Chapter 6. National Systems for Managing the Risks from Climate Extremes and Disasters

Coordinating Lead Authors
Padma Narsey Lal (Fiji), Tom Mitchell (UK)

Lead Authors
Paulina Aldunce (Chile), Heather Auld (Canada), Reinhard Mechler (Austria), Alimullah Miyan (Bangladesh), Luis Ernesto Romano (El Salvador), Salmah Zakaria (Malaysia)

Review Editors
Andrew Dlugolecki (UK), Takao Masumoto (Japan)

Contributing Authors
Neville Ash (Switzerland), Omar Dario Cardona (Colombia), Fenella Frost (UK), Stefan Hochrainer (Austria) Robert Hodgson (UK), Tarik ul Islam (Canada), Sabrina McCormick (USA), Carolina Neri (Mexico), Roger Pulwarty (USA), Ataur Rahman (Bangladesh), Ben Ramalingam (UK), Karen Sudermeier-Reiux (France), Emma Tompkins (UK), John Twigg (UK), Robert Wilby (UK)

Contents

6.5. Knowledge Gaps

Frequently Asked Questions (FAQs)

References

Executive Summary

Disasters cause significant socioeconomic impacts in all countries, but low and middle-income countries are especially vulnerable, and experience higher fatalities and higher direct economic losses (high confidence). Disasters can be important barriers for continued socioeconomic development (medium confidence). Low and middle-income countries are especially vulnerable, and experience higher fatalities even when exposed to hazards of similar magnitude. The number of deaths per cyclone event, for example, in the last several decades was concentrated in low-income countries even though a higher proportion of population exposed to cyclones live in countries with higher income. While in absolute terms, the direct economic losses from disasters are greater in high-income countries, low-income countries bear the heaviest burden of these costs in terms of damage relative to annual GDP. In small exposed countries. particularly, small island developing countries, these wealth losses expressed as a percentage of GDP (but not a loss of GDP itself) can be very high, with recent assessments suggesting that the average costs over recent decades can be close to 10% for countries such as St. Lucia or Grenada and individual events can amount to more than 200% of annual GDP. Disasters can cause adverse developmental effects in causing hardships and even forcing people below the poverty line, and reduced direct and indirect tax revenue, dampened investment and reduced long-term economic growth through their negative effect on a country's credit rating and an increase in interest rates for external borrowing. Amongst the reasons influencing their ability to adequately respond to disasters include a lack of disaster insurance and other risk financing instruments, reduced tax bases, and high levels of indebtedness, combined with limited household income and savings, little capital assets and limited social insurance (6.1).

Effective national systems for managing the risks of disasters and extreme events involve actors playing differential but complementary roles according to their accepted functions and capacities, working in partnership across levels of society, temporal and spatial scales (high confidence). Actors include national and sub-national governments, civil society and community-based organizations, bilateral and multilateral agencies, research agencies, media and the private sector, working in partnership to cost effectively support efforts to reduce vulnerability and exposure to hazards. National and sub-national government agencies play multiple roles by initiating and leading many functions of the system: developing policies and strategies, enacting legislation and regulatory measures, deciding on risk financing and transfers and creating the enabling environments for other stakeholders in the system to flourish (6.2).

Advances in disaster risk management at national scale offer lessons for organising national systems for adapting to climate change (high confidence). Managing disaster risk at national level involves a continuum of actions and policy options that are complimentary and include measures to manage uncertainty, reduce risk, transfer and share residual risk and prepare for and respond to disaster impacts. The relative emphasis placed on different actors and actions depends on the scale of potential impacts, the capacities of governments or agencies to act, comparative advantage of community based organizations, the level of certainty about the future, the timeframes associated with predictions and the costs and political consequences of decisions. A sample of lessons across this continuum includes that:

- Efforts to systematically manage risk are more likely to be successful if they are co-ordinated across sectors and scales and led by organisations at the highest political level.
- Efforts to systematically manage risk are more likely to be successful if focus is also placed development-risk reduction-risk management as a continuum and risk considerations are integrated into economic development and environmental management efforts as well as well focused on disaster response and management.

- Legislation for managing disaster risks is most valuable where it is complemented by clear regulations that are effectively enforced across scales and complemented by other sectoral development and management legislations where risk considerations are explicitly integrated.
- Making informed decisions about which policy options to pursue is strongly dependent on comprehensive national databases of observations, losses, forecasts and inventories of assets and socio-economic information, and capacity for risk assessment and management..
- Ecosystem-based investments, including conservation measures associated with forestry, land use, coastal wetlands and biodiversity, offer benefits for reducing disaster risk across multiple sectors, as well as provide other livelihood benefits.
- While financial and economic planning for disasters has been often ignored in the recent past, a number of countries have begun to plan and budget for extreme events.
- A common recourse for financing residual risk involves disaster risk insurance and setting up reserve funds or contingent credit instruments and insuring public disaster relief expenditure, such as in the cases of Mexico or in the Caribbean.
- Early warning systems are only effective if they place emphasis on translating complex scientific information and engaging with target audiences and encompass four interacting components: (i) generation and management of risk knowledge including monitoring and forecasting, (ii) surveillance and warning services, (iii) dissemination and communication and (iv) response capability (6.3).

While the Hyogo Framework for Action has been influential in improving national systems, measures to manage current disaster risks and extreme events at national level are not sufficient to prevent increases in adverse impacts on human and natural systems (high confidence). Existing climate-related disasters are partially attributable to weaknesses in the national systems, including gaps in national public policies, poor co-ordination in national systems and to sub-optimal risk management at multiple scales. However, there is high confidence that improvement in risk management at national level, through better co-ordination, rigorous risk assessment, enhanced early warning systems, investments in human development, critical infrastructure and natural capital, and adequate financing, can significantly reduce impacts, including economic losses, morbidity and mortality (6.3).

The trends in hazards, vulnerability and exposure detailed in Chapters 2-4 present new challenges for disaster risk management. The effectiveness of current and future efforts to manage disaster risk at national level are therefore dependent on the extent to which they respond to these trends and integrate knowledge about dynamic risks associated with climate change (high confidence). The assessment found very limited evidence of cases where national disaster risk management systems and associated risk management measures had explicitly responded to the impacts of climate change on disaster risk. While the risk management literature indicates concern that climate change is increasing the frequency and magnitude of hazards, is increasing uncertainty and may be responsible, at least in part, for upward trends in disaster impacts, adaptive actions to these changes still tend to remain normative. The literature suggests that national systems for managing disaster risk can adapt to a changing climate by assessing and ‘mainstreaming’ knowledge of dynamic risks on a regular basis, respond to uncertainty by linking learning and adaptive management practices across scales, improve co-ordination between disaster, climate and development organisations, increase standing emergency response capacity and pursue efforts to address the root causes of poverty and other drivers of vulnerability (6.3, 6.4).

While disaster risk management actions need to be reassessed based on observed and projected hazard, vulnerability and exposure trends, there is considerable overlap between current disaster risk management and climate change adaptation measures that can be considered as ‘no or low regrets’ at the national level (high confidence). No or low regrets measures offer benefits with or without climate change and tend to be overlapping risk management and adaptation practices associated with addressing vulnerability and exposure. The assessment considered such ‘no or low’ regrets options across a range of key sectors, with some of the most commonly cited measures associated with improvements to early warning and health surveillance systems, improvements to sanitation and drainage systems, investments in national water conservation measures, enhanced education and training, maintenance of existing infrastructure, enforcement of building codes and restoration of degraded ecosystems and investment in nature and natural systems (6.3.1).

6.1. Introduction

The socioeconomic impacts of disaster events can be significant in all countries, but low and middle income countries are especially vulnerable, and experience higher fatalities even when exposed to hazards of similar magnitude (UNISDR 2009; IFRC 2010). The number of deaths per cyclone event, for example, in the last several decades was concentrated in low income countries even though a higher proportion of population exposed to cyclones live in countries with higher income; 11 percent of the people exposed to natural hazards live in low human development countries, but they account for more than 53 percent of the total recorded deaths resulting from natural disasters (UNDP 2004). At the same time, while in absolute terms, the direct economic losses from disasters are greater in high-income countries when compared to low-income countries, low-income countries bear the heaviest burden of these costs in terms of damage relative to annual GDP (UNDP 2004; DFID 2005), where this ratio overall amounted to 0.5% averaged over disaster and non-disaster years the 25 year period from 1980 to 2004 compared to 0.15% of GDP for high income countries. In small exposed countries. particularly, small island developing countries, these wealth losses expressed as a percentage of GDP (but not a loss of GDP itself) can be considerably higher, with recent assessments suggesting that the average costs over disaster and non-disaster years recent decades can be close to 10% for countries such as St. Lucia or Grenada (World Bank/UN, 2010). The average costs during disaster years can be much higher, for example in the Samoa these have been reported to be as high as 45.5% as compared with 6.7% across disaster and non-disaster years (Betterncourt et al 2006). Costs of individual events though can be almost 200% of the annual GDP as experienced in Niue following cyclone Heta in 2004 (McKenzie et al. 2005).

