Geodata: Limitations in Current Concepts

The first of the nine Societal Benefit Areas (SBA) of the Group on Earth Observation (GEO) is Reduction and Prevention of Disasters. The SBA listing and high ranking reflects not only the increasing significance of disasters to society, but also that remote sensing, or geoinformation science in general, is very well suited to providing adequate information. Significant attention for disaster is not new, but we are seeing subtle change and developments in the perception, with the focus shifting away from the disaster itself and towards risk.

Limitations

As a result, the term ‘disaster management’ is being increasingly replaced by ‘disaster risk management’ (DRM). Definitions of risk vary greatly, but all revolve around the probability of a hazardous event and its consequences, particularly defined in terms of economic loss. ‘Disaster risk’ is referred to when vulnerable elements of value to individuals, groups or society as a whole spatially intersect an area of potential hazard. This situation leads to a disaster if and when the event occurs, and results in damage exceeding the stricken area’s coping capacity. At its simplest, risk is calculated as the product of hazard and vulnerability.

The above definition of risk is appealing and has for years been applied to estimate loss, typically to infrastructure, in hazard scenarios such as earthquakes of a given magnitude. Integrating estimated recurrence of earthquake allows the compiling of magnitude-intensity curves and calculation of annual risk. However, risk theory has evolved to reflect a more complex and subtle reality, raising the question of whether current geodata-based risk-assessment methods adequately reflect that theory. Several limitations may be identified, all requiring further research.

Multiple Hazards

An earthquake may not only destroy buildings, but also destabilise dams or mountain slopes, resulting in the risk of flood or landslide. Hence an area is rarely exposed to a single hazard, but rather to secondary risk emanating from the same source, in this case an earthquake. Multiple hazards may thus occur, each with their own area of impact and perhaps differing in size and times of recurrence, magnitude and nature of vulnerability. The impact of multiple hazards is determined by constructing single-hazard risk maps, subsequently summed. However, summing is often not the most appropriate mathematical operation, because hazards and vulnerabilities can compound and amplify each other. For example, a polluted living space may lead to people becoming weakened by frequent gastrointestinal infection, in itself a rather small hazard. However, this may increase peoples’ vulnerability to less frequent outbreaks of more severe disease. Such feedback processes are poorly understood and it is unclear how they are to be effectively integrated into geodata-based risk assessment.

How might various vulnerabilities in risk scenarios be included? Traditional risk assessment has focused on the physical aspects, but hazard effects have a broader impact on society. Risk theory distinguishes four main types of vulnerability: physical, social, environmental and economic, at times supplemented by technical, political, cultural, educational and institutional vulnerability. Each factor is dependent upon hazard type and magnitude, as well as amplification and feedback processes, so that comprehensive multi-vulnerability risk assessment is yet to be developed.

Index-based

How may risk be quantified? The traditional way of assessing risk has been by quantifying it in monetary terms. This might by fine when assessing physical loss only, but it is inappropriate for the other vulnerabilities listed above. Thus the trend is now towards index-based risk calculations. However, it remains unclear how the various vulnerabilities should be quantified in a combined-risk index. Risk quantification is meant to provide decision-makers at various spatial scales with sufficient and accurate information to enable them to plan and act. How can risk be most meaningfully communicated and visualised? The ambition of geoscientists to construct a four-dimensional, dynamic, multi-hazard, multi-vulnerability risk assessment will result in information that challenges contemporary means of visualisation and effective communication with stakeholders.

Scale

Risk may be considered at the level of family, nation or region, and is thus inherently scalable. Scale-dependent methods are therefore needed, with an increasingly macroscopic approach resulting in generalisations and assumptions the effects of which have to be assessed. Risk is also rarely crisply defined, but rather organic and constantly changing. Crisp representations of risk are thus inappropriate.

Theoretical considerations of risk may be traced back to the nineteenth century, with many disciplines contributing. Although the conceptual basis is sound, matching geoinformatics methods are missing.