Conclusions

The above comparative listing of terminology demonstrates how wide the range of the definition of one term can be and that many terms are tightly interwoven. The listing informs the reader about the multiple definitions in use across various disciplines and sectors which is an important stepping stone in dispelling the often lamented misunderstanding in the discussion around disaster reduction. What the above listing fails to offer is a harmonized concept of core terms that is precise enough to delineate the terms from each other but flexible and broad enough that it is vastly applicable across sectors and disciplines.

Terms such as vulnerability and risk are envelopes for complex and interconnected parameters and processes. A paradigm shift has taken place that puts more and more emphasis on “non-natural-science” issues. They are harder to conceptualize since they are often not tangible and of qualitative nature, e.g. coping capacity, resilience, institutional frameworks, cultural and social aspects, economic aspects etc.

Terms of such complexity are not easily defined in an exhaustive way. And they probably should not be - who can speak for all disciplines, contexts, and scales? It is more important to agree on the key characteristics. That way, a conceptual frame is created and the details that are put into that frame will vary with context, geographic scale, and time scale.

<u>Hazard:</u>
Every disaster starts with a hazard – known or unknown. There are many ways to characterize hazards, e.g. natural, technical, man-made, nuclear, ecological etc. The categories are probably as diverse as the disciplines and sectors involved. But they all have in common the potential to cause severe adverse effects that lie at the bottom of each emergency, disaster, and catastrophe.

A hazard can be as general as “flood” or “storm” and as such stands for groups of potentially harmful events of variable severity. Or a hazard can be as specific as a magnitude 7.2 earthquake in Los Angeles or a category 5 Hurricane hitting Miami. In that case we are dealing with a specific hazard scenario. One important feature of hazard is that it has the notion of probability, in other words a likelihood of happening. A hazard is a threat not the actual event. Any hazard can manifest itself in an actual harmful event. In other words, if it can be measured in real damage or harm it is no longer a hazard but has become an event, disaster or catastrophe.

Every specific hazard magnitude is attached to a usually empirically derived return period, which is site-specific. The return period of a category 5 hurricane is different for New Orleans compared to Porte-au-Prince. If hazard is pegged out more general such as “an epidemic” or “a drought” it is characterized by all possible magnitudes tied to a specific return period or frequency (its inverse). The latter ensemble is the magnitude-frequency relationship of a particular hazard and is an inherent characteristic of a specific locality or region.

<u>Vulnerability:</u>
Another prerequisite for a disaster is vulnerability. It is a dynamic, intrinsic feature of a community (or household, region, state, infrastructure or any other element at risk) that consists of a multitude of components. The extent to which it is revealed is determined by the magnitude of the event.

Vulnerability indicates a damage potential and is a forward looking variable. Or as Cannon et al. (2002) [18] characterized it, “vulnerability (in contrast to poverty which is a measure of current status) should involve a predictive quality: it is supposedly a way of conceptualizing what may happen to an identifiable population under conditions of particular risk and hazards." Determining vulnerability means to ask what would happen if certain event(s) hit particular elements at risk (e.g. a community).

Vulnerability is an intrinsic characteristic of a community that is always there even in quiescent times between events. It is not switched on and off with the coming and going of events but rather a permanent but dynamic feature that is revealed during an event to an extent which depends on the magnitude of the harmful event. At the same time this implies that vulnerability can often only be measured indirectly and retrospectively, and the dimension normally used for this indirect measure is damage or more generally harm.

What we normally see in the aftermath of a disaster is not directly the vulnerability but the harm done. The extent of harm done depends on the vulnerability and the magnitude of the event. Seeing the damage pattern of a community without knowing the magnitude of the event does not allow conclusions regarding the vulnerability. In that sense the magnitude-damage function reflects the vulnerability of an element at risk (community, household, nation, infrastructure, etc.).

For practical reasons a vulnerability analysis will often limit itself to a certain scenario (i.e. event magnitude) for which the analysis is carried out. This is usually an appropriate approach to assess vulnerability but the choice of the event scenario is a subjective one. What scenario shall be chosen? The 100 year event, the largest event that has occurred in the living memory, or the 5 m flood level? Despite of all the known shortcomings of databases (incompleteness) of historic events they provide some means to create a magnitude-frequency relationship over a range of event magnitudes. This magnitude-frequency relationship can be an important tool to support the decision making process with respect to the level of acceptable risk.

Vulnerability changes continuously over time and is usually even affected by the harmful event itself. It can increase for example if poverty has been heightened by a disaster, so that the next disaster will have a more devastating effect on the impoverished community. A small event, however, can raise the awareness of the community and that way decrease their vulnerability.

Vulnerability is a function of the sensitivity or susceptibility of a system (community, household, building, infrastructure, nation etc.). It is "independent from any particular magnitude from a specific natural event but dependent on the context in which it occurs. Vulnerability cannot be assessed in absolute terms; the performance of the urban place should be assessed with reference to specific spatial and temporal scales" [6]. In earthquake engineering this susceptibility is often quantified by means of a damage ratio that can vary between no damage (0%) and total destruction (100%). But vulnerability has many dimensions - physical (built environment), social, economic, environmental, institutional, and human - and many of them are not easily quantified.

