Chapter 3

Understanding disaster risk: hazard related risk issues

SECTION I
Geophysical risk

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Section I. Geophysical risk

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Introduction

Earthquakes and volcanic eruptions are the most hazardous geophysical processes that have their origin in the Earth's lithosphere (i.e. in the outermost solid part of the Earth). Both events are driven by common fundamental geodynamic procedures, namely the motion of the lithospheric plates and the resulting deformation that takes place, mainly at the plate boundaries but, on some occasions, in the interior of the plates too.

The largest and more frequent earthquakes occur without the involvement of volcanic activity. However, sometimes the latter is accompanied by strong earthquakes. Every year, thousands of people lose their lives due to large destructive earthquakes and volcanic eruptions. In addition, extensive loss of property, negative economic consequences, both tangible and intangible, as well as social disruption occur as a result of such events. Earthquakes may produce disastrous effects due to the ground shaking relatively close to their sources, say at distances of a few hundreds of kilometres at most. While volcanic eruptions produce multiple hazards, some of which, such as tephra fall, may cause disastrous results far away or even on a global scale.

When earthquakes and volcanic eruptions occur in submarine environments or close to coastal zones, the surface of the sea can be suddenly disturbed, thus generating large sea waves known as tsunamis. The catastrophic results produced by earthquakes and volcanic eruptions are often dramatically increased due to the associated tsunamis that may cause destruction at great distances from their seismic or volcanic sources. However, catastrophic tsunamis can be also generated from other processes, such as coastal or submarine landslides impacting the sea-water surface. Such landslides may be the result of gravity or ground shaking caused by earthquakes or volcanic eruptions.

Protecting population from geophysical risks such as earthquakes, volcanic eruptions and tsunamis, and mitigating the risks of such events is not an easy task because these phenomena are highly complex and usually unpredictable. Therefore, the assessment of their potential impact (i.e. the level of associated risks) is not a trivial procedure. However, the assessment of risk associated not only with these three types of geophysical processes but also with other types of natural hazards is characterised by some commonalities. The first is that one has to assess the level of hazard, in other words, to estimate some of the important elements or parameters of the phenomenon per se. For hazard assessment purposes of interest are the frequency of occurrence of the geophysical event (e.g. earthquake), in a given magnitude level and the probability to exceed or not to exceed this level in a given time interval. Depending on the probability model selected to apply the hazard assessment could be time independent or time dependent, the latter being more realistic but also less easy to apply. Another approach is to consider scenario-based hazard assessment, for example by selecting an extreme, a realistic or another scenario for the occurrence of the geophysical event in the future.

Both the probabilistic and the scenario-based hazard approaches are susceptible to a variety of uncertainties. Lack of knowledge and of data leads to epistemic uncertainly but the intrinsic uncertainty associated with the statistical perspective in order to understand the physical processes leads to the so-called aleatory uncertainty, which in practice is associated with randomness (Woo, 2010). Regardless of the method applied to estimate hazard, a common practice valuable for preparedness, risk management and decision-making is the preparation of suitable maps illustrating the level of the various types of hazards in a given area. For example, volcanic activity may threaten an area with various types of hazard, such as lava flows, tephra falls, etc. In such cases, the preparation of appropriate maps is needed to express the level of hazard of each type of hazard.

The assessment of hazard, however, is a representation of the phenomenon only and does not describe the expected impact of the geophysical events. For the estimation of the expected impact (risk), the vulnerability of the various assets that are exposed to the geophysical event should be taken into account (UNISDR, 2015). A wide range of vulnerabilities may be considered for population as well as for engineered structures (e.g. buildings) and other properties. But, again, the issue of time dependence is important. For example, levels of human exposure and vulnerability in a coastal zone threatened by tsunamis are quite different in the daylight hours of the summer season from those in the evening hours of the winter season. Eventually, for a qualitative or quantitative risk assessment, the results of the hazard, exposure and vulnerability assessments should be combined by applying techniques that depend on data availability. For better hazard assessment, the datasets regarding the record of the natural phenomena can be drastically improved with the expansion of the existing instrumental networks and other recording systems. Moreover, better socioeconomic data, such as those referring to populations and buildings, can help to improve risk components such as exposure and vulnerability.

The mitigation of risk can be achieved by a variety of actions that can be undertaken by decision-makers, civil protection authorities and other stakeholders. Of particular importance among these actions are the early warning systems (EWSs). These systems are composed of detection, monitoring of precursors and forecasting of probable event, analysis of risk, dissemination of meaningful and timely warnings or alerts of the possible extreme events and activation of emergency plans to prepare and respond. Some hazards are difficult to predict (e.g. earthquke) due to lack of knowledge, data or adequate measuring techniques of the precursors that lead to hazardous event. Early warning, however, takes place also when the event has already started. From the first recording stage and before the catastrophic culmination of the event, we may have some estimation of the maximum level of severity of the event and the expected time and location of its catastrophic stage. Other actions aiming to mitigate and manage risks may include preparedness, training, education and public awareness.

This chapter describes several recent developments across the different disciplines of earthquake, volcanic and tsunami risk assessment and highlights a multitude of resources currently available to the disaster risk reduction community.