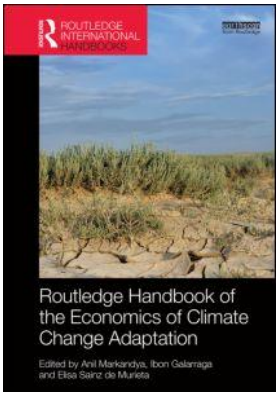

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DISASTER RISK MANAGEMENT AND ADAPTATION TO EXTREME EVENTS

Placing disaster risk management at the heart of national economic and fiscal policy

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21.1 Introduction

The year 2011 was the costliest year on record for disasters, with estimated global losses of US$ 380bn dominated by disasters associated with the Japanese earthquake, tsunami and nuclear disasters, Christchurch earthquake, Thailand floods and extreme weather in the U.S. Not only were aggregate losses extremely high, but the distributional and knock-on effects were also large. Recent data suggests that the 2011 floods in Thailand reduced Japan's industrial output by 2.6% in November 2011 compared to the previous month, a result of disruption to electronics and automotive just-in-time supply chains. Japanese car makers, whose production facilities are spread across the region, lost US$ 500m.[1] Lloyds of London reported that the disaster caused the third biggest loss in its market's 324-year history (US$ 2.2bn).[2]

The 2011 losses are an extension of a trend that has seen global average economic disaster losses rise by 200% over the last 25 years in inflation-adjusted terms (see Figure 21.2). The trend is predominantly the result of more people and assets being located in areas exposed to natural hazards. The population exposed to flood risk in Asia in 2030 will be more than two and a half times the figure in 1970 (Handmer et al., 2012) and 50% higher than in 2000 (Vafeidis et al., 2011). While recent data suggest disasters are already hampering economic growth in low and middle-income countries, a continuation of the current upward trend in disaster losses poses a severe threat to national and regional macroeconomic outlook in such countries. Tackling this

problem involves placing measures to address disaster risk at the heart of national economic and fiscal policy as well as embedding it within sector-based economic and land-use planning. At a country level, reducing losses or even stemming their increase will require investing in vulnerability reduction of people and infrastructure located in exposed areas or enacting policies that, over time, result in a safer spatial distribution of assets.

While a number of countries such as those highlighted later in this chapter have already started this process, progress is highly variable, with the balance of efforts focused on building budgetary reserves and establishing sovereign insurance mechanisms to help bolster and speed up the flow of money to support ex-post emergency assistance and relief processes (Surminski and Oramas-Dorta, 2011).[3] Yet, insurance reduces the variability around outcomes ("the rainy day") and any follow-on impacts, if losses exceed people's, business' and governments' ability to cope. Insurance, however, does not directly reduce risk in particular that related to frequently occurring events.

Direct and indirect losses are also difficult to measure accurately as they can extend across borders, through regional and global supply chains, as well as to intangibles, such as the cultural value of historic buildings or artifacts or the detrimental health impacts associated with stress and anxiety, which are difficult to insure. The effort, therefore, needs to be focused on holistically managing risk, losses and impacts through economic and fiscal policy. But how can this be achieved?

By drawing on examples, this chapter starts by examining whether disasters genuinely do inhibit economic development and whether rising disaster losses will have a greater impact on developing economies in the future. It then considers whether economic and fiscal planning at the national level can reduce exposure to disasters, before considering the necessary steps countries need to take if they are to achieve economic development in a way that is more resilient.

21.2 Do disasters affect economic development?

Not only do disasters directly lead to immense human suffering and loss, they may also directly and indirectly affect economic outcomes in the medium to longer term. Disasters can lead to microeconomic (household, business level) effects, as well as macroeconomic consequences. The macroeconomic, aggregate impacts, which are the focus of this chapter, comprise effects on gross domestic product, consumption, savings, investment and inflation due to the effects of disasters, as well as due to the reallocation of public financial resources post-event to relief and reconstruction efforts (Handmer et al., 2012).

The impact of disasters on aggregate economic performance and development has been examined by several studies over the last four decades based on empirical and statistical analysis as well as modelling exercises. While the earlier studies addressed predominantly developed economies and focussed on sectoral and distributional impacts of disasters, in recent years more emphasis has been given to developing countries. These studies generally find very limited aggregate macroeconomic impacts in developed countries, but important regional economic and distributional effects (Okuyama, 2009). In terms of developing countries, disasters have been found to lead to important adverse macroeconomic and developmental impacts and affect the pace and nature of socioeconomic development (Otero and Marti, 1995; Benson and Clay, 2004; ECLAC, 2003; Charveriat, 2000; Mechler, 2004; Raddatz, 2007; Kellenberg and Mobarak, 2008; Hochrainer, 2009; Noy, 2009; Cavallo and Noy, 2009; World Bank and UN, 2010; Handmer et al., 2012). As one example, Honduras following Hurricane Mitch in 1998

suffered setbacks to macroeconomic performance, and rural poverty increased by more than 5 percentage points to a staggering 75% (Morris et al., 2002) (see Box 21.1). However, as a recent review by Handmer et al., (2012) suggests, there is only medium confidence in these findings as a few studies have also found positive effects such as increases to GDP post-disaster (Albala-Bertrand, 1993; Skidmore and Toya, 2002). Yet, it is generally argued that these 'positive' findings can be attributed to the lack of systematic and robust GDP counterfactuals (what would have happened to GDP if the disaster had not occurred?) in these studies, a lack of accounting for informal sector effects, a lack of accounting for financial inflows (insurance and aid), and importantly the problem that national accounting generally measures flows rather than stocks. The latter point means that the relief and reconstruction effort (measured as a flow in terms of increased consumption and investment) shows up positively in national statistics, whereas the destruction (a loss to capital stock) does not enter the accounting at all.

Despite these reservations, there is consensus that macro effects are much more pronounced in lower income countries (Mechler, 2004, Lal et al., 2012). Handmer et al. (2012) suggest that developing countries exhibit higher economic vulnerability due to their (a) reduced resilience and dependence on natural capital and disaster-sensitive activities (such as tourism and agriculture); (b) lack of developed assessment processes and techniques of responding to disasters including preparedness, financing, information, and risk management; and (c) governance shortcomings. Countries with one or more of the following characteristics are considered particularly at risk of significant macroeconomic consequences post-disaster (see Mechler, 2004): (i) high natural hazard exposure; (ii) economic activity clustered in a limited number of areas with key public infrastructure exposed to natural hazards; and (iii) tight constraints on tax revenue and domestic savings, shallow financial markets, and high indebtedness with little access to external finance.

Box 21.1 The macroeconomic impacts of Hurricane Mitch on Honduras

Honduras may be considered a good illustration of a country subject to high disaster risk (severe exposure to hurricanes, flooding, drought and earthquakes), limited economic diversification with a reliance on cash crops such as bananas, and tight financial and fiscal constraints due to high indebtedness and high prevalence of poverty. Honduras was heavily hit by Hurricane Mitch at the end of 1998, killing 6,000 people, leaving an estimated 20% of the population homeless and causing assets losses of about two billion USD, or 18% of capital stock. Important macroeconomic effects ensued, and the figure shows actual GDP in absolute terms (solid line) as well as two pre-disaster projections (dashed lines). GDP growth in Honduras became negative in the year after the event (shown as the downward spike of GDP in absolute terms in the chart), but then rebounded later on with substantial inflow of foreign assistance, which increased by about 500 million USD or from about 6% pre-disaster to close to 16% of GDP post-disaster. For determining the impact on longer-term growth, the gap to the counterfactual projections without a disaster event can be taken as one indicator.

Using this approach for Honduras, a "GDP gap" can be identified. For example, in 2004, about six years after the event, this gap can be considered to have, ceteris paribus, amounted to about 6% of potential GDP given linear extrapolations of pre-disaster GDP with a 4-year average growth rate, and to about 9% based on another projection. Of course, the total cost as the sum of gaps over time would be much larger.

