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Technical Briefing Paper (5): Climate Vulnerability Assessment

Synopsis Climate vulnerability depends on the both the severity of projected climate change and the resilience of an impacted (water) sector to climatic trends and weather-related shocks. Vulnerability assessments help scope the most serious business risks using indices of climate change exposure, hazard intensity, or socio-economic and environmental outcomes.

Explanation The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability as *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 a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity*. Vulnerability can also be interpreted as the residual impact of climate change after adaptation measures have been implemented. Hence, climate vulnerability is highly context and scale-dependent. It reflects variations in wealth, social equality, food availability, health and education status, physical and institutional infrastructure, access to natural resources and technology. These determinants will also govern corresponding variations in the capacity to adapt.

Vulnerability indicators are useful for tracking changes in underlying processes, for measuring risk exposure and the effectiveness of adaptation strategies over time. Indicators also help to allocate resources to priority sectors or regions: so-called "hot spots". Examples of *exposure* indices include: percentage of a population living in floodplains or low-lying coastal zones, rain-fed cropped-area, percentage of sustainable groundwater resource allocated, or agricultural exports as a percentage of gross domestic product. Indices of climate change *hazards* include: hurricane (frequency, intensity, weighted by inhabited area, etc.), drought (based on seasonal rainfall totals, variability, spatial extent), flooding (frequency measured as peaks over thresholds, or magnitude), or fire (frequency, area affected). *Outcome*-based metrics include: loss of life, number of hospital admissions, counts of people displaced or made homeless, economic damages (insured and uninsured losses), or duration and extent of disruption to key services (such as domestic energy and water supplies).

Clearly, the availability and quality of data determine the feasibility of vulnerability indicators. Unfortunately, homogenous records of disasters (and their associated impacts) can be difficult to source, or recording practices may change. Other non-climatic factors may confound interpretations of apparent changes in risks or damages. For example, the iconic Munich Re graph of rising annual costs of extreme weather events is thought to reflect an increasingly urbanized and affluent global population increasingly juxtaposed with growing risks of hazardous weather (Figure 1).

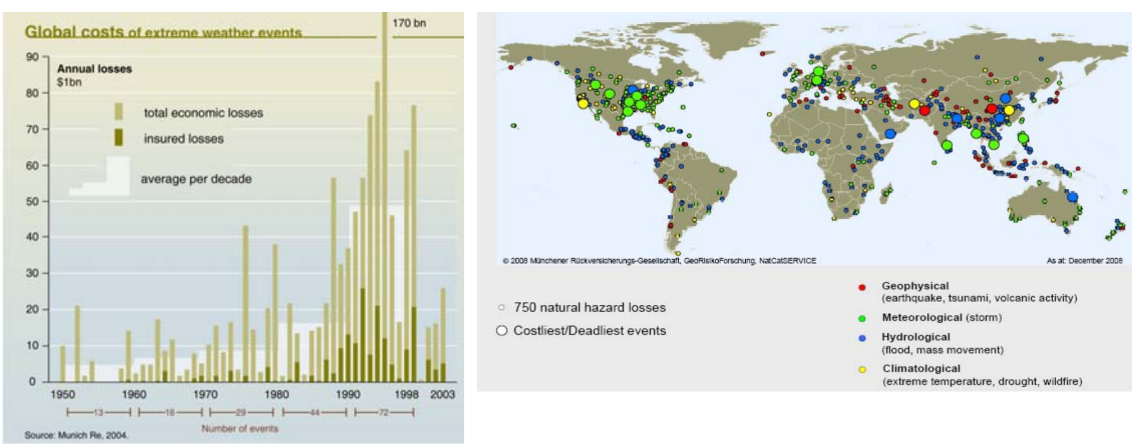

Figure 1 Weather-related losses (left panel). A large number of tropical cyclones contributed to 2008 being one of the most devastating years on record (right panel). Overall losses in 2008 totaled ~S$ 200bn (compared with US$ 82bn in 2007) but were still below the record set in 2005 (US$ 232bn in current values). Insured losses in 2008 rose to US$ 45bn, about 50% higher than in the previous year. Source: Munich Re Press Release, 29 December 2008.