A growing body of literature has shown significant adverse macroeconomic and developmental impacts of natural disasters (Cochran 1994; Otero and Marti 1995; Benson 1997; Benson 1997; Benson 1997; Benson 1998; Benson et al. 2001; Benson et al. 2001; ECLAC 2002; ECLAC 2003; Murlidharan and Shah, 2001; Crowards, 2000; Charveriat 2000; Mechler, 2004; 2009; Hochrainer, 2006; Noy, 2009). These include reduced direct and indirect tax revenue, dampened investment and reduced long-term economic growth through their negative effect on a country's credit rating and an increase in interest rates for external borrowing. Individuals, communities and even governments in developing countries often do not have sufficient capital to replace or repair damaged assets and restore infrastructure and livelihoods following major disasters. Amongst the reasons influencing their ability to adequately respond to disasters include a lack of disaster insurance and other risk financing instruments, reduced tax bases, and high levels of indebtedness, combined with limited household income and savings, little capital assets and limited social insurance. This body of evidence emphasises that natural disasters can cause a setback for development, and even a reversal of recent development gains in the short- to medium-term. Poor development status of communities and countries further increases their exposure to disasters. Disaster impacts can also force households to fall below the basic needs poverty line, further increasing their vulnerability to other shocks (Owens et al. 2003; Lal 2010). Consequently, natural disasters are seen as barriers for development, requiring ex-ante disaster risk reduction policies that also targets poverty and development (eg. Ninno et al. 2003; Owens et al. 2003; Skoufias 2003; Benson and Clay 2004; Cardona et al. 2010; IFRC 2010). There is though some literature that suggests that disasters may not always have a negative effect on economic growth and development and for some countries disasters are regarded as rather a problem of, and not for development (Albala-Bertrand, 1993; Skidmore and Toya 2002; Caselli and Malthotra 2004; Hallegate and Gill 2007).

As a response to the impacts of disasters on countries' economies, on levels of poverty and broader development trajectories, national disaster risk management systems have evolved in recent years, guided by international instruments, particularly the Hyogo Framework for Action 2005-2015 (see Chapter 7). Increasing knowledge, understanding and experiences in dealing with natural disaster risks and poverty has gradually contributed to a paradigm shift globally; a shift that recognises the importance of reducing risks and adaptation to climate change and as well as responding to and rebuilding after disaster events (Yodmani 2001; IFRC 2004; UNISDR 2004; UNISDR 2007; UNISDR 2008; Venton and LaTrobe 2008; IFRC 2010).While governments cannot act alone, majority of them are well placed and equipped to support communities and private sector to tackle disaster risk. It is at national level that overarching development policies and legislative frameworks are formulated and implemented to create appropriate enabling environments to guide other stakeholders to reduce, share and transfer risks (Carter 1992; Freeman et al. 2003), albeit in different ways. National level governments in developed countries are often the "insurers of last resorts" and used to be considered to be the most effective insurance instruments of society (Priest

1996). Governments are often what citizens turn to particularly when they do not have their own savings to fall back on or cannot rely on family or other social support in times when the effects of disasters affect many communities at the same time. However, there is disagreement in the literature about reliance on national governments as the appropriate foundation for a comprehensive risk management program, as it draws away from local concerns and initiatives (Aalbala-Bertrand 1993). Those holding this view favor reducing natural hazard risk through community-driven projects and programs developed by nongovernmental organizations (cross check with chapter 5). In practice, targeted governments' policies and actions aimed at ex-ante poverty reduction and improvements in their economic livelihoods can also help communities reduce their disaster risks, and better cope with disaster events (Ninno et al. 2003; Owens et al. 2003; Skoufias 2003; McGray et al. 2007).

National level governments also have the ability to mainstream risks associated with climate variability and change into existing disaster risk management and sectoral development, policies and plans; albeit to differing degrees depending on their capacity. These include initiatives to assess risks and uncertainties, manage these across sectors, share and transfer risks and establish baseline information and research priorities (Freeman et al 2003; Prabhakar *et al*. 2008; Mechler 2004). Ideally, national level institutions are best able to respond to the challenges of climate extremes, particularly given that disaster are largely covariate in nature, often surpassing people's and businesses' coping capacity (OAS 1991; Otero and Marti 1995; Benson and Clay 2002). National government are well placed to take a longer time perspective when making decisions and are amenable to better appreciate key uncertainties and risks associated with climate change (Priest 1996; Hallegate and Gill 2007).

With this in mind, valuable lessons for advancing adaptation to climate change can be drawn from existing national systems for managing current disaster risks. These systems are comprised of actors operating across scales, fulfilling a range of roles and functions, guided by an enabling environment of institutions, international agreements and experience of previous disasters (Carter 1991; Freeman et al 2003). These systems vary considerably between countries in terms of their capacities and effectiveness and in the way responsibilities are distributed between actors. They also vary in how much emphasis they place on integration with development processes, tackling vulnerability and reducing disaster risk, compared with preparing for and responding to extreme events and disasters (Cardona et. el 2010). As detailed in Chapters 3 and 4, climate change poses new challenges for these systems, which in many instances remain poorly adapted to the risks posed by existing climatic variability and extremes (Lavell 1998; McGray et al. 2007; Venton and La Trobe 2008)

Closing the current adaptation deficit and responding to the effects of climate change on disaster risk are seen as priorities for national risk management systems and as a crucial aspect of countries' responses to climate change. With a history of managing climatic extremes, a stronger institutionalisation across scales and levels of governance, a greater number of experienced actors and more widespread instances of supporting legislation and cross-sectoral co-ordinating bodies, national disaster risk management systems offer a promising avenue for supporting adaptation to climate change and reducing climate-related disaster risks. In many cases, it is at this national level that national systems for adapting to climate change and changing disaster risks, where policies themselves adapt to changing conditions, will provide a critical supporting environment for adaptation processes at all scales. Development of adaptive policymaking will require policymakers to treat policies as ongoing experimental and learning processes (McGray et al. 2007).

However, despite some recent progress in strengthening national systems, and despite the burden of disasters imposed are increasingly being recognized, measures to reduce the risks of disasters are still small, and for most part there is a continued reliance on post disaster response and disaster management support. While it is difficult to accurately indicate the level of funds allocated to disaster risk reduction efforts as compared to disaster response and rehabilitation efforts, major donors and international financial institutions, such as the World Bank, SIDA, and European Union in 2003 reported to have at times allocated in excess of 90% of their disaster management funds for relief and reconstruction and less than 10% of the funds for preparedness and risk reduction (LaTrobe and Venton 2003). This level of investment by government and development partners in preventing disasters can be partially explained inter alia by a difficulty in mainstreaming disaster risk management in all phases of national development due to a lack of understanding and knowledge and concrete evidence regarding the types and extent of the cost and benefits of measures to reduce disaster risk as compared with disaster management (LaTrobe and Venton 2003; Benson and Twigg 2004).

Costs and benefits information on disaster risk reduction and adaptation options could help motivate and defend investments in these measures. Some recent studies on sub-national level disaster risk reduction and adaptation measures have demonstrated that disaster prevention and adaptation can pay high dividends. Several studies (Mechler 2005; MMC 2005; Moench et al. 2007; UN/ World Bank 2010) reported that for every dollar invested in risk management broadly, two to six dollars are returned in terms of avoided or reduced disaster impacts on life, property, the economy and the environment. In the absence of concrete information on net economic and social benefits, and in the presence of limited budgetary resources, many policy makers have been reluctant to commit significant funds for risk reduction. Many international agencies also continue to invest considerable funds into high profile, post-disaster response particularly when these are reported in media stories (LaTrobe and Venton 2003; Benson and Twigg 2004).

While there is current lack of emphasis on risk reduction compared to response, there are nevertheless many success stories and promising initiatives for managing and reducing the risks of climate extremes and disaster that could provide valuable guidance for strengthening national systems for advancing adaptation to climate change.

Accordingly, this chapter assesses the literature on national systems for managing disaster risks and climate extremes, particularly the design of such systems of functions, actors and roles they play, emphasising the importance of government and governance for improved adaptation to climate extremes and variability. It reflects on the adequacy of existing knowledge, policies and practices globally and considers the extent to which the current disaster risk management systems may need to evolve to deal with the uncertainties associated with and the effects of climate change on disaster risks. Section 6.2 characterises national systems for managing existing climate extremes and disaster risk by focusing on the actors that help create the system - national and sub-national government agencies, bi-lateral and multi-lateral organisations, private sector, research agencies, civil society and community-based organisations. Drawing on a range of examples from different countries, section 6.3 describes what is known about the status of managing current and future risk, what is desirable in an effective national system for adapting to climate change and what gaps in knowledge exist. The later part of the chapter is organised by the set of functions undertaken by the actors discussed in 6.2. The functions are divided into three main categories – those associated with planning and policies (section 6.3.1), strategies (section 6.3.2) and practices, including methods and tools (section 6.3.3) for reducing climatic risks. Section 6.4 reflects on how national systems for managing climate extremes and disaster risk can become more closely aligned to the challenges of climate change and development – particularly those associated with uncertainty, changing patterns of risk and exposure and the impacts of climate change on vulnerability and poverty. Many aspects of section 6.4 are further elaborated in chapter 8.

