Floods

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Abstract

Floods occur when land that is normally above water becomes temporarily submerged. When they occur in areas inhabited or utilized by people they lead to losses. Flood risk management aims to analyse, assess and reduce risk of suffering these losses through implementing a variety of structural and non-structural measures. It is important to bear in mind that flood risk can never be completely eliminated, and unknown future changes, such climate or land use changes, need to be considered. One way to do this is by employing a range of approaches that perform well under a variety of possible scenarios and do not limit future options.

Floods

People benefit from living close to rivers, lakes and the sea. For millennia, water bodies have been used as trade and communication corridors, offered a defence measure against invaders, their fisheries provide an abundant high protein food supply that supports social and economic development, they supply energy and support industry, and they are often considered to be culturally and emotionally valuable. Flood plains also provide highly fertile agricultural land and their proximity to water offers an irrigation source. However, these societal benefits gained from settling close to the water come at the price of periodic flood damage.

Floods occur when land that is normally above water becomes temporarily submerged (Figure 1). They can result from heavy rainfall, when water overflows a river's levees or embankments, or from high tides and/or storms in coastal areas. Floods occur over many different spatial and temporal scales. Some floods take place very rapidly, such as flash floods (where high rainfall leads to a rapid rise in the river level), dam-break floods, glacial lake floods or ice jam floods (where a natural or man-made dam breaks suddenly leading to a torrent of water flowing down the river) or tsunamis. Other floods lead to a slower rate of water level rise, such as large river floods due to high rainfall or snow melt, or groundwater floods resulting from long periods of rainfall leading to a rise in the water table.

Figure 1. Large scale flooding in New Orleans, USA following levee breach following Hurricane Katrina in 2005 (left image, from: http://en.wikipedia.org/wiki/File:KatrinaNewOrleansFlooded_edit2.jpg) and small scale flooding in a mountain valley in Tirol, Austria (right image, from alpinesicherheit.com)

Flood risk

Floods that occur in areas inhabited or utilized by people are problematic because they can lead to damages resulting in human or economic losses. Flood risk deals with the probability of negative consequences from flooding. It is determined by the size (magnitude) and regularity (frequency) of flooding (called the flood hazard) combined with the vulnerability of the people and their properties. Vulnerability is a somewhat complex concept. It relates to the exposure of people and goods to flooding and the capacity of the population to cope with them (see Merz *et al*., 2010).

People's actions may result in an increase in flood risk in several ways by changing flood hazard and vulnerability (Figure 2). Vulnerability and exposure to floods increases as human populations expand and people occupy and use more land in previously unpopulated flood plains and coastal areas. Flood risk increases when a greater number of people, property and possessions are exposed to flooding which raises the potential for loss of life and economic loss, and as the GDP of a region or population increases the size of the damages also increases. Structural flood protection measures and river regulations give a false impression of safe settlement areas. However, in the event that the measures fail, such as for very large flood events, damages are very high, because of the so called ‘levee effect’, i.e., the fact that vulnerability has increased (more exposure and less preparedness) due to the lack of experience of flooding (see e.g., Viglione *et al*., 2014). Structural flood protection measures may also lead to a change in the hazard component of the flood risk. In many regions of the world, river regulations have been widely installed over the last centuries to protect people from floods, but at the same time they increase the flood risk downstream by transferring and concentrating the flow water to other areas. In addition, population growth has led to significant land use changes that include urbanisation and changes in agricultural practices that increase floods at the local scale. By replacing permeable soil with impermeable concrete and drainage systems, and modifying the land surface for agriculture, surface water can move faster to the river. Human induced climate change may also lead to an increase in flood risk by causing more frequent and larger storms or driving changes in seasonal snowmelt patterns due to temperature changes (IPCC, 2014).

