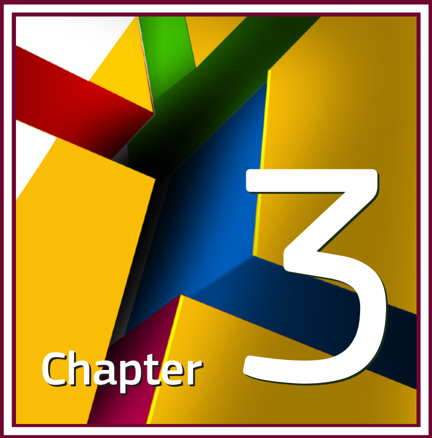

Assets at risk and potential impacts

3.2

Population

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3.2 Population

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3.2 Population

Introduction

Natural and human-made disasters affect and disrupt the lives and livelihoods of people in different ways. This is at the core of the Sendai Framework for Disaster Risk Reduction. The expected outcome of the framework is a 'substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries' (UNISDR, 2015, p. 12). In order to monitor this, the first two targets of the framework address the people killed or affected, because people are the most important asset to protect from risk and disaster. People are the ones we ultimately want to protect from the impact of disasters. As the Sendai Framework states, there are not only the direct and immediate impacts of hazards on people such as death or injury. There are also a number of indirect and long-term impacts on people that may not injure or kill directly, but instead may cause long-term impacts on individuals or entire societies. The impacts of disasters may deprive people of their homes, their livelihoods and impede the functioning of society as a whole.

Consequently, this subchapter will address the population at risk and the potential impacts of disasters on populations by analysing the different dimensions, from the individual to society as a whole. Starting from the individual,

Section 3.2.1 analyses how hazards threaten human lives in Europe, and the wider impacts of disasters on people's health and well-being, considering how different hazards interplay with the effects beyond immediate impacts. This section addresses the relations between the disaster management cycle and hazards causing death, injury or health damage across Europe. The temporal dimension plays a central role here; the speed of hazard onset (quick/slow onset) has to be linked to the duration of effects on humans (short/long term). The section proposes new approaches such as biomonitoring methods and biomarkers for improved assessment of exposure and human health risk; it also addresses the importance of human behaviour and measures of self-protection as factors influencing impacts, illustrating this with the example of the heatwave in Europe in 2003.

Section 3.2.2 enlarges the view from the individual to the immediate habitat of the people – their homes and immediate neighbourhood. It takes the housing/habitat as the asset at risk and analyses the impacts of three different disasters: the Toll Bar flood 2007 in the United Kingdom, the Grenfell Tower fire in 2017 in the United Kingdom and a series of earthquakes in Italy. The primary measure of impact analysed in this section is relocation or displacement of population from their homes. This takes into account the different spatio-temporal scales of displacement. The analysis highlights the importance of hindsight analysis and implementation of the lessons learned.

Section 3.2.3 finally expands the analysis of the impact of disasters to the entire society. By 'society', we refer to all the people that live together, have a common history and cooperate to carry on their lives and pursue fundamental interests. This can be a local society, but also parts of a nation or the entire population of a country or region. Society has a complex structure with uncounted social and economic relationships. The structure of society is dynamic, with many external and internal factors that are constantly changing and developing it. When disasters strike, they also affect societies and may lead to disruption of the way societies function. This section explores the Van earthquake in Turkey (2011) and a toxic cloud after a technical accident in Zevekote (Belgium) in 2017 to review the impacts of different types of disasters at the community/society level based on the results of case studies, to show social reactions to disasters and to better illustrate social patterns and vulnerable groups in society.

3.2.1 Threat to life

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1 Introduction

People are the most important element to protect from risk and disaster, being at the centre of three of the Sendai targets (UNISDR, 2015a). Human exposure to hazards has been increasing in magnitude and complexity as a result of population growth and expansion to hazardous areas (Ehrlich et al., 2018) and is likely to be the main factor inflating disaster risk in the near future (Peduzzi, 2019).

Disasters affect lives and livelihoods in different ways and with diverse intensities. From a social point of view, hazards may negatively affect people beyond those directly exposed to events, such as their families or social circles, or emergency responders. Spatially, even people living far from the damaged sites but having some relationship with affected communities can be affected. On the other hand, people exposed to a particular hazard can be less affected than expected, thanks to their ability to either reduce their vulnerability or increase their coping capacity. From a temporal point of view, besides direct and instantaneous impacts, disasters can also have gradual chronic effects. The latter can remain hidden or be underestimated in the immediate aftermath of events, and surface at a later stage, making it challenging to assess and address them fully.

In recent decades, the systematic collection of disaster-related data has become a crucial concern, with the recognition that comprehensive disaster loss data are essential to inform disaster reduction policies that are based on the impacts of past events and aim to calibrate and validate forecasting models (Faiella et al., 2020). Several international organisations and EU Member States collect information on people killed or injured by a number of severe disasters (De Groeve et al., 2013, 2014). However, data collection on the human impact of disasters is not a legal obligation in EU Member States, at either national or regional scale, and smaller events or those with few victims are generally omitted from statistics. Scientific groups create databases of effects on people for selected areas and events in order to model human behaviour and establish good practices and recommendations to improve safety (Petrucci et al., 2018; 2019).

Whereas data on direct impacts on people – albeit fragmented in space and time – are available, in contrast there is a shortage of data to monitor long-term effects of disasters, especially those related to climate change. In Europe, ongoing environmental and socioeconomic changes may combine to increase vulnerabilities and risk, leading to the creation of scattered risk hotspots (e.g. more frequent and/or intense droughts and heatwaves combined with ageing and depopulation of settlements, increasing the risk and impacts of rural fires).

This section addresses how hazards and vulnerabilities threaten human lives in Europe, and the wider impacts of disasters on people's health and well-being, considering how hazards' characteristics interplay with the effects beyond immediate impacts.

2 The determinants of effects on humans

HolisticHolistic and integrated disaster risk management (DRM) should be tailored to specific types of hazards. Mitigation and prevention of hazards should consider specific human vulnerabilities.

2.1. Characteristics of the hazard

Each type of hazard has different potentially dangerous effects on people. Despite the intrinsic differences between hazard types, the time in which the event develops and its spatial development can vary by orders of magnitude (Figure 1).

The speediness of the event affects the ability to evacuate the affected area. For example, a fluvial flood may allow more time for evacuation than a flash flood. Similarly, a slow-onset landslide may allow time for evacuation, whereas a rockfall develops almost instantaneously, giving no time for early warning, evacuation and protective actions. Figure 2 presents indicators of potential damaging effects on people, sorted according to the type of hazard.

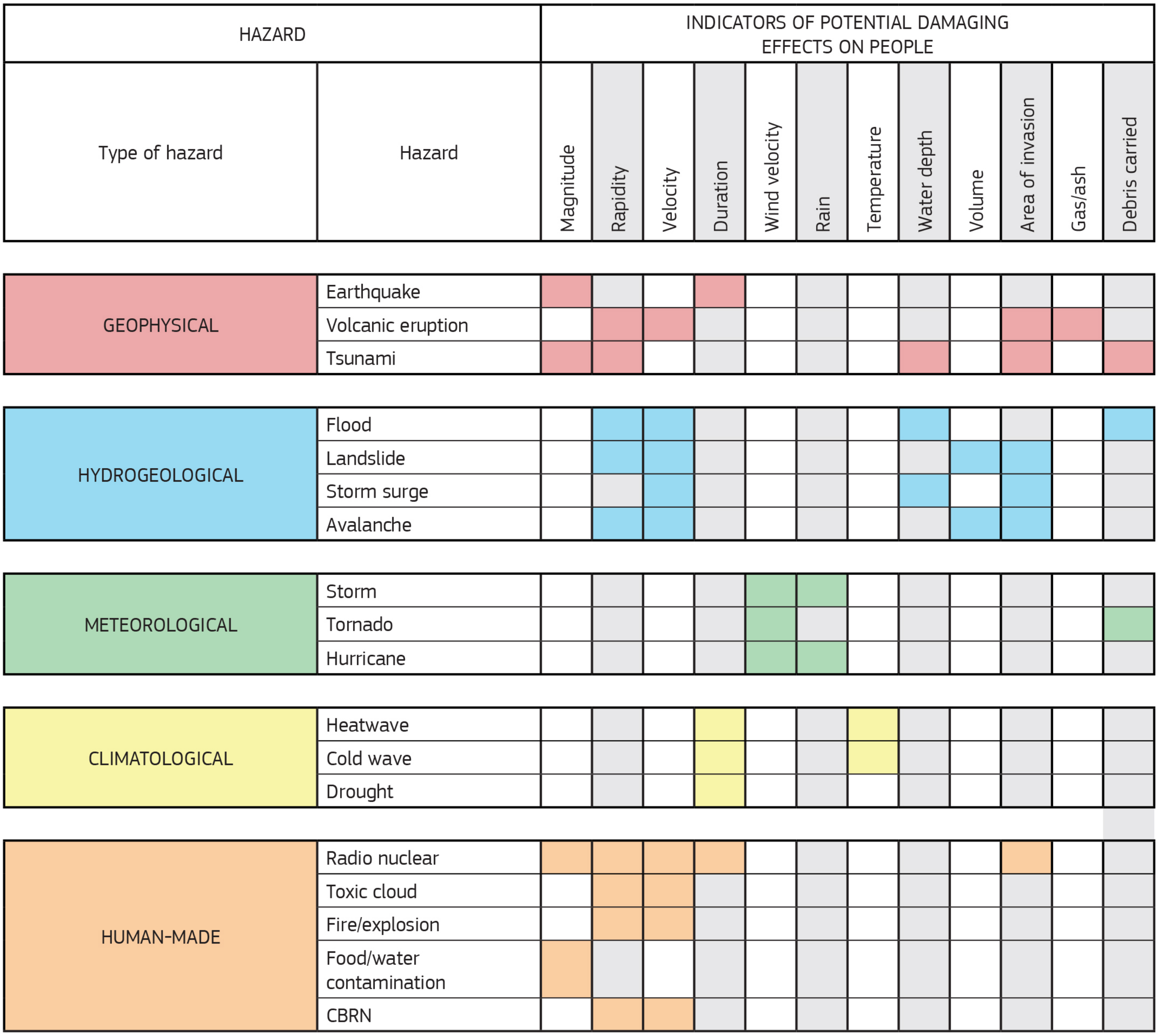
Typically, slow-onset events, such as drought, affect large populations throughout long periods, and the exact beginning and end of the disaster are difficult to identify. In contrast, fast-onset events can affect both small and large numbers of people in a more specific interval of time, ranging from seconds or minutes, in the case of earthquakes, to weeks, in the case of fluvial floods. Nevertheless, there are also hazards lasting for years, such as either bradyseism or large slow-moving landslides characterised by quiescent periods and acceleration phases. Regarding biological risk (included in CBRN - chemical, biological, radiological and nuclear), the rapid spread of infectious diseases into global pandemics has the potential to cause millions of casualties in a relatively short time (months). Disease outbreaks can also arise in the aftermath of, and as result of, other disasters.

In addition to the onset, the effects of hazards are influenced by the intensity or magnitude and duration of the event. For example, the potential harm of a fire to a person depends on both the heat radiation and the duration of the fire. Short fires with low heat radiation have less impact than long-lasting fires with high heat radiation. Similarly, long seismic sequences can have effects on the mental health of people and can strongly affect the quality of life (Catapano et al., 2001).

Figure 1. *Main temporal and spatial characteristics of hazards (CBRN: chemical, biological, radiological and nuclear)* ***Source****: Authors.*

		HAZARD DEVELOPMENT								
		Temporal					Spatial			
Type of hazard	Hazard	Minutes	Hours	Days	Months	Years	Local	Regional	National	Global
GEOPHYSICAL	Earthquake	■	■					■	■	
	Volcanic eruption		■	■	■			■	■	
	Tsunami		■	■				■	■	
HYDROGEOLOGICAL	Flood		■	■			■	■	■	
	Landslide	■	■	■	■	■	■	■		
	Storm surge		■	■			■			
	Avalanche	■	■				■			
METEOROLOGICAL	Storm		■					■		
	Tornado		■					■		
	Hurricane		■	■				■	■	
CLIMATOLOGICAL	Heatwave			■	■			■	■	
	Cold wave			■	■			■	■	
	Drought				■	■		■	■	■
HUMAN-MADE	Radio nuclear	■	■	■	■	■	■	■	■	■
	Toxic cloud	■	■				■	■		
	Fire/explosion	■	■	■			■	■		
	Food/water contamination	■	■	■			■	■		
	CBRN	■	■	■			■	■	■	

Figure 2. *Indicators of potential damaging effects on people sorted according to the type of hazard (CBRN: chemical, biological, radiological and nuclear)* ***Source****: Authors.*



2.2 Exposure and vulnerability

Population vulnerability can be subdivided into direct physical population vulnerability (injuries, deaths and homelessness) and indirect social vulnerability (Van Westen, 2013). For different types of hazards, empirically derived relations of vulnerability exist, although most information is available for earthquakes (Coburn and Spence, 2002; FEMA, 2004). For volcanic hazards, such relations were established by Spence et al. (2005) among others, for landslides by Glade et al. (2005), for drought by Wilhite (2000) and for flooding and windstorms by FEMA (2004) (Van Westen, 2013).

Individual biological or physical capacities, such as the ability to run or tolerate heat, may influence a person's vulnerability to a particular hazard. In addition, individual behaviour can reduce fatalities. For example, respondents who perceive a flood risk as threatening and feel that risk-mitigating options are feasible and useful will engage in risk-mitigating behaviours that may increase their self-protectiveness (Kievik, 2017). On the other hand, people who are not aware of flood risks are more likely to take chances and may have a higher likelihood of becoming victims.

At community level, socioeconomic aspects such as age, income and formal education can indicate individual and social vulnerability (Cutter et al., 2003). Socioeconomic inequalities can lead to different vulnerability and resilience patterns. Moreover, socioeconomic status has also been found to be correlated with exposure to hazards. Hazard-prone areas, for example, are in general characterised by lower land values and, consequently, are occupied by lower-income households (UNISDR, 2015b). In countries where the family, societal and economic roles of males and females are dissimilar, the genders have contrasting mortality rates. An analysis of fatalities from landslides and flooding in Italy, for example, showed that in most age categories males are more vulnerable to floods and landslides (Salvati et al., 2018).

Moreover, risk reduction measures also improve the capacity to deal with hazards. For example, flood risk can decrease through structural measures such as flood retention basins, reducing peak water levels or improvement of levees. Furthermore, non-structural measures such as zoning can also prohibit new developments in flood-prone areas to prevent a further increase in exposure. For slow-onset disasters, e.g. floods in large catchment areas, effective early warning can increase the ability of the people exposed to the imminent flood to evacuate in time, assuming that suitable evacuation routes and/or suitable buildings for a shelter-in-place area are available.

