State-of-the-Art and Definitions

The following section gives a brief overview of other approaches in the field, focusing on disaster risk at the global or regional level. The overview of selected current approaches also deals with some of their comparative advantages and shortcomings. The review of existing approaches might also help to understand the new elements of the WorldRiskIndex.

Disaster Risk Index (UNDP and UNEP GRID) 2004

In 2004, the United Nations Development Programme (UNDP) published the study "Reducing Disaster Risk, a Challenge for Development", introducing the Disaster Risk Index (DRI). The DRI distinguishes several classes of natural risks at the national level (Fig. 1), based on a model developed by UNEP GRID (United Nations Environment Programme, Global Resource Information Database). The UNEP GRID model assesses different physical and socio-economic parameters that influence the impacts of natural hazards. Terminologically, the study is in line with the United Nations International Strategy for Disaster Reduction (UN/ISDR), which means that the underlying comprehension and definition of risk as a function of natural hazard and vulnerability equals the approach of the presented concept.

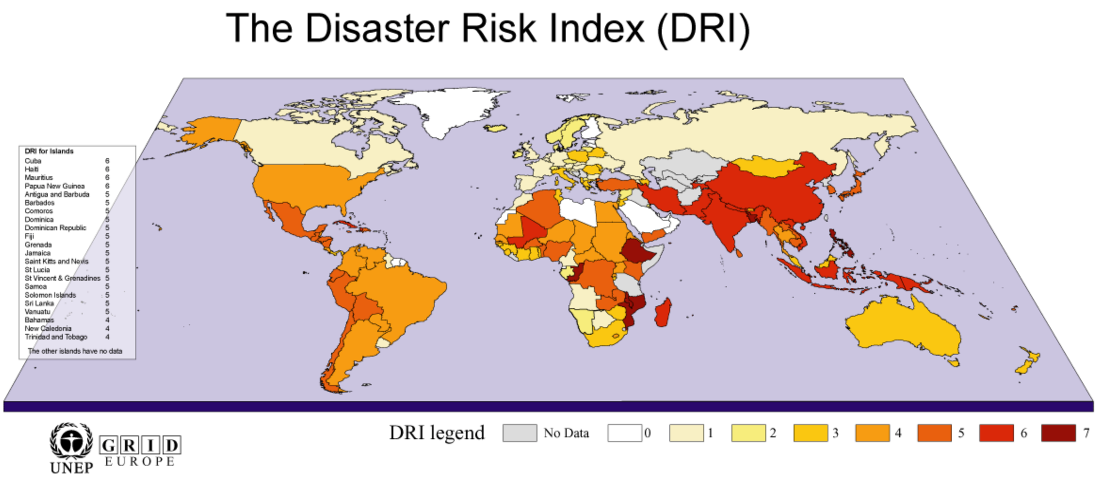

Fig. 1 Spatial distribution of DRI classes (0=no mortality risk to 7=highest mortality risk), source: Peduzzi et al. 2009:1157.

As a primary goal and intention, the DRI seeks to explain the correlation of a country's development status and its vulnerability to external (natural) hazards. It thus combines the physical exposure to hazards (annual average population exposed per spatial unit) and the vulnerability (expressed through socio-economic variables) to calculate the mortality risk for a certain hazard type (Peduzzi et al. 2009). Adverse effects of natural hazard impacts other than mortality, for example the population affected, are not included in the calculation.

The DRI is based on mortality data from the Emergency Events Database (EM-DAT) of the Centre for Research on the Epidemiology of Disasters (CRED) that contains approximately 15,000 large disaster events. Hazard events have to fulfil at least one of the following criteria, in order to be included in the database:

- Ten (10) or more people reported killed
- One hundred (100) people reported affected
- Declaration of a state of emergency
- Call for international assistance

(http://www.emdat.be/criteria-and-definition)

In addition to the physical exposure and mortality data from CRED, 32 socio-economic variables were selected as potential vulnerability indicators, but