6.2. National Systems and Actors for Managing the Risks from Climate Extremes and Disasters

Managing climate-related disaster risks is a concern of multiple actors, from national and sub-national governments, private sector, research bodies, civil society and community-based organizations and communities working in partnership to ultimately help individual households to reduce their risks and vulnerabilities (Twigg, 2004, UNISDR 2009). For an effective and efficient national system for managing climate-related disaster risks each actor would ideally play differential but complementary roles according to their accepted functions and effectiveness across spatial and temporal scales, supported by relevant scientific and traditional knowledge (UNISDR, 2008). This section assesses the literature on the roles played by different actors working within such national systems.

6.2.1. National and Sub-National Government Agencies

National governments have the moral and legal responsibility to ensure economic and social well-being, including safety and security, of their citizens from socio-natural disasters (UNISDR, 2004). It is also government's responsibility to protect the poorest and most vulnerable citizens from disasters, and to implement disaster risk management that reach all (McBean, 2008; O'Brien *et al.*, 2008; CCCD, 2009). In terms of risk ownership and responsibility, government and public disaster authorities "own" a large part of current and future extreme event risks and is expected for them to govern and regulate risks owned by other parts of society (Mechler, 2004).

Recourse to various normative theories could be included. As one example, economic welfare theory suggests that national governments are exposed to natural disaster risk and potential losses due to their three main functions: allocation of public goods and services (e.g. education, clean environment and security), the redistribution of income as well as their role in stabilizing the economy (see Musgrave, 1959, Twigg, 2004; White *et al,* 2004; McBean, 2008; Shaw *et al,*2009). The risks faced by governments include losing public infrastructure and assets. National level government also redistributes income across members of society and thus are called upon when those are in need (Linnerooth-Bayer and Amendola, 2000), such when in danger of become poor, and in need of relief payments to sustain a basic standard of living, especially in countries with low per capita income and/or have large proportions of the population in poverty (Cummins and Mahul, 2008). Finally, it can be argued that governments are expected to stabilize the economy, e.g. by demand side interventions, when it is in disequilibrium. National level government are often called "insurers of last resort" as the governments are often the final entity that private households and firms turn to in case of need. It may well be suggested that most national governments would accept those normative functions, yet their degree of compliance and ability to honour those responsibilities differs significantly across countries.

In the context of a changing climate, governments have a particularly critical role to play in relation to not only addressing the current gaps in disaster risk management but more importantly in response to uncertainties and changing needs due to increase in frequency, magnitude and duration of some climate extremes (Katz and Brown, 1992; Meehl *et al*., 2000; UNISDR, 2004; Christensen *et al*., 2007; UNISDR, 2009).

Different levels of governments – national, sub-national and local level governments as well as respective sectoral agencies play multiple roles in addressing drivers of vulnerability and managing the risk of extreme climate events, although their effectiveness varies within a country as well as across them. They are well placed to create multi-sectoral platforms to guide, build and develop policy, regulatory and institutional frameworks that prioritize risk reduction (Sudmeier-Rieux *et al*., 2006; Handmer and Dovers, 2007); integrate disaster risk management with other policy domains like development or climate change adaptation (UNISDR, 2004, 2009; White et al., 2004; Tompkins *et al*., 2008); and address drivers of vulnerability and assist the most vulnerable populations (McBean, 2008; CCCD, 2009). Governments across sectors and levels also provides many public goods and services that help address drivers of vulnerability as well as those that support disaster risk management (White *et al*., 2004; Shaw e*t al*., 2009) through education, training and research related to disasters (Twigg, 2004; McBean, 2008; Shaw *et al*., 2009). Governments play particularly a critical role in disaster risk management through the allocation of financial and administrative resources, and also with political authority (Spence, 2004; Twigg, 2004; Handmer and Dovers, 2007; CCCD, 2009). Resources must be available at all administration levels, but not sufficient policy and institutional commitment has been made to provide adequate resources at al level, especially in local governments (Twigg, 2004; UNISDR, 2009). The funds could be used in a complementary manner to address adaptation deficit, sustainable development and disaster risk reduction. Governments also has an important role to play in creating appropriate frameworks and enabling environment for the private sector, civil society organisations and other development partners to play their differential roles in managing disaster risk (O'Brien *et al*., 2008; Prabhakar *et al*., 2008). Such functions of national and sub-national governments are discussed further in section 6.3.

6.2.2. Private Sector Organisations

Some aspects of disaster risk management may be suited for non-government stakeholders to implement, albeit this would most effectively be coordinated within a framework created by governments. The private sector plays an important role in DRM and adaptation. Three avenues for private sector engagement may be identified (Roeth, 2009; UNISDR, 2008): (i) corporate social responsibility (CSR) in terms of advocacy and general awareness raising for DRR and involving funding support and the contribution of volunteers and expertise, (ii) Public Private Partnerships (PPP) enhancing the provision of public goods for DRR in joint undertakings of public and private sector players, and (iii) businesses model approaches. While a considerable amount of effort has been dispensed on CSR, PPPs and business model approaches remain rather untouched areas, one very important exception being risk financing and insurance.

Risk financing instruments in 2010 covered about 40% of disaster losses in exchange for premium payments, this albeit mostly in the industrialized countries (Munich Re, 2010). In developing countries, despite complexities and uncertainties involved on both supply and demand for risk transfer, risk financing mechanisms have been found to demonstrate substantial potential in for absorbing the financial burden of disasters (e.g., Pollner, 2000; Andersen, 2001; Varangis, Skees and Barnett, 2002; Auffret, 2003; Dercon, 2005; Linnerooth-Bayer et al. 2005; Hess and Syroka, 2005; World Bank, 2007; Skees et al., 2005; Cummins and Mahul, 2008; Hazell and Hess, 2010). There is some uncertainty as to the extent to which the private sector would continue to play this role in the context of changing environment due to uncertainty and imperfect information, missing and misaligned markets and financial constraints (see Smit et al., 2001; Aakre et al., 2010). Private insurers are less prepared to underwrite insurance for extreme event risks linked to climate change due to ambiguity aversion, i.e. the uncertainty about the chances of climate change induced modifications of extreme event intensity and frequency). Thus innovative private-public sector partnerships are required supported in developing countries by development partner funds as well (see section 6.3.3.3 *and case study in chapter 9).*

Although the potential for private sector players in DRR in sectors such as engineering and construction, information communication technology, media and communication as well as utilities and transportation seems large (Roeth, 2009), little evidence of successful private sector activity has been documented here, owing to a number of reasons: there has in fact been little cooperation and activity as the business case for private sector involvement in DRR remains unclear, hampering private sector engagement; companies may be averse to reporting activities which are fundamental to their business; and, in more community-focussed projects companies often work with local non-governmental organizations and do not report those efforts. Climate change seems to be an entry point here as well leading to an enhanced understanding of a business case in DRR particularly in terms of guaranteeing global value chains in the presence of potentially large scale disruptions triggered by disasters. As one example, the economic viability of the Chinese Coastal Zone, the economic heartland of China and home to many multinational companies producing a large share of consumer goods globally while at the same time highly exposed to typhoon risk, increasingly will depend on well implemented DRR mechanisms in terms of PPP and core business efforts (Roeth, 2009).

6.2.3. Civil Society and Community-Based Organisations (CSO and CBOs)

At the national level civil society and community based organizations have gained a major role in developing different initiatives to respond to disasters, reduce the risk of disasters and, recently, adapt to climate related hazards. CSO and CBO initiatives in the field of disaster risk management while may usually begin as humanitarian concerns, often evolve to also embrace the broader challenge of disaster risk reduction following community focused risk assessment, including specific activities targeting education and advocacy, environmental management; sustainable agriculture; infrastructure construction, as well as increased livelihood diversification (McGray, et al., 2007, Care International 2008; Oxfam America 2008; Practical Action Bangladesh 2008; SEED 2008; Tearfund 2008; World Vision 2008).

Recently in some high risk regions there has been a large development of national platforms of CSO and CBO that have been working together in order to push for the transformation of policies and practices related to disaster risk reduction, this is specially true in the case of Central America, where at least four platforms are functioning in the same number of countries, gathering more than a hundred and twenty CSO and CBO's (CRGR, 2007). In recent times the efforts of these platforms have been aimed to advocacy, training, research and capacity building in DRR. Advocacy on climate policy construction has been included as a new set of activities since 2007 (CRGR, 2008). In other cases, like in South America CSO have been developing efforts aimed at the local level, trying to link disaster risk reduction with local development goals (Lavell, 2009), as a matter of fact in most of the cases CSO are developing actions at the local level, emphasizing in different services such as water, sanitation, irrigation, social infrastructure or disaster preparedness (GNDR, 2009).