2.3 Classification of disaster impact

The effects of disasters on people can be classified according to severity levels but the boundaries between levels are difficult to define. Except for the most severe effect, death, there is a continuum of severity including injuries of different levels of gravity, more or less serious psychological distress and discomfort of different sorts. The impact of disasters on people can be classified as direct, causing physical harm (death and injury), or as indirect, related to impacts on well-being due to, for example, loss of home and/or job, or health deterioration owing to contamination of air, water, soil and food. Some impacts can be intangible, such as reduced quality of life linked to psychological stress caused by disaster-related losses or by temporary evacuation or relocation.

These types of impacts on people are mostly related to the length of time over which they develop. Direct impacts are immediate and can be quantified by the number of people killed and injured. Such figures are typically available quite soon, after the missing people are found or their deaths are confirmed. Indirect impacts develop on a short/medium temporal scale and their duration depends on the possibility of repairing damage to houses, workplaces and public services, thus restoring the pre-disaster condition.

The duration of intangible impacts can vary from short to long. In worst cases, people forced to undergo changes involving habits, house and work can suffer permanent impacts. Some follow-up studies indicate that first responders may suffer from health effects that may be in part unexplained. In this context, biomonitoring methods and biomarkers allow the assessment of exposure and human health risk. For chemical incidents, guidance was developed in the Netherlands to support the use of human biomonitoring following such events (Scheepers et al., 2011; 2014). More than 200 biomarkers reflecting exposure to more than 150 chemical substances can be measured in blood, urine and exhaled air (Scheepers and Cocker, 2019). The next subsection presents some case studies in which biomonitoring was used.

3 Case studies: gaps and lessons learned

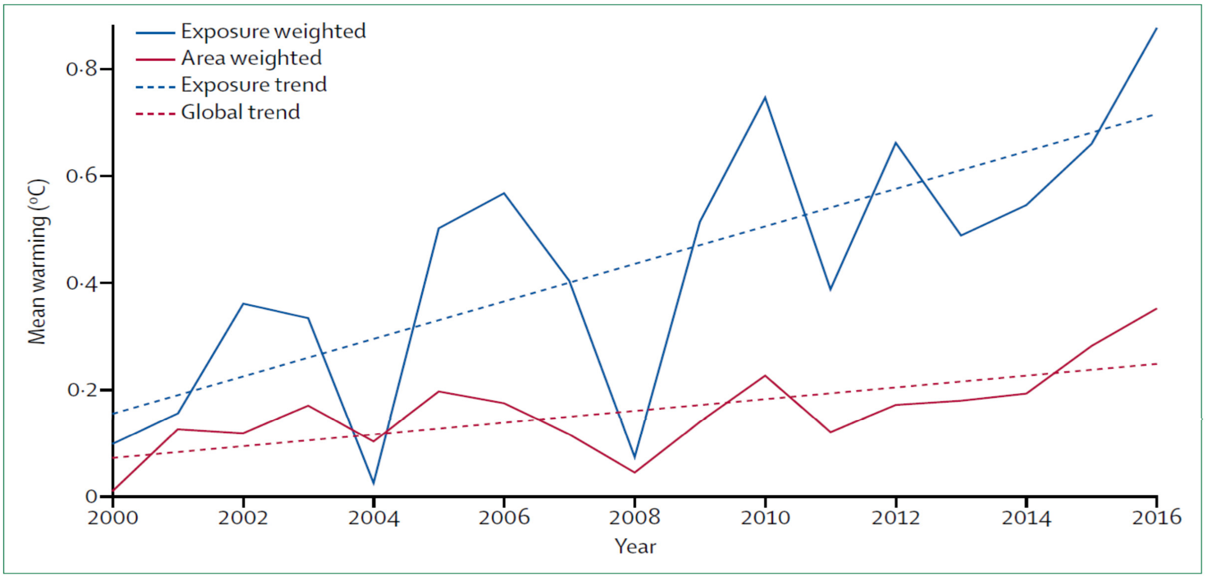
3.1 The 2003 heat wave in Europe

Prevention and mitigation actions should be especially directed at vulnerable population groups. Implementing a targeted heat action plan is the key to reducing human impacts.

Record-breaking temperatures occurred in the summer of 2003 in large parts of western and southern Europe. Temperature anomalies were observed during June and July, with the greatest deviation in June (Black et al., 2004). In the first half of August, temperatures reached a peak and generated unprecedented heat-related health impacts (García-Herrera et al., 2010). The excess deaths throughout Europe during the summer exceeded 70 000 (Robine et al., 2008). This event triggered the introduction of a wide range of adaptation efforts in those countries that were most affected. Studies suggest that, following the 2003 heatwave, several European cities have become less vulnerable to heat-related mortality (De' Donato et al., 2015). How much this is the result of successful adaptation strategies, community awareness and resilience, and how much the result of transient changes in vulnerable groups, is hard to quantify. Since 2003, many European countries have implemented early warning systems for heatwaves (Lowe et al., 2011), and the impact of the heatwave of 2018 created further incentives to improve the capacity to adapt to and mitigate unexpected, excessive heat among the countries of northern Europe as well (Åström et al., 2019). Implementing adaptation and mitigation measures is especially important because the proportion of Europe's population at very high risk of heat stress is expected to increase substantially by 2050 (Rohat et al., 2019). The impacts of the record-breaking temperatures in Europe in 2019, with above 45 °C observed in France, are not yet well understood.

As global temperatures increase, the frequency and intensity of heatwaves will also increase (IPCC, 2013).
The Lancet countdown on health and climate change has found that human exposure to abnormally high temperatures is increasing at a faster rate than the increase in global temperatures (Watts et al., 2018) (Figure 3). Between 2000 and 2016, the average human temperature exposure increased by 0.9 °C, double the overall global average. As populations and urbanisation continue to increase, this trend is likely to continue.

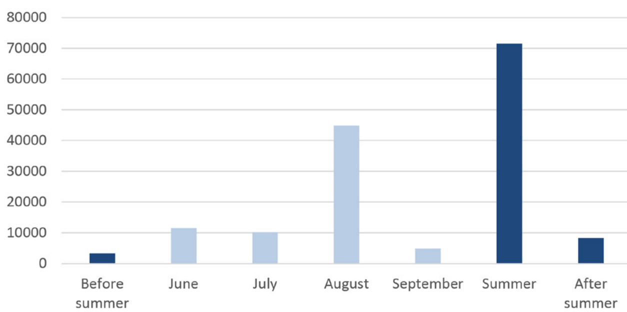
Figure 3. *Population exposure to abnormally high temperatures in response to global warming* ***Source****: Watts et al., 2018.*

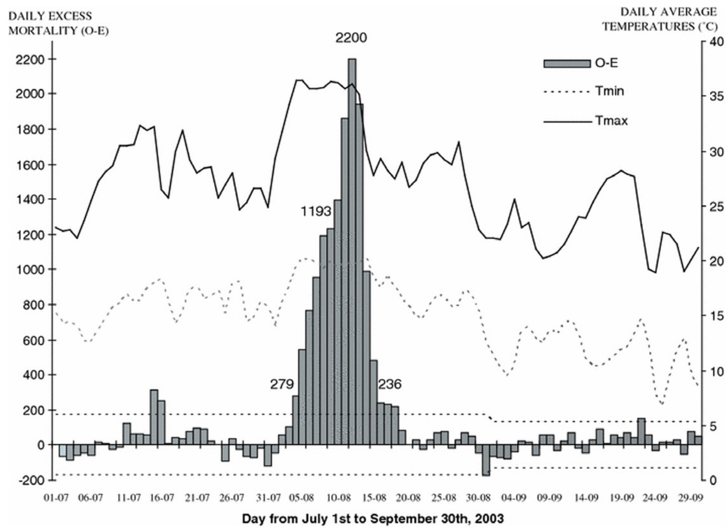


Timeline

The temperature extremes of summer 2003 were the result of the simultaneous occurrence of a range of meteorologically anomalous conditions, including widespread and persistent urban heat islands. This resulted in record-breaking temperatures mainly in southern and central Europe, with the severe health impacts in France, Germany, Portugal, Switzerland and the United Kingdom (García-Herrera et al., 2010). In the countries most affected, mortality increases were observed during June and July and peaked in August (Figure 4 ad 5). Among the 70 000 excess deaths, more than 20 000 occurred before the peak of the heatwave in August (Robine et al., 2008

Figure 4. *Left: excess mortality in Europe during 2003. Right: timelines of excess mortality in France during the 2003 heatwave overlaid with temperature recordings.* ***Source:*** *left, Robine et al., 2008, right Vandentorren et al., 2004.*





In Spain, excess deaths during the summer of 2003 in the 50 provincial capitals have been estimated at 3 166–4 151 (Simón et al., 2005). These cities represent approximately 48 % of the population and, assuming the temperature–mortality relationship is similar in the rest of the country, estimated excess mortality for the entire country would be between 6 596 and 8 648. The excess mortality occurred during June (9 %), July (5 %) and August (17 %). Switzerland experienced an increase of 7 % in mortality for June–August, resulting in 975 excess deaths (Grize et al., 2005).

In France the death toll was the highest among European countries (Vandentorren et al., 2004). There was a small increase in mortality during the middle of July, but the most devastating impacts occurred in the beginning of August. Temperatures increased during the first week of August and remained excessive for an additional week; mortality rapidly increased accordingly, peaking at an excess of 2 200 deaths on 12 August.

These patterns suggest that not only the intensity but also the duration of the heatwave affects the mortality patterns during a heatwave. These results have been found to be consistent with results from later studies. In the Netherlands, the highest temperatures were observed in less-populated regions. This may have resulted in a relatively modest increase in mortality compared with other European countries. Excess mortality was estimated to be between 1 400 and 2 200 for the summer of 2003 (Garssen et al., 2005). In Portugal, the main effects were observed in the first two weeks of August, when excess mortality was estimated to be 37.7 %, resulting in an additional 1 316 deaths for the mainland (Nogueira et al., 2005).

Vulnerable groups

The one common factor according to studies of the excess mortality during the 2003 heatwave is that the greatest impact was on elderly people. Age can act as an effect modifier by itself, but is usually interpreted as a proxy for underlying health conditions that are likely to increase vulnerability during a heatwave. In France a case–control survey was conducted among elderly citizens in four communities in and around Paris, analysing age, sex and residential area (Vandentorren et al., 2006). A number of factors were identified that increased mortality risk during the 2003 heatwave, such as chronic diseases, lack of mobility, lack of thermal insulation, sleeping on the top floor and ambient thermal characteristics of the surrounding area (Vandentorren et al., 2006). Similar results have been presented by studies from varying geographical contexts (Bouchama et al., 2007).

Heat wave action plans

The experience of the heatwave of 2003 motivated several European governments to implement heat action plans to reduce the health impact of heatwaves. No European country had implemented heat action plans prior to the summer of 2003; the first ones appeared in 2007. Unfortunately, inventories on the presence of established warning systems have used different criteria to define what constitutes a heatwave early warning system. Lowe et al. (2011) defined a heatwave warning system by heat-triggered interactions between meteorological institutions and health departments, and identified heat action plans in 12 of 33 European countries present in the study.

Eleven countries identified vulnerable subgroups such as children, elderly people, chronically ill people and people with existing health conditions. A majority of the systems identify in their plans people with obesity, disabilities and cognitive disorders and outdoor workers. Some include strategies related to homelessness, socioeconomic status and social isolation. The World Health Organization (WHO, 2008) has identified eight core elements of a heat action plan:

1. agreement on a lead body (to coordinate a multipurpose collaborative mechanism between bodies and institutions and to direct the response if an emergency occurs),
2. accurate and timely alert systems (heat–health warning systems trigger warnings, determine the threshold for action and communicate the risks),
3. a heat-related health information plan (about what is communicated, to whom and when),
4. a reduction in indoor heat exposure (medium- and short-term strategies; advice on how to keep indoor temperatures low during heat episodes),
5. particular care for vulnerable population groups,
6. preparedness of the health and social care system (staff training and planning, appropriate healthcare and the physical environment),
7. long-term urban planning (to address building design, and energy and transport policies that will ultimately reduce heat exposure),
8. real-time surveillance and evaluation.

Remaining gaps

Most studies investigating the heatwave of 2003 and heat-related health impacts in general focus on mortality. The effects on morbidity are less studied, and the long-term consequences for individuals even less. Even though Vandentorren et al. (2006) found evidence that housing conditions, apartment locations and surrounding thermal environments could play a role in estimating individual vulnerability, such studies face challenges in gathering individual data on these factors. In addition, there is a need to document the cost-effectiveness of interventions to mitigate heat impacts using randomised trials.

3.2 Overview of recent disasters and lessons learned

An example of different event management concerns two accidents that occurred in the Netherlands. In 1992, the crash of an aeroplane carrying apparently hazardous cargo in a densely populated area in Amsterdam caused 43 fatalities. The concerns of survivors were not well addressed and caused ‘toxic fear’ and the occurrence of medically unexplained physical symptoms, both in the local population and among first responders (Boin et al., 2001; Yzermans and Gersons, 2002). In 2000, in the same country, survivors of a fireworks explosion in Enschede received much more attention from authorities. A health surveillance programme was issued (Van Kamp et al., 2019) and the information and advice centre supplied support to survivors and rescuers to address mental health needs (Roorda et al., 2004). Four years later, the incidence of mental health problems among affected residents was still higher than in the general population, whereas rescuers recovered their pre-disaster mental conditions within 18 months (van Kamp et al., 2016). The health surveillance programme indicated that the relocation of residents who lost their homes and a pre-disaster history of psychological problems were the risk factors for post-disaster psychological problems. Affected residents with mental health problems were using healthcare services more often than unaffected residents, showing that this support was necessary.

The benefit of analysing biomarkers in the aftermath of a disaster was demonstrated in a 2003 train crash in Wetteren, Belgium, involving a fire that caused a toxic cloud of smoke and toxic chemicals, including acrylonitrile. Many inhabitants, after staying at home, had symptoms of cyanide intoxication in locations apparently unrelated to the incident. The exposure was caused by contaminated water that had been used to fight the fire and that had exceeded the capacity of water buffer tanks, resulting in toxic gases entering homes from the sewage system. The authorities evacuated these residents and shifted the response capacity to indoor measurements. When they plotted on a map the homes of residents with elevated blood values, it became clear that these were along the main sewage pipe system (De Smedt et al., 2014). Blood analyses for protein adducts of acrylonitrile indicated that some residents who reported to hospitals had very low values, suggesting that their complaints could be related to the incident but not to the primary chemical exposure (Colenbie et al., 2017). Moreover, relatively high blood values were observed in some residents who had not reported to accident and emergency. This mismatch clearly shows that a considerable number of persons with confirmed elevated exposures do not seek support from the healthcare provided. Then, the biomonitoring results did not match with the registries of victims who self-reported to the hospital emergency room (Simons et al., 2016; WHO, 2009). Self-reported health complaints should also be followed up, since they could be related to the incident but stemming from factors other than the exposure to the confirmed chemical emission of acrylonitrile.