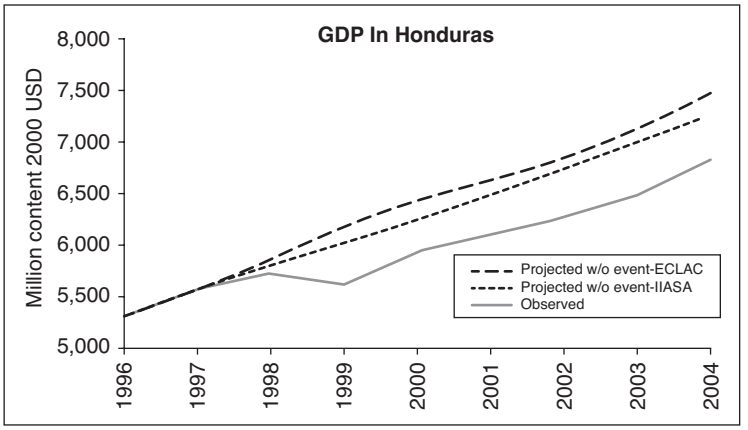

Figure 21.1 Observed GDP in Honduras with events vs. projected growth without events
Source: Mechler et al., 2006

21.3 Impact of disasters on future economic development

While there is high inter-annual variability in global insured and uninsured losses due to disasters, when adjusted for increases in wealth, disaster losses have in fact increased over the last few decades. As indicated in Figure 21.2, recent data show that 2011 was by some margin the costliest year ever recorded for disaster losses, amplified by losses associated with the earthquake, tsunami and nuclear disaster in Japan, flooding in Thailand and the earthquake in Christchurch, New Zealand.

However, economic exposure to disasters is not evenly distributed, with loss risk as a proportion of annual GDP concentrated in middle-income countries with rapidly developing economies and particularly exposed low-income countries, such as small island developing states (O'Brien et al., 2006; Kellenberg and Mobarak, 2008; Pelham et al., 2011). Figure 21.3 shows the largest ever events in terms of loss to assets ratio, and many affected countries are small and/or low-income countries. The burden of losses in middle-income countries has been increasing, with average losses of 1% of GDP from 2001–2006 (compared to 0.1% for

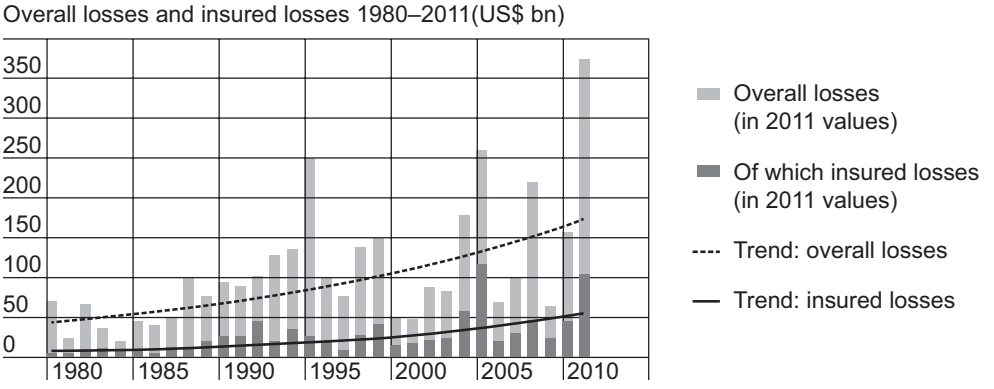

Figure 21.2 Increasing disaster losses. (Munich Re, 2012)

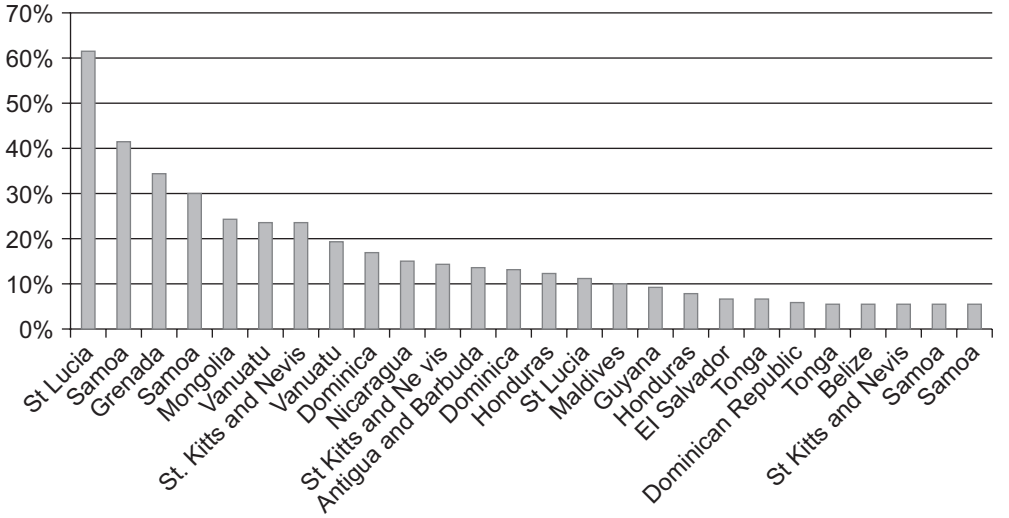

Figure 21.3 Largest monetary disaster losses since 1960 as measured in terms of assets destroyed
Source: Mechler, 2009

high income countries) (Cummins and Mahul, 2009). However, economic loss of GDP is even more concentrated, with China and countries of South Asia accounting for more than 49% of global annual loss since the 1970s (UNISDR, 2009). Given the influence of the economies of India, China and other Asian countries on global growth, future trends in disaster losses in such countries are of particular concern for other countries in the region and globally. Asia suffered disproportionally in 2008, a year regarded as one of the worst for natural and man-made disasters. A total of US$ 269bn were lost in Asia in that year, with emerging economies being particularly exposed because of high urban migration, intensification of natural resource use without adequate management and population growth (Swiss Re, 2009).

Without a significant recalibration of economic policy to take account of rising disaster risk, disaster losses will likely rise more rapidly than economic growth in the future in many low- and middle income-countries (Bouwer et al., 2007). This is because the rate at which economic exposure to disasters is increasing is faster than upward trends in wealth creation and of efforts to adequately protect people and assets (UNISDR GAR, 2011). The trend is caused by rapid urbanisation, which concentrates exposure, a global move of people and assets to coastal locations and degradation or loss of natural ecosystem buffers. These are coupled with a lack of appropriate legislation and land use planning. Figure 21.4 shows that this trend of increasing exposure and with it disaster risk, is particularly pronounced in Latin America and in South Asia, where risks are estimated to have risen. Whereas in East Asia and the Pacific and in OECD countries risks are declining due to progress on reducing vulnerability, even though exposure is still growing. The models used do not capture endemic or extensive risks well; particularly those associated with food security and slow onset disasters, meaning that the accuracy of assessments for Sub-Saharan Africa is limited. More research is needed to understand at what point disaster losses and economic growth decouple and the key drivers of this, but deployment of the type of tools introduced in section 21.4 are likely to be important, along with a greater progress in reducing poverty and upgrading infrastructure.

