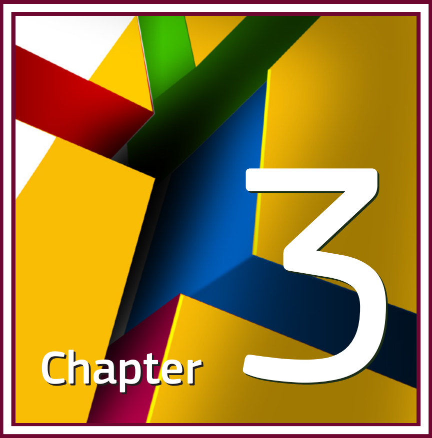

Assets at risk and potential impacts

3.1

Methodologies for disaster impact assessment

Online Version

3.1

Methodologies for disaster impact assessment

CONTENTS

3.1

Methodologies for disaster impact assessment

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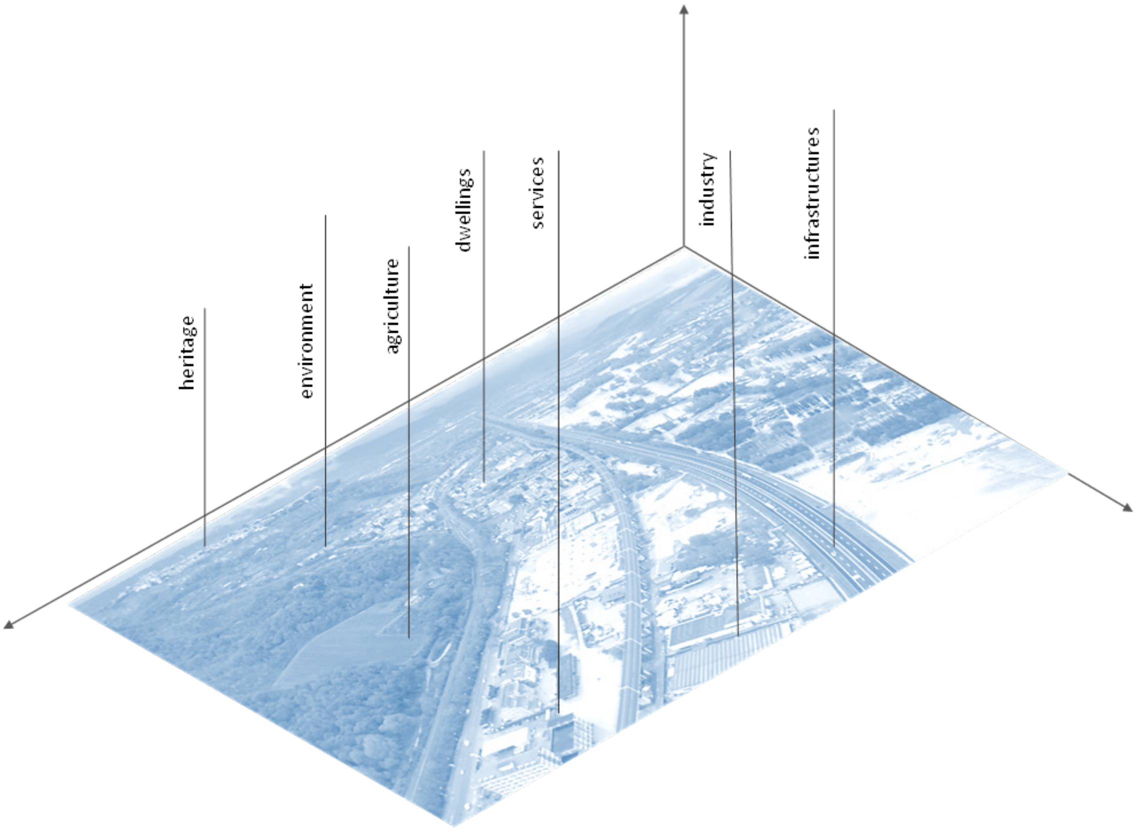
1 Introduction

‘Impact’ derives from the Latin impactus, meaning ‘hit’, and literally it refers to a body breaking into a rigid surface. The term has been widely used in physics, where it preserves its literal meaning, and in environmental sciences in a more metaphorical sense. The relevant branch of environmental impact assessment, which is also the object of a recently amended EU directive (Directive 2014/52/EU), can be recalled here and provides the basis for connecting sustainability to disaster risk reduction and climate change adaptation. In the latter domains, ‘impact’ refers to the consequences an event extreme and/or climate change may have on natural, social, economic and built systems. According to the UN General Assembly (2016) report on terminology prepared for the implementation of the Sendai framework, ‘Disaster impact is the total effect, including negative effects (e.g., economic losses) and positive effects (e.g., economic gains), of a hazardous event or a disaster. The term includes economic, human and environmental impacts, and may include death, injuries, disease and other negative effects on human physical, mental and social well-being' The understanding of disaster impacts has significantly advanced in recent years. For too long they were limited to a few sectors such as residential buildings or agriculture; more recently, research and practice have targeted damage to economic activities, lifelines and services, and cultural heritage in a much more comprehensive way.

