Guideline Vulnerability terminology

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Climate Proof Cities consortium
Peter Bosch (TNO) *Editor*

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Authors: Anikó Pásztor, Peter Bosch (TNO)

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Introduction

For discussing the impacts of climate change and the vulnerability of cities, several terms are in use for the same process of phenomenon. This document is intended to define preferred key expressions for communication and reporting by researchers of Climate Proof Cities. It helps us in communicating our findings if we can indicate very clearly what we mean, using the same word and the same definition to describe similar processes or phenomena.

The relation between the main terms

Global climate change will have impacts on cities. Impacts can lead to damage but that is not necessarily the case. How vulnerable the urban system is to damage, depends on the type of hazard, the extent of exposure, the sensitivity of elements in the city and on the adaptive capacity of cities. Vulnerability together with likelihood of occurrence of an extreme event determines the risk the urban system is subjected to. The following figure shows the relationship between these factors. See Figure 1.

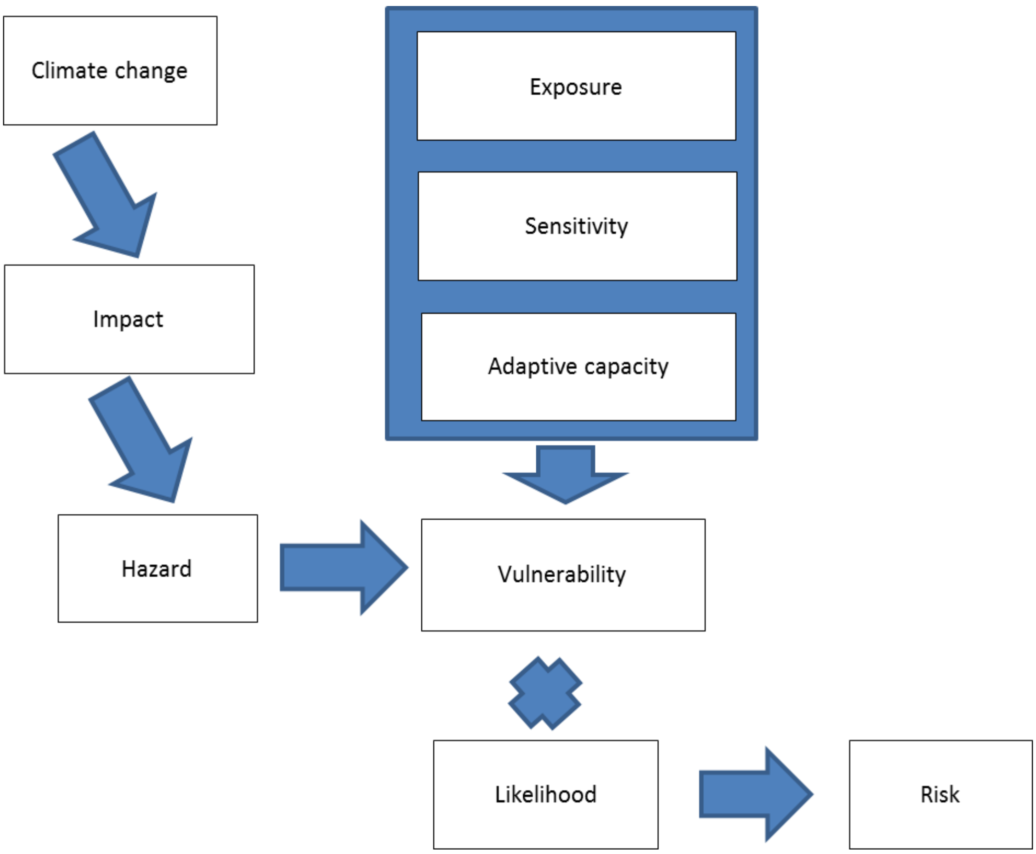


Figure 1 Climate change impacts on the urban system

Climate change (Dutch: klimaatverandering)