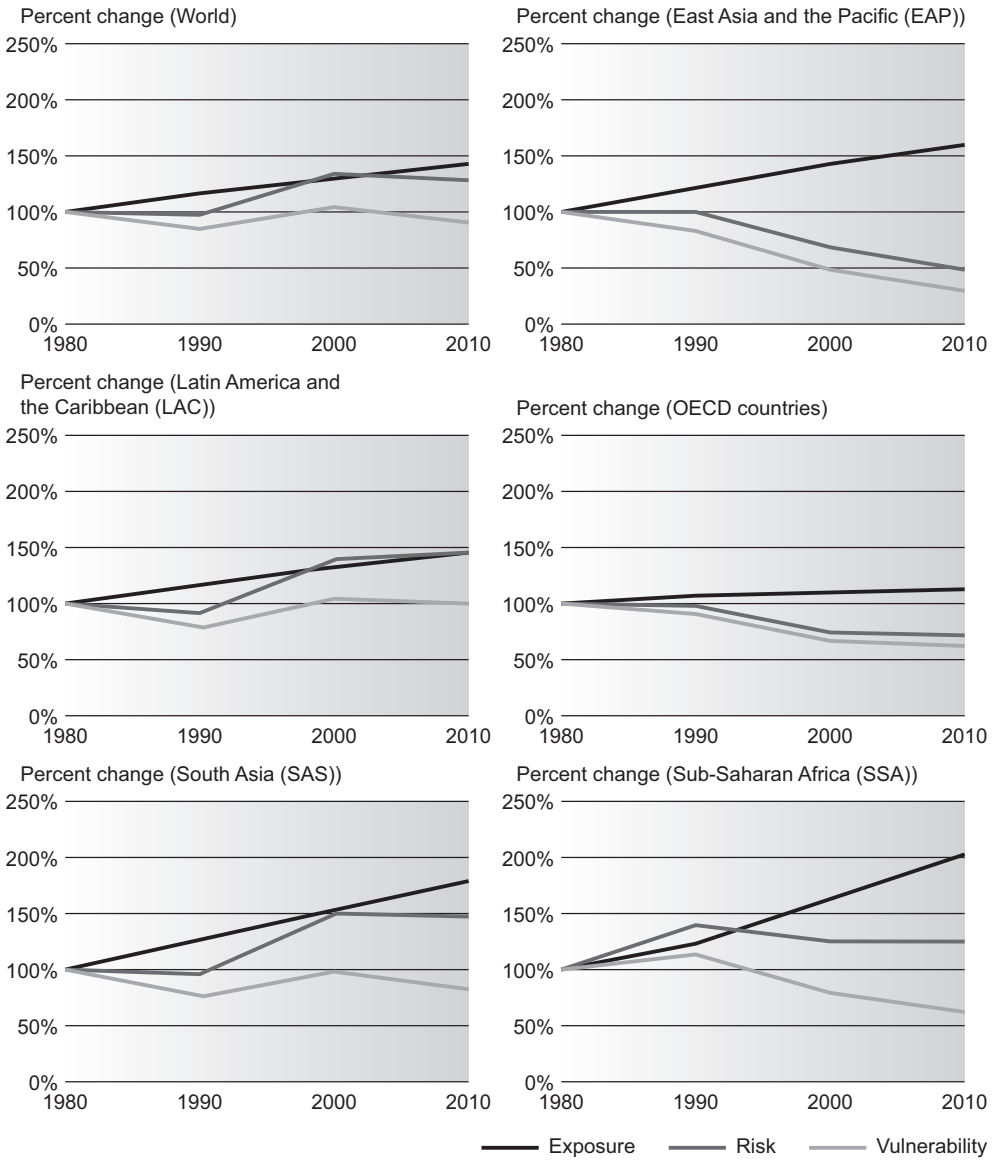

Figure 21.4 Graphs showing trends in disaster risk, exposure and vulnerability between 1980 and 2010 (UNISDR GAR, 2011)

21.3.1 Impact of climate change-related disasters on future losses

Although we cannot yet know the full effects of climate change on disaster risk, it is estimated that losses from disasters associated with weather events are doubling globally every 12 years.[4] While the recent rise in economic losses is mainly attributed to changes in exposure and asset values, natural climate variability and anthropogenic climate change could impact future

catastrophe losses. Therefore, future predictions cannot be based solely on historic patterns, but need to take into account future trends.

Many global projections of future disaster loss estimates are based on analysis from insurance and reinsurance companies, who are concerned that the changing frequency and intensity of climate extremes, alongside increases in exposure, will dramatically affect the industry in years to come. In 2007, the Association of British Insurers estimated worldwide annual losses from events associated with hurricanes and windstorms will increase by two-thirds by 2080 in inflation-adjusted terms (ABI, 2004). However, the industry is starting to adjust to these trends, warning about future uninsurability if risks remain unmanaged. As Chief Economist of Swiss Re Asia, Clarence Wong (2009) states, 'ex-post' risk financing is unsustainable. Investing in disaster risk management is the only way to reduce the burden on public budgets and build the foundation for more sustainable risk financing arrangements. Concerns have already been raised by the European Environment Agency (2008) that uninsured disaster losses are likely to rise as obtaining insurance gets more difficult in places experiencing increased disaster risk. And that those likely to experience uninsured disaster losses are those from socially deprived groups and increasingly those in countries where insurance markets will not operate or where premiums are too high to afford. In such cases, public-private partnership insurance and risk financing is one option which is attracting increased attention as a means to develop the insurance industry and support both public and private investments (European Environment Agency, 2008; Swiss Re, 2009). The Caribbean sovereign insurance scheme discussed in Boxes 21.2 and 21.5 is one example. Another interesting case in point is Mexico, where the government insured its disaster liabilities in the international markets using traditional and alternative insurance products. This arrangement built heavily on Mexico's' far-reaching expertise in modelling and managing risk, technical assistance provided by the World Bank and expertise provided by a large reinsurer in terms of acting as a joint bookrunner (see also Box 21.4).

Such ideas are also being considered by the United Nations Framework Convention on Climate Change under the Work Programme on Loss and Damage (2010–2012), which recognises that climate change mitigation and adaptation is sometimes not enough to avoid losses associated with climate change. Among other issues, the Work Programme is considering whether some form of insurance mechanism may be developed to ensure developing countries can be 'compensated' for such losses, where the public investments necessary to support such insurance markets could come from countries with higher historical greenhouse gas emissions.

21.4 Tools and approaches for integrating disaster risk management into economic and fiscal policy

Given the concepts discussed above and the experience presented, what are the tools and approaches available that countries, NGOs and the international community can draw upon? This section considers a set of tools and approaches that can be used to integrate disaster risk management into national economic and fiscal policy, with the goal of proactively reducing economic exposure to disasters and ultimately reversing the trend of rising disaster losses, especially in middle- and low-income countries. A recent assessment by the OECD (2012) on economic growth in the context of climate change finds that building in resilience to climate change impacts by integrating adaptation to climate change in development planning and infrastructure design is critical to the growth prospects of low-income countries.

21.4.1 Conducting comprehensive risk assessments as part of economic policy decisions

The first key step in managing risk is to assess and characterize it. In terms of risk factors, disaster risk is commonly defined by three elements: the hazard, exposure of elements, and vulnerability (Swiss Re, 2000; Kuzak, 2004; Grossi and Kunreuther, 2005). Thus, understanding risk involves observing and recording hazards and hazard analysis, studying exposure and drivers of vulnerability, vulnerability assessment and finally arriving at an estimate in terms of probabilistic risk. In a next step, disaster risk assessments can be factored into national development strategies, sector plans, the budget, regulations, programs and projects.

Comprehensive disaster risk assessments are dependent on having a clear baseline and strong time series information covering hazard, exposure and vulnerability data so it is easier to see what is changing (Lal et al., 2012). Given the dynamic nature of disaster risk, underlined by the possible effects of natural climate variability and anthropogenic climate change and attendant uncertainties, regular updates of information are necessary (Lal et al., 2012). For national level assessments, it is particularly important to have data on the distribution of national assets and their values (derived from inventories and census data) and also on institutional and organizational capacity at different scales (see Table 21.1).