These experiences suggest that the use of medical registries combined with questionnaires in the aftermath of a disaster is the most promising form of health surveillance (Korteweg et al., 2010). The authorities should acknowledge the situation of the survivors and address their health-related complaints. The European Human Biomonitoring Initiative (2017–2021) will make information available on the background levels of exposure to many priority substances in the general population of the European Union ([1]). These data can be used for interpreting the outcome of biomonitoring surveys related to chemical incidents.

4. Possible strategies to improve resilience

Designing and implementing hazard-specific action plans improves coping capacity, increases resilience, and reduces human impacts.

Projections show a rapid rise in the death toll due to weather-related disasters in Europe during the 21st century under a scenario of climate and population change (Forzieri et al., 2017). Building disaster-resilient societies, which are prepared for natural disasters and secure themselves against them, should be a common goal in line with the Sendai framework for disaster risk reduction. The most effective strategies to increase the resilience of communities lie in education, teaching individuals how to behave in case of disaster and to avoid risky situations, which can vary depending on the hazard. This goal involves several groups: the scientific community, policymakers, emergency management organisations and citizens. Outside Europe, Japanese society has a long history of good practices of prevention and preparedness for disasters (e.g. earthquakes) taught to children in schools. In the USA, the Federal Emergency Management Agency (FEMA) issues behavioural guidelines for citizens to protect themselves from a wide range of disasters, from floods to hurricanes.

Petrucci et al. (2019) analysed flood mortality in eight countries (Czechia, France, Greece, Israel, Italy, Portugal, Spain and Turkey), where, between 1980 and 2018, 812 floods killed 2 466 people. Flood fatalities were mainly among males, aged between 30 and 64 years. The victims were mainly working-age people, killed most frequently outdoors, and particularly on the roads, when travelling in motor vehicles. In contrast to other age group classes, elderly people are not particularly vulnerable: the few fatalities over 65 years of age were mainly killed indoors, when sleeping. The primary cause of death was drowning and the second was collapse/heart attack, which was detected in all the age classes. Hazardous behaviours, such as fording rivers, were more frequent in males than females. Further data can also be collected on people injured and 'people involved' (not killed or hurt but witnesses of the event) (Aceto et al., 2017; Petrucci et al., 2018), representing people who either managed to keep safe or behaved in a risky manner. Regarding their age, in Calabria (Italy), people involved were younger

([1]) *See www.hbm4eu.eu.*

than people injured or killed, perhaps because of the greater promptness of younger people to react in dangerous situations.

These outcomes can be used to strengthen the strategies aimed at saving people, and to customise warning campaigns according to the local risk features and people's behaviour. The results can improve understanding of the potential impacts of hazards on the population, increasing awareness among both administrators and citizens.

In some types of disasters, lives need to be saved in the initial moments, by alerting the public to an imminent threat. On a small scale, users of a building should learn how to respond to a fire alarm, so they can do so in large-scale incidents. Prior communication of what people must do in a particular scenario makes such signals effective, as does having local communities co-design emergency management plans. There is a shortage of research on how the public responds to the first communications following an emergency.

Television and radio still have a function, but, thanks to the widespread use of mobile phones, text messaging makes it possible to send out alerts tailored to the type of emergency or even brief video messages (Bandera, 2016). These communication technologies have the advantage of reaching persons who would not receive an audio signal, including persons with a hearing disability. An important limitation is that persons would receive this message regardless of their location. To overcome this limitation, the method of cell broadcasting, using radio frequencies in the mobile phone network, is an interesting alternative that has been used for tsunami warnings in Sri Lanka, for earthquake warnings in Pakistan and for general emergency purposes in Israel (Jagtman, 2010; Malik and Cruickshank, 2016).

Research using fictitious messages indicated an increased intention to adopt protective behaviours. Respondents reported increased risk perception, greater self-confidence and greater confidence in the effectiveness of the advice given, and indicated higher credibility/reliability of the sender (Gutteling et al., 2014). Information provided by cell broadcasting was perceived as more complete and reliable, and their responses were less emotional. Additional communication channels, such as websites and social media, can reinforce the resilience of citizens by sharing information and knowledge to a large audience. Having strong national public health systems is critical to build resilience to epidemics.

5 Conclusions and key messages

There remain several challenges to reducing threats to life and the human impacts of disasters. These include the erosion of public attention and support for continued measures beyond the immediate aftermath of events, confidence in official institutions in the context of uncertainty, and conflicts of interest due to concurrent stakeholder roles. This subsection summarises recommended practices and approaches that each stakeholder group should focus on in order to reduce the impacts of those threats.

Policymakers

Policymakers should ensure that complete data on human impacts of disasters (including on spatial and temporal descriptors, and demographics of victims) are collected over the long term and shared openly, by creating legal and technical frameworks, and by promoting information campaigns and training. Such information can increase risk knowledge and awareness, and supports mitigation, preparedness and response to events.

Practitioners

Practitioners must improve the prevention and mitigation of human impacts, focusing on potentially vulnerable and exposed populations. This can be accomplished by identifying specific human vulnerabilities, by better addressing psychological trauma and the mental health of victims and emergency responders, by making use of existing medical registries and questionnaires in DRM, and by biomonitoring people exposed to toxic substances.

Scientists

Scientists should focus on improving modelling of human exposure and vulnerabilities, by considering individual, social and locational aspects, and analysing factors that cause human impacts, including the roles of adaptation and risk awareness. It is also important to improve understanding of complex and cascading disasters, including how their spatio-temporal dynamics determine human losses. These objectives can be aided by DRM practitioners having a better understanding of needs through having a closer involvement in DRM activities beyond risk analysis and assessment.

Citizens

Citizens can contribute by investing in risk knowledge and self-protection, and accepting greater involvement in DRM, e.g. as local safety officers in their communities. Their proactivity can be increased by including personal safety and disaster prevention in school curricula.

3.2.2 Threat to housing and habitat

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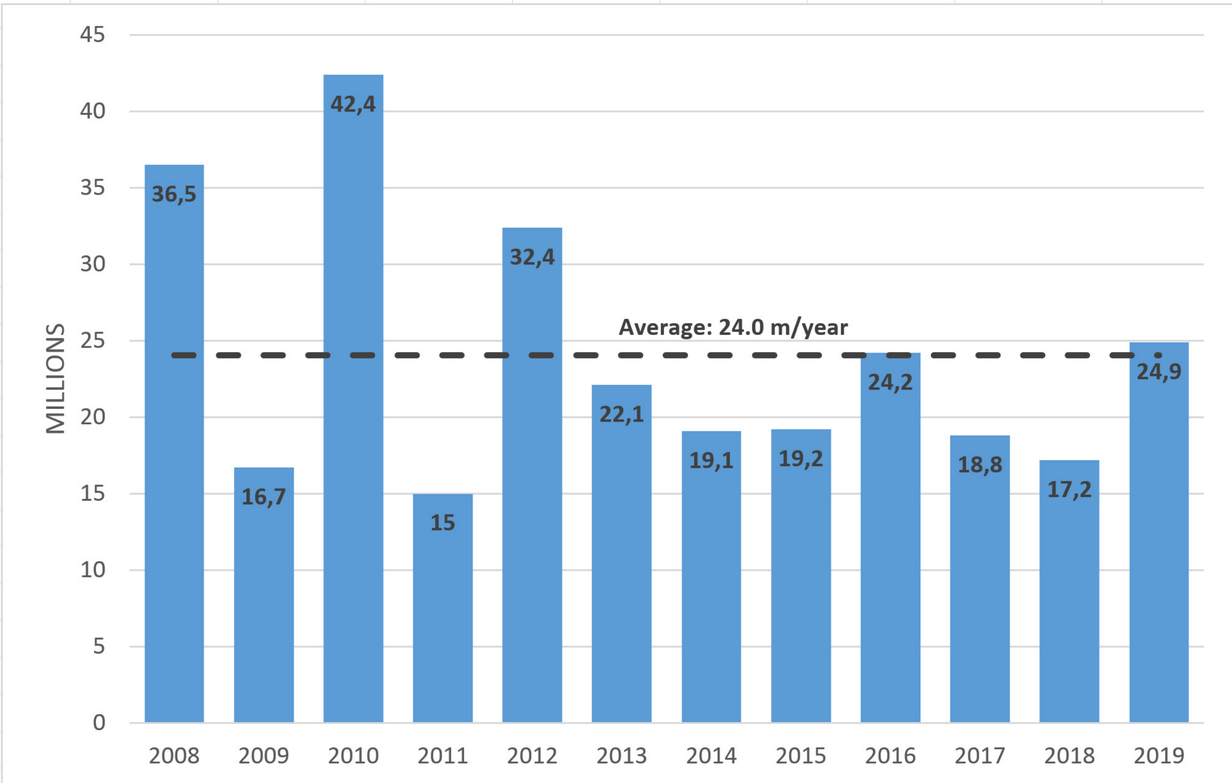
1 Introduction

Natural hazards and human-made disasters influence people's lives considerably. In particular, they can affect people's living environment, from their dwelling (i.e. housing) to the surrounding environment (i.e. habitat) composed of socioeconomic relationships (family, friends, neighbourhood, work, services). The consequences for populations of habitat and housing being under threat are the focus of this section. Population displacement is the primary measure of impact analysed in this section. This displacement works on various spatio-temporal scales, from temporary relocation (i.e. short evacuation) to semi-permanent relocation (i.e. long evacuation) or permanent relocation (i.e. impossibility of returning home). In cases of permanent relocation, post-event habitat conditions could allow people to be rehoused in the same area (e.g. rebuild the damaged or destroyed housing, use other buildings), but sometimes physical conditions (e.g. access limitations in the affected area, failure of basic services) or socioeconomic circumstances (e.g. loss of income/employment or social network, costs of reconstruction) lead people to resettle elsewhere.

Population exposure to natural hazards is constantly increasing (Ehrlich et al., 2018) and, in a scenario of climate change, they are forecast to uproot large numbers of people. Excluding pre-emptive evacuations, displacement due to disasters is a condition that currently affects globally about 24 million people each year (Figure 1; IDMC, 2020), 35 000 of them in EU (IDMC, 2020). Data on people displaced (e.g. number of people homeless, number of people who need their houses to be repaired) are often available after most disasters, as they are collected during response actions and for post-disaster compensation.

Figure 1. *People displacements by year due to disasters. .* ***Source****: Authors, with data from IDMC, 2020. .*



In a given area, the number of people displaced by disasters is a function of (1) hazards occurring (typology and intensity); (2) exposure (people, buildings, infrastructures); (3) vulnerability of assets exposed (including physical and socioeconomic vulnerabilities); and (4) institutional coping capacity. In a particular area, for a given entity of a disaster, building vulnerability influences the degree of displacement, from temporary (lower vulnerability, less damage) to permanent (higher vulnerability, more damage or collapse), while socioeconomic vulnerability could affect building vulnerability (e.g. maintenance) and determine the socioeconomic consequences of a relocation, even a long time after the event. Most people displaced after a disaster, when housing is damaged or destroyed, generally return to the same place to rebuild in the short term (IDMC, 2017), with the result of no reduction in exposure. The reduction of potential future hazard impacts through disaster risk reduction (DRR) strategies, by taking more risk-informed decisions, is the focus of the Sendai framework for disaster risk reduction (UN, 2015), which sets three targets for reduction of impacts on population (A, B and G), and two specific indicators (B-3, B-4) on dwellings. Reducing the number, frequency, intensity and duration of disasters is also an essential component of the 2030 agenda for sustainable development and its thematic agreements (UN, 2016, 2017), with a specific target (11.B) on settlement resilience to disaster.

2. Vulnerability of housing and habitat in relation to hazard conditions

Housing and habitat vulnerabilities determine the levels of spatiotemporal displacement during and after hazardous events and the consequences of displacement.

Housing and habitat vulnerability directly influence the impacts on population affected by hazard events. The capacity of the built environment to safeguard the inhabitants is one of the main factors in a risk assessment. The resistance of structures to natural phenomena (e.g. earthquakes, landslides or floods) or human-made disasters (e.g. dam failures, factory explosions, fires) strongly affects the numbers of people killed, injured and homeless, as well as the capacity of buildings to defend people from extreme events (e.g. heatwaves or intense cold) and the functionality of transport infrastructures and communication networks. Moreover, it could determine the duration of people's displacement after a hazardous event and the consequence on people's lives. The vulnerability of habitat and housing affected by a given hazard can be grouped into physical and socioeconomic conditions. Physical vulnerability is the probability that a group of people (e.g. children, adults, elderly people, people with disabilities) will be affected at a certain level by the consequences of a given hazard on buildings, critical infrastructures and environment. Socioeconomic vulnerability is the result of the interaction between individuals and their environment and/or social structure and its modifications.

2.1 Physical vulnerability

Physical vulnerability of habitat and housing affected by a given hazard means the 'indirect' consequences on people induced by physical damage (e.g. buildings, infrastructures), determining the number of casualties and the magnitude of the displacement of people. In this category it is also possible to include evacuation vulnerability (Cova and Church, 1997) (i.e. the physical conditions of the environment influencing transport in fast-onset events, like wildfires, volcanic eruptions, tsunamis).

Housing and habitat may be vulnerable because of different drivers. First, a fragile physical environment weakens populations in certain contexts (Wisner et al., 2004). When buildings collapse because of an earthquake, causing deaths and damage, the collapse may have various causes: absence of building codes or non-adherence to them, lack of maintenance, or lack of skills and knowledge on the part of workers (Wisner et al., 2004). Non-engineered buildings (i.e. buildings that are built with little or no intervention by engineers, or buildings with specific social or economic obstacles to improving their resilience) are often particularly vulnerable. All over the world, this type of construction suffers much damage when hazards materialise, and this damage tends to lead to a higher number of casualties than the damage to engineered constructions (UNESCO, 2016).

A set of reasons can therefore create a certain level of vulnerability of housing and habitat. Identifying appropriate construction technologies, material and measures that can easily be introduced into the habitat appears therefore crucial (Morrow, 2008; UNESCO, 2016). For more information on direct tangible impacts on residences see 3.3.1. Residential sector, in subchapter 3.3.

In emergency management, the evaluation of the expected number of homeless people and people seeking public shelter is an essential input. The probability that casualties will occur and/or people will be forced to leave their houses can be assessed as a function of the level of damage to buildings and infrastructures caused by a given hazard. In cases of earthquakes and hurricanes, multi-hazard loss estimation methodology assesses displaced persons as a linear consequence of building damage, based directly on damage to the residential occupancy inventory (e.g. Zuccaro and Cacace, 2011). In cases of floods, it assesses the displaced population on the basis of the inundation area, as a function of the depth of flooding at which travel into the area is restricted.