Figure 1. *Damage assessment should cover multiple sectors across different temporal and spatial scales.* ***Source****: Authors (1).*



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(1) *Figure developed as part of the Lode project, funded by the Directorate-General for European Civil Protection and Humanitarian Aid Operations (ECHO).*

It is clear now that, to better grasp and understand the real magnitude and extent of a disaster in a given territorial context, impact assessment must address multiple spatial and temporal scales while considering the whole range of sectors that may be affected, taking a systemic approach. For spatial scales, in an interconnected world, the impact is rarely restricted to the area that has been struck physically by the event. For example, the disruption of critical infrastructures may significantly disrupt mobility and strategic services in areas that may be very far away from the centre of the disaster (Mazzocchi et al., 2010; Nanto et al., 2011). For temporal scales, indirect and secondary damage must also be considered, therefore tracing damage that may become manifest some time after the triggering event, and even long-term damage, of which researchers are starting to find evidence (DuPont and Noy, 2015). Such a comprehensive assessment is essential to account for the role that each risk factor, such as hazard, exposure and vulnerability, have played as damage causes and drivers, providing an empirical foundation to choose among alternative risk mitigation measures. As shown by Pesaro et al. (2018), the full consideration of second- and higher-order damage may support much better the claim of a 1:4 or 1:7 ratio between mitigation expenditure and avoided damage in cost–benefit analyses.

2 Definition of damage and losses

Damage is usually related to the physical harm and destruction due to a disaster but it can also be triggered by a chain of cascading effects in time and space, including the effects of the decisions taken to mitigate the effects and facilitate recovery.

In the 2017 disaster science report, a framework was provided building on previous decades of research and studies to define damage and losses due to disasters (Menoni et al., 2017). First, a distinction can be made between damage and losses. The former is generally considered a more comprehensive term, including all sorts of negative consequences, ranging from physical damage to negative consequences for a range of societal sectors, such as interruption of businesses and services, health and psychological effects. Losses, in contrast, more frequently mean negative economic impacts, thus usually measurable in money. Even though such a distinction is not always respected in the literature, a tendency towards this use can be recognised.

For the unit of measurement of damage and losses, an important difference exists between tangible and intangible exposed assets and sectors. Tangible damage can be easily expressed in monetary terms, whereas for intangible damage it is either very difficult or controversial to assign a monetary value. It has been widely debated whether or not a monetary value should be assigned to loss of lives or permanent injuries, even though in principle this is possible using insurance premiums as a reference. For some assets, such as typically natural capital (including air, water and the quality of the latter) assigning a monetary value is hard, given the ‘absence’ of an exchange market. An extensive literature exists in environmental economics debating the possibility and the drawbacks of methods to determine a price for public goods, which include basic assets for human and nature survival. Similarly, determining the value of cultural heritage appears to be controversial, as it incorporates important elements constituting the identity of communities and provides multilayered testimony of past history, the disruption of which cannot be replaced by new or reconstructed artefacts.

A further distinction that is made in the literature regards direct and other types of damage. Direct damage refers to the physical harm and destruction provoked by a hazardous event.

Generally, such damage is relatively easy to link to the characteristics of the impacting phenomena, partly because the time span makes the relationship evident. However, longer-term relationships cannot be excluded: some physical damage may be delayed, for example in the case of flood damage if humidity causes mould, which may in turn affect human health or ruin mechanical and electrical components of machinery, equipment and products. Indirect damage is a very broad category encompassing disruption of normality leading to societal and psychological distress, and business and service interruption, including short- as well as long-term negative effects. Even though the term 'indirect' is still widely used in literature, alternatives exist that are perhaps preferable, as they point more exactly to the time of appearance and the specificities of what and/or who is affected. For example, Rose (2004, p.17) proposed to consider 'second and higher' consequences as a more precise way to refer to secondary short- and long-term damage. In particular, higher-order damage alludes to the fact that consequences such as distress or loss of function of entire systems and services are due to physical damage to one or more critical components either within the same system or even in other systems on which the ones disrupted depend. This leads to the consideration of cascading effects, which are consequences that follow, either temporally or functionally, not necessarily from the initial stress provoked by the hazardous event but more typically from the physical damage the event triggered. In a similar vein, Van der Veen and Logtmeijer (2005) defined systemic vulnerability not as the propensity to physical damage but rather as the inability to cope with the disruption that physical damage produces in components of highly interdependent systems. They were referring to economic systems; however, it has been shown how the concept can be easily extended to all systems (Menoni et al., 2012).