Climate change refers to changes in climate attributed to human activity. As opposed to climate variability: variations in the climate that are not related to human-induced climate change, but caused by natural parameters (Bicknell et al, 2009).
The concept of climate change thus refers to the human induced increase of the natural greenhouse effect. This is primarily caused by the emission of greenhouse gases, among others released by the burning of fossil fuels. Since the industrial revolution, and mainly during the 20th century, the average temperature of the Earth rose by 0.6 (± 0,2)°C (IPCC, 2001: 77). According to models of the IPCC the average temperature will rise by another 1.1 to 6.4 degrees by the end of the 21st century (IPCC, 2001: 3). Apart from increased average temperature, other climate stressors are decreases/increases of precipitation, reduction in frost periods and snow cover, increase in atmospheric circulation.

Impact (Dutch: gevolgen)

Climate change stressors cause impacts. Generally, impact is the intensity of factors potentially causing change in a system observed. Climate change impacts are the consequences of climate change on natural and human systems (IPCC TAR, 2001). Impacts may be expressed as: millimeters of torrential rain, centimeters of sea level rise, more frequent occurrence of warm and dry summers, changes in the number of tropical days , droughts, etc.

Hazard (Dutch: dreiging; gevaar)

Hazard relates to climate and weather related events which directly and indirectly have the capacity to harm people, places or things. The hazard indicates the extent, severity and probability of the phenomenon which has the capacity to cause harm. Harm or damage can occur for example through flooding or high temperatures. We talk about the hazard of the drying out of the soil and crop losses because of less rainfall. Other examples of hazards are more frequent occurrence of heat waves and heat stress, more frequent storm tides (note the difference with the neutral term “impact”: hazard is related to the capacity to harm).

Hazards may be directly caused by climate change, such as heat stress, but may also be the result of a chain of indirect events: rainstorms may cause floods, which may trigger petrochemical spills in factories along the river. Droughts can cause scarcity of water, which in turn impact on electricity supply.

A hazard does not necessarily lead to harm (Samuels and Gouldby, 2009). Three concepts determine the possible damage: Some hazards are more geographically constrained than others and this then relates to the idea of exposure; some systems are more easily disturbed than others, which relates to the concept of sensitivity (or susceptibility); and finally humans may have changed the capacity to cope with a hazard: changing the adaptive capacity.

Exposure (Dutch: Blootstelling)

Exposure is the degree to which elements at risk may come into contact with the hazard of interest (Lindley, 2009). For example, road workers engaged in making asphalt roads are during working hours exposed to high outdoor temperatures, low-lying areas in the Netherlands are exposed to flood waters in case of flooding.

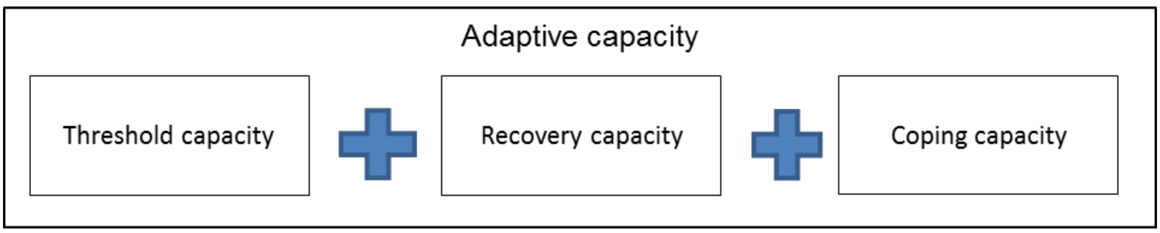
Samuels and Gouldby (2009) define exposure simply as: quantification of receptors that may be influenced by a hazard.