For all hazards, especially in human-made disasters (e.g. ionising radiation, toxic wastes, chemical spills), the number of displaced persons also results from utility losses (water and power). In cases of volcanic eruptions, given the destructiveness and rapidity of the phenomena, the areas potentially affected by pyroclastic flows (red zone) and/or lahar must be evacuated before the start of the phenomenon in question, and the displaced population is assessed on the base of the invasion sector of the flows (Zuccaro and De Gregorio, 2019). The same approach is replicable for some sudden human-made disasters (e.g. nuclear plant failure). Instead, for the areas hit by fallout deposits (depending on the strength and direction of wind), the number of displaced persons can be evaluated on the basis of roof collapses (Spence et al., 2005a,b).

Evacuation vulnerability measures the consequences on population during an evacuation event and it is affected by the whole context (e.g. transport network characteristics, quality of evacuation plans, evacuation behaviour). In cases of pre-emptive or forced evacuations (because of urban fires and wildfires, volcanic eruption, floods, tsunamis, nuclear power plant failure, etc.), urgent displacement can be impeded by limited road infrastructure (Cova et al., 2013) and evacuation behaviour is influenced strongly by perception of hazards and perception of readiness (Lechner and Rouleau, 2019). Increasing investments in early warning systems, models of community evacuation plans and effective evacuation communication can reduce evacuation vulnerability.

2.2 Socioeconomic vulnerability

Socioeconomic vulnerability describes 'the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard' (Wisner et al., 2004: p11). Past events show that the number of displaced persons is much larger than just the occupants of severely affected buildings (Pitilakis et al., 2014) because of households' internal socioeconomic and individual factors (Khazai et al., 2011).

Socioeconomic vulnerability in the context of housing is more than location and mere spatial exposure to hazards. Rather, culture, social structure and everyday practices of communities, developed to fit the place, influence the form of settlements and the design of houses (Oliver-Smith, 1990). Thus, as all aspects of housing have profound social and cultural meanings, 'social space and the character of houses and other structures within it may have profound implications' (Oliver-Smith, 1990: p9) for vulnerability as well.

Places of residence, housing types, DRR and preparedness measures depend on (1) the broader political, economic, social and cultural context (Wisner et al., 2004) and (2) the resources of individuals and households to afford safe housing. Research studies (Zhang and Peacock, 2010; Highfield et al., 2014; Hamideh et al., 2018) show that higher levels of damage can be found in low-income and marginalised communities.

Once a disaster has struck, social vulnerability plays a crucial role in the recovery process (Peacock et al., 2018). Insurance can be the primary funding for repairing and rebuilding housing but its availability and affordability for houseowners discriminate against most vulnerable communities (Brody et al., 2017). Poverty is an important aspect of increased social vulnerability, as it is directly associated with access to resources to cope with the impacts of disasters (Fatemi et al., 2017). For instance, in Chile the 2010 earthquake's impact on housing was greater in the low-income population: 12 % of the population in the poorest quintile experienced major damage to or destruction of housing, compared with 4.6 % in the richest quintile (Larrañaga and Herrera, 2010).

Empirical evidence indicates that people with subsistence incomes are very prone to be trapped in a cycle of poverty, and find their limited resources exhausted in facing repeated or catastrophic disasters (Tselios and Tompkins, 2019). Structural maintenance and mitigation initiatives are often out of reach for low-income households (Burton, 2010). In addition, lack of access to resources (e.g. information, knowledge and technology), limited access to political power and representation, social capital and networks, beliefs and customs, and frail and physically limited individuals (Singh et al., 2014) are factors that can contribute to increasing or reducing vulnerability.

Another important factor identified in the literature is that homeowners and renters have different patterns of social vulnerability in the recovery process, with the latter often recovering slower (Fussell and Harris, 2014). Moreover, as research from the United States shows (Comerio, 1997; Fussell and Harris, 2014; Peacock et al., 2018), disaster recovery polices and schemes can produce social vulnerabilities when unevenly distributed.

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3 Examples of relocation and rehousing

Examples show different ways of managing relocation: the quality of response can mitigate short- and long-term consequences.

Temporary and permanent relocation are presented through various examples: a flood in the village of Toll Barr (United Kingdom), the urban fire at Grenfell Tower (United Kingdom) and recent major earthquakes in central Italy.

3.1 Toll Bar floods, June 2007

In June 2007 large parts of the United Kingdom experienced devastating and unseasonal storms and rainfall. South Yorkshire was one of many areas that experienced severe flooding, and 48 areas of the large borough of Doncaster were affected. In the borough, 3 286 homes were flooded, with 2 275 suffering 'major damage', as defined by the local council (Easthope 2018: p11), which rendered them uninhabitable for many months. Moreover, 283 businesses were affected. There are 41 parishes in Doncaster, with Toll Bar being described as one of the most deprived. At the time of the floods in 2007, there were 440 properties in Toll Bar and 164 were council owned. Toll Bar had a population of 1 084 people. In total, 272 properties, mainly residential, were damaged. Over 52 households, which had resided in council-owned properties, were relocated to a temporary caravan park. Charity organisations and local government worked with the community to support those who had lost all of their personal possessions. As is often the case with flooded homes, the residents could not stay in their original homes until they were made habitable again, as the damage was so severe (Easthope, 2018).

3.2 Grenfell Tower fire, 14 June 2017

The Grenfell Tower fire in North Kensington, on 14 June 2017, was a disaster resulting in significant loss of life, with bereavement, displacement and trauma experienced by many, residents of both Grenfell Tower and the surrounding buildings. Seventy people and a baby in utero died on the night of the fire, and there was a further death from the effects in January 2018 (Strelitz et al., 2018). Their collective connections extend to many thousands of people, living locally, around London and the United Kingdom, and around the world.

The fire resulted in 373 people being made homeless, as the high intensity of the fire rendered the tower unfit for habitation. Families have been relocated across London. The approach taken to relocation involved the use of hotel rooms for over a year followed by a move to either a temporary home or a more permanent solution. People's traumatic experience of the night and bereavement was compounded by the loss of their homes and possessions, and of their community network. Several thousand people in both the tower and surrounding areas have engaged with the mental health support teams in the ongoing aftermath (Strelitz et al., 2018).

Government ministers directly influenced housing policy and were keen that survivors were moved quickly to four- and five-star hotels in the most affluent area of the United Kingdom. This ad hoc approach was fraught with a series of practical and logistical difficulties: survivors had to move regularly and were separated from neighbours and support structures. They were moved when rooms became harder to find as a result of international events such as the Wimbledon tennis tournament.

Suggestions of the creation of temporary villages (possibly in the large royal parks nearby) using high-quality prefabricated cabins, as seen after a number of other recent disasters, proved unpopular. Seven households have been in temporary accommodation for 3 years (Bulman, 2020). Important everyday rituals were impossible. In the area around Grenfell Tower, residents face challenges of low income, poor housing and difficulties in education and the labour market (Strelitz et al., 2018).

The health effects of relocation following a disaster are a growing trope in the disaster literature, and the effects previously described, e.g. physical health deterioration and psychological disorders such as anxiety and depression, continue to feature in this case (Uscher-Pines, 2009).

3.3 Italian major earthquakes, 1976-2017

Italy is a country at high seismic risk, and frequent past earthquakes have had several consequences on people (Table 1).

Table 1. *Most disastrous earthquakes in Italy since 1976.* ***Source****: Authors.*

Region	Year	Maximum magnitudes of events	Buildings rendered unusable	Dead	Injured	Homeless
Friuli	1976	6.5; 6.0; 5.9	48 000	993	3 000	80 000
Irpinia	1980	6.9	360 000	2 900	8 850	280 000
Umbria-Marche	1997	5.7; 6.0	80 000	11	100	40 000
Molise/Puglia	2002	5.7; 5.7	9 400	30	100	12 000
L'Aquila	2009	6.3; 5.5; 5.4	37 650	309	1 600	67 500
Emilia	2012	5.9; 5.4	7 500	27	300	45 000
Central Italy	2016-17	6.0; 5.9; 6.5	90 000	237	365	32 000

The first attempt to plan the management of people displacement was made after the devastating seismic sequence that occurred in the Friuli-Venezia Giulia region in 1976 (Boschi et al., 2000), highlighting the need to organise three different relocation approaches: temporary relocation, semi-permanent relocation and rehousing.

Initially hosted in makeshift camps (railway carriages, tents or caravans), homeless people were moved to more comfortable temporary housing (e.g. resorts near the earthquake areas) after other seismic events. Meanwhile, provisional prefabricated settlement areas were prepared along with the planning of the restoration of buildings that had suffered minor damage. In 5 years, half of the homeless people already had a final settlement.

The 23 November 1980 Irpinia earthquake, which affected over 6 million people, in over 680 municipalities, highlighted serious delays in the Italian state's response to the emergency. In some areas, relief operations started only after 5 days, when it was too late for many (Gizzi et al., 2012). One of the most urgent problems was the accommodation of the homeless, given that makeshift camps were not suitable for the harsh winter conditions.

Based on the experience of Friuli, the families were moved to hotels or second homes located on the Campania and Apulia coasts. In December 1981 almost all the homeless people moved from tents to prefabricated houses. However, many of them (130 000 people) preferred to resettle in other areas of Italy and EU as part of the major emigration that characterised the south of Italy in those years.

The 2009 L'Aquila earthquake occurred in the Abruzzo region. The main shock occurred on 6 April 2009, and its epicentre was near L'Aquila (Di Ludovico et al., 2017a,b). The response of the civil protection system (CP) to this event was very rapid. The same day, about 500 tents were set up and another 500 were under construction. By 19 April, the homeless were housed in 70 hotels (20 000 persons) and 120 tent cities (about 40 000 persons).

In terms of rehousing, some different solutions were set up. In the main city of L'Aquila, a project called Sustainable, Environmentally Friendly and Anti-seismic Complexes (CASE) aimed to provide, in 5–12 months, semi-permanent accommodation built using innovative seismic techniques. One year after the earthquake, about 14.462 relocated residents of L'Aquila were living in the apartments of the CASE project. In the other villages and municipalities (141 different locations), temporary residential emergency modules (MAPs, 4 650 single-storey wooden houses) were built, hosting more than 8.500 people. Another significant measure was the granting of an autonomous accommodation contribution (CAS) to households that chose to provide for their relocation themselves. Today, most of the private reconstruction is complete, but long delays occurred in the historical centre because of the complexity of the reconstruction operations on buildings bounded for historical and artistic interest.

The 2016–2017 central Italy earthquakes, characterised by a sequence of strong shocks (Mw 5-6.5) (see super case study 1), constitute the most recent critical Italian seismic event. The numbers of relocated people in June 2018 (2 years after the main event) were the following: 689 in containers, 488 in temporary evacuation/ accommodation centres, 2 253 in hotels, 38 596 having used CAS, 7.291 in emergency housing solutions and 781 in rural MAPs (MAPRE), which are useful to protect livestock from the harsh winter.

Thanks to the framework agreement for the supply, transport and assembly of emergency housing solutions and related services, the average delivery time was 245 days. More details of that event can be found in the Super Case Study 1 on the earthquakes in Central Italy.

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4 Social consequences of relocation and rehousing

Temporary relocation, rehousing and resettlement have profound psychosocial and social consequences, sometimes reinforcing existing social vulnerabilities.

A body of research after hurricanes in the United States (Abramson et al., 2008; Hori and Schafer, 2010; Patel and Hastak, 2013) documents that rehousing and resettlement are in many cases associated with chronic stress, post-traumatic stress disorders and poor mental health outcomes, as shown for the Grenfell Tower fire.

Even temporary relocation may cause psychological distress and can result in mental disorders or aggravate them (Nitschke et al., 2006; Munro et al., 2017). Depending on the duration, the quality of temporary housing and the severity of mental health effects, people can be affected physically too (Patel and Hastak, 2013).

Social effects of losing housing can be analysed using an extended capital approach (Bourdieu, 1986) that takes into consideration economic, social, cultural and symbolic (social status) capital. The loss of housing translates into the loss of different forms of capital or assets, as reported in Table 2. Already vulnerable groups (e.g. people with disabilities or with specific medical needs) especially may lose vital support networks.

Moreover, the already existing vulnerabilities of people that have lost their housing can redouble if they face additional stigmatisation, as research after the 2004 tsunami shows (Fernando, 2018). All these social consequences often interact with each other (e.g. relocation might result in a loss of social networks, which can also aggravate the loss of economic capital due to reduced business opportunities and so on). Therefore, an overall downward spiral is to be expected among all kinds of capitals and assets, significantly limiting individuals' recovery potential.

Table 2. *Different forms of relocation (temporary, permanent, resettlement) and different forms of capital*
Source: *Authors, based on Hoffman (1999); Nitschke et al. (2006); Levine et al. (2007); Abramson et al. (2008); Hori and Schafer (2010); Peek and Richardson (2010); Lein et al. (2012); Pardee (2012); Patel and Hastak (2013); Forino (2014); Fussel and Harris (2014); Munro et al. (2017); Fernando (2018); Peacock et al. (2018).*

Capital	Temporary relocation	Permanent relocation	Resettlement
Psychological	Distress Mental disorder	Chronic stress Mental disorder Health-related effects	Chronic stress Mental disorder Health-related effects
Economic	Loss of: - income	Loss of: - housing assets - income - government benefits	Loss of: - housing assets - employment - income - government benefits
Social	Temporary disruption of: - social networks - social support and services - primary healthcare	Loss of: - social networks - social support and services - access to primary healthcare providers	Loss of: - social networks - social support and services - access to primary healthcare providers
Cultural	Loss of: - educational continuity - feeling of security	Loss of: - educational continuity - feeling of security - known environment	Loss of: - educational continuity - feeling of security - known environment and culture - knowledge associated with place-based hazards
Symbolic	Social stigmatisation: - being dependent	Social stigmatisation: - living in shelters - being dependent on financial/ - housing support	Social stigmatisation: - being alien - living in shelters - being dependent on financial/housing support

The consequences of hazard events as described can also set free broader sociopolitical dynamics and processes. Relocations, for instance, can result in changes of sociodemographic structure such as the outmigration of certain segments of the population. Other areas, especially host communities, can be affected by the number of people migrating there and 'difference in composition of society, cultural characteristics, and economic conditions. Thus, re-location affects social and economic structures of both regions' (Patel and Hastak, 2013 p.96).

Oliver-Smith (1990), for instance, discusses the effects of urban sprawl as a result of losing housing in a disaster, and aggravated social inequalities due to social stratification in the recovery process. This could become a new cause of social vulnerability in terms of physically vulnerable housing, unsafe living conditions and reduced coping abilities in the future. Furthermore, economic and political repercussions of these social effects can be expected at the different political levels (regional and state). For more information on societal impacts 3.2.3. Threat to society, in this subchapter.

5. Lessons from past events

Decentralised emergency management usually guarantees to reduce the impact on the population, but converting lessons identified to lessons learned is sometimes problematic.

