending on the timing of funds allocation.

3. NATURAL DISASTERS: FUTURE TRAJECTORIES



In the last seventy-five years, earthquakes have been by far the most impactful events. However, this does not mean that future dynamics will be the same. The frequency and cost dynamics don't seem to share a common trend across different types of natural disasters (*§2.2*): while the number of disastrous earthquakes fell over the last decades, the number of other events, namely climate-meteorological ones, have shown a sustained growth (*§1.5*) (*fig.9*).

Moreover, analyses like the one conduced in previous chapters, as already pointed out, tend to not to fully capture these disasters (*§1.5*) due to their more gradual evolution both in terms of frequency and in terms of post-event allocations (*§2.2*). In this state of affairs, climatological and meteorological events are be better investigated through more specific analyses: studies on droughts, extreme hot or cold temperatures, violent storms and so on, provide more significant guidance when conduced on frequent observation, transcending the disastrous nature of events. Adopting this different focus, is possible to investigate for example how much extreme temperatures growth can be attributed to anthropogenic forcing (Pasini et al. 2017), or the evolution of spatial and temporal extension of drought periods (*Istituto Superiore per la Protezione e Ricerca Ambientale*, ISPRA), or the constant rise of average sea levels (Lindsey 2018), and so on. The evolution trajectories of these events, which turned into disasters in Italy "just" thirty-eight times over the last seventy-five years, are indeed hard task to forecast (Field et al. 2012), but for southern-Mediterranean region (like Italy) some tendencies can be outlined: projected changes show that the frequency and length of extreme heat waves is likely to increase, together with a significant rise in areas affected by droughts, while the frequency of cold nights and days is expected to decrease, and tropical storms are expected to increase (Field et al. 2012). Other disasters, not strictly natural, do not appear at all in this work, such as air pollution which is estimated of having caused more than 60,000 deaths in Italy just in 2012 (European Environment Agency 2016).

These dynamics should not be overlooked: if extreme events arising from them appear as a minority in nowadays disasters databases records, relative weights might nevertheless change

significantly in the future. Moreover, one most relevant difference applies: the occurrence of geophysical events might not be controlled, but their impact can be significantly mitigated through anti-seismic interventions realistically feasible in the medium-run (as for hydrological ones). Earthquakes with much higher magnitudes than those registered in Italy occur in many other regions of the world, but generally result in more limited damages thanks to the widespread presence of anti-seismic constructions. On the contrary, regarding climatological and meteorological events, it would be myopic to think in terms of mitigating their impact once they take place, instead of following global-level policies to reduce their anthropogenic causes. The economic impact of climate-related disasters, due to their non-reversible nature and their usually wide extension, could likewise be extremely high, as to their long-term effects on local communities, economic activities, and overall regional growth paths.
In any case, it is unlikely to see expenditures for natural disasters decrease in the following years: although geophysical disasters diminished over the years, their economic impact did not, hydrological ones have been constant for the last two decades and climate-meteorological are rising. In this context, national policy makers should be therefore mindful of the importance of mitigating now, through prevention interventions, the exposure to those disasters that are nowadays more frequent, as the weight of other kinds of events is likely to rise in the future, and so the financial needs to face them.

As learned from this work, natural disasters economics is still, to a large extent, an unexplored field, and it appears to be all the more complex, as economic estimates of shocks impact relate with multiple factors: business cycle phases, nature and timing of public aids, local economic structures, coping capacity and resilience of local communities, just to mention a few. Hence, the research focus is generally driven at a highly detailed level, so as to obtain reliable empirical estimates. It seems nevertheless important not to lose the big picture, to detect not only how disasters impact today, but also how they will evolve in the future, as this work tried to do.

CONCLUSIONS

During the period 1944-2018, Italy was affected by 149 ascertained natural disasters, among which floods accounted for 35% and earthquakes for 25%. The latter were the most mournful, having caused more than seven-thousand deaths over the years. If, at a global level, natural disasters are unquestionably growing, at a national level the evolution appears instead to be more discontinuous and volatile. However, looking at decennial averages, values seem to be attesting at relevantly higher levels than seventy years ago. Some disaster categories, namely climatological and meteorological ones, showed a more sustained growth in the past decades. All these events had an overall weight on public finances estimated at €308 billion (at 2018 prices) from 1946 onward. Italy is the main recipient of the EU Solidarity Fund, having received €2.8 billion from 2002, over total €5.54 allocations from this Fund.

Spending data are driven by the strong incidence of a small share of events: 4.7% of these, all earthquakes, accounted for almost one half of total expenses. Despite this, allocations in anti-seismic prevention are relatively low (€963 million starting from 2009), while total estimated sums necessary to secure buildings in high-risk areas (44% of the Italian territory) would be around €36 billion. This figure is anyhow lower than the estimated €40 billion allocated just for the last three major earthquakes in *Abruzzo (2009)*, *Emilia (2012*) and *Central Italy (2016*).

Reducing the economic exposure to present major disasters (namely earthquakes) through prevention interventions, should be a primary concern for policy makers, as the incidence of climate-related events is constantly growing and might pose in the next decades, not only a significative additional pressure on public finances, but also relevant threats to the socio-economic equilibrium of vast areas of the National territory.

DATSETS REFERENCES

All the datasets elaborated within this work, for a matter of reproducibility of the results obtained, are available for each chapter at the following links:

- *Ch.1*: Natural disasters evolution
  https://drive.google.com/file/d/1y-XN5T2STc37SGM2QMeMaLOvBsG-B-42/view?usp=sharing

- *Ch.2*: Public spending for natural disasters
  https://drive.google.com/file/d/1IqjWUqRCxBl8Gx6t_wAOZEp7IbFaxDwH/view?usp=sharing

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