Sensitivity (Dutch: Gevoeligheid)

Sensitivity or susceptibility is the easiness by which a system is disturbed by a hazard. Sensitivity depends on both the nature of the natural-spatial structure that may be able to cope with the hazard and the social and economical structures that are negatively influenced by the hazard. Sensitivity may, for example, depend on: surfacing (full or partial), population density, density of capital goods (Ministerium für Umwelt, 2010). Neighborhoods with a high percentage of surfacing are more sensitive to flooding in case of extreme rainfall than neighborhoods with many green surfaces. Sensitivity equally depends on the economic or societal value of objects in an area: a transformer station supplying part of a city with electricity is more sensitive to flooding than a bicycle workshop.

Adaptive capacity (Dutch: Adaptatievermogen)

Adaptive capacity is an inherent capacity of a(n urban) system, population or individual household to undertake actions to be able to cope with the impact of climate change. This, of course, depends on time and resources at the afflicted region's disposal. (Bicknell et al, 2001: 9) Adaptive capacity is a function of wealth, scientific and technical knowledge, information, skills, infrastructure, institutions and equity. Therefore it varies considerably among regions, countries and socioeconomic groups and will vary over time. (IPCC, 2001: 63) Adaptive capacity depends on threshold-, coping- and recovery capacity of the urban system, and adds to these the long term adaptability of the urban system (De Graaf et al, 2007)(See Figure 2).



Threshold capacity
Threshold capacity is the ability of the urban system to build up a barrier against damage in case of a disturbance. Examples of measures include dikes and dams, enlarged seasonal storage of water (against drought).

Coping capacity
Coping capacity is the capacity of the system to reduce damage when disturbance beyond damage threshold has occured. Levina et al (2006: 13) define coping capacity as the means by which people or organizations use available resources and abilities to face adverse consequences that could lead to a disaster. An example of a measure is an improved drainage system.

Recovery capacity
The capability of the urban system to return to its original state (state before the impact) after having been subjected to an impact (damage beyond threshold). Measures include redundant pumping capacity and cleaning services.

Adaptive capacity is then the overall (spatial) planning and management capacity to realise the above mentioned capacities.

Figure 2 Adaptive capacity
Source: adapted from Van de Ven et al, 2009.

Vulnerability (Dutch: Kwetsbaarheid)

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. *Vulnerability* is the function of the climate change hazard, the degree of exposure, its sensitivity, and its adaptive capacity (IPCC, 2007: 27). Frequently vulnerability is expressed in a formula: vulnerability = exposure x sensitivity / adaptive capacity (Fünfgeld & McEvoy, 2011).

Risk (Dutch: Risico)

The concepts mentioned above are sufficient when it refers to slow and long-stretched processes or average changes, such as soil subsidence or an increase in average temperature. However, in the case of extreme events the likelihood (=the chance of something happening) of an extreme event occurring becomes important. The concept of risk is used for those situations with a chance on an (often extreme) event. Risk is the product of the combination of likelihood and vulnerability. Likelihood is the probability of a (climate or weather related) event taking place at some point in the future and its expected frequency (IPCC, 2001). When talking about risk of pluvial flooding we thus refer to both the chance of an extreme rainfall event and the potential damage to people and their livelihood and investments (e.g. building, infrastructure).
Risks can be direct, as in larger and/or more floods, or indirect as climate change may negatively affect livelihoods or food supplies and prices, or access to water (Bicknell et al, 2009).

Alternative presentations

There are various ways to present the relation between the concepts above, which often depend on the analysis framework. In the literature a distinction is made between a 'vulnerability approach' with a focus on who and what experiences the impacts, versus a 'risk management approach' focusing on (technical) solutions to decrease the risk.

From a risk management approach a diagram like in Figure 3 will be appropriate. Climate change influences both the likelihood (the chance) of an extreme event and the extent of exposure. These two together constitute the hazard. The risk of adverse consequences of the hazard depends on the vulnerability, which in turn is dependent on sensitivity, exposure and adaptive capacity.