Application Vulnerability assessment is all about scoping risks and increasing resilience to climate change. This may involve reviewing the impact of historic weather or extreme events on a receptor (at the scale of an individual species, across a region, or entire economic sector) then assessing the changing likelihood of such events under projected climate change. Although there are no universally accepted approaches to vulnerability assessment, studies typically include the following elements:

Statement of objectives – for comparison between regions or groups, initial assessment of threats or to improve understanding of the causes and options for reducing vulnerability;

Statement of definitions – of vulnerability, the time and space scales at which the processes operate, the units of investigation, and assumptions;

Appraisal of indicators – relevance to stakeholders or target audience, homogeneity, reliability and representativeness of data, supplementary information on confounding factors;

Summary of threats and opportunities – review scientific research, local knowledge, anecdotal evidence and analogues of socio-economic impacts, thresholds, tipping points, and hot-spots.

The UK Climate Impacts Programme is supporting vulnerability work in the UK through provision of guidance for businesses (see below), searchable databases of weather-related impacts (see: http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=226) and an Adaptation Wizard (see: http://www.ukcip.org.uk/index.php?option=com_content&task=view&id=147&Itemid=273).

Case Study Vulnerability of water management in Colorado (adapted from Ray et al., 2008)

The 2007 Colorado Climate Action Plan (CCAP) called for an assessment of the vulnerability of Colorado's water resources to climate change, an analysis of potential impacts on interstate water compacts, and planning for extreme events such as drought and flooding. The multidisciplinary study of observed and projected trends in hydro-climatic variables is also informing other planning initiatives such as the Joint Front Range Climate Change Vulnerability Study. The table below provides a summary of the main water sector vulnerabilities linked to observed and projected climate changes. The inter-related nature of the impacts underlines the need to incorporate climate risk information within Integrated Resource Planning, and to maintain flexibility given the uncertain climate projections.

Issues	**Observed and/or projected changes**
Water demands for agriculture	Increasing temperatures raise evapotranspiration by plants, lower soil moisture, alter growing seasons, and increase water demand.
Water supply infrastructure	Changes in snowpack volume and timing of melt may affect reservoir operations including flood control and storage, as well as the functioning of diversion, storage and conveyance structures.
Legal water systems	Earlier runoff may complicate prior appropriation systems and interstate water compacts affecting which rights holders receive water and operational plans for reservoirs.
Water quality	Changes in water temperature as well as the hydrograph timing and shape may affect sediment loads and pollution, impacting human health.
Energy demand and operating costs	Warmer air temperatures may place higher demands on hydropower reservoirs for peaking power. Warmer lake and stream temperatures may affect water use by cooling power plants and in other industries.
Mountain habitats	Rising temperature and soil moisture changes may shift mountain habitats northwards and toward higher elevations.
Disturbance regimes	Changes in air, water, and soil temperatures may affect the relationships between forests, surface and ground water, wildfires, and pests wildfire, and insect pests. Water-stressed trees, for example, may be more vulnerable to pests.
Riparian habitats and fisheries	Rising water temperature could have direct and indirect effects on aquatic ecosystems, including the spread of in-stream non-native species and diseases to higher elevations, and the potential for non-native plant species to invade riparian areas. Changes in streamflow peaks and timing may also affect riparian ecosystems.
Water- and snow-based recreation	Changes in reservoir storage affect lake and river recreation activities; changes in streamflow volume and timing will continue to affect rafting directly and trout fishing indirectly. Changes in the character and timing of snowpack and the ratio of snowfall to rainfall will continue to influence winter recreational activities and tourism.
Groundwater resources	Changes in long-term precipitation and soil moisture can affect groundwater recharge rates; coupled with demand issues, this may increase pressures on groundwater resources.

Supporting materials and links

Adger, N., Brooks, N., Bentham, G., Agnew, M. and Eriksen, S. 2004. New indicators of vulnerability and adaptive capacity. *Tyndall Centre for Climate Change Research*, Technical Report 7, University o East Anglia, Norwich, http://www.tyndall.ac.uk/research/theme3/final_reports/it1_11.pdf

Ray, A.J., Barsugli, J.J. and Averyt, K.B. 2008. *Climate change in Colorado: A synthesis to support water resources management and adaptation*. Western Water Assessment for the Colorado Water Conservation Board, University of Colorado at Boulder, http://cwcb.state.co.us/Home/ClimateChange/ClimateChangeCOReport.htm

UK Climate Impacts Programme, 2009. *A changing climate for business: Business planning for the impacts of climate change*. Oxford, UK: http://www.ukcip.org.uk/images/stories/Pub_pdfs/Georgette.pdf

WWF, 2008. *Thames basin vulnerability report: technical summary.* WWF-UK, Godalming, 11pp. http://www.wwf.org.uk/filelibrary/pdf/thames_tech_summary.pdf