Civil society organizations and Community-based organizations have always played a critical role in humanitarian support, although more recently they have become more active in the field of disaster risk reduction and climate change adaptation (UNISDR 2008; Oxfam America 2008; Practical Action Bangladesh 2008; Tearfund 2008; World

Vision 2008). Such expansion of roles has coincided with the increase in frequency and severity of disasters (Wilchez-Chaux, 2008), providing a variety of services including training, preparedness, food security, environment, housing and microfinance (Benson, 2001).In several countries of Latin America CSO and CBO are considered, by law, as part of the national systems for civil protection, this is the case.(CRGR, 2007a., Lavell and Franco, 1996). Among the biggest challenges for civil society organizations the following can be mentioned: securing resources for replicating successful initiatives and scaling up geographically (Care International 2008; Oxfam America 2008; Practical Action Bangladesh 2008; SEED 2008; Tearfund 2008; World Vision 2008); supporting capacity development to replicate and sustain projects (Care International 2008; Oxfam America 2008); sustaining commitment to work with local governments and stakeholders over long term and maintaining partnerships with local authorities (Oxfam America 2008), and coordinating and linking local level efforts with sub-national government initiatives and national plans during the specific project implementation (SEED 2008).

6.2.4. Bi-Lateral and Multi-Lateral Agencies

In developing countries, particularly where the government is weak and has limited resources, bilateral and multilateral agencies are major players in supplying financial and technical support to government and non-government agencies to tackle multifaceted challenges of disaster risk management and more recently climate change challenges. In managing climate-related risks, donor agency with multiple recipient countries, may take a pragmatic approach to delivering regionalised support given that extreme climatic events normally occur contiguously within specific region, such as across Pacific Islands, Southeast Asia and regions of Africa and Latin America. This also strengthens the role of regional agencies charged with helping countries manage climate extremes and disaster risks, such as SOPAC and SPREP in the Pacific (Gero, Méheux et al. 2010; Hay 2010).

Many bilateral and multilateral agencies though continue to address disaster risk management and climate change adaptation separately, linking with respective regional and national agencies and those associated with respective international instruments (Gero et al 2010). However, it is increasingly expected that multilateral and bilateral assistance is provided to support nationally-owned strategies, development plans and disaster risk management policies, though many such strategies, policies and plans still tend to treat climate change and disaster risks separately and predominantly focus on the response and preparedness dimensions of managing disaster risk.

Consequently, bilateral and multilateral agencies often adopt different approaches and modalities to supporting different dimension of risk management and climate change adaptation. This in itself is not a bad thing – particularly in countries with weak delivery capacity at the local level supporting a diversity of stakeholders and approaches can help to ensure progress – for example through supporting local level NGOs and CBOs, along with government agencies. However, the critical challenge in such situations becomes that of coordination. Ultimately, a lack of effective coordination, including amongst external partners, often results in competing approaches and priorities and an unnecessary burden on government. While coordination of effort in countries are expected to be guided under national action plans for adaptation and disaster risk management, these have not necessarily been acted on in a coordinated manner, largely because of policy and funding gaps (Wickham, et al. 2009; Hay 2010). This situation is improving, for example in the Pacific; countries are using their prioritised national action plan to engage with development partners to appropriately sequence and coordinate the support (Hays 2010). Countries, too, are trying to use national action planning processes on climate change and disasters to better coordinate their own as well as development partners support and resource allocation. This is being achieved through their budgetary allocation processes as well as with coordinating requests coming from sub-national to national levels.

6.2.5. Scientific and Other Research Organisations

The effectiveness of national systems for managing climate extremes and disasters risks is highly dependent on the availability and communication of robust and timely scientific information (Sperling and Szekely 2005; Thomalla et al. 2006) and traditional knowledge (UNISDR, 2008) to not only communities but also amongst researchers, and researchers and policy makers who manage national approaches to disaster risk and climate change adaptation. Even a progress has been reported in the communication and availability of scientific information, still a lack of for example sufficient local or sub-national data of hazards (UNISDR, 2009).

Scientific and research organisations range from specialised research centres and universities, regional organisations, to national research agencies, multilateral agencies and NGOs playing differential roles, but generally continue to divide into disaster risk management or climate change adaptation communities. Scientific research bodies play important roles in managing climate extremes and disaster risks by: (a) supporting thematic programmes to study the evolution and consequences of past hazard events, such as cyclones, droughts, sandstorms and floods; (b) analysing time- and space-dependency in patterns of weather-related risks; and (c) building cooperative networks for early warning systems, modelling, and long-term prediction; (d) been actively engaged in technical capacity building and training; (e) translating scientific evidence into adaptation practice; (f) collating traditional knowledge and lessons learnt for wider dissemination, and (g) translating scientific information into user-friendly forms for community consumption (Sperling and Szekely 2005; Thomalla et al. 2006).

Disaster practitioners largely focus on short term climate forecasting and effective dissemination and communication of hazard information and responses (Thomalla et al 2006). Such climate change expertise can typically be found in environment or energy departments and in academic institutions (Sperling and Szekely 2005), while disaster risk assessments have been at the core of many multilateral and civil society organisations and national disaster management authorities (Sperling and Szekely 2005; Thomalla et al. 2006).

6.3. Functions of National Systems for Managing the Risks from Climate Extremes and Disasters

As section 6.2 highlighted, national systems are comprised of a range of actors, undertaking certain functions and with varying success, cover the full range of disaster risk management activities, from managing uncertainty and reducing risk to responding to the impacts of climate extremes and disasters. It is important to recognise that in many countries national and sub-national government agencies initiate and lead many of the functions within the national system. However, in some countries, where governments are weak, unwilling or unable to extend their reach to all people, social groups and areas of the country, other actors, particularly CSOs and multi-lateral organisations undertake a greater proportion of these functions (see section 6.2). Furthermore, some national systems might organise and allocate responsibilities for functions more formally; others are constituted by actors fulfilling functions where they see gaps. However, even where governments are weak or unwilling, it is important to continue efforts to strengthen national government capacity to lead national risk management systems (OECD 2010), given that governments are usually expected to lead the management of disaster risks and that governments typically have the greatest potential for delivery and implementation.

The functions of national systems for managing the risks of climate extremes and disasters are multidimensional across actors and scales. As detailed in 6.2, national and sub-national governments usually have the mandate and capacity to create the enabling environment for other actors through its own agencies to reduce risk, share and transfer residual risk and manage the impacts of disasters. By drawing upon a range of cases from different developed and developing countries, this section describes what is known about the status of managing current and future risk, what is possible in an effective national system and what gaps in knowledge exist. It is organised by the set of activities undertaken by the actors discussed in 6.2 and is divided into three main categories – those associated with planning and policies (section 6.3.1), strategies (section 6.3.2) and practices, including methods and tools (section 6.3.3).

6.3.1. Planning and Policies for Integrated Risk Management, Adaptation, and Development Approaches

The management of climate and disaster risks today and into the future is a cross-cutting process that requires leadership, planning and coordination of policies at all levels of government, but especially at the national level (UNISDR, 2009; CCCD, 2009). In spite of differences and given that learning will come from doing, there are many ways that countries can learn from each other in prioritizing their climate and disaster risks, in mainstreaming climate change adaptation and disaster risk management into plans, policies and processes for development and in securing additional financial and human resources needed to meet increasing demands (UNDP, 2002; CCCD, 2009;

Schipper, 2009). This sub-section will address frameworks for national disaster risk management and climate change adaptation planning and policies (6.3.1.1), the mainstreaming of plans and policies nationally (6.3.1.2) and the various sectoral disaster risk management and climate change adaptation options available for national systems (6.3.1.3).

6.3.1.1. Developing and Supporting National Planning and Policy Processes

National and sub-national government agencies and other actors have a range of planning and policy options to help create the enabling environments for departments, public service agencies, the private sector and individuals to act (UNDP, 2002; Heltberg et al, 2009; OECD, 2009*)*. When considering risk management and adaptation actions, it is often the scale of the potential climate and disaster risks and impacts, the capacity of the governments or agencies to act, the level of certainty on future changes, the timeframes within which these future impacts and disasters will occur and the costs and consequences of decisions that play an important role in their prioritization and adoption (Heltberg et al, 2008; World Bank, 2008b).

Both DRR and CCA have a common goal of risk reduction, with DRR concerned with an ongoing problem (disasters) and CCA more concerned with an emerging climate change issue (McGray et al, 2007; WRI, 2007; UNISDR, 2009). Similarly, both DRR and CCA are best mainstreamed or implemented through other sectors and other policies, including those for agriculture, water resources, infrastructure, health, land use, environment, early warning services, finance and planning (UNISDR, 2009). Both are also linked with other plans, policies and strategies for poverty eradication, planning for sustainable development, education and use of hydro-meteorological science (WRI, 2007; UNISDR, 2009).

There is a continuum of national planning and policy options that can be used to implement (or mainstream) DRR and CCA actions. The options range from climate vulnerability approaches through to climate change impact-based approaches. On the left hand side of the continuum, the vulnerability oriented CCA options overlap with existing DRR practices and realize “no regrets” benefits, with or without climate change. These vulnerability-based approaches are described in Chapters 2 and 4. At the far right side of the continuum are the specialized climate change science dependent activities that exclusively target and reduce distinct climate change impacts. Many of these climate science based approaches are described in Chapter 3. In between the ends of the continuum lie a broad spectrum of activities with gradations of emphasis on vulnerability and impacts. In some cases, mal-adaptation can occur when vulnerabilities to the current climate are addressed without consideration of climate change impacts (e.g. changes to agricultural livelihoods to strengthen resilience today could undermine DRR gains over the longer term when climate change impacts on future flood risks are ignored). Maladaptation actions are discussed in detail in section 1.4.