While considerable advances have been made in terms of data availability, including in developing countries, many countries lack relevant datasets, and assessments are not regular practice. Nonetheless, a variety of disaster risk assessment tools and methods have been developed, including the Comprehensive Approach for Probabilistic Risk Assessment (CAPRA). CAPRA is a GIS platform where probabilistic assessments are made of hazards and then combined with exposure and vulnerability data, enabling users to examine multiple hazards and different risks simultaneously. Since its inception in 2008, it has faced problems of building the necessary capacity to use the tool and to collect enough data on national assets to ensure the exposure module is accurate (GFDRR, 2009). It has been applied in Central America, and has been designed to facilitate decision-making, including of risk transfer instruments and the evaluation of cost-benefit ratios for risk reduction strategies. A roll-out of CAPRA is currently underway in South Asia (Cardona et al., 2010).

Box 21.2 includes examples from the Caribbean and Central Asia on how risk assessments are being used to shape economic policy.

21.4.2 Integrating disaster risk management into fiscal policy and budget planning

Based on such comprehensive risk assessments, a key entry point for governments to better deal with disasters is to budget for disaster risk and to include strategies for managing disaster risk in wider fiscal policy. Historically, losses in developing countries have been financed by diversions of funds from the national budget, loans and donations by the international community. Yet these sources are often insufficient, and ex-post gaps in necessary financing of disaster losses are frequently encountered. When stimulus is most needed, such lack of timely funding can lead to important follow-on effects. As one example, in Honduras after Hurricane Mitch, aid measured in terms of GDP almost tripled from 6% to 15% or from US$ 0.3 to US$ 1 billion, yet it remained far below what would have been necessary to support effective relief and recovery. As

Table 21.1 List of information requirements for selected disaster risk management and climate change adaptation activities

Activities		*Examples of information needs*
Cross-cutting	Climate change modelling	Time series information on climate variables – air and sea surface temperatures, rainfall and precipitation measures, wind, air circulation patterns, and greenhouse gas levels
	Hazard zoning and 'hot spot' mapping	Georeferenced inventories of landslide, flood, drought, and cyclone occurrence and impacts at local, sub-national and national levels
	Human development indicators	Geospatial distribution of poverty, livelihood sources, access to water and sanitation
	Disbursement of relief payments	Household surveys of resource access, social well-being, and income levels
	Seasonal outlooks for preparedness planning	Seasonal climate forecasts; sea surface temperatures; remotely sensed and in situ measurements of snow cover/depth, soil moisture, and vegetation growth; rainfall-runoff; crop yields; epidemiology
	A system of risk indicators reflecting macro and financial health of national, social and environmental risks, human vulnerability conditions, and strength of governance (Cardona et al., 2010)	Macroeconomic and financial indicators (Disaster Deficit Index) Measures of social and environmental risks Measures of vulnerability conditions reflected by exposure in disaster-prone areas, socioeconomic fragility, and lack of social resilience in general Measures of organizational, development, and institutional strengths
Flood risk management	Early warning systems for fluvial, glacial, and tidal hazards	Real-time meteorology and water-level telemetry; rainfall, stream flow, and storm surge; remotely sensed snow, ice, and lake areas; rainfall-runoff model and time series; probabilistic information on extreme wind velocities and storm surges
	Flooding hot spots, and structural and non-structural flood controls	Rainfall data, rainfall-runoff, stream flow, floods, and flood inundation maps Inventories of pumps, stream gauges, drainage and defense works; land use maps for hazard zoning; post-disaster plan; climate change allowances for structures; floodplain elevations
	Artificial draining of proglacial lakes	Satellite surveys of lake areas and glacier velocities; inventories of lake properties and infrastructure at risk; local hydro-meteorology
Drought management	Traditional rain and groundwater harvesting, and storage systems	Inventories of system properties including condition, reliable yield, economics, ownership; soil and geological maps of areas suitable for enhanced groundwater recharge; water quality monitoring; evidence of deep-well impacts
	Long-range reservoir inflow forecasts	Seasonal climate forecast model; sea surface temperatures; remotely sensed snow cover; in situ snow depths; multi-decadal rainfall-runoff series
	Water demand management and efficiency measures	Integrated climate and river basin water monitoring; data on existing systems' water use efficiency; data on current and future demand metering and survey effectiveness of demand management

From Lal et al., 2012, adapted from Wilby, 2009

another example, Mexico has been one of the foremost countries to recognise these liabilities and integrated disaster risks with fiscal planning. Box 21.3 describes Mexico's approach to fiscal planning for extreme events.

Box 21.2 Experience of risk assessment in economic policy: Central Asia and the Caribbean

Central Asia has been identified as one of the most vulnerable regions to the impacts of climate change. While prone to extreme temperatures and rainfall-related landslides, recurrent drought in the first decade of the 21st century has affected hydropower generation, water supply for irrigation, rain-fed cropland and pasture productivity. Electric power generation shortages in Kyrgyzstan and Tajikistan stalled industrial growth in both countries as well as deprived millions of people of access to heat and electricity in severe winter conditions, resulting in a humanitarian crisis (see http://www.npr.org/templates/story/story.php?storyId=18784716, accessed 25/04/12).

A new partnership between UNDP's Central Asia Climate Risk Management Programme and CDKN is focused on improving capacity and methodologies for comprehensive and integrated climate risk assessment tools. The partnership has found that systematic risk assessments require a broad range of expertise given the range of data needs. A successful process depends on adequate capacity to conduct assessments, interpret results and identify appropriate actions.

In the **Caribbean**, in 2009, CARICOM Leaders established the *Liliendaal Declaration*, which recognises that countries in the region need to take decisive and potentially transformative action to build disaster resilient, low carbon economies. A risk assessment approach to disaster risk management in macro-economic planning is a central component to its implementation plan.

As well, the Caribbean Catastrophe Risk Insurance Facility (CCRIF), discussed further below, is supporting the development of country risk profiles and their integration with economic and fiscal planning. The country risk profiles offered via the Multi-Peril Risk Evaluation System (MPRES) catastrophe risk modelling platform provide a systematic basis and entry point for more detailed information. These data have been generated and used to underpin CCRIF policies since the 2010/11 policy year and represent a valuable regional public-good resource informing holistic disaster risk management. As a next step, the CCRIF will be emphasising the integration of country risk profiles with economic and fiscal planning (CCRIF, 2011).

Box 21.3 Fiscal planning for extreme events in Mexico

Mexico has been a pioneer in planning for disaster risk and using sovereign risk financing instruments to reduce the public costs of bearing risk. More than 9,000 people lost their lives in the 1985 Mexico City earthquake, and estimates put the direct economic cost of the disaster at about $8 billion (in 2010 prices). Lying as it does within one of the world's most active seismic regions and in the path of hurricanes and tropical storms, Mexico's population and economy are highly exposed to natural hazards. Severe natural disasters (the type likely to occur infrequently but at great cost) imply large fiscal liabilities for the Mexican government. In the case of a disastrous event, the Mexican government is responsible for providing emergency aid and economic support for its low-income population. According to Mexican law, public assets are to be insured and thus

reconstruction will be financed by insurance claims. In the past, severe disasters have created large fiscal liabilities and imbalances. Given its financial vulnerability, over the last few years, the Mexican government has been working to improve its fiscal and debt management to reduce the costs imposed by natural disasters and other shocks. Alerted by the Mexico City catastrophe, in 1996 the national government authorities created a budgetary program called FONDEN (Fund for Natural Disasters) to enhance their country's financial preparedness for natural disasters. As a budgetary item, FONDEN is established at the start of each fiscal year by the Mexican parliament as part of the federal government budget plan and provides last-resort funding for uninsurable losses, such as emergency response and disaster relief. In addition to the budgetary program, in 1999 a reserve trust fund was created, which is filled by the surplus of the previous year budget item. FONDEN's objective is to prevent imbalances in the federal government finances derived from outlays caused by natural catastrophes.