> *"only five of them were finally retained by the multiple regression analysis (i.e. GDP purchasing power parity per capita, modified percentage of arable land, percentage of urban growth, percentage of country forest coverage, transformed value of the percentage of the country dedicated to crop land)" (Peduzzi et al. 2009:1156).*

Limitations of the DRI, intended to be reduced within the World Risk, Vulnerability and Adaptation Index, result from the consideration of mortality risk only, as well as from the selection of the above vulnerability criteria that are very narrowly concentrating on the quality of the environment and composition of the economy. Most indicators used within the DRI focus mainly on the direct consequences of disasters, in terms of the identification of the variables that directly correlate with observed fatalities and losses. The proposed World Risk, Vulnerability and Adaptation Index, in contrast, puts more emphasis on the context conditions and accounts for direct losses, as well as the broader development and governance context of a country, through indicators like the Corruption Perceptions Index (CPI).

Natural Disaster Hotspots
(International Bank for Reconstruction and Development/World Bank/Columbia University, 2005)

The hotspots study by Dilley et al. (2005) presents an alternative approach for an index of the global risk to natural hazards. This includes economic losses, in addition to mortality, and disposes a higher resolution (5km x 5km grid) than the DRI. The primary goal of this study is to identify regional hotspots of risk. Like the DRI, it uses the CRED EM-DAT database as basis for its calculation and is thus limited to large events. Within the study, three separate indices are calculated:

1) Index on mortality risk (based on gridded population of the world data),
2) Index on risk of absolute economic losses, and
3) Index on risk of economic losses as proportion of GDP per grid.

The societal vulnerability within this study is estimated based on mortality and economic losses (for different levels of income) of past events. Areas with low population density or without agricultural importance are not regarded in this study, which might be problematic, as these areas show high relative mortality to floods which can lead to the exclusion of particularly vulnerable areas (Birkmann 2007). Risk is calculated based on natural events, elements exposed and vulnerability. The fundamental drawback of this study results from the lack of specific indicators of vulnerability. Vulnerability, in the understanding of this concept, cannot simply be determined by past losses of life and economic values.

Hazard-independent Vulnerability Index (Stefan Schneiderbauer, 2007)

In his PhD-Thesis on *"Risk and vulnerability to natural disasters – from broad view to focused perspective. Theoretical background and applied methods for the identification of the most endangered populations in two case studies at different scales"*, Schneiderbauer presents a very comprehensive vulnerability analysis, which gave important methodological input to the proposed concept.

Based on the availability and actuality of data, Schneiderbauer selected 37 variables and performed a principal component analysis (PCA) to obtain a fewer meaningful indicators. He then developed a composite indicator for hazard-independent vulnerability at national scale (Fig. 2).

In the process of concept development, it was considered to use a PCA for the creation of the Index, in order to describe the variability of the different input variables and to weight them accordingly. The idea was rejected, however, due to the modular structure of the Index which allows the modification of weights and input variables over time (please see chapter on methodology for details).