Increasingly, studies suggest that the most pragmatic CCA and DRR options depend on the adaptive capacity and ability of the country or sector to deal with uncertainties (McGray et al, 2007; Wilby and Dessai, 2010; Auld, 2008b; UNISDR, 2008; Lu, 2009). Cases where certainty is greater in projecting future climate change impacts may better lend themselves for the “top down” modelling approaches, while cases where adaptive capacity is low or the uncertainties over future climate changes are high may be more suited to the “no regrets” and vulnerability-oriented approaches (McGray et al, 2007; UNISDR, 2008; Auld, 2008b; Wilby and Dessai, 2010; Lu, 2009). No-regret approaches are little affected by uncertainties in the information on future climate changes and hence, can be justified under all plausible future climate change scenarios, including no climate change (i.e., they deliver benefits greater than costs no matter what happens to the uncertain parameters in the decision-making) (McGray et al, 2007; Eales et al, 2006; Agrawala and van Aalst, 2008; OECD, 2009; Prabhakar et al, 2009; Auld, 2008b). These no regrets actions would include interventions enhancing the provision and dissemination of climate information for agriculture in drought-prone regions or improving hazard warning and dissemination systems or updating climatic design information for engineering projects. At the other end of the spectrum, some long-term, high implication planning issues (e.g., to plan for the relocation of a large population) or large investments (e.g., a system of major infrastructure projects or watershed management) start with the current and future climate, involve climate change impacts studies and may also incorporate additional redundancies that account for the uncertainties of the future climate (Lu, 2009; McGray et al, 2007; Wilby and Dessai, 2010). Given the consequences, the high irreversibility of the decisions, the significant investment costs and the long-lived nature of these national decisions, more climate information may be needed to treat the range of uncertainties for the future.

Some CCA and DRR options involve "win-win" outcomes for greenhouse gas reduction, disaster risk management, climate change adaptation and development synergies (Heltberg et al, 2009; Ribeiro et al, 2009; World Bank, 2008b). Many of the "win-win" options, illustrated in Table 6-1, include ecosystem-based adaptation actions, sustainable land and water use planning, carbon sequestration, energy efficiency and energy and food self-sufficiency. An example would include afforestation, reforestation and conservation of forests for disaster risk reduction from floods, landslides, avalanches, coastal storms and drought while contributing to adaptation for future climates, economic opportunities, increased biomass and carbon sequestration.

[INSERT TABLE 6-1 HERE:
Table 6-1: National policies, plans, and programs: selection of disaster risk management and adaptation options.]

Under both current and future climate conditions, disaster risk sharing is another viable option and includes instruments such as insurance, micro-insurance and micro-financing, government disaster reserve funds and government-private partnerships involving risk sharing (Linnerooth-Bayer and Mechler, 2006; World Bank, 2010). These risk sharing options provide much needed, immediate liquidity after a disaster, can allow for more effective government response, provide some relief of the fiscal burden placed on governments due to disaster impacts and constitute critical steps in promoting more proactive risk management strategies and responses (Arnold, 2008). The catastrophe insurance pool in Turkey for flood risks, as illustration, offers incentives for improved standards and thereby can mitigate climate risks (von Lucius, 2004, Hoff et. al, 2005). The decision to "bear residual losses" is also an option when uncertainties over the directions of future climate change impacts are high, when capacity is initially limited or adaptation options not available or when the risks of future impacts are considered to be very low (Linnerooth-Bayer and Mechler, 2006; Heltberg et al, 2009; World Bank, 2010). Residual losses are also the reality when very unusual events—well beyond those typically expected—result in exceptionally high impacts. All of these policy and planning options are particularly relevant at the sectoral level where governments either define enabling environments for development projects or define risks that are shared or transferred to different parts of society.

It is important that uncertainty over future climate change risks not become a barrier to climate change risk reduction actions. In cases where climate change uncertainties will remain high, countries may choose to increase or build on their capacity to cope with uncertainty, rather than risk maladaptation from use of ambiguous impact studies or no action (McGray et al, 2007; Lu, 2009). National policies may need to become more adaptable in cases where national plans and policies operate within a limited range of conditions and are oriented towards providing certainty (McGray et al, 2007; UNISDR, 2008). Without flexibility, rigid national policies may become disconnected from evolving climate risks and have unintended consequences (Sperling and Szekely, 2005).

6.3.1.2. Mainstreaming Disaster Risk Management and Climate Change Adaptation into Sectors and Organisations

Mainstreaming of CCA and DRR implies that national, sub-national and local authorities adopt, expand and enhance measures that factor disaster and climate risks into their normal plans, policies, strategies, programs, sectors and organizations (CCCD, 2009; Few et al 2006; UNISDR, 2008). In reality, it can be challenging, even for experts within the fields of CCA and DRR, to provide clear pictures of what mainstreaming is, let alone how it can be made operational, supported, and strengthened at the various national and sub-national levels (Olhoff and Schaer, 2010). The real challenge to mainstreaming adaptation is not planning but implementation.

The existing barriers to managing the disaster risks from current climate variability may need to be addressed in order to reduce the even greater barriers that inhibit actions nationally towards future climate disaster risks (UNDP, 2002; UNDP, 2004); CCCD, 2009; Prabhakar et al, 2009). A key challenge, and an opportunity in mainstreaming DDR and CCA lies in building bridges between current disaster risk management actions to deal with existing climate vulnerabilities and the additional and revised efforts needed for adaptation to future climate change (Few et al, 2006; Olhoff and Schaer, 2010). The DRR community has a long tradition in multi-disciplinary, vulnerability and community-based approaches to reducing risks, often based on response to events, while the CCA community has traditionally placed emphasis on atmospheric prediction science, technological advances, monitoring, warning-response-relief approaches or in the longer term, on climate change modelling and potential impact reductions (Thomalla, 2006; Basher, 2009). As a result, CCA approaches to date have been predominantly "top-down" or information cascading processes, but with limited tangible examples of planned adaptation decisions being based on these approaches (Wilby and Dessai, 2010; UNISDR, 2008). On the other hand, most disaster risk management planning has traditionally aimed to reduce disaster risks from existing climate hazards and vulnerabilities, sometimes little appreciating that the future may not be a repetition of the past uncertainties, hazards and risks (Dilley, 2005, Prabhaker et al, 2009). The DRR community also has a long tradition and strength in multi-disciplinary, vulnerability and community-based approaches to reducing risks Inherent in the bridge building is a need to better understand how existing DRR practices need to be augmented or revised for future adaptation. Some studies advocate a concurrent or twin-track approach to mainstreaming CCA and DRR, consisting of: (1) "bottom-up" approaches or vulnerability assessments of social and economic strategies for coping with present climate extremes and variability, as practiced by the DRR community and (2) "top-down" approaches using climate forecast tools and scenarios to evaluate sector-specific, incremental changes in risk over the next few decades (Wilby et al, 2009; Wilby and Dessai, 2010; Auld, 2008b; Schipper, 2009). In many cases, the approaches can be combined and "streamlined" by considering a range of climate change scenarios and impacts relative to critical vulnerability thresholds defined by decision-makers (Wilby et al, 2009; Auld, 2008b; McGray et al, 2007). The combination of 'top-down' and 'bottom-up' thinking allows vulnerability and impacts approaches to be "mixed and matched" for the realities of different geographic scales, uncertainties and governance mechanisms. In some cases, changing climate risks can be monitored and mainstreamed into decision-making through regularly updated revisions to hazard and vulnerability assessments (Prabhakar et al, 2009; Dilley 2006). Redundancies can also be incorporated into existing disaster management planning in order to strengthen against the unforeseen risks of the changing climate (Prabhakar et al, 2009; McGray et al, 2007). In other cases, downscaled ensembles of future climate change and socio-economic scenarios, impact models, vulnerability assessments and their uncertainties can be incorporated or mainstreamed into planning (Wilby and Dessai, 2010; Wilby et al, 2009; Prabhakar et al, 2009).

In reality, limitations on the availability of current climate hazards and risk information, a mismatch between climate model outputs and the information needs of adaptation planners, limited access to dependable high-resolution regional climate change projections, a shortage of good quality climate data and methodologies for downscaling relevant climate variables to decision-making scales, uncertainties in the climate scenarios themselves, limitations in the relevant climate parameters available from existing models, and a shortage of guidance on the contributions that climate hazards alone make to risks all limit mainstreaming actions (Prabhakar et al, 2009; Basher, 2009; Wilby, 2009; Auld, 2008b). Even when good quality climate risk information is available to meet needs, there may be other factors, including political and economic realities, that influence whether climate guidance is accepted for decision-making (UNISDR, 2008; WCC 2009, NTREE, 2009) . The scope for mainstreaming climate change scenario information into CCA and DRR planning depends on the risk management approach taken, the availability of technical and financial capacity, scale of the risk(s) and the type(s) of adaptation being considered (Adger et al., 2005; Dessai et al., 2005; Wilby et al, 2009).