The concept of 'different orders' better accounts for the varied timing of damage, including longer-term negative consequences. In 1992 Di Sopra, studying the Friuli earthquake, raised the issue of longer-term damage, considering both the economic and the social negative effects some communities and municipalities were suffering many years after the earthquake occurred in 1976. Such damage was the consequence of the decisions made after the event, leading, for example, to urban sprawl and underutilisation of the reconstructed built stock. This is an aspect that should not be neglected. Damage is not provoked only by the physical phenomena that triggered a chain of cascading effects, but sometimes is also the consequence of the decisions that were made to mitigate both the physical and the indirect damage. Preventative measures taken before the impact of a hazard, or responses carried out during the emergency, recovery and reconstruction may entail significant costs for communities or for some social groups. This has also been the case in more recent cases in Italy. For example, analysing the market value of reconstructed houses in the L'Aquila region after the 2009 seismic event, Carbonara and Stefano (2019) showed that, despite the indisputable improvement of construction quality, their market value has dropped dramatically. On the one hand, this is due to the intensification of the trend of emigration from some of the reconstructed hamlets and villages and even from the city of L'Aquila. On the other, the focus on physical reconstruction, neglecting other equally if not more important aspects of economic rehabilitation, risks ending up as a remarkable waste of public money invested in the reconstruction. It is necessary to identify "gainers" and "losers" in different spatial scales in the long-term to assess the real effect of the impacts in the long-term.

The examination of longer-term effects introduces an important element to the present discussion on damage, as economists used to state that, in the longer term, losses due to the disaster could be considered negligible or even turned into gains. The latter would be the effect of investment in reconstruction, which brings resources to the area and boosts activities connected mainly with the construction and infrastructure sector. While this proved to be true in many cases, in others more recent research has highlighted that such recovery investment is not always able to restore economy to the pre-event levels (DuPont and Noy, 2015). An interesting comparison can be drawn between the case of Anchorage in Alaska after the 1964 earthquake and that of Kobe after the 1997 quake. In the former, the new port that was almost ready before the disaster was boosted by the need to restart shipping at the expense of the destroyed port of Valdez; in the case of Kobe, DuPont and Noy (2015) were able to demonstrate that, 15 years after the earthquake, the port's activities had not recovered to the full pre-event level. Hallegatte and Dumas (2009) seem to come to the same conclusions when analysing the positive side of disaster impacts. What emerges also from those recent studies is that a very clear spatial-scale standpoint must be adopted, as gainers and losers must be identified making reference to a precise local, regional, national or international level. Other positive impacts derive from lessons learned from the disaster, such as the improvement of building codes and the rebuilt/retrofitted building stock, the establishment or reorganisation of civil protection, or the introduction of better and more stable prevention mechanisms. However, benefiting from the window of opportunity created by the disruption is highly dependent on the capacity and determination of governments and on the social and human capital present in the affected areas. Therefore, the possibility of transforming the losses and disruption caused by the disaster into opportunities for a better recovery depends very much on the resilience of the entire system and on the capacity of decision-makers to take appropriate actions for the shorter and longer terms. This highlights the importance of recovery and reconstruction as crucial phases, as wrong and inappropriate decisions can instead produce longer-term higher-order damage, implying larger costs for the communities than those necessary to rehabilitate the physically disrupted assets.

2.1 Disasters' reported impacts at the European level in existing databases and reports

As declared in the United Nations Office for Disaster Risk Reduction strategic framework 2016–2021, disasters triggered by natural phenomena still claim a significant death toll, affect the well-being of entire communities worldwide and cause extensive economic damage. Losses due to disasters triggered by natural events average USD 250 billion to USD 300 billion each year worldwide. In Europe, causalties are mostly associated with earthquakes and heatwaves, while economic losses and annual numbers of affected people are caused mainly by earthquakes, floods and storms. Disaster occurrences and the reported damage are unevenly distributed across different regions of Europe, partly because of the different geographical distributions of hazards. Since 2006, storms (meteorological) and floods (hydrological) have been the most frequently reported in Europe, with significant differences between regions. Europe has experienced several extreme summer heatwaves in the last few decades. High numbers of fatalities due to heatwaves were recorded in western Europe in 2003, 2006 and 2015.

Overall, weather- and climate-related natural hazards such as heatwaves (climatological) and heavy precipitation (hydrological) have become more frequent and/or intense in Europe (IPCC, 2012; Donat et al., 2013; EEA, 2017a, 2017b). The number of very severe flood events in Europe has varied since 1980, but the economic losses have increased (EEA, 2017b). A total of 13 floods hit Europe in 2018, the second most frequently reported disaster, exceeded only by 15 extreme temperature events recorded in the same year. Floods are more common than they used to be in both eastern and western Europe. Earthquakes and volcanic eruptions (geophysical) occur less frequently by their nature; however, when they occur the impact, especially in terms of human losses, can be very high. Southern Europe is the part most exposed to such phenomena, in particular Greece and Italy (EM-DAT, 2018). Landslides are a natural hazard that causes fatalities and significant economic losses in various parts of Europe (EEA, 2017b). Projected increases in temperature and changes in precipitation patterns are likely to affect rock slope stability conditions and favour increases in the frequency of shallow landslides, especially on European mountains (EEA, 2017b).

Regarding technological disasters, an in-depth analysis of accidents (Directorate-General for Environment, 2017) reported in the Major Accident Reporting System (MARS) database shows that an average of 33 accidents per year occurred in the period under consideration, 2000–2014. Out of 490 reported cases, 421 were major ones. Given the relatively low number of occurrences, no clear downward or upward trend can be recognised.