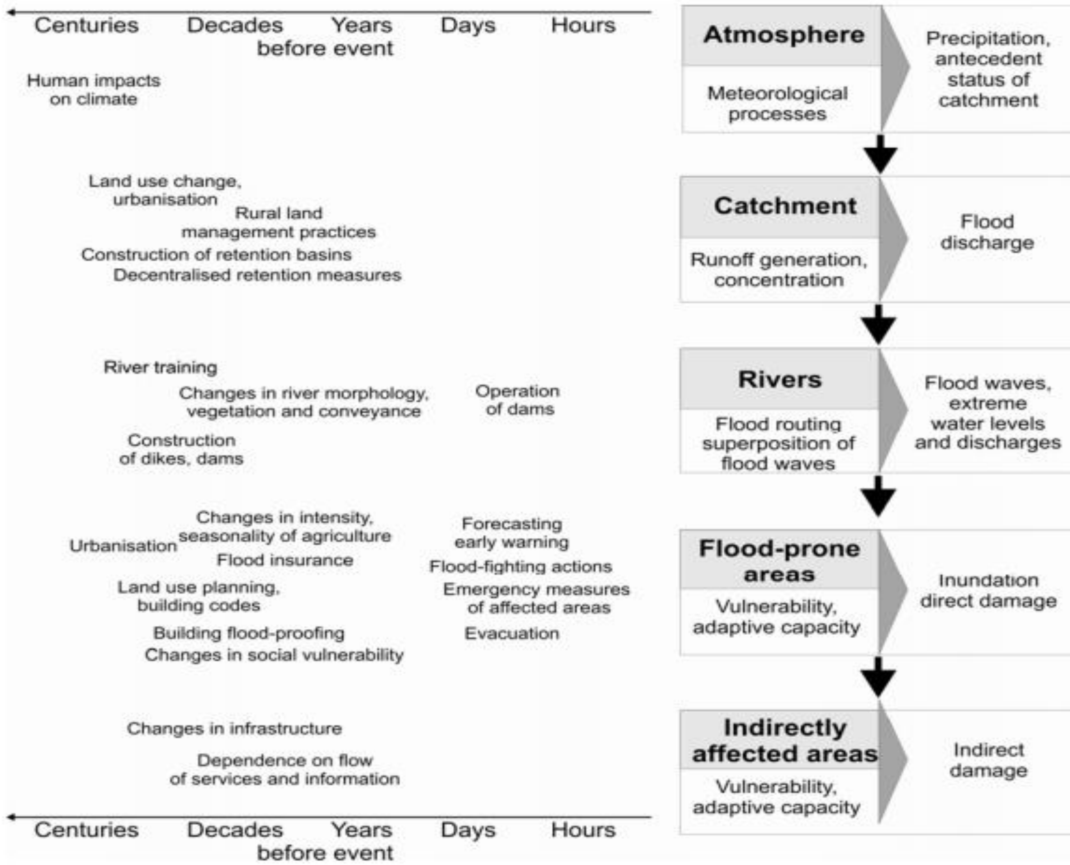

Figure 2 Human actions and interventions that impact on flood risk and their time scales (left side of figure) and drivers of flood risk (right side of figure) (from Merz *et al*., 2010).

Flood risk management

Schanze (2006) categories flood risk management according to three aspects: *risk analysis, risk assessment and risk reduction* (Figure 3). *Flood risk analysis* is concerned with determining the past, present and future risks of flooding. It aims to comprehensively capture the flood hazard (natural system) and the vulnerability (human system) and the interactions between the two systems. Knowledge, understanding and information from meteorology, hydrology, hydraulics, geology, ecology, economics, sociology, law, political sciences and psychology have to be brought together to fully understand the flood hazard and the vulnerability to achieve the most complete analysis possible of flood risk. Modelling methods that can integrate understandings and data from both natural and social sciences, and capture the feedbacks between the two are, in many ways, in their infancy. Their development is essential to fully understand flood risk and make predictions on future risks (see Di Baldassare *et al*., 2015). The challenges to this are many and include finding ways to combine natural and social science data sets, overcoming or capturing the current day uncertainty in the flood risk system (for example, how, where and when water moves through the hydrological system; how, where and when people make decisions on flood risk management), and dealing with unknown and uncertain future changes in the river system (such as climate change, land use change or population change).