Much of the guidance and tools used for mainstreaming tends to be tailored for decision-making at the local, regional and project level, rather than the sectoral and national level (Few et al, 2006; Olhoff and Schaer, 2010). Generally, studies indicate that the most effective means for effectively mainstreaming both DRR and CCA nationally involve "whole of government" coordination across different levels and sectors of governance and include the involvement of a broad range of stakeholders (Few et al, 2006; Thomalla et al, 2006; OECD, 2009). In spite the strong interdependencies, governments have tended to manage these issues in their "silos". Typically, environment or energy authorities as well as scientific institutions have tended to be responsible for climate change adaptation while disaster risk management authorities may reside in a variety of national government departments (Prabhakar et al, 2009; Thomalla, 2006; Sperling and Szekely, 2005). Progress within government agencies usually depends on political commitment, institutional capacity and in some cases, on enabling legislation, regulations and financial support (Few et al, 2006; OECD, 2009). Nationally, it may be important to clearly identify a lead for disaster and climate risk management efforts where that lead has influence on budgeting and planning processes (Few et al, 2006; OECD, 2009). In some cases, countries may be able to build on phases of raised awareness and increased attention to disaster risk in order to develop and strengthen their responsible institutions (Few et al, 2006).

While developed countries may be equipped to meet many of the challenges of mainstreaming adaptation and disaster risk reduction into national plans and policies, the situation is often much less satisfactory in developing countries (Basher, 2009). Nonetheless, there are examples from developing countries where progress is being noted in mainstreaming CCA and DRM, as shown in the Chapter 9 case studies. In other cases, international and national funding mechanisms such as the LDC (Least Developed Countries) Fund, the Special Climate Change Fund, Multi-donor Trust Fund (MDTF) on Climate Change, the Climate Investment Fund of the Pilot Programme for Climate Resilience (PPCR), are making funding and resources available to developing countries to pilot and demonstrate the integration of changing climate risks and resilience into core development implementation and providing incentives for scaled-up action and transformational change (see section 7.4.3 for details).

6.3.1.3. Developing Sector-Based Risk Management and Adaptation Approaches

National planning and policies can be challenged to manage short-term climate variability while also ensuring that different sectors and systems remain resilient and adaptable to changing extremes and risks over the long term (UNISDR, 2007; Füssel, 2007; Wilby and Dessai, 2010). The challenge is to find the balance between the short-term and the longer-term actions needed to resolve underlying causes of vulnerability and to understand the nature of changing climate hazards (UNFCCC, 2008; OECD, 2009). Achieving DRR and CCA while attaining human development goals requires a number of cross-cutting, inter-linked sectoral and development activities, as well as effective strategies within sectors and coordination between sectors (Few et al, 2006; Thomalla et al, 2006). Climate change is far too big a challenge for any single ministry of a national government to undertake (CCCD 2009).

In many countries, sectoral-based organizations and government departments play a central role in national decision-making and are a logical focus for adaptation actions (McGray et al, 2007). Table 6-1 provides examples of some sectoral CCA and DRR approaches that have been documented at the national scale, including governments, agencies and the private sector. These national level sectors and landscapes included in the table include natural ecosystem management, agriculture and food security, fisheries, forestry, coastal zone management, water management, health, infrastructure including housing, cities and transportation, and energy. As described above, the options in the table can be considered as a continuum of potential actions that are incremental and reinforce each other. The national DRR and CCA options for sectors are categorized in Table 6-1 as follows:

- Plans and policies to accept and deal with residual risks (e.g. can't adapt, unavoidable risks);
- Plans and policies to transfer or "spread" the risks due to current or future hazards;
- Climate proofing or "no regrets" plans and policies to reduce existing climate risks ;
- Plans and policies that prepare for the uncertainties associated with the future climate;
- Climate change adaptation plans and policies that reduce disaster risks from future climate change;
- "Win-win" plans and policies offering synergistic solutions for GHG reductions, climate change adaptation, disaster risk reduction and human development.

Several national level sectoral risk management and adaptation options, along with their challenges and opportunities, are described in the Chapter 9 case studies. In many of these case studies, the starting point for risk management and adaptation are the options that address existing vulnerabilities.

The impacts of changing climate risks in one sector can affect other sectors and scales, operating vertically and horizontally—vertically from national to local levels or scales within the same sector and horizontally across different sectors at the same level or scale (Urwin and Jordan, 2007; CCCD, 2009; UNFCCC, 2008). The complex and multi-disciplinary nature of these cross-sectoral impacts will require innovative national approaches (Urwin and Jordan, 2007). While the case and need for integration across sectors and levels may be clear, the issue of how to integrate or mainstream nationally across multiple sectors still remains challenging, requiring governance mechanisms and coordination that can cut across governments and sectoral organizations (UNFCCC, 2008; CCCD, 2009). Typically, multi-sector integration tends to deal with the broader national scale (e.g. entire economy or system) and aims to be as comprehensive as possible in covering several affected sectors, regions and issues (UNFCCC, 2008). Effective CCA and DRR coordination between all sectors may only be realized if all areas of government are coordinated from the highest political and organizational level (CCCD, 2009; Schipper and Pelling, 2006; Prabhaker, 2009; UNISDR, 2008).

CCA and DRR approaches for most sectors benefit from ecosystem based adaptation and integrated land, water and coastal zone management options. For example, conservation and management of ecosystems, forests, land use and biodiversity have the potential to create win-win disaster risk protection services for agriculture, infrastructure, cities, water resource management, food security, etc and also create synergies between climate change adaptation and mitigation measures (CCCD, 2009; CBD, 2009; UNISDR, 2009). Water resources management options cross or thread up and down different spatial scales and levels and policy options, from the local to the global and international and also require integrated approaches (CCCD, 2009; Urwin and Jordan, 2007). Water shortage due to climate induced drought will not only limit people's access to drinking water but also seriously affect a range of economic activities, ranging from farming to industry to energy production (CCCD, 2009; IPCC, 2007; WHO, 2003). However, adaptive agriculture and integrated coastal zone and water management practices may prove particularly important in managing water resources in light of climate change (CCCD, 2009; UNFCCC, 2008; IPCC, 2007; UN-WWAP, 2009). Human health will be impacted both directly and indirectly from the changing climate and public health planning and policies may need to shift from focusing only on relatively short-term risks to include the projected long-term impacts of climate change (IPCC, 2007; CCCD, 2009; World Bank, 2009; WHO, 2003). National energy systems are closely linked to adaptive capacity, GHG mitigation, disaster risk reduction, land and water use and human development—sometimes with competing objectives (Marcel and Kok, 2008; UNDP, 2005). Access to energy services and energy efficiency options will become increasingly important for countries and their development, given that the capacity of countries to adapt to climate change risks is much greater where access to energy supplies and energy efficiency options is greater (CCCD, 2009; Klein et al, 2007). The literature indicates that, traditionally, no country in modern times has substantially reduced poverty initially without an increase in its use of commercial energy and/or a shift to more-efficient energy sources that provide better energy services (CCCD, 2009; UNDP, 2005).

6.3.2. Strategies including Legislation, Institutions, and Finance

National systems for managing the risks of extreme events and disasters are shaped by legislative provision and associated compliance mechanisms, the approach to co-ordinating actors in cross sectoral, cross stakeholder bodies and financial and budgetary processes that allocate resources to actors working at different scales. These elements tend to form the 'technical infrastructure' of national systems, but there are also other non-technical dimensions of 'good governance', such as the distribution and decentralisation of power and resources, structures and processes for decision-making, equity, transparency and accountability, and participation of a wide range of stakeholders groups (UNDP 2004a). It is important to recognise the variation between countries in governance capacity for managing the risks and uncertainties of changing climate extremes. This recognition is based on the understanding that risks and uncertainties are addressed through both formal and informal governance modes and institutions in all countries (Jaspars and Maxwell 2009), but the balance between the two can be different across countries depending on the specific economic, political or environmental context of the individual country or the scale at which action is taking place (Menkhaus, 2007; Kelman, 2008).

6.3.2.1. Legislation and Compliance Mechanisms

Legislation that supports disaster risk management by establishing organisations and their mandates, clarifies budgets, provides (dis)incentives and develops compliance and accountability mechanisms is an important component of a national disaster risk management system (UNISDR HFA 2005, UNDP 2004). Legislation creates the legal context of the enabling environment in which others, working at national and sub-national scales, can act and it can help define people's rights to protection from disasters, assistance and compensation (Pelling and Holloway 2006). With new information on the impacts of climate change, legislation on managing disaster risk may need to be modified and strengthened to reflect changing rights and responsibilities and to support the uptake of no, low, medium and high regrets adaptation options (UNDP 2004; see Chapter 9 case study on 'effective legislation for adaptation and disaster risk reduction). 'National Platforms' for managing disaster risk, the multi-stakeholder, cross sectoral co-ordination bodies supported by the Hyogo Framework for Action, are seen as key advocates for new and improved legislation (UNISDR 2007), but regional disaster management bodies, such as in the Caribbean or the

Pacific region, can also be influential at national level where national co-ordinating bodies lack capacity or are missing (Pelling and Holloway 2006).

