Chapter

Introductory Chapter: Earthquakes - Impact, Community Vulnerability, and Resilience

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1. Earthquake trends 1998–2017

Earthquakes may be regarded as one of the most devastating and terrifying natural forces on earth. Past earthquake disasters (including tsunamis triggered by earthquakes) have demonstrated that literally within a few or a fraction of seconds, many people can be killed or injured; further, the psychological impact on communities can last for years. Furthermore, due to its force of destruction, any physical infrastructure could be (and have been) damaged or destroyed.

But what are the trends? In the UNISDR report [1], some of the key conclusions relevant to earthquakes during a 20-year period (i.e., 1998–2017) were the following (**Figure 1**):

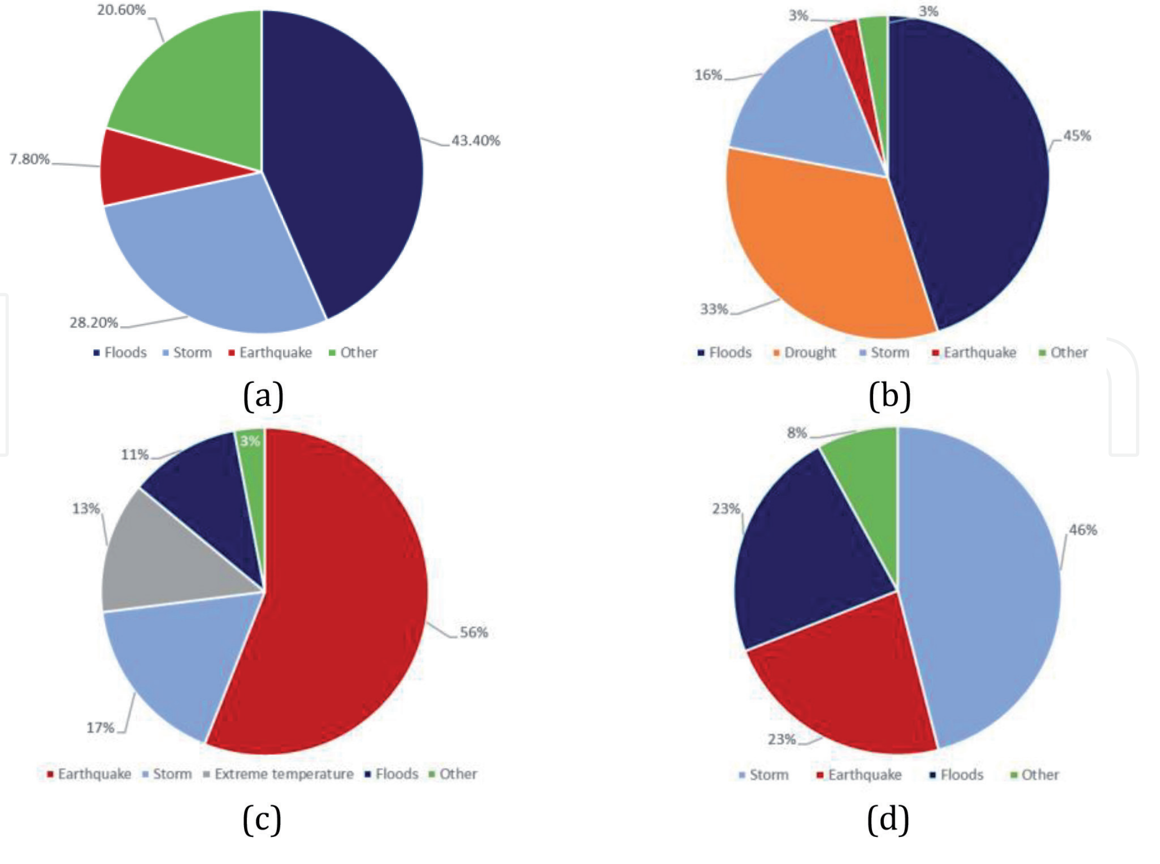

Figure 1.
(a) Number of earthquake disaster occurrence and other types of natural disasters in the 20-year period between 1998 and 2017. (b) Number of affected people by earthquakes and other natural disasters. (c) Deaths caused by earthquakes and other types of natural disasters. (d) Economic losses caused by earthquakes and other natural disasters, during the same time period, in US$.

a. There was a total of 7255 natural disasters between 1998 and 2017.

b. The number of earthquake disasters during the 20-year period was 563 (7.8%) (it is believed that 91% of "climate"-related disasters occurred during the 20-year period, and floods accounted for 43%).

c. The number of affected people by earthquakes was 125 million (3%).

d. Earthquakes have killed 747,234 people (56%) (17% of deaths were caused by storms and 13% by "extreme temperature," among other disaster types).

e. Earthquakes have caused economical losses of US$ 661 billion.

It is clear from the abovementioned conclusions that earthquakes have killed more people than any other type of natural hazards during the 20-year period.