But the series of natural disasters that occurred in recent years forced them to look at alternative risk management strategies. From 2000, the Mexican government began collecting data to assess the exposure of its assets to losses from earthquakes and to analyse different financial instruments that could be used to transfer the risk. In 2006, it became the first emerging economy to transfer part of its public-sector natural catastrophe risk to the reinsurance and capital markets – and thus out of the country. This decision came just over 20 years after the 1985 Mexico City earthquake had highlighted the shortcomings of after-the-event approaches for coping with disasters and associated losses. The public sector risk management strategy in Mexico is strongly informed by risk analysis, including modelling as well as economic assessment. Lessons learnt are that data collection over a longer time horizon is crucial to inform sound planning. Building research and analytical capacity domestically has paid off with universities leading the data collection and modelling efforts.

Source: see Linnerooth-Bayer et al., 2011.

While governments are right to consider financial mechanisms, including reserve funds and insurance products, that offer financial protection against different parts of their residual disaster risk portfolios, it is crucial that with rising disaster risk, further ex-ante measures, such as physical infrastructure, building codes and improved preparedness, are taken to protect lives and livelihoods and to increase the affordability of insurance. Taking disaster risk assessments as a starting point, it is crucial that decision makers can make informed decisions about the relative costs and benefits of investing in measures to reduce risk compared to preparing for and financing residual risk. Further, it is desirable that the disaster risk financing strategy incentivises such investment through explicitly costing risk and providing for cost savings on insurance premiums after the further implementation of risk reduction strategies. Figure 21.5 highlights the range of policy options open to decision makers in the way they manage risks.

However, the process of evaluating policy choices to manage the disaster risk portfolio can be complicated, with considerable attendant uncertainties associated with the frequency and severity of hazards, challenges in projecting the distribution of vulnerability into the future and a competing range of budgetary and investment priorities. Box 21.4 describes a model to support decision makers navigating these challenges, particularly with relevance to fiscal policy.

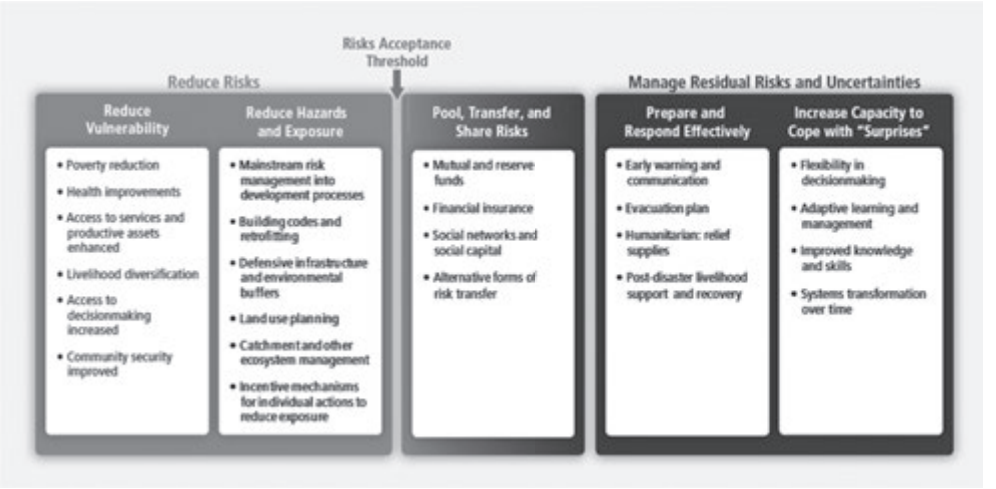

Figure 21.5 Complementary policy options for managing disaster risk portfolios at the national level (Lal et al., 2012)

Box 21.4 Modelling fiscal vulnerability, the liquidity gap and risk

The CATastropheSIMulation (CATSIM) model, developed by IIASA, is a risk-based economic framework for evaluating economic disaster impacts and the costs and benefits of measures for reducing those impacts. CATSIM uses stochastic simulation of disaster risks by randomly and repeatedly generating disaster events in a specified region and examines the ability of the government and private sector to finance relief and recovery. The model is interactive in the sense that the user can change parameters and test different assumptions about hazards, exposure, vulnerability, general economic conditions and the government's ability to respond. As a capacity-building tool, it can illustrate the trade-offs and choices government authorities are confronted with for increasing their economic resilience to the impacts of catastrophic events. The model can be used for supporting policy planning processes for the allocation of resources between ex-ante spending on disaster risk management (such as prevention, national reserve funds, sovereign insurance) and ex-post spending on relief and reconstruction.

For example, CATSIM and other tools are now being used to support a multi-sector steering committee in Madagascar to simulate the impacts of hazards and disasters on the budget and assessing costs and consequences of financial solutions adopted in terms of important indicators such as economic growth or debt. The tool will thus allow the development of comprehensive funding strategies for disaster risk, stimulated by the 2008 cyclone season which saw economic losses of 4% of GDP through impacts on housing, agriculture, trade, tourism and transport. The project called 'Mainstreaming Disaster Risk Management and Climate Change in Economic Development', is being financed by the Global Facility for Disaster Reduction and Recovery (GFDRR)

The model compares asset loss distribution with fiscal resilience, defined as the total of ex-post and ex-ante risk financing (see Figure 21.6).

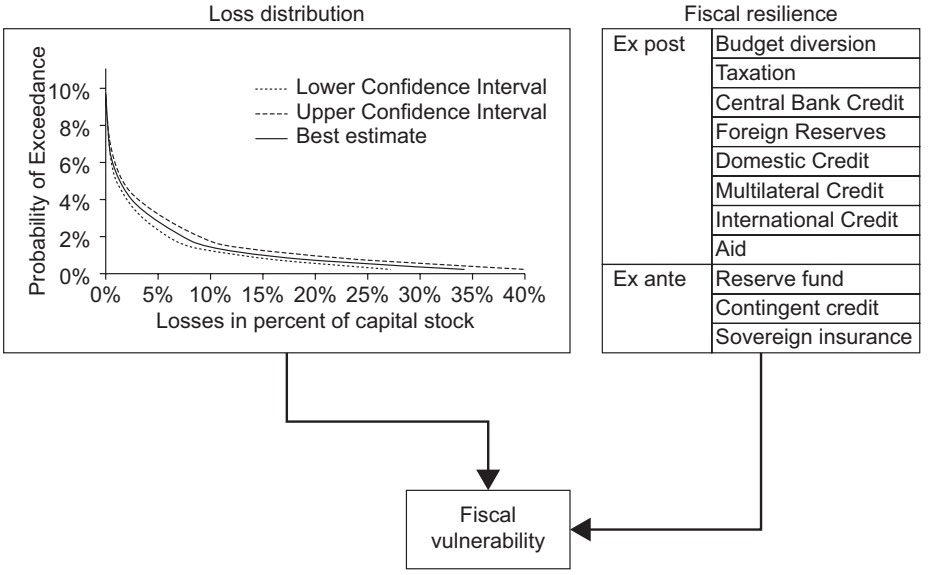

Figure 21.6 Modelling fiscal vulnerability and resilience to natural hazards
Source: Mechler et al., 2010

Using this approach, countries can be identified that exhibit high fiscal and economic vulnerability, and can help quantify the 'fiscal gap' (Hochrainer, 2006; Mechler et al., 2010).

The model, applied globally, highlights the following countries to be particularly fiscally vulnerable: (i) some small island developing states in the Caribbean and Pacific, (ii) countries in Latin America (Honduras, Nicaragua, El Salvador and Bolivia), Africa (Madagascar, Mozambique, Zimbabwe, Sudan, Nigeria and Mauritania) and Nepal in Asia. These countries are prime candidates for stepping up activities to plan, reduce and manage risks in order to reduce serious human and financial loss burden to exposure populations, business and wider macroeconomic health.