On natural hazards triggering technological disasters (natech), Krausmann et al. (2017) point out that most studies have focused on earthquakes, because of their potential severe impact on hazardous installations, and on lightning and floods, which are the most frequent triggers of natech incidents in the EU. However, the reality is that in current databases it is very difficult to find a homogeneous, comparable set of data regarding different types of events and their relative impacts. Furthermore, owing to constraints in current methods of classifying hazards and initial events, it is virtually impossible to cluster complex, multi-hazard events, such as natech.

3 Damage data collection and estimation

Damage data collected after an event is initially required to respond to the most direct impacts and to deal with the recovery of it.

Damage data collection is usually carried out by public administrations in charge of emergency and recovery, and by insurance companies, to determine the level of expenditure/compensation that will be required to deal with the initial crisis and the subsequent recovery and reconstruction. Such assessment generally leads to the identification of monetary losses in order to find out what financial resources are needed, be it by insurance companies in the common pools and/or reinsurers, or by the state in ad hoc arrangements that are either fed by pre-allocated funds or redirected from other budget items. Initially damage is assessed through direct surveys of affected assets, buildings and infrastructures. A rapid reconnaissance is made a few hours after the event using various means. In Europe, the Copernicus service offers a first damage map within 6 hours after its activation, with regular updates made to verify and validate initial maps.

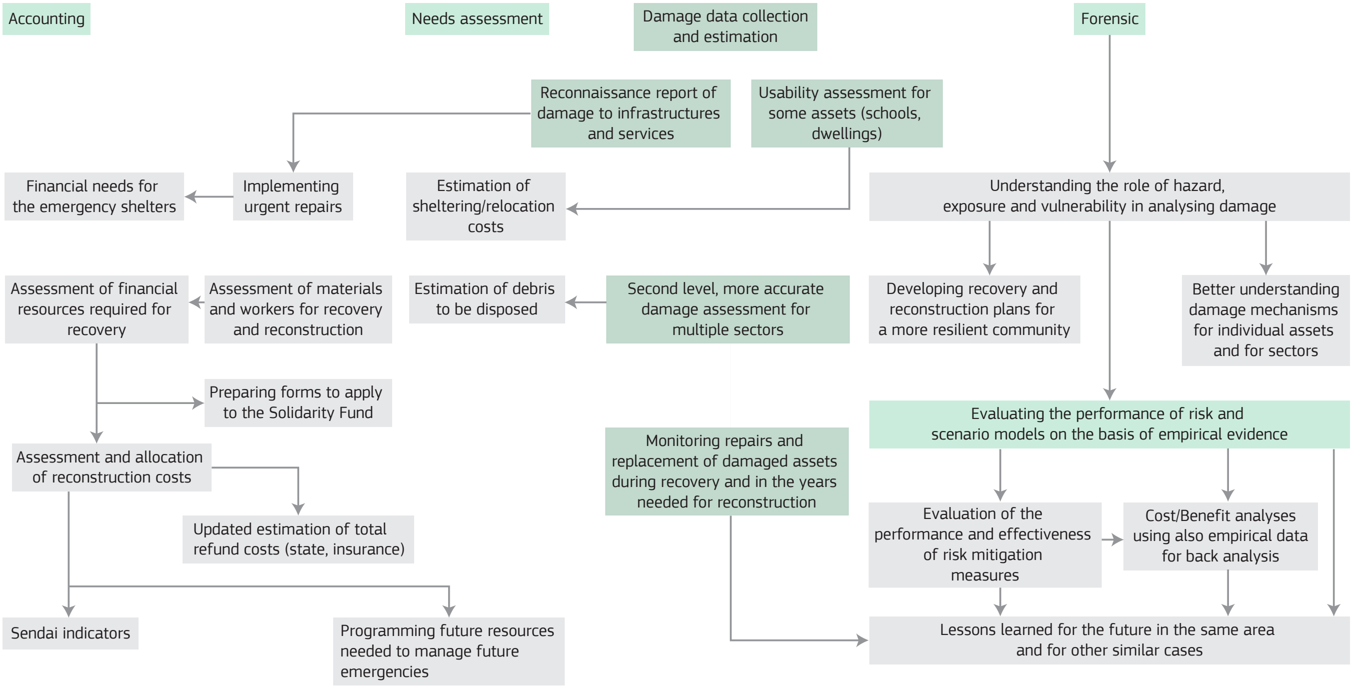
Other means can include maps derived from flights using drones, or field surveys in sampled areas. An activity that is often carried out especially in the aftermath of very destructive events is the assessment of the usability of dwellings, services and infrastructures, to determine their residual level of safety. The immediate uses of such assessment are the closure of access to certain areas, prioritisation of emergency repairs, and relocation and evacuation of affected people. On some occasions in the past, usability data were used also as a basis for determining compensation costs, a practice that should not be encouraged, as the purposes of usability and damage assessments are different. The inappropriate use of usability assessments to calculate costs of reconstruction may result in significant overestimation of financial needs (Boni, 2020). Usability assessments must be on the safe side, telling affected people whether it is safe or not for them to continue living in their houses or to send their children to school. Damage assessment, in contrast, can be carried out at a later stage, without significant liabilities being involved, and can therefore be more accurate in estimating the real costs that repair will entail. Similar considerations led Xue et al. (2011) to develop a rather advanced methodology for assessing earthquake damage suffered by reinforced concrete buildings in Taiwan to fine-tune insurance policies.