While the large majority of countries (in excess of 80%) have some form of disaster management legislation (UNISDR 2005; Bhavnani et al. 2008), little is known about what proportion of legislation is oriented toward managing uncertainty and reducing disaster risk compared with disaster response, whether legislation includes provision for the impact of climate change on disaster risk and whether aspects of managing disaster risk are included in other complimentary pieces of legislation (see chapter 9 case study). However, where reforms of disaster management legislation have occurred, they have tended to: (a) demonstrate a transition from emergency response to a broader treatment of managing disaster risk, (b) recognise that protecting people from disaster risk is at least partly the responsibility of governments, (c) promote the view that reducing disaster risk is everyone's responsibility (see case study in chapter 9). For example, Viet Nam has taken steps to integrate disaster risk management into legislation across key development sectors –its Land Use Law and Law on Forest Protection. Viet Nam's Poverty Reduction Strategy Paper also included a commitment to reduce by 50% those falling back into poverty as a result of disasters and other risks (Pelling and Hollway 2006; Viet Nam National Report on Disaster Reduction 2005). The chapter 9 case study highlights a number of components of effective disaster risk management legislation. An act needs to be: (a) comprehensive and overarching act, (b) establish management structures and secure links with development processes at different scales and (c) establish participation and accountability mechanisms that are based on information provision and effective public awareness and education. Chapter 9 includes detailed case studies from legislation development processes in the Philippines and South Africa. Box 6-1 supplements these cases with reflections on the process that led to the creation of disaster risk management legislation in Indonesia.

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Box 6-1. Enabling Disaster Risk Management Legislation in Indonesia

Indonesia: Disaster Management Law (24/2007)

The legislative reform process in Indonesia that resulted in the passing of the 2007 Disaster Management Law (24/2007) created a stronger association between disaster risk management and development planning processes. The process was successful because of the following elements:

- *Strong, visible professional networks* - Professional networks born out of previous disasters meant a high level of trust and willingness to co-ordinate became pillars of the legal reform process. The political and intellectual capital in these networks, along with leadership from the MPBI (The Indonesian Society for Disaster Management) was instrumental in convincing the law makers about the importance of disaster management reform.
- *Civil Society Leading the Advocacy* - Civil society led the advocacy for reform has resulted in CSOs being recognised by the Law as key actors in implementing disaster risk management in Indonesia
- The impact of the 2004 South Asian tsunami helping to create a conducive *political environment* - The reform process was initiated in the aftermath of the tsunami which highlighted major deficiencies in disaster management. However, the direction of the reform (from emergency management towards DRR) was influenced by the international focus, through the HFA, on DRR.
- An *Inclusive Drafting Process* - Consultations on the new Disaster Management Law were inclusive of practitioners and civil society, but were not so far-reaching as to delay or lose focus on the timetable for reform.
- Consensus that *passing an imperfect law is better than no law at all* - An imperfect law can be supplemented by additional regulations, which helps to maintain interest and focus.

Source: United Nations Development (2009); UNDP (2004a); Pelling and Holloway (2006)

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Where risk management dimensions are a feature of national legislation positive changes are not always guaranteed (UNDP 2004a). A lack of financial, human or technical resources and capacity constraints present significant obstacles to full implementation (UNISDR 2005 *review of national submissions*), especially as experience suggests legislation should be implemented continuously from national to local level and is contingent on strong monitoring and enforcement frameworks (UNDP 2004a) and adequate decentralisation of responsibilities and human and financial resources at every scale (Pelling and Holloway 2006). There is anecdotal evidence of disaster risk management legislation that is technically excellent but practically unenforceable (UNDP 2004a). Building codes for instance are often not implemented because of a lack of technical capacity and political will of officials concerned. Where enforcement is unfeasible, accountability for disaster risk management actions is impossible – this supports the need for an inclusive, consultative process for discussing and drafting the legislation (UNDP 2007). 'Effective' legislation also includes benchmarks for action, a procedure for evaluating actions, joined-up planning to assist co-ordination across geographical or sectoral areas of responsibility and a feedback system to monitor risk reduction activities and their outcomes (UNISDR 2005, Pelling and Holloway 2006).

Improving risk management legislation in the context of climate change suggests stronger synergy with economic development, land-use planning and environmental protection laws, and the integration of environmental management principles into existing legislation (UNISDR 2007, UNISDR GAR 2009). However, the limited political power of risk management actors in many governments limits the ability to affect change alone across other areas of legislations and reform requires cross-sectoral coalitions. Evidence from the Philippines cited in Chapter 9, one of the first country to enact legislation that explicitly attempts to integration climate change and disaster risk management dimensions across scales, highlights the importance given to ensuring co-ordination across all levels of government, provision of financial resources for implementation across scales and a commitment to regularly assess the impact of climate change on disaster risks and extremes.

6.3.2.2. Coordinating Mechanisms and Linking across Scales

Given that the task of managing the risks of climate extremes and disasters cuts across the majority of development sectors and involves multiple actors, multi-sectoral and multi-stakeholder mechanisms are commonly cited as preferred way to 'organise' disaster risk management systems at national level. The Hyogo Framework for Action (HFA) terms these mechanisms *National Platforms*, which are defined by the HFA (footnote 10) as 'a generic term for national mechanisms for co-ordination and policy guidance on disaster risk reduction (DRR) that are multi-sectoral and inter-disciplinary in nature, with public, private and civil society participation involving all concerned entities within a country'. National Platforms were first supported by a resolution of the UN General Assembly in 1999 (UNGA 1999/63) and more recently reaffirmed in A/RES/62/192. Guidelines on establishing National Platforms suggest that they need to be built on existing relevant systems and should include participation from different levels of government, key line ministries, disaster management authorities, scientific and academic institutions, civil society, the Red Cross/Red Crescent, the private sector, opinion shapers and other relevant sectors associated with disaster risk management (UNISDR 2007). Limited independent evaluations of National Platforms exist and conclusive evidence of their establishment leading to more effective disaster risk management is largely absent though strong in normative literature (UNISDR 2007).

Many national climate change adaptation co-ordination mechanisms remain are largely disconnected from such disaster risk management platforms though joint bodies are beginning to emerge [UNISDR GAR 2009], despite calls to involve climate change focal points/organisations into National Platforms (UNISDR 2007). Benefits of improved co-ordination between climate adaptation and disaster risk management bodies, and development and disaster management agencies include the ability to (i) explore common trade-offs between present and future action, including addressing human development issues and reducing sensitivity to disasters versus addressing post disaster vulnerability ; (ii) identify synergies to make best use of available funds for short-to longer term adaptation to climate risks as well as to tap into additional funding sources, (iii) share human, information, technical and practice resources, (iv) make best use of past and present experience to address emerging risks, (v) avoid duplication of project activities; and (vi) collaborate on reporting requirements (Mitchell and Van Aalst 2008). Barriers to integrating disaster risk management and adaptation co-ordination mechanisms include the underdevelopment of the 'preventative' component of disaster risk management, the fragmentation of projects that integrate climate change in the context of disaster risk management, disconnects between different levels of government and the weakness of both disaster risk management and climate change adaptation in national planning and budgetary processes (Few *et al*., 2006; Mitchell and Van Aalst 2008) (see Box 6-2).

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Box 6-2. National and Sub-National Coordination for Managing Disaster Risk in a Changing Climate: Kenya Case Study

Kenya's National Platform sits under the Office of the President and has made significant achievements in co-ordinating multiple stakeholders, but is constrained by limited resources and lack of budgets for DRR in line ministries (Kenya Submission to Global Platform 2009). Key constraints of the national system are recognised as being difficulties in integrating DRR in planning processes in urban and rural areas and lack of data on risks and vulnerabilities at different scales (ibid 2009; Few *et al* 2006). In this regard, Nairobi has experienced multiple periods of drought and heavy rains in the last decade, prompting action to reduce exposure and vulnerability to what is perceived as changing hazard trends (ActionAid 2006). Increasing exposure and vulnerability has resulted from a rapid expansion of poor people living in informal settlements around Nairobi, leading to houses of weak building materials being constructed immediately adjacent to rivers and blocking natural drainage areas. While data and co-ordination systems are still lacking, the Government of Kenya has established the Nairobi Rivers Rehabilitation and Restoration Programme (ADB, Tunis 2010), designed to install riparian buffers, canals and drainage channels, while also clearing existing channels. The Programme also targets the urban poor with improved water and sanitation, paying attention to climate variability and change in the location and design of wastewater infrastructure and environment monitoring for flood early warning (ADB Tunis 2010). This demonstrates the kind of no or low regrets options for investments that can be achieved in the absence of a fully fledged nationally co-ordinated disaster management system and in the absence of complete multi-hazard, exposure and vulnerability data sets.