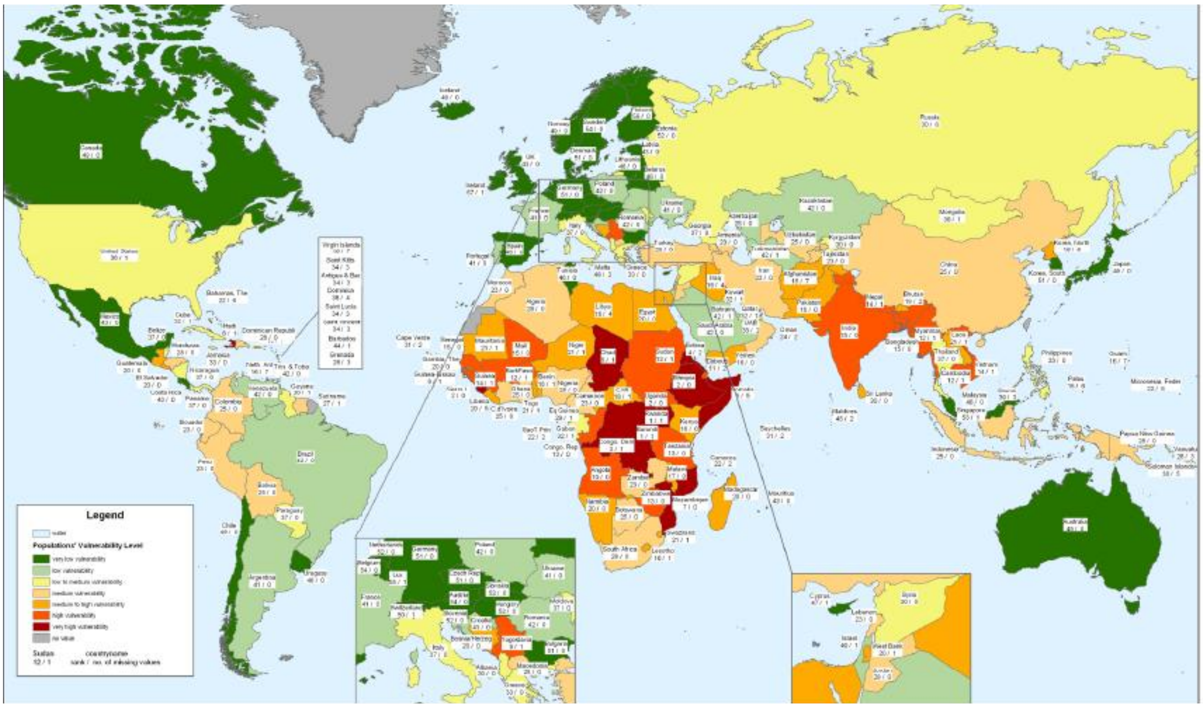

Fig. 2 Hazard Independent Vulnerability of Populations , an estimation at national level (dark green = very low vulnerability to dark red=very high vulnerability), source: Schneiderbauer 2007:63.

UNISDR – Global Assessment Report 2009

The “Global Assessment Report on Disaster Risk Reduction: Risk and poverty in a changing climate. Invest today in a safer tomorrow” has its focus on the relation of poverty and risk in the face of climate change. The report shows disaster risks and their causes on a global scale and introduces measures for disaster risk reduction. The emphasis is thus put on a more applied access to disaster risk and disaster risk reduction. The intention of the report is not only to picture risk exposed population, but also to make the connection of the recent findings of the climate change community and the expected increasing damages, thereby putting in a claim of an improved risk reduction.

The report underlines the particularly high affectedness of the poor, who suffer most from natural hazards (compare Fig. 3). One of the key messages of the report is that the implementation of risk-reducing measures can simultaneously abate poverty and make a contribution to development as well as to climate change adaptation.