3.1 Data uses

Data about damages and losses serve to study the drivers and conditions that lead to disasters, to design models to estimate risk in the future and to learn about the actions taken before the hazard materialized

De Groeve et al. (2013) were the first to our knowledge to discuss the different uses of damage data in a structured and comprehensive way (see also Ehrlich et al., 2017). In a later report, Marín Ferrer et al. (2018) highlighted the value of damage data as the key to supporting informed decision-making and policy implementation at both EU and national levels. In Figure 2 an attempt has been made to correlate the different uses providing a framework to accommodate the rather wide range of applications and situations in which damage data become highly relevant.

Figure 2. *Different uses of damage data for multiple purposes and to support a variety of policies.* ***Source****: Authors.*



Needs assessment

Needs assessments evolve through time along with the disaster phases. Immediate repairs have to be prioritised for those assets, especially critical infrastructures, that are essential to carry out emergency operations and activate first recovery.

An initial assessment of the number of evacuees and services to be relocated derives from initial fast reconnaissance and usability reports. At a later stage, needs assessments encompass a wider range of aspects, including the re-establishment of basic services and the search for appropriate disposal areas for the debris if a large number of artefacts have been destroyed. Such assessments must be updated over time, including on the basis of more accurate damage assessment, permitting one to better establish what can be repaired and what must be totally rebuilt instead. In the framework we have decided to distinguish between needs assessment and financial needs estimation. For example, psychological support for victims and for workers coming from outside the area for the reconstruction must be considered together with the money that will be required to pay their salaries and for repair and reconstruction materials.

Accounting

In the immediate aftermath of a disaster the effort to provide a rough overall estimate of the financial losses associated with the disaster is of paramount importance, especially for insurance companies, which rely for this on their consultants, who are able within a few hours to provide a scenario of expected damage given the hazardous event that has occurred and the exposure and vulnerability of assets. At later stages, such financial estimation becomes more accurate and reliable, as loss adjusters estimate the actual payouts and states are able to get declarations from municipalities and other appointed administrations on the basis of paid invoices. Some countries carry out initial assessment on the basis of parametric coefficients that can be revised later on the basis of the real expenses borne by various private and public entities. At the same time systematic accounting carried out for different sectors is necessary to apply to the Solidarity Fund (2) that supports emergency expenses for public assets and services. In the longer run, keeping multi-sector damage and loss data is essential to compile the indicators in the Sendai framework. As shown by an exercise that has been conducted within the DRMKC for the Catalunya Civil Protection Authority (3), the Sendai indicators require rather accurate management of data not only about direct physical damage but also about second-order damage, such as lifeline outages and business interruption. Last but not least, systematic damage accounting is used by governments to be able to forecast the financial resources to be committed for emergency and recovery management in the future, given the experience of past disasters. This is the reason why countries are required not only to invest in developing and maintaining more advanced and performing databases to record and analyse future losses, but also to gather information regarding past events, going back in time as long as is possible given available reports. An example of this is the catalogue of past floods in Europe managed by the EEA (2018).

Forensic

Forensic investigation in the field of disaster studies encompasses a variety of different approaches, including engineering and geological investigations aimed at supporting judicial cases (Slosson and Shuirman, 1992), failure analyses in technological accidents (Livingston et al., 2001) and analyses carried out by insurance companies such as the post-event review capability (PERC) methodology developed by the Zurich Insurance Company (Venkateswaran et al., 2015). In 2010 the International Research on Disaster Risk (IRDR) (Burton, 2010) launched the Forensic Investigations of Disasters (FORIN) project aimed at providing a broad and comprehensive overview of causes of damage in a disaster. An advanced framework and methodology for identifying drivers and root causes of disaster damage has been developed and applied in Germany on both German and foreign cases by the German Committee for Disaster Reduction (DKKV, 2012). In France the 'Return of experience' reports have been developed with the idea of collecting and preserving crucial information on extreme events in order to develop knowledge regarding the cost of disasters across different economic and societal sectors (Territoriale Méditerranée du Cerema, 2014).

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(2) *https://ec.europa.eu/regional_policy/en/funding/solidarity-fund/*

(3) *See the service delivered to the Catalonia Civil Protection Directorate (https://drmkc.jrc.ec.europa.eu/innovation/SupportSystem).*

The investigation of accidents has a long history, firmly rooted in the aviation industry but not only there, and may count on a significant apparatus for the identification and the analysis of causal links. In the analysis of the causes of an accident, one has to identify the key factors triggering the sequence of failures that led to the 'top event', and their interplay in the specific case given environmental, organisational and cultural settings (Livingston et al., 2001).

The main objective of FORIN is to find out the social and political root causes and drivers, meaning those factors such as poverty, corruption, poor practices and poor enforcement capability that are at the root of the damage suffered during and after severe disasters (Oliver-Smith et al., 2016).

The PERC methodology consists in a thorough analysis of some damaging events as part of the social corporate responsibility mission of the insurance company Zurich, but has inevitably as one of its main objectives to 'develop perspectives on appropriate risk transfer and risk management solutions in flood vulnerable areas, including the pre-requisites for their effective functioning' (Zurich, 2015, p. 15T).