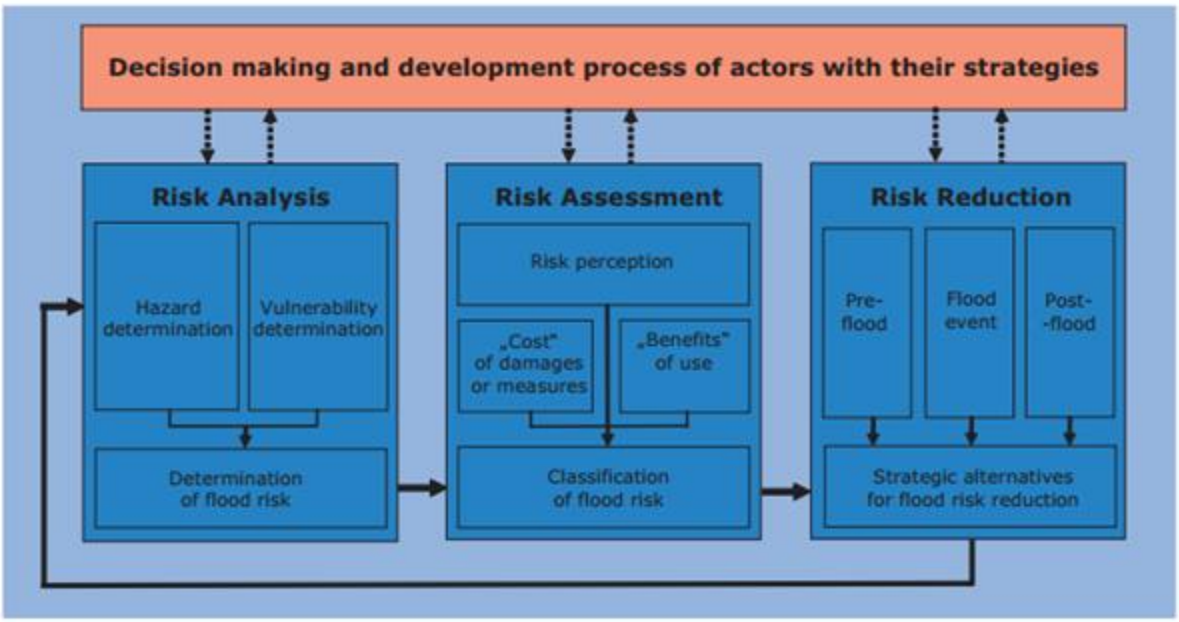

Figure 3 A framework for flood risk management (from Schanze, 2006)

The *flood risk analyses* provide (scientifically) derived information about the probability of a flood event and the related damages. It is important to remember that flood risk can never be completely eliminated. During *flood risk assessment* society makes a decision as to the level of flood risk that they are willing to accept. This decision will not only be shaped by the flood risk analyses provided by scientists, but also by the risk perception perceived by the communities or populations and their decision makers combined with their financial and institutional capacity to implement desirable flood risk reduction measures. For example, the Netherlands has a very low acceptance of flood risk and choose (and have the capacity) to spend on expensive flood management strategies that aim to protect against large but highly unlikely flood events. It is also important to note that the collective risk perception, and therefore risk assessment, is highly fluid, and can be changed or influenced by the experiences of the population. As such, experiencing a flood event may lead to a decrease in risk acceptance even though the actual risk of flooding (as determined by the flood risk analysis) remains the same.

There are a great range of measures that can be implemented for *flood risk reduction* (see Figure 2 and Figure 4). Preventative measures include dikes, dams and retention basins in the river basin and land use zoning and regulations to prohibit, for example, high flood risk areas being used for residential properties. Precautionary measures encompass building codes to ensure properties are flood proofed, insurance requirements that ensure land-owners recognise flood risks and contribute to their costs, risk communication and awareness raising, preparation and training, and early warning systems.