2. Unpredictability of earthquakes

Following the two deadly 2017 earthquakes in Mexico (i.e., M8.2 on 7 September and M7.1 on 19 September) [2], there has been a debate on the "unusual cause" of these events [3–5]. However, what is less debatable is the fact that earthquakes occur at "unpredicted times in unpredicted places" [6]. This may be one of the reasons why earthquakes are so terrifying.

The 2017 earthquakes in Mexico may illustrate the above:

a. The quake on 7 September (M8.2) was not expected (see above) (the earthquake is considered as the strongest occurring in more than a century).

b. It occurred at mid-night when most of the residents of the capital city were at home (and probably in bed) (i.e., at 23:49:17 local time). Fortunately, the earthquake early warning (EEW) system worked as expected (see the next sub-section).

c. A second earthquake occurred on September 19th, this time during a daytime (i.e., 13:14:40 local time), but the warning was not issued in time [2]; further, it occurred the same date (i.e., on 19 September) as the 1985 earthquake that caused death and destruction in the capital city.

d. The time in between these two earthquakes was very short; i.e., only 12 days. We were still recovering from the earthquake on September 7th, then came the second one, which caused panic among the residents of the capital city.

e. We were expecting a "big' earthquake with the epicenter occurring along the "Guerrero gap," in the Pacific coast of the country, but the epicenter of the M8.2 earthquake was in fact in "Tehuantepec" [2]. Similarly, we were expecting a strong earthquake (or the "big-one") coming from the "Guerrero gap" [7]; however, the September 19th earthquake occurred inland, causing death and suffering.

Some similar experiences, in the context of the unpredictability of earthquakes, have been experienced by communities exposed to seismic risk world-wide. Although not directly associated with earthquakes, it is worth to mention that in 2018, a landslide caused a tsunami in Indonesia, killing hundreds of people [8]. These events show the unpredictability of mother nature.

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The above has illustrated communities' vulnerabilities, lack of resilience capacity to such events. We must learn to live with seismic risk, by building community resilience, among other things, to mitigate the impact of these events; also, governments should invest, for example, in EEW systems to warn communities of an earthquake occurrence.

3. Resilience and vulnerability, earthquake early warning systems

Cities, communities, have experienced the destructive force of earthquakes, not only in terms of human life, but also, in the disruption of critical infrastructure facilities (roads, bridges, power and gas supply, transport systems, supply chain, etc.). In short, earthquakes can, in principle, bring down the functioning of a whole city/community.

The concept of resilience has gained increasing importance in earthquake disaster management. The UNISDR, for example, has defined it as "The ability of a system, community, or society exposed to hazards to resist, absorb, accommodate, adapt to, transform, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management" [9]. It has been argued that EEW systems have the potential to improve communities' resilience to seismic risk [2, 10], given the fact that earthquakes cannot be predicted.

However, to be effective, EEW systems should be people-centered [2]; i.e., people should be well educated on the basic functioning of the system, among other things. Further, an effective EEW system should be able, in principle, to warn people a few seconds before the ground shaking. As any technical system, EEW systems have limitations; for example, during the September 19th earthquake, the warning (i.e., the "siren") was issued almost simultaneously with the ground shaking, given not enough time to seek protection or safety [2]. Had the system worked at the time, it is very likely that lives could have been saved. Similarly, with the case of the most recent 2018 tsunami in Indonesia, where there was not a tsunami early warning system installed [8].

Within the resilience literature, it is worth mentioning the "science of resilience" [11], which is quite relevant to earthquakes; it essentially stresses the need to integrate "basic science" (e.g. physics, mathematics, seismology, volcanology, etc.) and "social science" (sociology, psychology, economics, etc.) to build a "resilient society" [11]. In a way, the content of the book covers the multidisciplinary approaches aiming at a better understanding of seismic risk and to contribute to the mitigation of the impact of earthquakes.

It is widely recognized that the degree of communities' vulnerability is "determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards" [9]. A good example is provided in [1], where it has been reported that those communities that were not prepared to earthquakes were the most affected; i.e., 2004 tsunami, which occurred in the Indian Ocean, and the 2010 earthquake in Haiti. On the other hand, countries that are prepared for seismic risk (e.g., earthquake resistant buildings, people's preparedness, etc.), the impact, for example, of the 2010 earthquake in New Zealand was zero in terms of human loss [1].

4. Some final reflections

a. It may be highlighted that earthquakes will occur at any time and are effectively unpredictable.

b. We must learn to live with seismic risk. In this regard, and in relation to earthquake occurrence, we might ask ourselves, "what-if here and now" and "what-if there and then" and be prepared for the unthinkable.

c. Earthquake early warning (EEW) systems should be people-centered.

d. Learning from past earthquake disasters (including tsunamis).

e. Learning from success stories worldwide.

f. Engage in "creative thinking" in devising creative solutions, aiming at the mitigation of the impact of earthquakes.

g. Continuously assessing seismic risk since everything is continuously changing.

h. Other.

Finally, all of what has been given in the introductory chapter, explicitly or implicitly, are covered in the book, which may be considered as an important source.

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