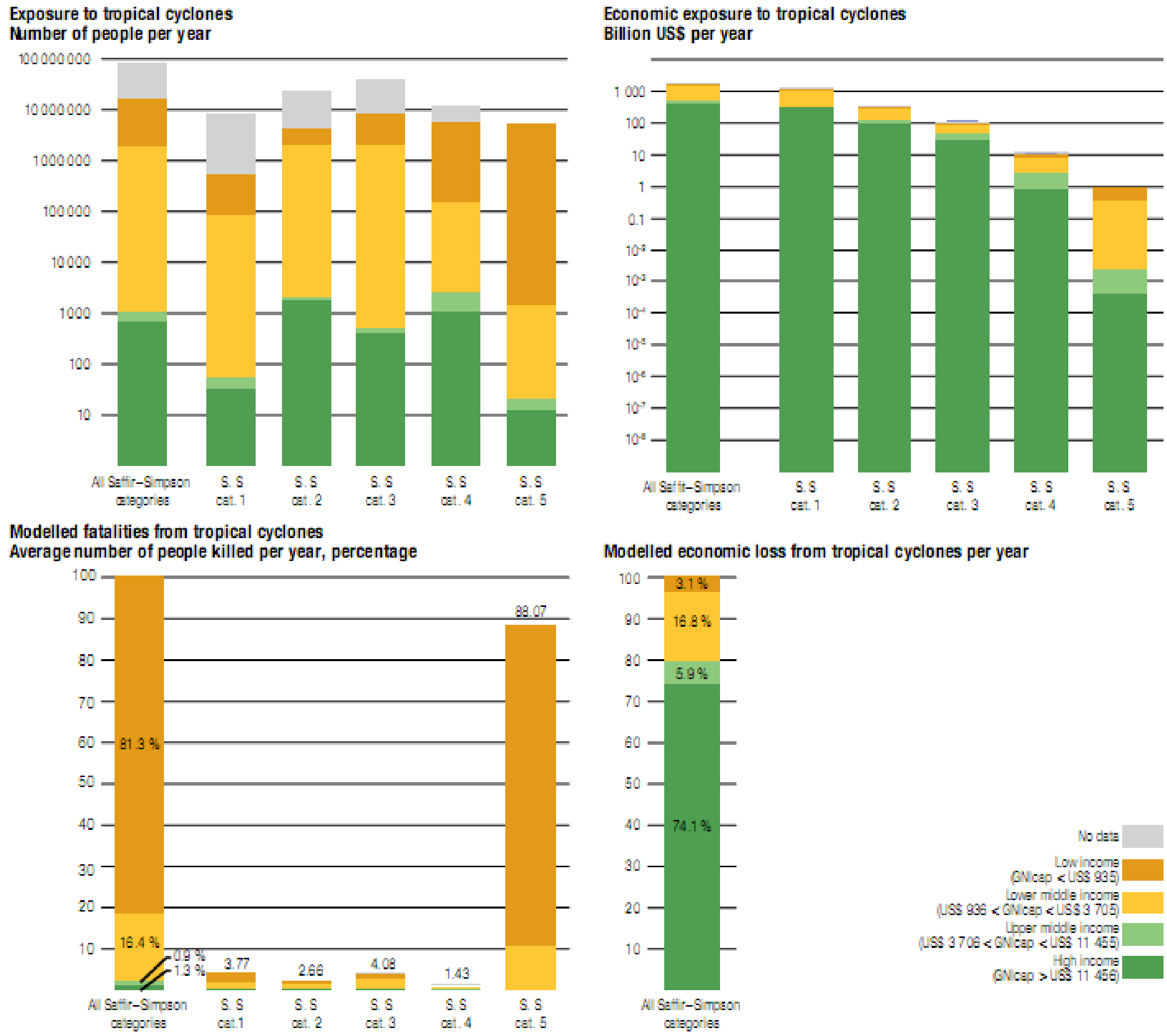

Fig. 3 Mortality and economic losses from tropical cyclones compared to the exposure of different income levels, source: UNISDR 2009:32.

The analysis is undertaken on a local scale in twelve Asian and Latin American states, taking into account a total of 126,620 survey reports, covering the period from 1970 to 2007. Among the key findings of the report were the importance of high frequent, smaller magnitude hazard events, that were indeed not responsible for most of the fatalities, but accounted for the majority of other risks, for example the damage or destruction of housing.

Another claim of the report is thus to put a stronger focus on small-scale events, which are not yet accounted for in most global statistics, but crucial for the vulnerability of people to natural hazards.

Indicators of Disaster Risk and Risk Management (Inter-American Development Bank/ Universidad Nacional de Colombia, Manizales, IDEA)

Produced under the lead of Omar Dario Cardona, this study can be regarded as a special case, compared to the approaches above, as it evaluates the national levels of vulnerability and disaster risk management performance in relation to an assumed maximum considered hazard event and does not analyse the number of people killed and/or affected from past events. The study builds a very complex model for measuring vulnerability to natural disasters, based on four independent indices (for detailed explanations see Cardona 2005a, 2005b):

1) Disaster Deficit Index (DDI)

The DDI measures the risk of financial and macro-economic impacts a country may experience resulting from the exposure to a maximum considered event occurring in a given timeframe (derived from hazard return periods of 50, 100 and 500 years) and factors attenuating the potential impacts (e.g. insurance schemes, financial resources reserved for emergencies, potential external assistance, etc.).