5.1. Toll Barr: successful disaster management

Disaster research from the last 50 years has emphasised the importance of keeping stricken communities in close proximity when relocated (Easthope, 2018). Despite the logistical challenges with this approach, it turned out to be highly effective in Toll Bar: it kept a close community together and followed the advice of a number of charities about avoiding the severance of close local ties after a humanitarian disaster (Easthope, 2018). A further lesson that proved beneficial was the high-standard specification of the caravans, linked to other community centres and with a cabin offering neighbourhood support. Recognising the importance of community ties, and the meaning of a place of safety and something akin to home, allowed people stability and a place to live, granting education and support for children. This contrasted starkly with the long-term use of hotels, where children and their parents noted severe impacts on their well-being (Strelitz et al., 2018).

The heritage and structure of the damaged physical forms that the community had inhabited were also protected; the caravans were placed in the same order as the damaged homes so that neighbours stayed as neighbours, and replica street signs were installed. The caravan park set up in Toll Bar was seen to have worked well and drew on international experiences. Similar successful attempts to keep communities together, albeit on a much larger scale, were replicated in New Zealand in 2011 (MBIE, 2013).

5.2 Grenfell: A failure of hindsight

Despite over a decade of requests to lead government departments to develop a coherent UK post-disaster housing strategy, at the time of the Grenfell Tower fire in 2017 this had still not been developed. The conversion of lessons identified into lessons learned is generally problematic. We quite often know what lessons to learn but, as Donahue and Tuohy (2006) suggest, not how to learn them. For instance, Turner and Pidgeon (1997, p.4) suggest a 'failure of foresight' whereas Toft and Reynolds (2005, p.66) suggest a 'failure of hindsight', which is a significant issue with regard to this event. Research shows other barriers exist: interoperability during response, and those difficulties that occur between responding organisations, from government to emergency services, that are unable to accept their own vulnerabilities, or that debrief without sharing the results with others (Donahue and Tuohy, 2006).

After the 7 July bombings in London in 2007, the UK government initiated the joint emergency services interoperability programme (JESIP) in 2012 in an attempt to deal with these issues and avoid them happening again. Consequently, joint principles, joint decision-making protocols, joint training and joint organisational learning have been put in place. Nevertheless, the same problems are still being experienced (Kerslake, 2017; Moore-Bick, 2019).

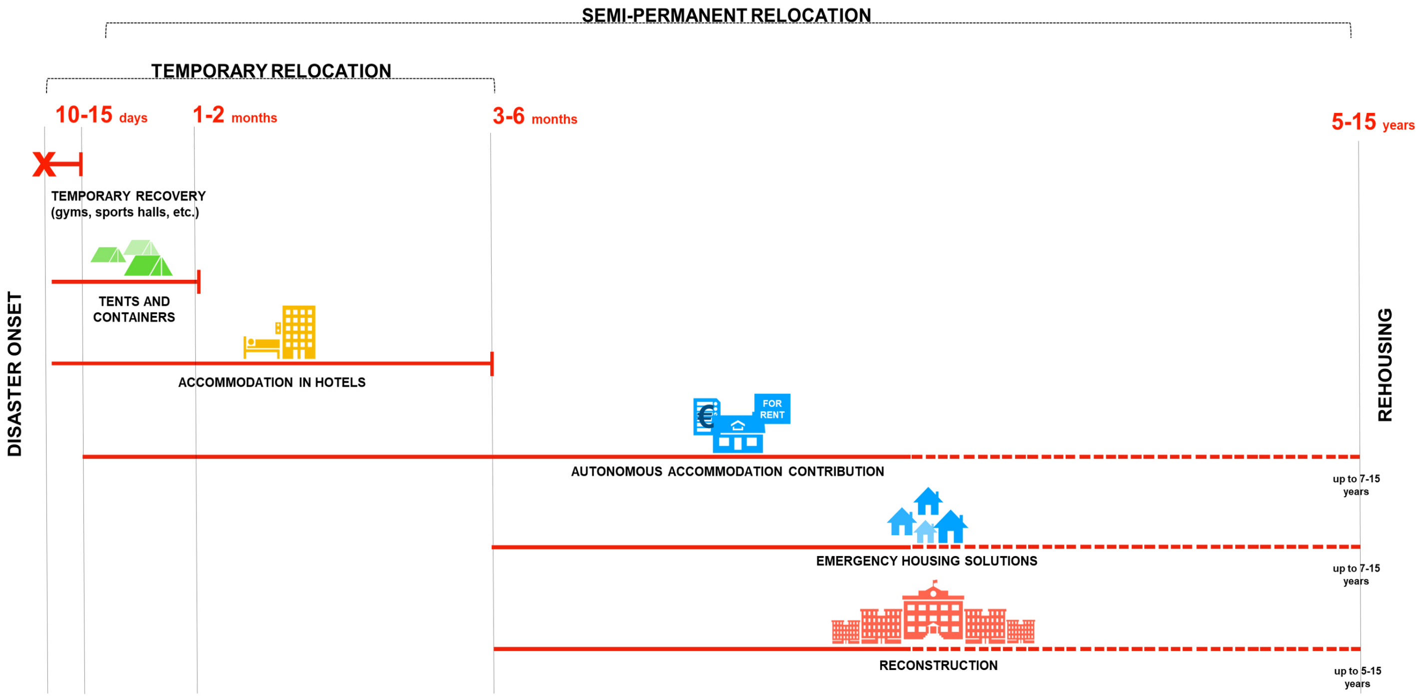
It is becoming increasingly apparent that when the Grenfell Tower fire happened in June 2017 there was neither policy-level nor organisational learning. Yet the signals were already there regarding what could happen. They had been gathered over many years but these lessons were forgotten and not implemented. Being able to pick up on such signals and learn from them is what Toft and Reynolds (2005, p66) refer to as 'isomorphic learning'. Over several decades, from the 1973 fire on the Isle of Man to the 2009 Lakanal House fire in south London, lessons were identified but not acted upon (e.g. the fire risk from external cladding of high-rise buildings was known, but there was no training for the fire service on evacuating such buildings; Moore-Bick, 2019).

This demonstrates a lack of learning by all response organisations, from the government to the emergency services. Indeed, in some cases when recommendations were made they were simply pushed aside until a new disaster happened (Bulman, 2019; Davies et al., 2019). Moreover, problems experienced in London between 2017 and 2019 would suggest that further consideration is needed to manage and mitigate the challenges of post-disaster relocation and specifically the use of hotels. Residents complained of not being able to start any sort of recovery and that the solution was a problem and had not considered their cultural and religious needs. The 'total' loss of personal effects, including all mementos of the lost relative, was a further devastation that is often overlooked in traditional emergency response plans (Easthope, 2018).

5.3 Italian earthquakes: learning from recurrent events

The numerous earthquakes that have occurred in Italy provided valuable lessons on which the current framework for management and planning of seismic emergencies is based. An appropriate model for the management of people displacement has been consolidated over time and, even if not yet structured in a specific law, clearly identifies three relocation steps (Figure 2)

Figure 2. *Timeline of people displacement management in the event of seismic emergencies in Italy* ***Source****: Authors.*



After the Friuli earthquake in 1976, in the early hours of the seismic emergency the displaced people were hosted in temporary accommodation (e.g. gyms, sports halls). Subsequently, the population was housed in tents and/or containers (up to 1 or 2 months) and in hotels (up to 3 or 12 months) closer to the earthquake areas in order to reduce the economic and social unease. Conversely, after the Irpinia earthquake (1980), people were moved to locations very far from the areas hit and many of the inhabitants did not agree to separate themselves from their livestock or from their own land. After the L'Aquila earthquake (2009), the emergency management adopted different solutions: (1) CAS for the families that chose their own temporary relocation using the economic contribution; (2) the MAP (and MAPRE) prefabricated buildings; and (3) the CASE semi-permanent rehousing.

In parallel with the management of housing for displaced persons, the seismic reconstruction phase integrates other crucial aspects deduced from past events.

- Decision decentralisation. Quick reconstruction could be encouraged by decentralising decisions and en trusting responsibility to municipalities, as shown in the 1976 Friuli event. This depends on the capacity of local management and the characteristics and severity of the specific event.

- Emergency technical management. During the major seismic sequence in the Umbria and Marche regions in 1997 (Dolce et al., 1999), the CP tested its organisation, with favourable results and laid the basis of an articulated system of technical management of the emergency for rapid and effective damage assessment and evaluation of the post-earthquake structural safety check, by an ad hoc form, called AEDES (*Agibilità E Danno nell'Emergenza Sismica* - First level form for damage detection, first aid and usability for ordinary buildings in the post-seismic emergency, Papa et al., 2014) through the integration of resources in collaboration with the regions and based on working tools and training programmes for technical operators (researchers and private or public technicians). The structural safety check determines the length of the wait in temporary shelter before returning to one's home. Since 1997, it has constituted the standardised way to produce a database on buildings' seismic damage, available to institutions and researchers, and it is the key for access to private reconstruction funds (Albanese et al., 2019).

- Updating of technical building standards. The most emblematic effect of the 2002 Molise Region earthquake (Maffei and Bazzurro, 2004) is represented by the collapse of a school building in the village of San Giuliano di Puglia: 27 children and 1 teacher died. The tragedy, caused by human negligence, accelerated the reorganisation of Italy's seismic legislation and technical codes for structural design, especially for strategic and relevant buildings. Since then, Italian technical legislation has undergone rapid development through a progressive code aligned with the standards by Italian National Unification (UNI) and the Eurocodes (MIT, 2018).

- Speeding up the recovery of productive activities. The resumption of productive activities is very important for the relaunch of a territory hit by seismic events. The 2012 Emilia earthquake constitutes a positive example. The event was characterised by heavy damage to rural and industrial buildings, with a strong impact on the regional economy (Meroni et al., 2017). For the reconstruction of productive activities (industrial and agricultural), EUR 1.9 billion was granted to fewer than 3 500 approved projects (Emilia Romagna Region, 2019). Eight years later, the productive activities are going better than before the earthquake, thanks to effective policies supporting the growth of economically more resilient activities by stimulating the reconstruction and the seismic adaptation of buildings and by developing projects that encouraged research and innovation. Moreover, this event induced the development of the standardised AEDES procedure applied to industrial buildings, and highlighted the need for internal emergency plans for companies.

- Revitalisation of urban centres. The reconstruction of L'Aquila's historic centre after the 2009 earthquake was rather slow compared with the suburbs, owing to the complexity of the reconstruction work on buildings of great architectural value. Instead, it would have been better to promote the revitalisation of the historical centre immediately, as essential to the civil and social recovery of the city, regardless of its housing function. In this perspective, during the Emilia (2012) and central Italy (2016–2017) earthquakes, specific measures were envisaged for the revitalisation of urban centres, aiming to create new attractive service hubs that could host better functions than those prior to the earthquake

6 Technology and vulnerability

Remote sensing techniques have potential for assessing impacts and reducing vulnerabilities, but the use of all these techniques is still on a small scale

There is a large range of available remote sensing techniques to assess the impacts of disasters and the state and vulnerability of a single building or infrastructure (e.g. Constanzo et al., 2016; Infante et al., 2016; Luzi et al., 2017; Schröter et al., 2018; Gonzalez-Drigo et al., 2019). These techniques, including satellite-, drone- and ground-based sensors, are non-invasive and can be used avoiding social unrest. They can provide valuable information (e.g. building stability, thermal behaviour, humidity, cracks, damage or anomalies) to improve the efficiency of response and reduce cost in the emergency phase (i.e. assessing the damage and losses) and to increase resilience for prevention purposes. The use of these techniques for prevention purposes is still minor compared with the development of new technologies.

Data from the European Ground Motion Service (Copernicus) has encouraged a step forward in the use of satellite data for the whole urban hazard management cycle, allowing continuous assessment of its potential impact. A good example of this is the use of Sentinel-1-based synthetic aperture radar interferometry. Sentinel-1 is an operational satellite constellation that provides useful data for natural hazard risk management and disaster impact assessment. Projects of the Directorate-General for European Civil Protection and Humanitarian Aid Operations (ECHO) such as Safety and U-Geohaz have contributed to the development of procedures that are nowadays used operationally by the CP. In Italy, the regional CPs of Tuscany, Valle d'Aosta and Veneto use these data to continuously assess the activity of ground instabilities and their potential impacts (Raspini et al., 2018; Solari et al., 2020). Europewide, countries as Germany and Norway have implemented nationwide ground motion services for mapping rock slide risks and subsidence of infrastructure. Ground motion services are also close to operation in Denmark and the Netherlands.

The success of these initiatives has been endorsed by the creation of Copernicus, which is an ongoing project aiming to monitor ground displacement at the EU level (EU-GMS Task Force, 2017; Larsen et al., 2020). These initiatives are complemented by others focused on data gathering and sharing, such as the Group on Earth Observation. This group has significantly contributed to making more Earth observation datasets openly accessible and exploitable via the Global Earth Observation System of Systems (GEOSS), a worldwide system aiming to use Earth observation data to improve the lives of citizens and help governments make good, evidence-based decisions. EuroGEO is the EU contribution to GEOSS, with Copernicus as a major element.

7 Conclusions and key messages

Past events have highlighted a lack of awareness among citizens, and a lack of shared and common procedures on post-crisis disaster risk management. The dissemination of a standard protocol related to the impact expected and reducing housing/habitat vulnerability can improve the resilience of housing and habitat. There is a need for common short- and long-term procedures to minimise post-event population disturbances. For example the 'safe village' programme developed in Portugal aims to reduce impacts on population by creating collective shelter during wildfire events. Italy showed how it is possible to consolidate a flexible model, even if it not structured in a single ad hoc regulation, by learning valuable lessons from numerous past events with an effective system of civil protection. On the other hand, the identification of lessons without learning could lead to disasters, as happened in the Grenfell tower fire.

The need to overcome political constraints and the lack of policy/legislative change is urgent, but in some cases political or other factors constrain the ability to redesign policies and to incorporate the required changes. Moreover, all stakeholders should know their roles, as risk is everybody's business. Horizon Europe (the EU's research and innovation framework programme from 2021 to 2027) will incorporate research and innovation missions to increase the effectiveness of funding by pursuing clearly defined targets.

Preparations for Horizon Europe are proceeding, with a cluster on civil security for society planned under Pillar II, Global Challenges and European Industrial Competitiveness, as can be found in the Partial General Approach on Horizon Europe (Council of the European Union, 2019). In addition, Earth and environmental observation, which can inform decisions and actions for the benefit of humankind, is included in two clusters (4 and 6).

The newly available satellites and the development of ground- and drone-based sensors have resulted in a noticeable increase in the use of these techniques for assessing the potential impact of natural hazards in urban areas. The development of new remote sensing techniques has been endorsed by intensive research activity focused on the exploitation of these data for natural hazard risk management and by several initiatives from regional to EU level to exploit this data in a massive way. Initiatives such as GEOSS also contribute to this exploitation, aiming to develop a new generation of measurements and spatial statistics products in support of post-2015 international processes on sustainable and urban development, climate change and DRR.

