What is flood vulnerability?
Summary for public administratrion and private entities

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What are floods?

Floods are defined in Czechia by Act no. 254/2001 Coll. on Waters and on amendment of certain acts (Waters Act) as *"temporary significant increase in water levels in watercourses or other surface waters, in which water inundates areas outside the watercourse bed and may cause damage."*
Generally speaking, floods are a natural part of landscape formation (Langhammer, 2007, ed.) and have been, in many regions and historical periods, an unconditional prerequisite for development of human culture. At the same time, they pose a serious natural hazard with extreme impacts on human society and landscape.

How serious are current flood damages?

Floods are one of the most significant natural hazards globally (EC 2007/60/EC). A report of MunichRe for the year 2016 (MunichRe 2017) even called the year the Year of Floods. According to the report, floods were the most frequent natural dangerous phenomena globally in 1980-2016 along with meteorological dangers, and their numbers have been increasing in the long run (Table 1).

Country	Years	Loss of lives	Economic damages [billion €]
Czechia	1997, 2002, 2013	60	5 078
Germany	2002, 2013, 2016	38	26 500
Poland	1997, 2001, 2010	101	7 280

Table 1: Impacts of three most important floods in selected Central European countries (1990-2018, EM-DAT database)

How can impacts of floods be classified?

Monitoring and assessment of flood loss is an integral component of assessing vulnerability of societies and areas to floods.
Based on classification of flood damage and data availability (Table 2), the most appropriate vulnerability assessment method and aggregate vulnerability indicators can be determined for different types of elements in an area.

Sector/type of objects	Data availability and stadardization
Households	High availability, higher ability to standardize
Industry	Low availability, high price variability
Services	Low availability, high price variability
Public sector	Depend on administrative level
Infrastructure	Variable, standardization only for some structures
Agriculture	Higher availability, higher degree of standardization
Other	Low availability, standardization for some units only

Table 2: Classification of flood damage by data availability and ability to standardize them (i.e., ability to determine average representative values; Merz et al. 2010)

What is vulnerability?

Reducing impacts of floods requires detailed understanding of various aspects of floods, as well as understanding of their comprehensive nature. A suitable tool for that is a model, used by experts as a simplified image of reality.
The risk process model is one of the most common; it is based on work of the Office of the United Nations Disaster Relief Coordinator, and has been in common use for 40 years. The model represents risk as a function of three variables, or components.

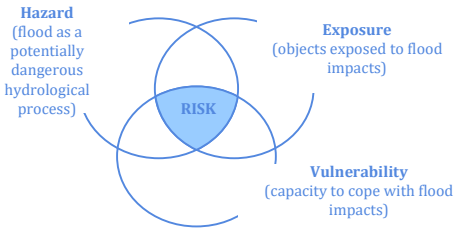

Fig. 1 Process model of risk

Flood risk is thus the result of combined actions of the three components and can be defined as the probability of a flood occurring in a given area that will cause specific social, economic or environmental loss.

Box A – Combined effects of flood risk components

Imagine a watercourse, the size of the Jizera for example, with a symmetrical bed and valley bottom. Two villages are located on opposite banks.
Any flood in the area can be evaluated as an equally dangerous phenomenon, because the flood wave will have equal hydrological characteristics in the area (culminating flow rate, water level). In spite of that, the flood risk will be different for each of the villages: they may differ in the numbers of structures, inhabitants and extent of economically used land.
However, the flood damage may still differ even with the same numbers and extents (i.e., the same exposure) due to differing levels of vulnerability: building materials, presence of rescue services, degree of population mobility, species of crops.

For what structures is vulnerability determined and on what scales?

Although vulnerability has become a key term in mitigating damage caused by floods, there are significant differences among experts and politicians as to what the term vulnerability means. Among other things, "preferences" are affected by agenda they manage. In practice, depending on different data availability and applicability of vulnerability in various sectors, degrees of vulnerability are determined separately for populations and for various types of structures, activities and economically used[1] land:

- population - at the level of whole population in a territory (country, region, municipality), households or individuals;
- structures - at the level of territory or individual structures (buildings, infrastructure);
- activities - at the level of economic sector or businesses;
- land - at the level of territory or individual types by use.

[1] *Only a few attempts have been made so far to determine the level of environmental vulnerability of a territory.*

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What does vulnerability depend on and how to reduce it?

Papers dealing with natural risks typically define four basic "global" approaches, which also represent differing understanding of factors affecting the degree of vulnerability. The approaches evolved gradually but are rather complementary, and each of them may contribute differently to reducing the degree of vulnerability (Table 3)..