2) Local Disaster Index (LDI)

The LDI focuses on lower magnitude events at the local level, which via their cumulative impact, determine chronically social and environmental risks. These events are mostly not encountered in larger scale databases, although they may have a very serious effect on societal vulnerability to natural hazards.

3) Prevalent Vulnerability Index (PVI)

The PVI captures the predominant vulnerability conditions, assessing the exposure of prone areas, the socio-economic fragility and the lack of social resilience. It thus takes into account the underlying structural conditions shaping vulnerability (vulnerability as starting point for analysis in the sense of O'Brien et al., 2004).

4) Risk Management Index (RMI)

The RMI refers to the risk management performance of a country and thus to its hazard response capacities. The input variables portray the respective level of identification of risk, risk reduction, disaster management, and governance and financial protection.

Pooling these four indicators, the approach of Cardona and his team represents probably the most complex model for vulnerability analysis available at the international scale. It is, however, geographically limited to countries in Latin America and the Caribbean (new version 2009: 17 countries assessed for DDI and RMI, 14 countries for LDI, and 19 countries PVI) and not feasible to apply at global scale, mainly due to the lack of data availability.

Definition of key terms

Against this background, the following section provides definitions of the key terms used. Further details regarding the measurement are given thereafter in the indicator and methodology section.

Risk

Risk is the product of the interactions between natural or human-induced hazards and vulnerable conditions, including the probability of the occurrence of the hazard phenomena (UNISDR 2004, Birkmann 2006; Cardona 2003).

Vulnerability

According to the UNISDR vulnerability encompasses conditions determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards (UNISDR 2004). This term is consider as an "internal side of risk", as an intrinsic characteristic of a system or element at risk. The main elements of vulnerability are those conditions that increase and determine the likelihood of injury, death, loss and disruption of livelihood of human beings; and the extension of the concept is associated to a 'dualistic structure' of vulnerability when considering in addition the ability and capacity to cope with and recover from these stresses and negative impacts of a hazardous event (Birkmann 2006; Wisner 2002).

Exposure

Exposure in its core meaning in natural hazard research encompasses entities exposed and prone to be affected by a hazard event. These entities include persons, resources, infrastructure, production, goods, services or ecosystems and coupled social-ecological systems, etc. (see e.g. UNISDR 2009 website, MOVE Project). Exposure can be further differentiated in terms of a spatial (geographic exposure) and a temporal component. Often, communities or regions might be exposed spatially to a certain degree. Additionally, some people might only be exposed to natural hazards during a certain time of the day, due to their place of work or place of living. Beside an inventory of elements exposed to natural hazards, exposure can also be more precisely assessed in terms of spatial and temporal exposure. Moreover, exposure can be mapped in terms of

hazard events per country, population exposed or land area exposed. One of the key challenges of mapping and measuring exposure of countries or societies to different natural hazards and creeping changes, such as sea level rise, is in fact the potentially very different nature of these hazards – such as the different reoccurrence interval (frequency) and magnitude. In this regard, it would be desirable to consider - besides the spatial exposure - also the frequency of the different hazards. The intention to compare different exposure types also requires a standardisation or normalisation of the respective hazard data.
Overall, the concept developed in this study aims to use either the population exposed, since it can be compared between countries and communities, or the land area exposed. The analysis of exposure often has to be based on past hazard frequencies. However, for the issue of sea level rise, the study also promotes the integration of exposure data that is based on a GIS analysis.

Susceptibility

Susceptibility, in the understanding of this study, refers to the conditions of exposed communities or other exposed elements (infrastructures, ecosystems, etc.) that make them more likely to experience harm and to be negatively affected by a natural hazard or by climate change. On the contrary, societies or households that are characterised by a low susceptibility might be exposed; however, they will face only minor harm due to their low level of susceptibility. While susceptibility – in the perspective of the authors – is more closely linked to structural characteristics, coping and adaptation, as societal response capacities refer more to the agency and the potential to act. However, it is also evident that, in practical assessments, susceptibility and coping capacity are overlapping and are closely linked. For example, the lack of a social network could be seen as a feature of susceptibility; however, in terms of coping, the availability of the social network, that might help to cope in stress situations, might also be seen as a source of coping capacities.