Policymakers

- Pay greater attention to a systemic approach to risk analysis and emergency management.
- Social and economic policies need to be informed by vulnerability in order to not increase existing vulnerabilities, but rather reduce them.
- Adapt policies according to lessons learned:
    - learning lessons generally means organisational change, and that enduring change needs to address the structure, system and culture of an organisation so that patterns of behaviour can be adjusted;
    - listen to the advice of experts and act upon it;
    - trust is critical to the success of learning, so develop trust relationships with your stakeholders and interested parties;
- Make remote sensing techniques for impact and vulnerability assessment fully operational by promoting among the different actors educational courses, workshops and demonstration exercises.

Practitioners

- Follow professional updating and training in accordance with shared standards.
- Challenge mental models:
  - test 'taken for granted' assumptions;
  - learn from others;
  - use inductive rather than deductive approaches to training;
  - consider cross-training to develop shared mental models for multi-agency teams.
- Relocation should be supported by social assistance, especially for the most vulnerable groups.

Scientists

- Methodological synthesis of the complexity of the problems to provide information (mainly quantitative)
- Focus on past issues and share results:
  - what went wrong or was a mistake and why,
  - develop new models of learning.
- Research needs to take into account the complexity and multifaceted importance of (the loss of) housing.

Citizens

- Be aware of:
  - the hazard in their territory;
  - the vulnerability of their buildings;
  - health and safety rules and evacuation plans.
- Be prepared: have a plan for yourself and family.
- Report safety issues and/or act to reduce them.

3.2.3 Threat to society

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1 Introduction

Thousands of people die every year because of disasters globally; societies suffer social and economic losses. Institutions are d amaged and therefore the social structure becomes unsustainable. In this section, society and institutions will be examined sociologically. Then, vulnerability at the community level will be examined, displaying how disasters affect institutional structures with examples of past disasters. Based on that information, the role of the society in disaster risk management (DRM) will be briefly examined and, in the final part, the effects of disasters on society will be analysed and crucial messages will be given to different segments of society.

2 Society and institutions

Formal institutions have a vital role in ensuring regulations and action to avoid disaster impacts on multiple sectors and services.

Society is a concept used to describe the structured relations and institutions among a large community of people which cannot be reduced to a simple collection or aggregation of individuals (Giddens and Sutton, 2017). According to Maclver and Page (1959), society is "a system of usage and procedures, authority and mutual aid, of many groupings and divisions, of controls of human behaviour and of liberties. Society involves the whole gamut of relations. It is structural and functional arrangement. From structural point of view it concerns role, status, norms, values, institutions.

In addition, society is described as a network of organisations and connections that are formed by a large number of people who interact to address their needs and share a common culture. This network of connections has to act by means of the institutions it composes. In this context, each member of society has a basic relationship with institutions and also has to playa part, abiding by social rules. Institutions are the basic mechanisms that ensure the continuity of society. Besides designing its inner arrangements, they also manage its external interactions. Commonly, the word 'institutions' refers to schools, hospitals or public enterprises. Sociologically, however, an institution is not only a special place with specific physical features. In broad terms, an institution is a social unit dealing with social problems and requirements in the economic, social and cultural fields. Conceptually, institutions, is described as rules and standards aiming to satisfy social needs as a whole,have links among them in an organized manner, and also have permanent values (Türkkahraman, 2009).

Disasters are events that influence social life and institutional structure in societies. Hazards of natural or human-made origin cause damage to the social structure and lead to disruption of institutions, property and the environment (Akyel, 2007). The role of institutions in DRM is to reduce uncertainty for people in cases where there are many different economic, social and environmental variables (Raschky, 2008). Moreover, institutions lend support for people to deal with an issue or need when they cannot overcome it alone, to an acceptable level of satisfaction and in less time, with less effort. Continuity, stability and harmony in society are achieved only through social institutions. Institutions constrain and limit human behaviour in line with the standard functioning of society and optimum expectations (Türkkahraman, 2009).

Institutions are grouped in three classes by Giddens (1984): legal, economic and political. These groups also include subsectors such as family, religion, politics, the economy, health, education, science, law, civil society, mass media, transport, energy, food, water, land use, and environmental regulation and protection. In this framework, the main aim of this section is to display the various impacts of disasters on society and to detect possible degeneration in social structures. The key question is: "how do disasters affect society and institutions?" Two case studies, the Van earthquake in 2011 and the Belgian nitric acid leak in 2017, are used in order to find answers to this question.

3 Vulnerability of society

The socio-economic and environmental situation of a society before the disaster determines the potential consequences of the event.

Vulnerability is described in the general literature as a condition that determines the characteristics and situations of a person or group that affect their ability to cope, to resist and to recover from a natural hazard (Oliver-Smith, 1994; Weichselgartner, 2001; Cutter et al., 2003; Wisner et al., 2004; Adger, 2006; IPCC, 2014).

If the issue of vulnerability is addressed at the societal level, it is essential to consider many agents. Donner and Rodríguez (2011) underline in their study that population increase, urbanisation and lack of settlement and infrastructure in disaster risk areas increase vulnerability. In addition, they emphasise that the proportions of poor people, migrants, women, children, people with disabilities and elderly people in society are factors that increase social vulnerability.

The Natural Disaster Report of the Centre for Research on the Epidemiology of Disasters (CRED) (2018) illustrates that aggregated losses in lower-income countries will inevitably remain below those in higher-income countries, because of lower asset values. The costs in human and financial terms can, however, be enormous at the household and community levels, especially when damaged or destroyed property is uninsured. Lost crops and damaged agricultural land also have the hardest impact on the poorest, with long-term consequences. Similarly, Raschky (2008) illustrates that economic growth is an important factor in determining the vulnerability of institutions, and higher-income countries experience a lower death toll from disasters. In other words the mortality rate is lower in societies that have strong institutional structures,because institutions play an important role in preparation for disasters, prevention of them and protection of society against their effects. He also remarks that there is a non-linear relationship between disaster losses and economic development.

To sum up, there are many factors influencing vulnerability of countries,such as population ratio, geographical location, economic conditions and disaster risks. Therefore, a multi-factor evaluation is essential to illustrate countries' vulnerability.

4 Impacts of disasters

Disasters, whether they arise from natural hazards or are of human-made origin, hit social structures and lead to damage to assets. Disaster impacts are not only physical; they have social, economic and political dimensions. Since disasters potentially influence all of us and occur frequently, it is important to understand their complex forces from every perspective in depth. A primary stage of DRM is to understand the conditions of disasters and examine their impact. This subsection investigates how disasters harm the institutional structures of the society physically, politically, socially and economically.

Disaster risk cannot significantly reduce unless the impacts on society are fully understood scientifically.

According to the Emergency Events Database, a total of 23 704 natural or human-made disasters occurred between 1900 and 2017 globally. Approximately 40 million people died. However, Table 1 showsthat, although more disasters occurred in the Americas than in Europe, and the economic losses were higher, the mortality rate was lower.In addition, the rates of economic losses in Asia and the Americas appear very similar, but the mortality rate was disproportionately low in the Americas. In short, we can say that disasters do not cause the same results in every society. Some societiessuffermore than others, being deeply affected.

***Table 1**. Disasters' total effects worldwide, 1900–2017* ***Source**: EM-DAT, n.d.*

Continent	Occurrence	Total deaths	Injured	Damaged people	Homeless	Total affected	Total damage (1 000 USD)
Africa	4 881	1 498 567	470 766	544 266 429	9 649 874	554 387 069	35 770 093
Americas	5 197	893 757	3 179 794	413 872 512	12 426 131	429 478 437	1 458 288 554
Asia	9 874	27 016 807	5 350 323	6 837 443 687	149 486 584	6 992 280 594	1 480 081 715
Europe	3 008	9 209 146	179 306	65 265 086	3 574 533	69 018 925	413 427 640
Oceania	744	21 765	19 328	25 478 923	470 565	25 968 816	90 766 908

4.1 Physical Impact

Disasters can cause deaths and injuries to people, and also strike buildings, facilities and infrastructure. In 2018, globally 315 natural disasters happened and USD 131.7 billion in economic losses resulted. Between 2008 and 2017, an average of 348 natural disasters occurred each year, with an average economic loss of USD 166 billion per year (CRED, 2019). At the individual level, the major damage is loss of life, injury or damage to house or property. If the issue is addressed at the social level, impacts are more widespread and should be considered regionally, such as by neighbourhood or district, or on a sectoral basis, such as public facilities, energy, roads, communication, water, food, transport and health.

4.2 Critical Infrastructures

Infrastructures are designed to satisfy the basic needs of people and guarantee to sustain cities and social life in regular order. Factors such as wars, disasters or migration lead to failures in and destruction of these infrastructures, endangering the progress of society. Therefore, the resilience of cities should be the main interest in the planning stage of DRM. In addition, the Sustainable Development Goals (SDGs) indicate the importance of building and managing urban areas to achieve sustainable development.Theyalso state that infrastructure investment and innovation is the critical driving force of economic growth and development. In order to make cities safe and sustainable, countries should aim to improve safe and accessible cities and infrastructures (United Nations, 2016). In developed countries, economic damage is typically covered by restructuring, insurance company payments and the financing of national government investments and payments. Restoration of infrastructures is vital for business to re-open and recover after an event. In this way, the infrastructure can be quickly replaced by the national government (Luke, 2011).

Infrastructure systems provide citizens with services such as energy, potable water, sewage, transport and communication. Continuity of infrastructure systems is extremely important in disasters because they influence recovery in all parts of a country, including businesses (Chang and Rose, 2011). Infrastructure services are so rooted in modern life that they tend to be wide spread everywhere, so the damage may be often disproportionately extensive.

Nowadays, damage to systems – especially electricity, potable water and sewage – may be the main reason for people to move from cities after a disaster materialises. Even if housing survives storms, earthquakes or other hazards, without services a place becomes uninhabitable. It is important to emphasise that these systems are not only vital for people and businesses, but also a significant input to other infrastructure systems (Chang, 2016). In general, degradation in infrastructure services may be greater than predicted,so the restoration process may take a long time, depending on the magnitude of the disaster. During this period, communities may overreact to this circumstance when responding to the local authority or municipality in the short term. However, long-term disruptions may result in more extensive social consequences; many people may escape or migrate from the disaster zone.

For example, the Marmara earthquake in 1999 damaged 490 km of power lines, 60 km of highway, potable water and sewage infrastructure, 25 schools and some health facilities (Aktürk and Albeni, 2002). In the Gölcük district, the epicentre, approximately 25 000 people migrated from the region because of the catastrophe and lack of services (Südaş, 2004).

Similarly, Hurricane Katrina,a natural result of climate change, displaced an estimated 645 000 people in Louisiana and 66 000 people in Mississippi (US Census Bureau, 2015). Table 2 shows that exchanges in some sectors in Louisiana and Mississippi within a year period. In general, bussiness numbers experience a downward trend in all sectors between 2005-2006 except building.

Table 2: *Damage from Hurricane Katrina in Louisiana and Mississippi, by sector.* ***Source****: adapted from US Census Bureau data, 2015.*

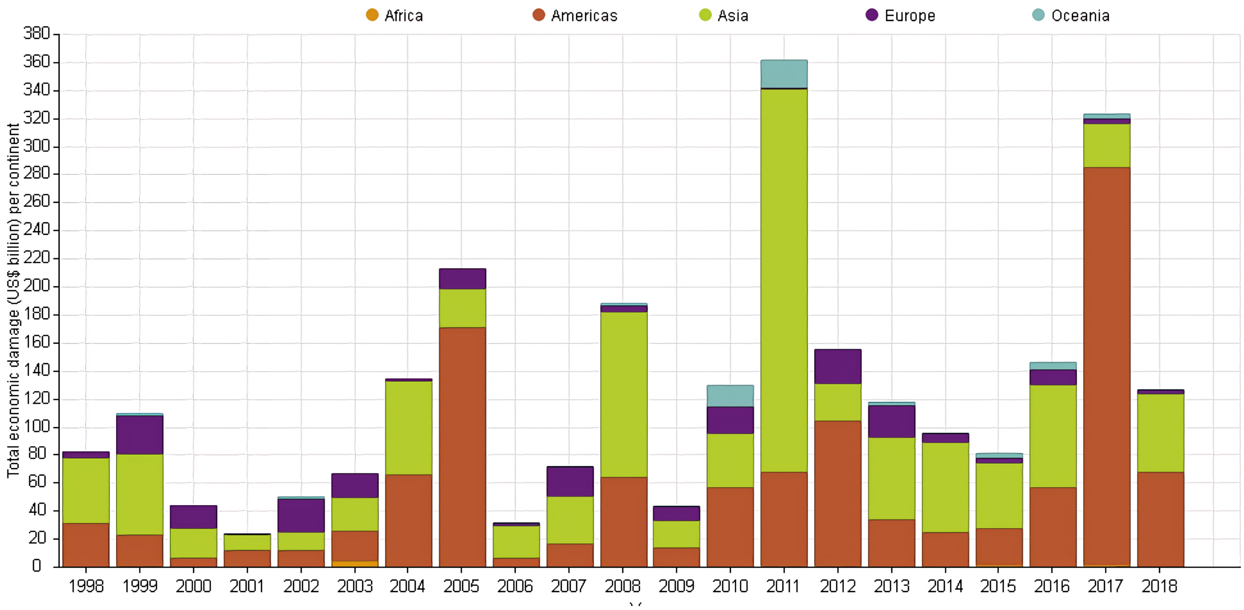
Sectors	Louisiana		Missisipi	
	2005	2006	2005	2006
Grocery stores	573	430	71	62
Gasoline stations	447	407	194	164
Pharmacies and drug stores	221	165	105	72
Hotels	259	227	259	227
Restaurants and eating places	2 138	1 860	547	471
Residential building construction establishments	535	652	156	201
Nonresidential building construction establishments	189	220	38	48
Highway, street and bridge construction establishments	28	26	16	21

In sum, disasters are severe and costly, and particularly damaging to cities. In terms of sustainability, it is vital to protect the social fabric. The Sendai framework for disaster risk reduction (2015–2030) prioritises the local and national levels for the identification of risks to public services and vital infrastructures, and the allocation of resources to strengthen them, and it emphasisesthe importance of doing better (United Nations Office for Disaster Risk Reduction, 2015).

4.3 Economic Impacts

Disasters do not just strike society physically; they can also resultin economic troubles for countries. The Centre for Research on the Epidemiology of Disasters (CRED and UNISDR, 2018) reported that countries were exposed to multiple disasters between 1998 and 2017 worldwide, and recorded the volume of economic damage as USD 2 908 billion. In addition, Figure 1 shows the distribution of economic loss by continents in detail between 1998-2018. The report also stresses that, although fewer disasters had happened in the United States in the previous 20 years, the economic damage totalled USD 945 billion, more than in China (CRED and UNISDR, 2018). So having more financial assets or value, which are mostly destructible, can lead to more economic damage. Botzen et al. (2019) conclude that economic and population growth have been the key driver increase in direct losses due to natural hazards, although studies with longer time-spams would provide more light to measure the economic effects of disasters due to natural hazards in the long-term.