Learning lessons and tacit knowledge elicitation

One important result of disaster forensic is certainly the ability to learn from events, in very detailed terms. Such learning can be used to improve risk models by fine-tuning how hazard, vulnerability and exposure are assessed and measured, and to better understand the disaster's context and implications. Such understanding should lead to the revision of emergency preparedness tools, as was the case for the Joint Research Centre (JRC) Nedies project (Colombo and Vetere Arellano, 2002). Not only short-term emergency mitigation but also long-term structural and non-structural measures can be improved on the basis of the lessons learned. Forensic investigation that has been carried out so far has shown the deficiencies of hazard maps or made it possible to evaluate the effectiveness of mitigation and adaptation measures that were put in place in the past. Such stress testing of mitigation measures in the light of damage that has actually occurred is important to provide an evidence base for cost–benefit analysis, which is usually developed to decide between alternative options. As is widely accepted, though, lessons are only 'identified' and not necessarily learned if they are forgotten or not attended to. In this regard, significant added value could be brought by knowledge management systems as a means to share, co-develop and maintain knowledge in a given field and especially within complex organisations.

Knowledge of disaster impacts, both actual and potential, resides in the minds of those, both organisations and individuals, that have experienced disasters in the past and can connect these experiences to current situations, and even project them into the future. It has been argued that a significant part of organisational knowledge remains in the minds of its members (Wah, 1999); organisations in charge of emergency and recovery are no exception.

It is important therefore to manage this tacit knowledge, as the process of impact assessment itself generates rich learning. Recognition of the importance of tacit knowledge, and subsequently capturing it and converting it into both tacit and explicit knowledge (Nonaka and Teece, 2001), will add richness to the field of risk assessment and management (Dorasamy et al., 2013). In this regard, knowledge management systems could, on the one hand, provide access to structured databases of losses incurred during and after disasters, as is done for example in the JRC Risk Data Hub. They could offer to users a wide range of tools and methods that have been developed to collect post-disaster damage data so that national and regional organisations can initiate their own processes and establish better procedures not only to gather the data but also to use them for the multiple purposes expressed above. On the other hand, such systems can be nurtured by tacit knowledge leading to innovation (Seidler-de Alwis and Hartmann, 2008), which in the disaster data management domain will consist of better procedures, improved understanding of indicators to be analysed and an influx of ideas on how to capitalise on citizens' experience of disasters.

3.2 From forensic analysis to the improvement/validation of risk models

Disaster risk models permit one to assess expected damage due to hazard impact, understood as a function of various variables, i.e. hazard, exposure, vulnerability, coping capacity, etc. Such expected damage can be assessed in qualitative, semi-quantitative or quantitative terms. Expected damage can be forecast as a probability of suffering certain losses given hazard intensity and probability in an area, or deterministically, as an event scenario produced by one event the features of which have been pre-identified (Simmons et al., 2017). Investigation of damage, that is, learning from real damage to assets, has been always a core activity to figure out indicators of vulnerability, especially physical vulnerability of buildings and infrastructures. Direct surveys after earthquakes, volcanic eruptions and floods have made it possible to develop fragility and damage curves correlating construction characteristics, main hazard variables and observed damage (Petrini, 1996; Pistrika et al., 2014; Jenkins et al., 2014).

Insurance companies use risk models that include high-quality data exposure, hazard, vulnerability and risk layers to calculate the insurance premiums for properties. Such models are translated into computer codes, which generate a set of simulations providing estimates of the intensity, magnitude and location of events and determining the amount of damage, before calculating the amount of insured loss as a result of each disaster event. More recently, post-disaster damage data have been used to assess the reliability of such forecasts (Yates, 2009). In order to further improve the reliability of damage estimates, a necessary step to be considered is increasing the transparency of underlying assumptions and adoption also of open source models in the insurance industry together with proprietary ones (Global [Re]insurance, 2013).

In recent years advances have been made in data-driven multi-variable impact models (e.g. Merz et al., 2013; Wagenaar et al., 2017, 2018). In such models the impact is calculated using much more information than just the dominant hazard variable (e.g. water depth or wind speed). For example, for floods this means that, instead of only a depth–damage curve, variables such as waves in the flood water, flow velocity, flood duration, building materials, warning time and the inhabitants' experience of floods are also taken into account. Such improvements enable questions to be addressed that previously could not be adequately answered. In the case of floods, for example, the differences in impact due to inundation duration, waves or warning time can be now be better estimated, providing a larger number of options for evaluating the benefits of measures such as improved building codes, improved warning or complex changes to the hazard (e.g. reduction in waves in the flood water).

New frontiers to extend the possibilities of currently used methods for risk assessment are provided by artificial intelligence and big data, the aim of which is to extract from large datasets and a large number of events data and information that can be organised and structured according to ontologies in such a way as to identify basic constant features and dynamics of disasters in order to be able to forecast what may be the expected impact given triggering phenomena or incidents. However, for the full development of such advanced techniques, major improvements must be achieved in the way post-disaster damage and loss data are collected, stored and organised.