Approach	Use
Technical	Integration of spatial data makes it possible to define sites with high flood risk and design suitable measures with a priority for such areas.
Structural	Knowledge of demographic, social and economic data makes it possible to intervene in order to reduce risks, improve crisis management and improve monitoring of flood damage.
Behavioural	If we understand motivations of individuals and groups for activities in an area, it is easier to explain risks arising from such activities and increase efficiency of flood protection strategies.
Developmental	Better for international level (captures development specifics and flood management problems arising from them).

Table 3: Approaches to vulnerability when mitigating flood damage (Smith and Petley, 2004)

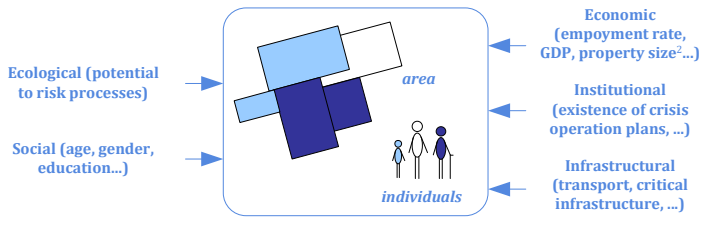
Other authors classify vulnerability according to whether it represents (Cutter, 1996):

- pre-existing condition (nature of territory expressing extent of potential damage);
- response (degree of ability of society to cope with flood consequences);
- threat to place (combining territorial conditions with nature of social relationships, expressing ability of society's reaction).

A. Determining vulnerability of population

Population protection is a key task for a state. However, floods cause loss of numerous lives annually. That is why greater emphasis is placed on determining the degree of vulnerability of populations to floods to be able to identify places of greater risk. This is done at the level of entire populations (e.g., proportion of population assessed as vulnerable, proportional vulnerability; Adger, 2006), or smaller territories (regions, neighbourhoods) or households and individuals. Vulnerability is determined as an index (e.g., Social Vulnerability Index; Cutter et al., 2008) by aggregating input data (Fig. 2).

Fig. 2: Indicators of social vulnerability



² Determining property at the household level is problematic due to data availability; it is resolved by usual prices, for example.

B. Determining vulnerability of structures

While determining the degree of (economic) vulnerability of society may be complicated because detailed data about movable assets are not available (the issue is then solved by determining average prices of appliance, etc.), the starting points for determining vulnerability of structures are better. In their case, we use information about the structure and we can model damage caused by a flood of certain depth (hydrostatic effect) and flow rate (hydrodynamic effect) for each type of building. The results are expressed using damage functions(Schinke et al., 2016; Fig. 3). They make it possible to model savings if any (damage reduction) due to implementation of suitable flood protection measures. Determination of building prices in an international comparison has been attempted, e.g., by EC Harris (2010). For the year 2010, he states, e.g., that 1 m2 of residential area cost 1055 euros in Czechia while it was 2159 euros in Germany.

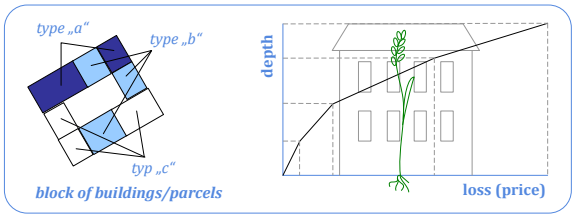


Fig. 3: Vulnerability of buildings/agricultural land

C. Determining vulnerability of agricultural land

As in the case of buildings, damage functions are used for agricultural land. The damage is determined based on land use, crop type, sowing procedures and other indicators as the case may be (Fig. 3). It can be done down to the level of a plot. An international comparison has been made for assessment of vulnerability of agricultural areas. Vulnerability rates are determined for the whole territory based on land cover data (CORINE Land Cover) and added value per hectare (Huizinga et al., 2007; based on World Bank, 2015). The average added value was determined to be $ 983 per hectare in Czechia, while it was $ 1568 in Germany.

Relatively little attention has been paid to indirect losses on land (ecological, recreational and aesthetic functions). One of the ways to assess these losses and determine the vulnerability is to use assessment based on landscape ecosystem services.

Are there any available maps of vulnerability to floods?

So-called flood danger and flood risk maps have been made at the national level in conjunction with the European Flood Directive (2007/60/EC). Vulnerability (potential damage) is expressed in them by combining flood danger maps with functional land use. They are accompanies by usual price calculations (http://cds.chmi.cz, www.boris.nrw.de)

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