Flood risk management therefore takes places in different forms at different times in the management process and can be termed the Flood Risk Management Cycle (Figure 4) (Thieken *et al.*, 2016). Pre-flood management involves understanding and predicting where and when a flood might occur using mapping, modelling and scenario development. At this stage, structural and non-structural flood protection measures are explored and implemented. Unknown future changes, for example climate changes that may lead to heavier and more frequent rainfall events, or social change such as mass displacement and relocation of people due to war, need to be considered. Ways to do this include identifying robust and "no-regret" strategies, those that perform well under a variety of possible scenarios and give benefits regardless of future changes and that do not limit future options (Blöschl *et al*, 2013). For example, early warning systems and risk awareness raising. Employing a diverse range of approaches also helps to ensure that in the worst case scenario possible, if one flood management approach fails (such dikes being overtopped) others are present to reduce the impact of the event (such as early warning systems and evacuation plans). Post-flood management involves recovery and taking measures to prevent further negative impacts such as outbreak of disease. Post-flood management should be followed by pre-flood management in order to enhance preparations for future floods. Embedded within this process of continual learning and refinement of flood risk management is the fact that the river system and its human occupants co-evolve. A flood event can lead to a human induced change in the hydrological system (e.g. allocation of land for water retention during future high rainfall events or restoration of flood plains) and the vulnerability of the population (through early warning and preparedness), which subsequently reduce the impact of future (potentially more severe) events. Understanding and utilising this co-evolution to enhance flood risk management is critical for addressing flood risk in their multitude of settings around the world.

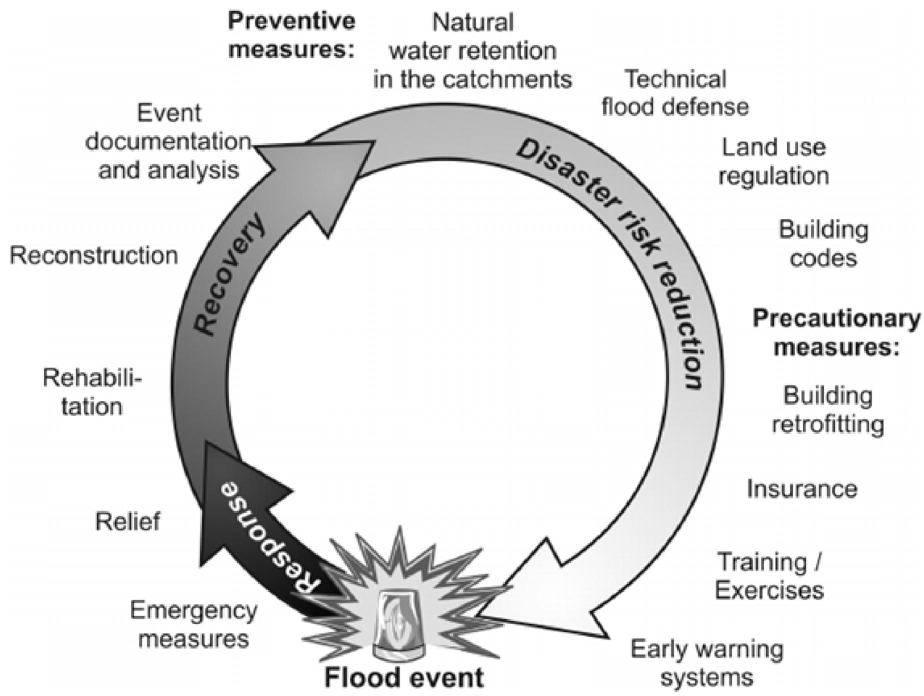

Figure 4 Flood risk management cycle (from Thieken et al., 2007)

Learning resources

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