Figure 1. *Global economic loss ratio 1998-2018* ***Source****: EM-DAT, n.d.*



Raschky (2008) highlighted that economic growth is an important factor determining vulnerable areas. In particular, disasters cause less mortality in high-income countries. Moreover, it is noted that economic growth means good protection against natural hazards, but the connection between them is not linear.

Major disasters can have devastating consequences immediately. The type of event, its magnitude and extend can cause varied and important changes in the economy of the place (Chang and Rose, 2012; Panwar and Sen, 2019). In addition, when they occur frequently, they can have negative consequences in reducing economic growth and increasing poverty in the long term (Benson and Clay, 2004). Actually, Chang and Rose (2012) indicate that pre-disaster trends, in terms of economic growth, are often accelerated, exacerbated or intensified during recovery, highlighting the importance of the pre-disaster state for understanding the effects of the disaster on the economy of the place. In terms of climate-related disaster losses per income group compared to GDP losses 1998-2017, while high income countries reported US$ 1,432 billion in climate-related disaster losses, or 65% of the global total, that only represented 0.41% of their gross domestic product (GDP). The US$ 21 billion in climate-related disaster losses recorded by low income countries amounted to an average of 1.8% of their group (1) GDP (CRED and UNISDR, 2018).

On the other hand, disasters can influence the labour market indirectly. Usually, it is expected that there must be shrinkage in terms of the labour market when disasters strike the business sector. However, in the examples studied in this section, we can observe unusual results. There is no great difference in employment rate before and after the Van earthquake of 2011 in Turkey (Kalaycıoğlu et al., 2015). Although the unemployment rate was 43.4 % in 2011, a year after the earthquake it decreased to 42 % (AFAD, 2014). The decrease in unemployment is attributable to some victims migrating from the region, and another key factor is supportive policies for the workforce. Another example is among the evacuees due to Hurricane Katrina in 2005; the unemployment rate was 30.6 % for people who left the disaster area and resettled elsewhere while this figure was of 6 % among the evacuated that had returned to their home (Groenand and Polivka, 2008).

Finally, if we look at the agricultural sector, the report on the impact of disasters on agriculture and food security by the Food and Agriculture Organization of the United Nations (FAO, 2015) remarked that, between 2003 and 2013, 140 major catastrophes in developing countries caused the loss of crop and animal production worth a total of USD 80 billion. This loss of 83 % of Gross domestic product (GDP) was a result of floods and droughts. This loss happened in countries where agriculture was one of the main economic drivers and often contributed 30–40 % of national GDP and employment.

4.4 Political Impacts

Disasters not only threaten lives or damage assets but can also destroy sociopolitical structures (Albrecht, 2017). Furthermore, they can open political space for the contestation or concentration of political power (Pelling and Dill, 2010). Owing to government policies, sufferers can experience a reduction in the quality of life related to their housing when a disaster occurs or afterwards. This negative result can reflect politically on the governments. For example, Hurricane Katrina increased the national political dissatisfaction rate in the United States (Wilson, 2015). In contrast, after the work to rescue people from the 2002 flood in Germany, the government obtained positive results, as it increased its share of the vote (Bechtel and Hainmueller, 2011; Bytzek, 2008). Similarly, even if Albrecht (2017) underlines that disasters have the power to influence government support and political trust, he remarks that there is no clear evidence of which kind of disaster damage directly influences public opinion about trust in and satisfaction with the state.

4.5 Social impacts

If society understands all aspects of disasters, it can develop the right strategies and manage risks.

The social impacts of disasters need to be addressed under a few headings. The best example of the social impacts is the 2010 Haiti earthquake. Approximately 300 000 people died and 1.3 million people were made homeless by the disaster. All segments of civil society, such as government, schools, universities, businesses, health clinics, non-governmental organisations and churches,were damaged. It was not clear who could provide

(1) List of countries/territories per income group (World Bank, 2018).

assistance to victims.The destruction was so large that not until a year later were institutions were able to coordinate with each other again (DesRoches et al.,2011). Another recent example of big magnitude in the society is described in the Super Case Study 6 on the COVID-19 emergency.

Jones and Faas (2017) display the added value of analysing social networks for more effective recovery actions. It seems to be necessary to understand what individual, families and groups have lost and need (which can be tangible or not) after the disaster and to adequately facilitate how people would interact to give or receive those resources.

Education

Disasters have a significant impact on education systems. Every student has the right to high-quality education, recognised as one of the SDGs (United Nations, 2016), but many students cannot attain this right under the influence of disasters. Many students cannot be educated for months after disasters strike. In this way, they have a negative impact on all school experiences. Disasters directly destroy schools located in the wrong place or built poorly.Another reason for interruption is that some schools are often used as evacuation centres. Furthermore, disaster preparedness is often not a priority in the curriculum and the repairing of schools is often delayed. The fundamental issue is, however, that, if training activities are promoted before the disaster, it can save lives, protect children and benefit all communities. Schools can be a catalytic force strengthening human effectiveness, reducing vulnerabilities and promoting risk reduction for future hazards (Save the Children, 2016).

Healthcare

Disasters may affect healthcare for diverse reasons. These events may cause immediate direct injuries that require health interventions and are also linked to long-term increases in health conditions ranging from infectious diseases to non-communicable diseases and mental health. Depending on the existing services and their surge capacity, an increase in health needs may lead to the over crowding of services, impairing their quality and availability, thus affecting healthcare capacity. Moreover, healthcare may be affected by direct destruction of health institutions, migration of health personnel and suffer from economic constraints. Disasters strike healthcare and, in the following period, interrupt services, damage physical assets, cause loss of workforce, make income chaotic and destroy operations.

The physical consequences of the disaster are obvious and can be more or less predicted. Health facilities that are empty after being evacuated or because they have suffered damage can become targets for burglars. Reconstruction can be delayed as demands met slowly. When the disaster ends, the sector can face a possible drop in credit supply, reducing transactions and constraining finances. Drug supply chains can be disrupted by product operations going offline, which can lead to product and labour shortages. During this period, health systems and pharmaceutical companies can improve the pace of recovery and avoid making early decisions that can cause long-term harm. The main concern toaddress in damaged hospitals is about the continuity of patient care. After the disaster, providers may be held accountable for the death and suffering of patients. Therefore, comprehensive physical checks of health assets should be made, with good emergency planning and a public relations unit for a more resilient health system (PwC Health Research Institute, 2018).

Migration

Disasters can cause demographic movements in society. Migration has always been a traditional response or survival strategy for people when they faced disaster threats (Hugo, 1996). People, in general, migrate for various reasons: to survive, to live a better life, to have prosperity or to escape from environmental degradation due to disaster. Of the 28 million new displacements recorded in 2018, 10.8 million were linked to conflict and 17.2 million to disasters, 16.1 million being linked to weather-related disasters (IDMC, 2019). These displacements may be temporary or permanent, voluntary or involuntary, and maybe a response to both physical and economic damage.

In addition, Oliver-Smith (2006) categorises demographic movements into four types.

- Flight or escape means urgently leaving risky areas for the nearest safe place.
- Evacuation is like flight but more organised,in the face of an approaching threat from internal or external agents.
- Resettlement can result in permanent housing in a new area.
- Forced migration often covers permanent, longer-distance movements to completely different environments for a long period.

As an example of evacuation, the 2002 European floods led to the evacuation of 50 000 residents of Prague (Czech Republic), on 13th August, and a total of 200 000 Czechs during the second week of August (BBC, 2002). Elsewhere in Europe, more than 120 000 people were evacuated in the German city of Dresden, 36 000 in the German state of Saxony-Anhalt and 1 500 in Hungary (Euro-Atlantic Disaster Response Coordination Centre, 2002). In another case, in 2011, climate change led to amajor drought in East Africa. Failed rains in Somalia, Kenya and Ethiopia led to high livestock and crop losses. Hence, the residents migrated to seek food and water, motivated by an inability to maintain traditional lifestyles.

Family

Disasters have unusual effects on the family, which is a basic institution of society. The study by Cohan and Cole (2002) demonstrates that the year after Hurricane Hugo, in 1989, marriage and birth rates rose in the region affected. Similarly, marital stress, depression and anxiety in couples were adversely affected and therefore divorce rates increased significantly. Particularly after the disaster, in the acute period, children experience much great psychological disorder and they become more dependent on parents. The exposure of parents to trauma influences children’s psychology negatively. In disaster times, if parents display unstable moods or behaviours, it can raise the child’s anxiety. Concerned parents may have difficulty in perceiving the current emotional needs of children. Traumatic processes can lead to behavioural disorders and attention deficit in children. Children’s reactions to disasters can be panic and great fear or more severe prolonged stress disorder. These reactions depend on gender, social circumstances and severity of exposure to trauma. Finally, Bryant et al. (2017) relates higher risk of depression in the after-math of a disaster among individuals who were related to depressed people, had few social connections or were connected to community members that emigrate.

Religion

People who suffer from disasters seek an answer to the question of ‘why this happened to me’and feel a significant gap in their spiritual world. Religious foundations provide moral support for victims in such cases. However, there is no single view on spiritual support for people in Europe. In the United Kingdom, a significant number of professional social workers advocate secular social work rather than supporting spiritually based social work. In Germany, however, emergency spiritual service is more inclusive than in the United Kingdom

(Seyyar and Yumurtacı, 2016). Societies have religious needs and so this issue should be taken into account in DRM, accepting the diversity of communities.

5 Case studies

If the disaster risks are unknown to society, it is like travelling on a dark road that ends with a cliff edge. Public awareness must be raised to learn about risks and be more resilient.

5.1 Van earthquake, Turkey

On 23 October 2011, an earthquake of magnitude 7.2 occurred in the province of Van,which is located in the east of Turkey. According to official data, 38 515 houses were heavily damaged, 1 966 people were injured and 604 people were killed. While people were trying to deal with the suffering from the first earthquake, asecond earthquake hit the same region on 9 November 2011. Including two hotels, 25 dwellings collapsed. Forty people were killed under the debris and the total loss of life rose to 644.

There was one question in people's minds: why did the earthquakes cause so much damage? The main reason is that, although similar quakes had occurred previously, and scientific data existed on the earthquake history of the region, unfortunately society had no earthquake awareness and was unprepared for a great catastrophe. Many factors contributed to the scale of the catastrophe. The city was not built under the zoning laws. The development plan included no measures to protect against, prevent or mitigate earthquake risk. In the city, many dwellings were built illegally without engineering, without any control, and used poor materials. The Disaster and Emergency Management Authority (AFAD) noted that the damage was devastating and approximately 77 of every 100 buildings had been destroyed (Figure 2).

Figure 2. *Damaged buildings due to earthquake in Van province, Turkey.* ***Source****: photos courtesy of Aslan Mehmet Çoşkun.*

Unfortunately, the governor's office and the municipality had no risk reduction strategies or plan for the city. Furthermore, the response plan did not clearly define responsibilities in detail so local units were not prepared for an event of such magnitude. It also had no possible disaster scenario.

Therefore, during the intervention, full coordination among the responsible companies was not ensured. Moreover, key staff in the plan did not know anything about their duties or have experience of it. Nobody knew what to do except for the Civil Defence and Search and Rescue Unit.

Although all officials worked hard forhours, unfortunately this effort was not enough to prevent the chaos and problems effectively. Thereafter much work was supported and performed by national units. Within the first 24 hours, 3 221 staff were sent to the region to carry out search/rescue and first aid. National and international teams made great efforts and they rescued 252 victims alive from under the debris (AFAD, 2014).

Seventy-two hours after the shock, 17 836 tents were urgently transferred to the region because there were no pre-stocked shelter supplies locally. However, it was observed that some distribution problems were observed in some districts.There was chaos during the distribution and some people tookmore than one tent (Zaré and Nazmazar, 2013). These unfair events together with the winter condition pushed the people to chaos, and nobody wanted to see anything like distribution crisis, which lasted for days, ever again.

Although camps were established in the region after the first earthquake, the people affected refused to stay in them. They were afraid of leaving their homes and not being able to protect them from thieves,because they considered that security issues had not been solved fully. Therefore, everybody wanted to have special tents to stay near their homes.

Over the following days, the need for tents become the main challenge in the city.This urgent need was supplied fromthe national source and also using international channels. Ultimately 13 tent cities were built in the region and approximately 290 000 people stayed there for days. Hot food, hot water, toilets and showers, social areas, pre-school education, health and religious areas, and psychological support services were provided in the tent cities (AFAD, 2014).

The government found new solutions for shelter in winter conditions, moving 40 000 victims who volunteered from the disaster zone to other cities. They stayed in public guesthouses and all their essential needs were covered by AFAD. In addition, many charity campaigns were organised by non-governmental organisations.
The community welcomed the earthquake victims. Many people living in other cities voluntarily accepted the affected people as guests.This campaign found hosts for 15 000 people and it was a great case of solidarity in society.

On the other hand, the council decided that the victims should stay in containers instead of tents in severe winter conditions. For this purpose, 30 000 containers of 21 square metre each were purchased, which had kitchens, bathrooms, toilets, hot water and electric heating (Figure 3). During the winter, 175 000 people stayed in these containers and their needs were covered by the state.

Many school buildings were damaged, so primary and secondary education stopped for 2 months. Universities were closed for 3 months.Four undamaged hospitals and six tent hospitals continued to work for victims. Electricity and telephone lines were interrupted after the first shock but these services had returned to normal within a few days (Zaré andNazmazar,2013). Critical infrastructures in Van city were not completely damaged.

Figure 3. *Photos of the container city, built after the earthquake in Van province, Turkey.* ***Source****: Photos courtesy of Aslan Mehmet Çoşkun.*

Ten months after the earthquakes, people wanted to come back to normal life as soon as possible. Therefore, 15 332 houses were built by the Housing Development Administration.The new residences were distributed to the disaster victims on 4 September 2012, considering the rights of the victims according to the law. The Van earthquake caused economic losses of approximately TRY 4.9 billion.

In summary, this case tells us that the Van earthquake caused deep social losses in society. The people of the region showed great solidarity among themselves. The whole community mobilised for the region nationwide. Although conditions were hard, society spent a great deal of effort on overcoming these troubles and improving the situation.

If the disaster risks are unknown to society, it is like travelling on a dark road that ends with a cliff edge. Public awareness must be raised to learn risks and be more resilient.