However, while risk financing products are becoming increasingly popular, the IPCC (2011, p. 8) concluded that there is medium confidence in the findings that "risk sharing and transfer mechanisms at local, national, regional and global scales can increase resilience to climate extremes". Such mechanisms provide a means to finance relief and recovery of livelihoods and reconstruction, reduce vulnerability and provide knowledge and incentives for reducing risk (see Box 21.5). However, the IPCC also concedes that such mechanisms – if not well integrated with risk reduction and economic planning and policy – can actually provide disincentives for reducing disaster risk by focussing money and effort on the more infrequent risks covered under the policies and thus providing a feeling of safety, while drawing attention from frequent and dynamically increasing risk.

Box 21.5 Containing the fiscal costs of disasters: Case of Caribbean Catastrophe Risk Insurance Facility (CCRIF)

Disaster risk is high and prevalent in the Caribbean. On an annual basis it can amount to up to 6% of GDP, when these direct asset losses are measured in terms of GDP (see Figure 21.7). In most instances, climate and socioeconomic changes are projected to increase this risk despite and because of economic development (ECA, 2009).

The Caribbean Catastrophe Risk Insurance Facility (CCRIF) was established in 2007 as a regional mechanism designed to contain the fiscal costs of disasters and bridge the liquidity gap in the immediate aftermath. It is the world's first regional catastrophe insurance pool, reinsured in the capital markets, to provide governments with immediate liquidity in the aftermath of hurricanes and earthquakes. Sixteen Caribbean countries contribute resources ranging from US$ 200,000 to US$ 4 million, depending on the exposure of their specific country to earthquakes and hurricanes (Young, 2010). The CCRIF requires comprehensive and sound risk analysis, and a number of Caribbean countries have started budgeting for disaster risk, which represents a shift in mindset in terms of Caribbean governments treating risk pre- rather than post-event. The next step with CCRIF is to tackle key gaps in terms of providing stronger linkages to risk reduction and economic policy. As one course of action, CCRIF is currently investing further in developing country risk profiles, which by helping to study the reduction of risk (and fiscal costs) over time effectively provides incentives for building down risk.

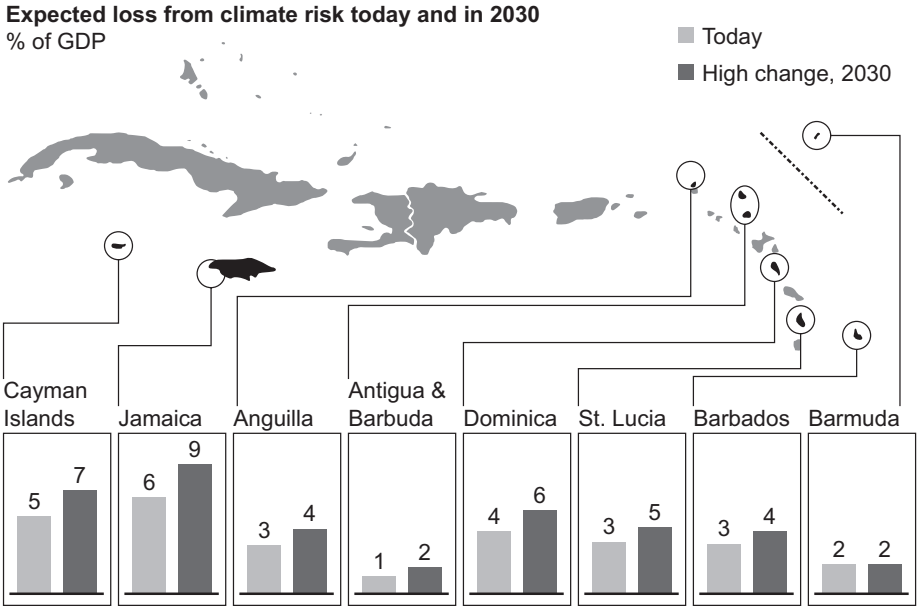

Figure 21.7 Current and future disaster risk measured as a share of GDP in the Caribbean
Source: ECA, 2009

21.4.3 Mainstreaming disaster risk management in sector planning

In order to reduce disaster losses, the balance of effort needs to shift towards reducing exposure through national and sector-based economic planning that takes detailed account of risk assessments. Such strategies benefit from being part of a national strategic risk management processes. In Kiribati, the Kiribati Adaptation Program (KAP) is designed to 'develop and demonstrate the systematic diagnosis of climate-related problems and the design of cost-effective measures, while continuing the integration of climate risk awareness and responsiveness into economic and operational planning' (World Bank, 2011, p. iv). On the basis of extensive consultations and detailed risk assessments, risk management has been integrated across national development strategies and ministry operational plans for all relevant sectors. All of the Programme's investments are tied directly to priorities and activities identified in government planning documents, guided by a National Strategic Risk Management Unit in the Office of the President. However, there are few documented, detailed examples in developing countries of where sector-based investments and planning have been systematically shaped by comprehensive disaster risk assessments and national-level strategic risk management plans. In this regard, early stage work on energy sector risk management tools and methods is being supported by CDKN in Central Asia and West Africa.

One of the most critical implementation issues surrounds the extent to which disaster risk assessments influence the location of critical infrastructure and other important economic assets. As UNISDR (2010) state, reducing climate-related risk will involve protecting critical infrastructure, such as schools and health facilities, retrofitting buildings, relocating settlements and restoring ecosystems, or better yet, avoiding risky development in the first place. The majority of countries now have some form of disaster risk management legislation (Llosa and Zodrow, 2011), but few developing countries have the capacity (or political will) to develop disaster risk zonation and then implement the necessary regulatory and compliance processes. This is because of competing pressures, lack of incentives, a common practice of unplanned development and difficulties involved in blocking access to areas that often offer rich livelihood resources, such as flood plains, volcanic slopes or the coastal strip. Based on Llosa and Zodrow's (2011) assessment of disaster risk management legislation, the most effective in reducing risk are those (i) that are coherent with other legislation and policies across scales and sectors, (ii) that allocate sufficient finance across levels of government, (iii) that clarify institutional arrangements, (iv) that are based on up-to-date risk assessments and mandate periodic reassessments and (v) that establish regulatory and accountability mechanisms and associated penalties (Llosa and Zodrow, 2011; Lal et al., 2012). Reducing exposure will require legislation to be in place that either blocks building on exposed areas or ensures building standards are commensurate with current and future risk profiles. This will require clear communication, mechanisms to integrate this into planning and comprehensive enforcement and penalties. Box 21.6 describes the current situation in Nepal.

Box 21.6 Disaster risk management legislation to reduce exposure: Case of Nepal

Recent work has demonstrated the high vulnerability of Nepal and the potentially large economic and development losses should a major disaster affect the country (ADPC, 2010). One factor behind the high vulnerability is insufficient uptake of building codes. While national building

codes do exist in Nepal, there is currently no clear mechanism for implementing these. This means that high-risk buildings continue to be constructed, including in heavily populated seismically active zones. Even where implementation has started, no city administration has managed to implement building regulations through prior approval, inspection and enforcement. Land use planning is not clearly regulated, and its responsibility is split between the Ministry of Physical Planning and Public Works and municipal authorities. New developments occur without approval and there is no clear mechanism for ensuring these meet safety standards or do not occur on land at high risk from natural hazards. There is no legal mechanism to relocate individuals or communities from highly exposed land, though this has been implemented ad hoc, primarily following a disaster.

It is hoped that a new national Disaster Management Act, currently under development, will address some of these issues. It will supersede the 1982 Natural Calamity (Relief) Act, which is focused on response and relief. The Act will establish new and more broadly representative disaster management institutions at national, regional, district and local levels, including (i) a National Commission for Disaster Risk Management chaired by the Prime Minister; (ii) a National Authority for Disaster Risk Management as the implementation authority; (iii) specialist committees on rescue and relief, preparedness and mitigation, resourced by the Ministries of Home Affairs (MoHA), Local Development (MoLD) and Physical Planning and Works (MoPPW), respectively; and (iv) regional, district and local disaster management committees involved in both planning and implementation.