The complexity of vulnerability is not only given by its multiple dimensions but also by the fact that it is site-specific and that its parameters change with geographic scale. The parameters that determine vulnerability are different on the household-, community-, and country-level. In the economic dimension on the household-level parameters such as the amount and diversity of income of single persons are relevant whereas on a country-level inflation rate and GDP are more appropriate.

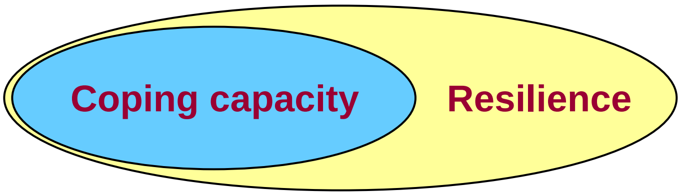
<u>Exposure:</u>
After vulnerability and hazard exposure is another pre-requisite of risk and disaster. Here exposure is understood as the number of people and/or other elements at risk that can be affected by a particular event. In an un-inhabited area the human exposure is zero. No matter how many hurricanes will affect a deserted island, the human exposure and, hence, the risk of human loss remains zero. While the vulnerability determines the severity of the impact event will have on the elements at risk, it is the exposure that will

drive the final damage or harm. So in its economic dimension vulnerability is the depicted by the projection that a family will loose 50% of its assets. How many families will do so is captured by the exposure. In an overly simplifying example the poverty of a community will determine the degree to which it will be affected by an event of a certain magnitude (→ susceptibility) and the number of the community members represents the exposure. In that sense a densely populated area is at higher risk then a sparsely populated one, all other conditions being equal.

<u>Coping Capacity/adaptive capacity and resilience:</u>
However, it gets more complicated, because in real life the harm done also depends on the coping capacity and the resilience of the element at risk. In the literature most definitions show a large overlap between coping capacity and resilience and are often used as synonyms. Those two dimensions of a harmful event are not easily separated from each other.

Here coping capacity encompasses those strategies and measures that act directly upon damage during the event by alleviation and containment of the impact or by bringing about efficient relief as well as those strategies that strive for adaptation, i.e. behaviour or activities that circumvent or avoid damaging effects.

Resilience is all that, plus the capability to remain functional during an event and to recover from it. So resilience includes coping capacity but at the same time goes beyond it.



The difficult question that arises from this definition is: does vulnerability already account for coping capacity and resilience or are they separate counteracting parameters? This is not easily answered. It depends on how we define the damage/harm. If the extent of the damage/harm is defined also by the duration of the adverse effects and by the repercussions in poverty, economy, awareness etc. then vulnerability has to include coping capacity and resilience.

<u>Risk:</u>
Vulnerability is measured in terms of expected harm/damage and so is risk. How can those terms be delineated from each other?

Risk always involves the notion of probability of occurrence. So information on “when?” or on “how often?” indicates we are talking about risk. That could be captured in a continuous damage-frequency relationship or just the definition of the return period for a particular event scenario. While vulnerability informs about the consequences of possible adverse events, risk is trying to tell us how often or with what probability we have to expect those scenarios.

For example: information on expected losses for an event during which the water level reaches 5 m above normal refers to hazard and vulnerability. Information on expected losses for a 200 year event during which the water level reaches 5 m above normal refers to risk. In another context: projecting the consequences of a 15m tsunami is important but in order to make informed disaster management decisions it is necessary to know how often such an event can be expected. Disaster Management decisions are based on risk and not only on hazard.

To summarize, here risk is understood as a function of hazard, vulnerability, exposure, and resilience (see also the figure below):

$$\text{Risk} = f\,(\text{hazard}, \text{vulnerability}, \text{exposure}, \text{resilience})$$

The frequency or return period of adverse effects allows the individual or official decision maker to define a level of acceptable consequences. This is only possible if the decision maker understands what events to expect over time. In the notion of vulnerability the individual cannot put this information in context with the actual threat. Decisions will be different for a 10 year event as compared to a 5000 year event. For decision making information on the probability of occurrence is crucial. It will drive the decisions. Problematic is the fact that normally the historical record is too short to provide reliable magnitude-frequency relationships for particular hazards and regions. In addition global change has started to change those relationships.

This can be seen in Germany where for the Rhein and the Danube the return period of the 100-year event had to be revised to be rather a 20-year or even 10-year event [87]. Or in the US where the Missouri River has had 6 100-year floods since 1946 [88]. Fluke of nature or real trend? – Hard to decide. But many scientists agree that the trend is strongly supported by data. In situations of uncertainty it would be most appropriate to heed the precautionary principle. After all, we are not even prepared to deal with the current risk situation. How shall we cope with and adapt to a deteriorating situation due to climate change?