Lesson learned

After this devastating disaster, not only people in the region and the response units but the whole of society gained significant experience. First of all, the earthquake demonstrated that society and the city were not ready for a severe earthquake. In particular, the community lost control in the acute period and peopledid not know what to do and where to go. Unfortunately the local government failed to carry out work correctly. There was no institution to guide society correctly. The importance of communication at the social level was better understood. Based on this experience, society understood that the priorities were to learn the disaster risks very well, to take individual and social measures, to support non-governmental organisations and to strengthen social networks. Immediate capacity building was required at all levels, technical, institutional and governmental (Ergünay and Özmen, 2013).

First, disaster hazard and risk maps were prepared for the regions in order to determine risk.Inaddition,the building code was updated and disaster response plans were extensively revised in accordancewith the lesson learned. New strategies and plans were developed for the challenges encountered in the disaster.

Much scientific research was conducted for the region by universities. Damaged buildings were demolished and sturdy residences were built in the city. In order to raise public awareness, in 2015 a comprehensive project was launched nationwide. The project aimed to create disaster awareness invarious sections of society. By 2020, more than 200 000 people in Van city (students,families,workers,volunteers) had been trained on 'the basic disaster preparedness (Van AFAD, 2020).

These projects good motivate the people of Van, and they are more aware of earthquake hazards and more ready for them. But education projects such as that are not enough; society needs radical changes on strengthening of living space.City administrators need to become aware of the need for and importance of DRM. New strategies must be developed in many fields, especially city planning, strong building and infrastructure.With the support of the central government, many projects and good practices were implemented, in order to restorethe city and societyto normal in a short time.

5.2 Toxic cloud over the town of Zevekote, Belgium

On the evening of Friday 31 March 2017, around 17.30,a tank containing nitric acid leaked on a farm in Gistel, Belgium. The farm used nitric acid to process manure. The leak caused a big yellow gas cloud that could be seen from afar. Nitric acid irritatesthe eyes and lungs and causes chemical burns on contact with the skin. Several policemen experienced this irritant effect of the poison cloud. There were no fatalities. Various measurements were taken during the intervention at various locations. The gas cloud did not reach concentrations that would cause alarm about the safety of the food chain. At the time of the incident, it was unclear what had caused the crack in the tank.

At the news of theemergency,a crisis response groupwas called together and decided to evacuate the village of Zevekote. A safety perimeter of 1 km had been set and the municipal contingency plan was activated. The local fire brigade was first onsite but had to seek help because of the dangerous situation. Later the fire brigades of Gistel, Ostend, Middelkerke and Leke and civil protection operatives arrived on site. Meanwhile, all 570 inhabitants of Zevekote were evacuated to the reception centre in Gistel or went to family and friends. In the reception centre the Red Cross offered psychosocial support for the evacuated and was on standby for medical attention if needed. Later, because of the wind, the cloud with nitric acid also reached another village, Sint-Pieters-KapellenearMiddelkerke. Around 21.00its350 inhabitants also had to leave their homes. These people were also evacuated to the reception centre in Gistel.

People had a lot of questions at the reception centre. They wanted to know what was happening, if their pets would be unharmed, and especially when they would be able to go back. This ambiguity over when they could return remained until the next day and was considered very frustrating by the inhabitants of Zevekote. Communication during the first hours of the disaster was poor. This resulted in frustration and sometimes anger among the people who were waiting for news,especially people with crops and animals that might be at risk. The absenceof the municipality from social media and the lack of an emergency number that people could call to with their questions were considered a great loss. During the relief effort, people took these frustrations to Twitter. Among the people affected there were also farmers whose livelihood depended on their infrastructure within the perimeter. People had the feeling there was a lot at stake, but at the same time felt powerless and did not know what to expect. According to the implementation principles of Hobfoll et al. (2007), one might say that the perceived lack of information here for some people opposed the principles of safety, calmness and hope. The communication with civilians proved a difficult point in the beginning. This is why oneof the lessons learned bythe local government was to develop and use a municipal Facebook page to communicate with civilians. Although some people felt it was too late, the setting up of an emergency number and overall communication, later on, were considered favourable for people's future prospects.

The Red Cross Psychosocial Intervention Service has three main tasks: providing reception, information and guidance. This translates into offering people a listening ear, meeting their needs at that moment, giving information about their relatives, connecting people and facilitating their resilience. Together with giving social support, the volunteers started to register who was in need of a place to sleep. During the registration, other inhabitants came by and offered places to sleep in their homes outside the perimeter.The Red Cross facilitated this process by structuring it. Volunteers registered the offers, while other volunteers registered the people in need of a place to sleep. After this, the coordinator of the reception centre made the match. In the end, apart from a very few individuals, everyone inthecentre found a place to sleep without the help of the government. Normally the local authorities, after consultation, would decide to reorganise a location as a dormitory or to turn to private accommodation services. But, social solidarity came out in groups as natural reaction and people found accommodation quickly. This act is a clear example of what group efficacy, resilience and connectedness after a disaster means.

Another fact worth mentioning that clearly responded to the need for hope was the visit of the mayor to the reception centre. The mayor spoke to the evacuated persons and answered their questions as far as possible. The presence of an authority figure who could assure people to a certain level was considered added value for the inhabitants. While people were leaving the reception centre, they received the information that at 10.00 an information sessionwas going to be organised in the reception centre. All residents of the municipalities of Zevekoteand Sint-Pieters-Kapellewere welcome. They could ask their questions and receive the latest updates. The next day, the inhabitants of Sint-Pieters-Kapelle were the first to be allowed to return to their homes. Around noon the tank was pumped empty and the governor ended the emergency. Shortly after noon, the residents of Zevekote were also allowed to return home under the guidance of the fire department.

By ending the provincial phase of the emergency and intervention plan, Gistel switched back to the municipal phase of the emergency and intervention plan. But that plan was also terminated at 16.00. The situation wasunder control; only traces of nitric acid were still being measured at the site ofthe tank. None was found in the surrounding zones.

Lessons learned

Compared withother disasters, this intervention can be seen as a rather small one, but it is a nice example of the resilience of citizens. Nearly 1 000 evacuees found shelter with neighbours, family or friends. In a culture where people tend to be very closed off and isolated, this act of groupefficacy is remarkable. Furthermore, it is a good opportunity to try to understand and apply the five principles of Hobfoll et al. (2007).

- A sense of safety. The visualisation of the danger (the big yellow toxic cloud), the memory of another disaster in Belgium with toxic chemicals in 2013and the lack of information gave rise to an unsafe feeling. People did not know if the gas cloud was dangerous for their health and that of their pets. On the other hand, the evacuation and the caregivers, who assured people that they were safe in the reception centre (safe zone), promoted a sense of safety.

- Calming. Most of the people were calm once in the reception centre. The lack of information and the ambiguity over when people could return home caused frustration in some of the people affected. There were a lot of uncertainties and for some people there was a lot at stake. Bringing calmness was more difficult without certain assurances. The emergency information number, the information in the reception centre and the information through social media gave people the opportunity to calm down. Other solutions thatmet their needs at that time (medication, babyfood, nappies, etc.) were also able tobringabout a sense of calm.

- A sense of self- and community efficacy. The biggest example of supporting self- and community efficacy is probably the moment where the volunteers from the Psychosocial Intervention Service matched the needs for and offers of sleeping places for inhabitants. Although disaster relief would normally have taken care of this need, the solution sprang from the inhabitants in and around the affected area. The role of the caregivers was to facilitate and support this already ongoing process, so that it could be easier for the inhabitants involved.

- Connectedness. The media caused connectedness simply by reporting the news. The fact that all the people in the reception centre were evacuated immediately also caused a form of connectedness within the group of evacuees. Letting them sit together at the tables they chose (e.g. a table where their neighbours were sitting) supported this feeling. But it was not only limited to the reception centre; there was also clearly a sense of connectedness with the people who lived outside the perimeter and offered a place to stay the night.

- Hope. This principle was harder to promote, since there was only little information, especially in the early hours of the disaster. For a long time, the evacuated families had no clue when they could return home. The information sessionthe next morning is seen as a good action to promote this principle, because it gave people the chance to put things in a broader perspective and let them start planning ahead again. For the same reason, the emergency number and the visit from the mayor to the reception centre also instilled a sense of hope.

6 Role of society in disaster risk management

Disaster risks cannot be managed through trial and error. Societies should learn from disasters they have experienced and develop risk reduction strategies. The main responsibilities of societies in DRM should be protecting individuals, families, institution and assets for the continuity of social structures.

To be resilient, a society should be built on strong institutions, define rules, produce a strong policy as a legal basis, motivate people and guide them.

Public awareness is the key to achieving these. If a society raises awareness, it can easily interact with other societies and learn mutually. A conscious society can also motivate people and push them towards individual preparedness by using social channels. In addition, it can create pressure on the policy area for the right prevention and mitigation strategies and policies to be developed. Hence, we can say that a conscious society can cope better with the effects of disasters so most of the efforts in DRM should be towards enlarging their understanding and engaging them.

Data are an important resource when driving the decisions to be taken by the institutions and communities after an event. Data collected in advance, such as the indicators set for the implementation of the SDGs, loss databases from statistical offices in the country, can be an interesting source of data to exploit to guide the planning of recovery. Indirect impacts on society can be of greater magnitude than the direct effect of the event in the first hours and weeks, so the indicators and the goals established before the event should propose which capacities to strengthen and which vulnerabilities to reduce in the aftermath of an event, following the concept of 'building back better' (UN, 2016). Moreover, the availability of data on several sectors and aspects of society can be useful not only for compensation but to identify the drivers and causes of disasters (De Groeve et al., 2013), to, to design more resilient societies.

7 Conclusion and key messages

In summary, the effects of disaster risks have been found to cause significant losses in many different areas. Depending on the characteristics of disasters, they change daily life, goals, expectations of individuals, priorities and individuals' perspective on life because of physical, economic and social losses, and these effects remain in society's memory for many years. Individual priorities can prevent people from accepting social responsibilities and lead to the reshaping of individuals' decisions.

Major disasters cause rapid and massive destruction in all areas and cause disruption to many services. On the other hand, it is seen that disasters that occur relatively slowly can create a chain effect and affect a wider area and greater numbers of people. In addition, when the threshold of survival in the disaster-affected area is exceeded, migration emerges as a necessity.

Consequently, raising public awareness of these threats, by better communication about the regional and local impacts of disasters, should be a priority for disaster risk reduction. Training and exercises must be organised to raise individual awareness. However, even if individual preparedness for disaster risks is a critical beginning, it does not provide adequate protection for the whole society. Dissemination throughout the whole society and its institutions should follow a collective resistance approach in all areas.

Society is generally unaware of its important roles and responsibilities in DRM. Society can actively reduce risk and provide protection against disasters by using internal dynamics, which have a vital role in the recovery phase. Therefore, it is necessary to provide motivation for families and individuals to increase awareness and prepare the ground for collaboration among all actors of society, reinforcing prevention and mitigation action while preparing communities to face events better.

Policymakers

There is a need to design and implement the right DRM strategies at national and other relevant levels, so policymakers should build policy frameworks that promote coherence and sustainable policies while covering all the dimensions of society. Having DRM strategies is mainly relevant to reinforcing prevention and mitigation of disasters.

Practitioners

International dialogue is rarely sufficient on DRM. To overcome the existing challenges for preventing and mitigating risk, practitioners should play a more active role in the dialogue between societies to facilitate mutual learning from past events.

Scientists and practitioners

Scientific groups play an important role in the planning of prevention measures. They must understand the patterns of societies and their dynamism, exploring the development of new tools for educational programmes, to implement together with practitioners.

Citizens

The level of awareness of citizens is still low for many events that they could possibly face, although progress has been made. Citizens should engage more actively in the prevention of risk, by learning from the events that could take place where they live, taking individual precautions against disasters and participating in local community work for collective protection.

Conclusions

People are the most important element to protect from disaster. This chapter assessed the impact of natural and human-made disasters on population in all its facets, from the individual to society as a whole. The chapter covered case studies at various spatio-temporal scales. There is the slow-onset, long-duration example of the heatwave in Europe in 2003, which affected many countries for a rather long time. At the other extreme, there is the impact of rather local events such as the fire in the Grenfell Tower (United Kingdom) in 2017 or the toxic cloud in Zevekote (Belgium) in 2017. In terms of hazards with fast onset and short duration, there is the analysis of the earthquakes in Van (Turkey) in 2007 and a number of earthquakes in central Italy.

The spatio-temporal dimensions of onset, intensity and duration are central points when analysing the impact of disasters. The most obvious impacts (and the most reported and discussed) are the direct impacts causing death, injury or loss of livelihood. They affect the individual strongly. The indirect losses are related to changes in everyday life due to loss of homes and/or jobs, or even health deterioration through environmental effects such as contamination of air, water, soil and food. Indirect losses affect individuals and their habitat, but they may also influence the functioning of entire societies. Finally, the intangible impacts reduce the quality of life by psychological stress caused by the disaster, such as losses or temporary evacuation or relocation. The intangible impact is often neglected, in particular the long-term effects such as post-traumatic stress disorders.

Populations are not equally vulnerable to any specific hazard. Individual capacities and behaviour influence a person's vulnerability to a particular hazard. While the direct physical vulnerability of the individual to death, injury or homelessness is well understood (for example through physical building vulnerability studies), indirect social vulnerability is often overlooked. At the community level, socioeconomic aspects such as age, income and formal education can indicate the social vulnerability of specific groups. Socioeconomic inequalities can lead to very different vulnerability and resilience patterns, which calls for better incorporation of socioeconomic aspects in vulnerability assessments and research.

A common feature from the analysis of the case studies is that the population (individual citizens, policymakers, society as a whole) is often unaware of disaster risk reduction and prevention measures. Policymakers should invest in risk knowledge and awareness creation as well as in self-protection. This could be achieved by systematically including personal safety and disaster prevention in education curricula.

Although a lot of information is already available for the prediction, assessment and possible mitigation of the effects of hazardous events relating to population, researchers should exploit the increasing data available to investigate the still existing gaps, trying to get the full picture and develop tools for informed decision-making. At the same time, policymakers should create legislation to

support systematic data collection on all human impacts of disasters over a longer period, beyond death and physical injury, including the location, the demography of the affected population and temporal descriptors of the event. Specific attention should be given to the indirect impacts such as long-term effects on people exposed (including emergency responders), with a focus on psychological trauma and mental health.

The wealth of information provided by new data sources such as social media, mobile phone data or Earth observation should be used by scientists to improve the modelling of human exposure and vulnerabilities, addressing individual, social and locational factors. For example, Earth observations can inform decisions and actions for the benefit of humankind. The new satellites available as well as the development of ground- and drone-based sensors has resulted in a noticeable increase in the use of these techniques for assessing the potential impact of natural hazards. Initiatives such as the Group on Earth Observation also contribute to this exploitation, aiming to develop a new generation of measurements and spatial statistics in support of post-2015 international processes on sustainable and urban development, climate change and disaster risk reduction.

Horizon Europe (the EU's research and innovation framework programme for 2021–2027) will incorporate research and innovation missions to increase the effectiveness of funding by pursuing clearly defined targets.

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3.2.1 Threat to life

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