Source: IFRC (2011)

21.4.4 Challenges of managing risk through economic and fiscal policy

While entry points exist for reducing exposure through risk-sensitive economic and fiscal planning, experience suggests that reducing risk via this mechanism remains challenging. Few countries do in fact budget for risk and contingent liabilities, and the capacity is often limited, requiring major efforts in terms of training and building the knowledge and skills. The recent and ongoing financial crisis has shown that it is unaffordable to continue leaving risks unattended in countries exposed to high risk (disaster, fiscal and financial). Turning these hidden and unrecognised liabilities into explicit budget items (and costs) is a first step to being better prepared and more effectively managing potential shocks to the system. As most governments do not deal with risk directly, significant effort would be necessary to generate the additional capacity necessary for assessing and effectively managing risks.

In order to do so, a key related challenge is integrating economic and fiscal risk planning with comprehensive disaster risk management. Although both efforts lead in a similar direction as they identify and manage risks, the framing of risk management by the different experts involved differs importantly. Economic planning is by definition a top-down effort involving macroeconomists and public finance experts, whereas disaster risk management experts are predominantly working on local scales (villages and communities) and employ more bottom-up processes to identify vulnerable households and communities. Bridging the gaps between these different discourses and integrating risk management expertise across layers of government decision-making requires considerable efforts.

Beyond these technical and procedural challenges, a systemic challenge remains in terms of the political economy of disaster response. While this is not the focus of the chapter, effective

disaster risk reduction requires engagement, empowerment and leadership across layers of government and in way that supports marginalized people. This is difficult to achieve given the political capital attached to 'heroic action' in disaster response, the media focus on this element of a disaster and the considerable increase in funding flows, each provide a disincentive to significant investment in ex-ante action.

As we demonstrate, making the economic case for disaster risk management is possible, but difficult. Although many entry points and improved data and technologies are being made available, these difficulties will not easily go away. Innovation in the field of disaster risk financing is currently outpacing demand. Responding to risk, even when quantified, remains a hard sell for politicians, particularly in resource-constrained environments. It remains tempting for policy makers to rely on a retroactive and myopic "wait and see" approach and provide relief and reconstruction assistance after an event, which can be easily and effectively promoted through the mass media, and thus creates high visibility with potential voters.

21.5 Conclusions: Promoting disaster resilience for climate-compatible development

As this chapter has demonstrated, disaster losses are rising and threaten future economic development, especially given the associated threat of climate change. A policy solution is to integrate risk management into economic and fiscal policy with the goal of reducing exposure and vulnerability over time. To be successful, it would be well worth considering the following:

- Ensure disaster risk assessments are included in economic projections and economic planning across key sectors. Tools and indicators are available to support such exercises, including ways to include assessments and scenarios in growth diagnostic and economic competitiveness tools. However, examples of detailed sector-based approaches are limited.
- Possibly create a frequently updated and accessible national risk atlas, which includes probabilistic assessments of natural hazards, current and projected distributions of assets and people and their associated vulnerability and capacity. This needs to inform economic decisions at all levels through its inclusion in impact assessments for new investments and in country-wide and provincial and local development planning. Such assessments need to consider how the investment will influence the distribution of people and other assets, for example a new road will likely attract people and services, magnifying potential losses if the road passes through highly exposed areas.
- Enact suitable legislation and adequate enforcement measures that seek to carefully manage exposure, for example by establishing suitable building codes and in some cases prohibiting development in flood plains or in low-lying coastal areas for example.
- Integrate government risk financing schemes with risk reduction and economic planning. Bridging the gap in government insurance with risk reduction and economic planning would provide incentives for monitoring and reducing risk, as well as adequately put a cost on risk in economic planning as a way to incentivise investment in risk management.

More broadly this will require a shift in focus from ex-post relief and reconstruction financing to ex-ante investment at national and sub-national levels, recognising that the former is unsustainable.

How can uncertainties associated with dynamic hazards, catalytic events and complex system-wide responses, such as impacts through international supply chains, be factored into economic

models and cost-benefit analysis? How can remote disasters that disrupt supply chains and impact prices be factored in? Can models of society accurately predict future patterns of exposure and vulnerability? Is a 'green' economy inherently more resilient to disasters (and other shocks and stresses) than a more traditional model of economic development? These questions need to be taken up by researchers, decision makers and the private sector in particular, who would benefit from improved data collection nationally. Further linking disaster risk reduction, climate change adaptation, development planning and climate change mitigation institutionally and analytically through an integrated climate-compatible development approach offers a promising avenue to better calculate the trade-offs and benefits of action and may help with political buy-in and improving longer-term fiscal and economic development planning.

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Notes

1 http://www.bloomberg.com/news/2011-12-27/japan-factory-output-falls-on-global-slump.html
2 http://www.guardian.co.uk/business/feedarticle/10092592
3 From an insurance perspective, Surminski and Oramas-Dorta (2011) found 123 disaster risk transfer schemes in developing countries. Of these, 12 could be classed as sovereign schemes, with 7 of those operation and 5 under development. See: http://www2.lse.ac.uk/GranthamInstitute/publications/Policy/briefingNotes/2011/sustainable-risk-transfer-economies.aspx
4 http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=485&ArticleID=5422&l=en

References

ABI (2004) A changing climate for insurance: a summary report for chief executives and policymakers. London: Association of British Insurers.

ADPC (2010). *Nepal Hazard Risk Assessment*. ADPC, Bangkok.

Albala-Bertrand, J.M. (1993). *Political Economy of Large Natural Disasters with Special Reference to Developing Countries.* Clarendon Press, Oxford.

Benson, C. and Clay, E. (2004). *Understanding the Economic and Financial Impacts of Natural Disasters*. Disaster Risk Management Series. No. 4. The World Bank, Washington, D.C.

Bouwer, L.M., Crompton, R.P., Faust, E., Höppe, P. and Pielke Jr., R.A. (2007). 'Confronting disaster losses', *Science* 318, 753.

Cardona, O., Ordaz, M., Reinoso, E., Yamin, L. and Barbat, A.H. (2010). *Comprehensive Approach for Probabilistic Risk Assessment (CAPRA): International Initiative for Disaster Risk Management Effectiveness.* 14th European Conference on Earthquake Engineering, Ohrid, Macedonia, August 30–September 3, 2010.

Caribbean Catastrope Risk Insurance Facility (2011). Quarterly Report. Sepember–November. Caribbean Catastrope Risk Insurance Facility.

Cavallo E. and Noy, I. (2009). *The Economics of Natural Disasters: A Survey*. RES Working Papers 4649. Inter-American Development Bank, Research Department, Washington, D.C.

Charveriat, C. (2000). *Natural disasters in Latin America and the Caribbean: An Overview of Risk*. RES Working Papers 434. Inter-American Development Bank, Research Department, Washington, D.C.

Cummins, J. and Mahul, O. (2009). *Catastrophe Risk Financing in Developing Countries: Principles for Public Intervention*. World Bank, Washington, D.C.

ECA (2009). *Shaping Climate-Resilient Development: A Framework for Decision Making Study.* Report of the Economics of Climate Adaptation Working Group, New York, NY, 159 pp.

ECLAC (2003). *Handbook for Estimating the Socio-economic and Environmental Effects of Disaster*. ECLAC, Mexico City.

European Environment Agency (EEA) (2008). *Direct Losses from Weather Disasters* (CLIM 039) 2008. Copenhagen: European Environment Agency.

GFDRR (2009) *GFDRR Case Study: Central American Probabilistic Risk Assessment (CAPRA)*. Global Facility for Disaster Reduction and Recovery, Washington, D.C.

Grossi, P. and Kunreuther, H. (eds.) (2005). *Catastrophe Modeling: A New Approach to Managing Risk*. Springer, New York.