Coping and adaptation

As this study aims at putting an emphasis on the capacities societies have in response to natural hazards and considers novel threats caused by climate change, it is necessary to distinguish between short-term and long-term responses or adjustments to changing conditions and natural hazards. Owing to the topicality of climate change, many different definitions and discussions on the distinction between coping and adaptive capacities can be found in the recent scientific literature, which demands a particular clarification of the usage of the terms within this study (O'Brien and Vogel 2003, Birkmann 2011).

Coping capacities

Coping capacities are mainly defined as the ability of a society or group, organisation or system to use its own resources to face and manage emergencies, disasters or adverse conditions that could lead to a harmful process caused by a hazard event (see UNISDR 2009). Coping mechanisms usually build on experiences that have been made with past disasters and "are based on the assumption that what has happened in the past is likely to repeat itself following a familiar pattern" (Bankoff et al. 2004:32). Drawing on traditional knowledge as well as on societal learning, coping, is bound to very specific conditions and may become ineffective in the face of changing risks (see Bankoff et al. 2004). Coping, in the view of Birkmann (2011) and this study, is – compared to adaptation – is a direct response to the impact of a given hazard event. Thus it comprises the immediate reaction during a crisis or disaster. Consequently, coping is hazard-related and primarily short-term oriented. Coping can also be classified as more unstructured action, such as swimming during a flood or eating fewer meals during a drought. This rather short-term and hazard-impact oriented response clearly distinguishes coping from adaptation (see Birkmann et al. 2009). Characteristics of coping and coping capacities can be associated with existing resources that help to face and manage emergencies, natural hazard impacts and disasters, such as early warning systems, medical care and hospital capacities or even negatively the lack of these capacities, for example regarding the provision of an effective civil protection system or social security that covers health insurances.

Adaptive capacities

Adaptation, within the context of this study, is defined as a long-term strategy that might be linked to a certain hazard. It can be oriented towards various future changes that might occur (multi-hazard perspective). According to the IPCC (2007), adaptation is defined as:

> *"Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities".*

Although the term adaptation, within the IPCC definition, remains relatively abstract and does not refer to coping or extreme events, the emerging scientific literature in the field stresses an important difference between short-term coping and long-term adaptation. O'Brien and Vogel (2003) stress that adaptation is a more structured behaviour that aims to promote change and transformation. For example, a farmer who aims to adapt to climate change – in particular, to drought – might need to change his/her seasonal calendar of cropping and perhaps the crops themselves, in order to be able to live with the changing environmental conditions without suffering. Whereas coping is directed more at the compensation of a singular impact at a time, adaptation hence focuses on changing conditions.

Additionally, the IPCC differentiates between types of adaptation such as anticipatory, autonomous and planned adaptation. Anticipatory adaptation is mainly characterised by the fact that it takes place before impacts of climate change are observed (pro-active focus). Autonomous adaptation characterises adaptive changes in natural systems or by markets in human systems constituted by a response to climate change that just happens without planning. The last type – planned adaptation – refers to adaptation as a result of a deliberate policy decision, based on the awareness that conditions have changed or will change and that respective actions are required to maintain or achieve a desired state (see IPCC 2007).

Overall, the assessment of adaptation and adaptive capacities is a major challenge. However, abilities that enable communities to change and to transform, in the light of environmental and socio-economic changes, are an important asset and characteristic of these adaptive capacities. In our point of view, as an example, skills that enable people to shift potential livelihood strategies, income-earning activities, educational and scientific capacities of nations or the awareness regarding the need to consider climate change adaptation in development strategies of the country, are used as first characteristics to grasp a notion of what adaptation capacities might mean to various hazards and creeping changes in the future.

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