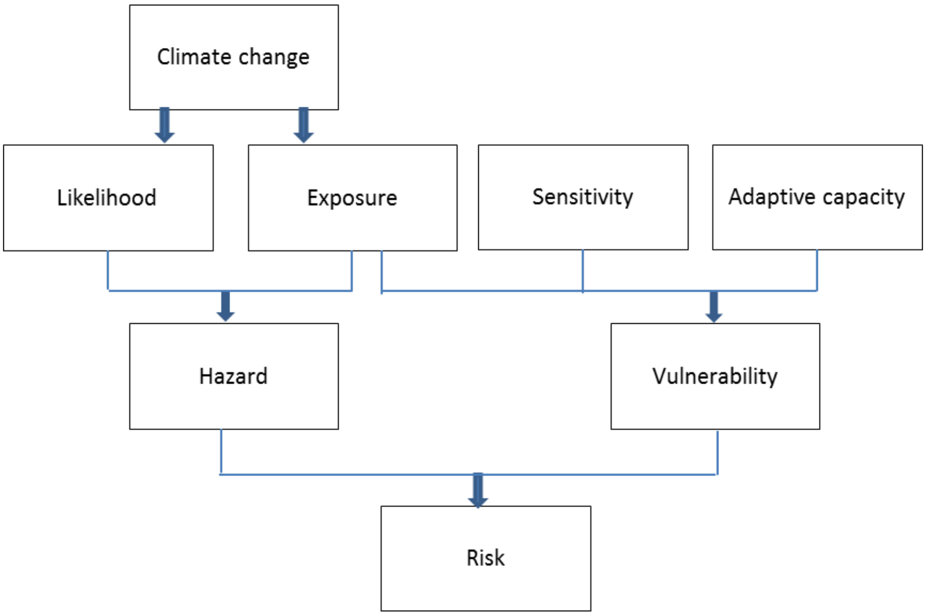


Figure 3 Alternative scheme 1
Source: adapted from CPC, 2011.

Focusing on who suffers from the effects of climate change, results in a diagram like in Figure 4. In this diagram the definition of vulnerability as "exposure x sensitivity / adaptive capacity" is expressed within the blue box. In scenario studies the residual consequences have also been called the "outcome vulnerability", which is the vulnerability after all feasible adaptation options have been taken into account (Fünfgeld & McEvoy, 2011).

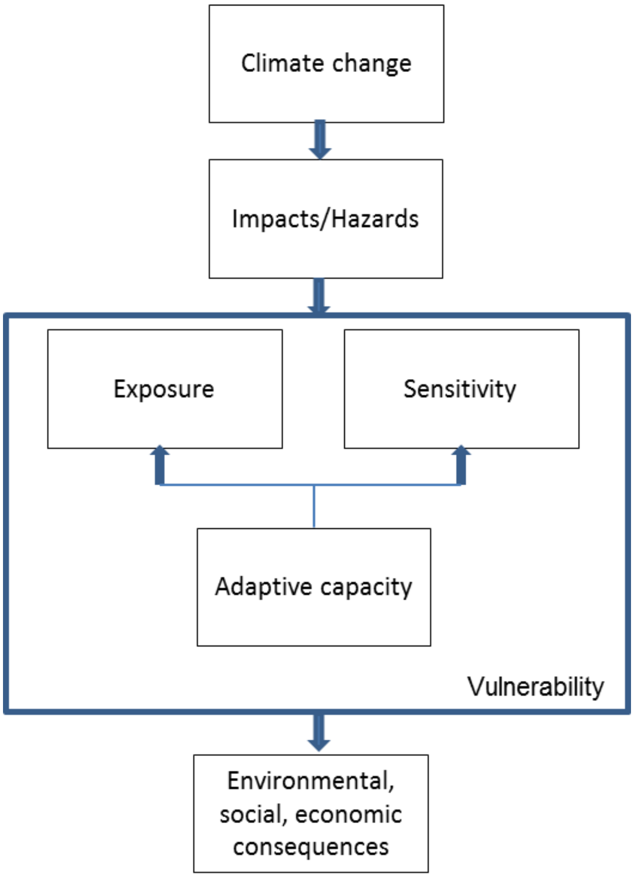


Figure 4 Alternative scheme 2
Source: Fünfgeld & McEvoy, 2011.

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