Handmer, J., Honda, Y., Kundzewicz, Z.W., Arnell, N., Benito, G., Hatfield, J., Mohamed, I.F., Peduzzi, P., Wu, S., Sherstyukov, B., Takahashi, K. and Yan, Z. (2012). 'Changes in impacts of climate extremes: human systems and ecosystems'. In: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. Field, C.B., Barros, V., Stocker, T.F., Qin, D., Dokken ,D.J., Ebi, K.L., Mastrandrea, M.D., Mach, K.J., Plattner, G.-K., Allen, S.K., Tignor, M., and Midgley, P.M. (eds.). A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 231–290.

Hochrainer, S. (2006). *Macroeconomic Risk Management Against Natural Disasters*. German University Press, Wiesbaden.

Hochrainer, S. (2009). *Assessing Macroeconomic Impacts of Natural Disasters: Are There Any?* Policy Research Working Paper, 4968. World Bank, Washington D.C.

IFRC (2011). *Analysis of Legislation Related to Disaster Risk Reduction in Nepal*. Prepared by Picard, M. International Federation of Red Cross and Red Crescent Societies, Geneva, Switzerland.

IPCC (2011). 'Summary for policymakers'. In: *Intergovernmental Panel on Climate Change Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. Field, C.B., Barros, V., Stocker, T.F., Qin, D., Dokken ,D.J., Ebi, K.L., Mastrandrea, M.D., Mach, K.J., Plattner, G.-K., Allen, S.K., Tignor, M., and Midgley, P.M. (eds.). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kellenberg, D. and Mobarak, A. (2008). 'Does rising income increase or decrease damage risk from natural disasters?' *Journal of Urban Economics,* 63(3), 788–802.

Kuzak, D. (2004). 'The application of probabilistic earthquake risk models in managing earthquake insurance risks in Turkey'. In: E. Gurenko (ed.) *Catastrophe Risk and Reinsurance: A Country Risk Management Perspective*. Risk Books, London.

Lal, P.N., Mitchell, T., Aldunce, P., Auld, H., Mechler, R., Miyan, A., Romano, L.E. and Zakaria, S. (2012). 'National systems for managing the risks from climate extremes and disasters'. In: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation* Field, C.B., Barros, V., Stocker, T.F., Qin, D., Dokken ,D.J., Ebi, K.L., Mastrandrea, M.D., Mach, K.J., Plattner, G.-K., Allen, S.K., Tignor, M., and Midgley, P.M. (eds.). A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 339–392.

Linnerooth-Bayer, J., Hochrainer, S. and Mechler, R. (2011). 'Insurance against Losses from natural disasters in developing countries. evidence, gaps and the way forward'. *Journal of Integrated Disaster Risk Management*, doi:10.5595/idrim.2011.0013

Llosa, S. and Zodrow, I. (2011). 'Disaster risk reduction legislation as a basis for effective adaptation'. *Global Assessment Report on Disaster Risk Reduction*. United Nations International Strategy for Disaster Reduction.

Mechler, R. (2004). *Natural Disaster Risk Management and Financing Disaster Losses in Developing Countries*. Verlag fuer Versicherungswissenschaft, Karlsruhe.

Mechler, R., Linnerooth-Bayer, J. Hochrainer, S. and Pflug, G. (2006). Assessing financial vulnerability and coping capacity: The IIASA CATSIM Model'. In: J. Birkmann (ed.). *Measuring Vulnerability and Coping Capacity to Hazards of Natural Origin: Concepts and Methods*. United Nations University Press, Tokyo, 380–398.

Mechler, R. (2009). 'Disasters and economic welfare: can national savings help explain post-disaster changes in consumption?' World Bank Policy Research Working Paper Series No. 4988. World Bank, Washington D.C.

Mechler, R., Hochrainer, S., Pflug, G., Lotsch, A. and Williges, K. (2010). 'Assessing the financial vulnerability to climate-related natural hazards'. Background Paper for the World Development Report 2010 "Development and Climate Change." Policy Research Working Paper 5232. World Bank, Washington, D.C.

Morris, S., Neidecker-Gonzales, O., Carletto, C. Munguía M. and Medina, J. (2002). 'Hurricane Mitch and the livelihoods of the rural poor in Honduras', *World Development*, 30(1), 49–60.

Munich Re (2012). *Münchener Rückversicherungs-Gesellschaft, Geo Risks Research, NatCatSERVICE.*

Noy, I. (2009). 'The macroeconomic consequences of disasters'. *Journal of Development Economics*, 88(2), 221–231.

O'Brien, G., O'Keefe, P., Rose, J. and Wisner, B. (2006). 'Climate change and disaster management'. *Disasters*, 30, 64–80.

OECD (2012). *Enabling Local Green Growth: Addressing Climate Change Effects on Employment and Local Development*. Green Growth Strategy. OECD.

Okuyama, Y. (2009). 'Critical review of methodologies on disaster impacts estimation'. Background paper for World Bank/UN Report Unnatural Disasters. World Bank, Washington D.C.

Otero, R.C. and Marti, R.Z. (1995). 'The impacts of natural disasters on developing economies: Implications for the international development and disaster community'. In: M. Munasinghe and C. Clarke (eds.). *Disaster Prevention for Sustainable Development: Economic and Policy Iss*ues, World Bank, Washington D.C., 11–40.

Pelham, L., Clay, E., and Braunholz, T. (2011). *Natural Disasters: What is the Role for Social Safety Nets?* The World Bank, Washington D.C.

Raddatz, C. (2007). 'Are external shocks responsible for the instability of output in low-income countries?' *Journal of Development Economics,* 84, 155–187.

Skidmore, M. and Toya, H. (2002). 'Do natural disasters promote long-term growth?' *Economic Inquiry* 40(4), 664–687.

Surminski, S. and Oramas-Dorta, D. (2011). 'Building effective and sustainable risk transfer initiatives in low- and middle-income economies: What can we learn from existing insurance schemes?' Briefing note of Policy Paper: December 2011. (www2.lse.ac.uk/GranthamInstitute/publications/Policy/briefingNotes/2011/sustainable-risk-transfer-economies.aspx).

Swiss Re (2000). *Storm over Europe. An Underestimated Risk*. Swiss Reinsurance Company, Zurich.

Swiss Re (2009). 'Disaster risk financing: a paradigm shift?' Clarence Wong, Swiss Re's Chief Economist Asia online article. Posted October 2009. Available at: http://www.swissre.com/clients/insurers/property_casualty/disaster_risk_financing_a_paradigm_shift.html.

UNISDR (2009). *Applying Disaster Risk Reduction for Climate Change Adaptation: Country Practices and Lessons.* ISDR, Geneva.

UNISDR (2010). *Policy Brief 3: Strengthening Climate Change Adaptation through Disaster Risk Reduction*. United Nations, Geneva.

UNISDR (2011) *Revealing risk, redefining development. Global Assessment Report on Disaster Risk Reduction (GAR).* United Nations International Strategy for Disaster Reduction, Geneva, Switzerland.

Vafeidis, A., Neumann, B., Zimmerman, J. and Nicholls, R.J. (2011). *Analysis of Land Area and Population in the Low-Elevation Coastal Zone.* Paper for the Foresight Study on Migration and Global Environmental Change.

Young, S. (2010). *CCRIF: A Natural Catastrophe Risk Insurance Mechanism for Caribbean Countries Insurance, Reinsurance and Risk Transfer.* Presentation at IDB Capacity Building Workshop on Climate Change Adaptation and Water Resources in the Caribbean. March 22–23, 2010, Trinidad and Tobago.

Wilby, R.L. (2009). *Climate for Development in South Asia (Climdev-Sasia): An Inventory of Cooperative Programmes and Sources of Climate Risk Information to Support Robust Adaptation*. Report prepared on behalf of DFID. Department for International Development, UK.

World Bank (2011). *Kiribati – Second Adaptation Program (Pilot Implementation Phase II) Projec*t. The Worldbank, Washington D.C.

World Bank and United Nations (2010). *Natural Hazards, Unnatural Disasters: The Economics of Effective Prevention*. The World Bank, Washington, D.C.