4. Post-disaster impact assessment

To analyse the consequences of a disaster in the after-math of the event, it is necessary to have already in place a system to collect and share data of the event and its impact among different stakeholders, ensuring timely availability and in consistency, accuracy and interoperability among sources.

'Access to information is critical to successful disaster risk management. You cannot manage what you cannot measure' (Margareta Wahlström; United Nations Office for Disaster Risk Reduction, 2012).

To assess the diverse range of impacts on multiple sectors, data related to post-disaster impact should be shared among different stakeholders including governments, various levels of public administrations, private companies, social organisations and academic institutions, also with the aim of creating greater consistency, accuracy and interoperability among different sources. Data from countries, institutions and even the international databanks that already exist lack uniformity in the type of data and how to gather and report them. Currently such data are still fragmented and structured differently, and no authority is in charge of coordinating them, contrary to the recommendation of the EU Expert Working Group on Disaster Damage and Loss Data (2015).

Various initiatives have been promoted to improve the current situation. For example, the IRDR's Data Project aims to establish a general framework for data loss collection and utilisation, promoting a higher level of comparability and compatibility between data from different sources. The Disaster Risk Management Knowledge Centre of the European Commission at the JRC is developing the Risk Data Hub, providing on the one hand information layers that are needed to carry out risk assessments and on the other hand gathering and structuring historic data regarding past events and consequent losses. It also aims to establish harmonised, more standardised procedures at the European level for future improved post-event impact data collection and analysis.

Overall, innovative methods and tools to facilitate post-disaster damage data collection are needed, in order to facilitate and mainstream their use for the various purposes highlighted in Section 3, not only by the same collectors or the coordinating agency, but also by other organisations and administrations that for various reasons would benefit from such data as a way to support a variety of risk mitigation and climate change adaptation policies. For this, tools must include the indicators and data that are relevant to all societal sectors, which undergo different impacts from different events at various spatial and temporal scales.

For spatial scales, computerised systems allow upscaling or downscaling more easily, especially if data are collected at local or asset level. For temporal scales, an important challenge to be met relates to second-order, higher-order and longer-term losses, which tend to be harder to identify and measure. Various approaches are necessary to identify and assess longer term losses, as information is required from economic organisations and associations about business interruption and recovery, and from mental health systems to be able to track post-traumatic disorders in the affected population.

BOX 1.

Available databases and relevant indicators for assessing them

Global databases on disaster impacts

There are currently a number of (more or less) global information systems, such as:

- EM-DAT;
- The National Map (US);
- National Oceanic and Atmospheric Administration (NOAA) Natural Hazards Viewer (US);
- Asia-Pacific Natural Hazards and Vulnerabilities Atlas, Hawaii;
- Swiss Re Worldwide Natural Hazard Atlas CatNet;
- and Munich Re Natural Hazards Assessment Network (NATHAN).

Visual information repositories are also being developed for floods, fires, sandstorms, volcanoes, tropical cyclones and other natural disasters:

- Moderate Resolution Imaging Spectroradiometer (MODIS) Rapid Response system (NASA-US);
- Worldview Snapshots;
- Global Imagery Browse Services (GIBS);
- International Charter on Space and Major Disasters;
- National Aeronautics and Space Administration (NASA) Earth Observatory Natural Event;
- Global Earth Observation System of Systems (GEOSS) that is an international initiative comprising more than 100 countries and even a larger number of organisations;
- NASA Disasters Program;
- European Flood Awareness System;
- European Forest Fires Information System;
- Global Disaster Alerting Coordination System (GDACS);
- Radio Distress-Signalling and Infocommunications (RSOE) Emergency and Disaster Information Service (EDIS) provided by Hungary;
- Global Risk Map.

State and local information sources

An important information source is the databases and inventories supported at state and local levels. Good practices can be found, for example the Slovenian database for post-disaster damage and loss data management. However unfortunately most national databases are not as good and as comprehensive as would be required. Pilot experiences have been supervised in selected countries and cities by the JRC's Disaster Risk Management Knowledge Centre (Antofie et al., 2020).

Databases' accuracy and harmonisation

Accuracy and harmonisation of different datasets are essential, as very often there is no interoperability between various databases. The Inspire 2007/2/EC directive addressed this topic, significant steps forward have been achieved on this topic but gaps are still evident. Advancements can be expected following the 2019 (EU) 2019/1024

Data interpretation

Efficient data classification methods must make it possible to upgrade the data content and features. A good example is offered by the Land Cover Classification provided within the Corine Land cover Inventory.

4.1 Methods of post-disaster impact assessment

Despite the importance of disaster data for a variety of uses, and the fact that for a long time scholars have lamented the poor quality and availability of such data (White, 1945; Hoyt and Langbein, 1955; Pielke, 2000), available tools to collect such data extensively and comprehensively, in accordance with a standardised and structured methodology, are few, only recently released, or not yet fully operational and adopted as agreed standards. In the following, two will be considered, one developed in the field of industrial accidents and the second largely applied by international organisations after natural disasters.

A tool that is of particular relevance has been developed in the field of incidents involving hazardous chemicals (HazMat incidents) named the Flash Environmental Assessment Tool (FEAT) (UNEP/OCHA Joint Unit, 2017). FEAT resulted from the collaboration between practitioners from the United Nations Disaster Assessment and Coordination teams and experts on chemical incidents and risks. FEAT is a swift integrated impact evaluation intended to identify as early as possible the potential consequences of HazMat-induced chemical releases on human health (as a consequence of inhalation of toxic gases or consumption of toxic water sources or food), livelihoods and ecosystems (as a consequence of environmental pollution contaminating livelihoods such as drinking water or resources for fishing).

The first version of the tool, published in 2009, was meant to be used reactively in the aftermath of incidents. The second version of the tool also encompasses a priori evaluations of the risks posed by hazardous installations, so it is used in incident prevention by safe spatial planning (FEAT Preparedness), as well as in a posteriori incident assessment and management (FEAT Response).

Different distances for the various impact endpoints are the most important indicator that is assessed through FEAT, the specific impact distances being derived from scenario analysis, in which chemical incident experts listed hazardous facility types and substances used, environmental chemists derived distance–concentration predictions (as concentrations dilute with distance), and toxicologists and ecotoxicologists calculated the impact assessment at each distance. Different impact distances between hazardous chemicals and the various endpoints are plotted on a situation map, to look at overlays with, for example, population centres and various assets, so that field teams can prioritise and take swift action on the most hazardous chemical flows (followed by all others of relevance later, till all have been managed). On the basis of the mapping, back-office teams deliver provisional key insights, which are summarised as hazard identification tools and inform the field teams and local authorities; the use of FEAT by field teams facilitates prioritization and management of needs.

The post-disaster needs assessment (PDNA) method (GFDRR, 2013; GFDRR, 2017) was developed initially by the United Nations Economic Commission for Latin America and the Caribbean and then improved through the collaboration of several international entities, including the World Health Organization, the Pan American Health Organization, the World Bank, the Inter-American Development Bank, the United Nations Educational, Scientific and Cultural Organization and the International Labour Organization.

The PDNA is composed of two parts – the damage and loss assessment and the needs assessment – and is meant to be adopted in large disasters where international aid is required. Based on the assumption that the necessary basis for prioritising needs is a detailed, comprehensive and multi-sector assessment of damages, the PDNA provides a rather precise methodology in terms of the procedure for conducting surveys, the scale at which they should be carried out and the timing.

The PDNA recommends that damage and loss assessment be conducted at different stages of emergency and recovery: first, immediately in the aftermath of the event, to identify the most critical areas and impacts; then, later, to analyse funding requirements and get a more precise and reliable estimation of both physical damage and financial losses that must be covered for repair and return to normal. Monitoring damage over time is also recommended, to check what has already been accomplished during recovery and reconstruction, what is lagging behind and what has still to be addressed.

The PDNA methodology has been extensively applied in recent disasters, as it has been embedded as part of the intervention protocol shared by the UN, the European Commission and the World Bank, covering events such as Cyclone Nargis in Myanmar in 2008, the Haiti earthquake in 2010, the Nepal earthquake in 2015, the Fogo eruption in 2014–2015 and the floods in Serbia in 2014.

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5 Conclusions and key messages

There are many challenges in collecting disaster loss data. First, data collection may not be seen as a priority in the aftermath of a disaster, especially if strategies and procedures have not been previously established and shared among all stakeholders involved. Second, this type of data must be coordinated among multiple stakeholders such as insurance companies and health services, and even in the government they may be spread across different levels, sectors and ministries to give rise to innovative data governance models.

Policymakers

Decision-makers must become aware that standardisation of methodologies for gathering and presenting disaster loss data are key, as confirmed at the fifth Global Platform for Disaster Risk Reduction in 2017. An effort to promote bottom-up collection and distribution of disaster loss data and a standardised method is warranted, and national governments as well as international organisations should stimulate activities that promote it. This effort should not only aim to collect at least data to fulfil the global targets agreed in the Sendai framework, but, as discussed thoroughly in this subchapter and the next, should provide evidence and an empirical base for implementing European and national policies and strategies in disaster risk reduction and climate change adaptation.

Practitioners

Practitioners, comprising officials of public administrations as well as professionals working for the insurance industry, lifeline management companies and critical infrastructures, would certainly benefit from enhanced damage data collection practices and from sharing and co-developing, through knowledge management systems, knowledge of the impacts of natural extremes and climate change on their assets and systems. Tacit knowledge of methods, and of aspects of damage that may occur in different systems and have been identified in the past, should be implemented in such knowledge management systems to preserve collective memory of best practices and methods.

Scientists

Researchers can contribute greatly to the whole effort of identifying, codifying and developing data models and information systems that are not only usable but also flexible and smart, to allow the maximum added value in terms of empirical evidence acquisition with relatively simple software and relying on what has been learned in the past and in contiguous fields (environmental impact assessment, for example).

Citizens

Increasingly, citizens will be asked to contribute to damage data collection efforts, with self-declaration using online platforms, easing the task of surveyors, and/or through crowdsourcing information through social media, which may provide significant benefits if such efforts are effectively coordinated (Roberts and Doyle, 2017).

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