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While national level co-ordination is important and the majority of risks associated with disasters and climate extremes are owned by national governments and are managed centrally; a broad range of research reflects that decentralization is critical to effective risk management, especially in supporting community-based disaster risk management processes. Whereas, other literature suggests that decentralisation as not always been successful in achieving improved disaster risk management outcomes, on the contrary, on some occasions it has been utilized in inappropriate ways, for example by delegating responsibilities to local governments when these are not prepared to do so because they do not have the skills or finances required, and neither the jurisdiction or political power (Twigg, 2004). It is important to take into account that decentralization is not only based on governance systems supported by policy and legislation, but also in allocation of time, resources and in building trust (Tompkins *et al*., 2008). Therefore, a tension exists between devolution or centralization of disaster risk management. While on the one hand centralization is necessary to overcome compartmentalization (Wisner 2003), ad hoc decision-making, and the concretization of localized power relations (Naess et al. 2004), devolution is critical because it results in more accountable, credible, and democratic decision-making. These decisions about governance approaches are critical because they shape efficiency, effectiveness, equity, and legitimacy of responses (Adger et al. 2003). In addition, motivation for management at a particular scale promises to influence how well the impacts of disasters and climate change are managed, and therefore affect disaster outcomes (Tsing et al., 1999). Finally, decisions made at one scale may have unintended consequences for another (Brooks and Adger 2005), meaning that governance decisions will have ramifications across scale and contexts. In all cases, the selection of a framework for governance of disasters and climate change related risks may be issue or context-specific (Sabatier 1986).

Current management practices have tended to be centralized at the federal/national level. This may be, in part, due to the ways in which many disasters and climate extremes affect environmental systems that cross political boundaries resulting in scale discordance if solely locally managed (Cash and Moser 1999), or because human reactions cross local boundaries, such as migration in response to disasters, necessitating national planning (Luterbacher 2004). In addition, in situations where civil society is flattened due to poverty, marginalization, or historical political repression, regional and federal governments with access to resources may be most important in instigating public action (Thomalla et al. 2006). National-level policies can facilitate otherwise impossible localized strategies through the establishment of resources or legal frameworks (Adger 2001) and often shape what localities can accomplish within existing governance frameworks (Keskitalo 2009).

Yet, centralized approaches have faced many challenges. Disaster preparedness in least developed countries, which has often been centralized and focused on a particular risk rather than a holistic approach, has been unable to advance capacity at the grassroots level (O'Brien et al. 2006). For example, national adaptation efforts in Southern Africa have been insufficiently integrated into local strategies, resulting in resilience gaps (Stringer et al. 2009). Challenges regarding credibility, stability, accountability, and inclusiveness are some of the critical issues that plague efforts at the national level (Bierman 2006). The private sector has begun to engage in financial assistance for climate change impacts through insurance for developing nations that have limited supplies to assist impacted households (Hoeppe and Gurenko 2006). However, it is not yet clear how effectively such funding can be distributed to households themselves. Devolution of management is supported by the need to overcome these challenges.

As a general rule, actions generated within and managed by communities are most effective since they are context-specific and tailored to local environments (Cutter 2003; Liso et al. 2003; Mortimer and Adams 2001). Bottom-up management of climate and disaster risks acknowledges that the vulnerable live within countries, and are not nations themselves (Kate 2000). Involvement of local or grassroots groups in the planning and implementation of preparedness plans can lead to greater resilience (Larsen and Gunnarsson-Östling 2009). For example, communities themselves can lead vulnerability assessments as a part of community-based adaptation (Yamin et al. 2005). Communities can also be effectively engaged in information dissemination and training, awareness raising, accessing local knowledge or resources, and mobilizing local people (Allen (2006). Local management may need assistance from non-traditional sources. The private sector can facilitate action through the provision of resources, technology, and tools, such as insurance against the extreme impacts of climate change to support (Linnerooth-Bayer et al. 2005). Such programs could introduce preventive measures, such as retrofitting buildings and public education.

Since environmental systems relate to risks for local population and since environmental management functions across scales (Berkes 2002), the creation of effective multi-level governance within national systems for managing risk that span these scales are critical in responses to climate change and changing disaster risks (Adger et al. 2005; Olsson and Fulke 2001). Devolution of activities for climate-related disaster risk reduction can also be managed by cities that develop plans for multiple communities, such as that in Dhaka, Bangladesh where urban-level plans have advanced community resilience (Roy 2009). Such city-level plans can be communalized through the incorporation of participatory approaches (Laukkonen 2009). When necessary, localized plans should be supported by the integration of multiple levels of management, although questions about how to scale up from localized assessments to national-level plans still remain (van Aalst et al. 2008). Dryland communities in Chile have created local committees to manage extreme events when national and regional level institutions did not effectively communicate or collaborate with them (Young et al. 2010). The Cayman Islands responses to Hurricane Ivan in 2004 after three prior events, Gilbert, Mitch, and 2000 Michelle, demonstrated that adaptation planning at community and national levels was necessary to improve preparedness and resilience (Adger et al. 2005). These measures included improving localized social cohesion and diversifying adaptation strategies (Tompkins 2005). Procedural dimensions, such as participatory models, that allow for involvement for a wider range of local stakeholders provide a mechanism to mitigate existing power dynamics that might otherwise be concretized in localized planning (Paavola and Adger 2002). If multiple levels of planning are to be implemented, such mechanisms for facilitation and guidance on the local level is needed in order that procedural justice is guaranteed during the implementation of national policies (Thomas and Twyman 2005). Taking these ideas into account might allow national governments to help facilitate programs where local community members jointly engage in risk management (Perez et al.1999). Such programs may allow for an integration of bottom-up and top-down approaches that overcomes each approaches strengths and weaknesses (Urwin and Jordan 2008).

6.3.2.3. Finance and Budget Allocation

Governments in the past have ignored catastrophic risks in decision-making, implicitly or explicitly exhibiting risk-neutrality (Carpenter, 2000). This is consistent with the Arrow Lind theorem (Arrow and Lind 1970), according to which a government may efficiently (i) pool risks as it possesses a large number of independent assets and infrastructure so that aggregate risk becomes negligible, and/or (ii) spread risk across the population base, so that per-capita risk to risk-averse household is negligible. Governments, because of their ability to spread and diversify risks, are considered to "the most effective insurance instrument of society" (Priest 1996). It has been argued that, although individuals are risk-averse [to natural disasters risk], governments should take a risk-neutral stance. The reality of developing countries suggests otherwise and the above does do completely apply to developing countries, forcing a recent paradigm shift and critical reevaluation of governments taking 'risk neutral' approach to managing risks. Government decisions should be based on the opportunity costs to society of the resources invested in the project and on the loss of economic assets, functions and products. In view of the responsibility vested in the public sector for the administration of scarce resources, and considering issues such as fiscal debt, trade balances, income distribution, and a wide range of other economic and social, and political concerns, governments should not act risk-neutral (OAS, 1991).

Many highly exposed developing countries have a precarious economic base, are faced with shallow and exhausted tax bases, high levels of indebtedness and the inability to raise sufficient and timely capital to replace or repair damaged assets and restore livelihoods following major disasters, exacerbating the impacts of disaster shocks on poverty and development (OAS, 1991; Mechler, 2004; Linnerooth-Bayer, Pflug and Mechler, 2005; Hochrainer, 2006; Mahul and Ghesquiere , 2007; Cummins and Mahul, 2009). Exposed countries often also rely on donors to "bail" them out after events, which can be described as an instance of *moral hazard*, although ex–post assistance usually only provides partial relief and reconstruction funding, and such assistance is also often associated with substantial time lags (Pollner, 2001; Mechler, 2004). Consequently, a risk neutral stance in dealing with catastrophic risks may not be suitable for exposed developing countries with little diversified economies or small tax bases. Accordingly, assessing and managing risks over the whole spectrum of probabilities is gaining momentum (Cardenas, 2007; Cummins and Mahul, 2009).

Also, in more developed economies less pronounced but still important effects have been identified. For example, disasters pose significant contingent liabilities for governments and prudent planning is necessary to avoid debilitating consequences (Mechler et al. 2010). This is shown by the Austrian political and fiscal crisis in the aftermath of large scale flooding that led to losses in billions of Euro in 2002. Climate change, projected to increase the disaster burden, adds additional impetus for planning for and reducing disasters risks. Given the uncertainties associated with climate change and extreme events, development planning for reducing risks will need to be based on a systematic estimate of risk.

Budget and resource planning for extremes is not an easy proposition. Governments commonly plan and budget for *direct* liabilities, that is liabilities that manifest themselves as certain and annually recurrent events. Those liabilities can be of explicit nature (as recognized by law or contract), or implicit (a moral obligation) (see Table 6-2). In turn, governments are not good at planning for contingencies, that is, obligations for probable events, which is where climate extremes and adaptation fall into. Explicit, contingent liabilities have to do with the reconstruction of infrastructure destroyed by events, implicit ones with providing relief which generally throughout the globe is a recognized moral liability, albeit serviced to varying degrees (Schick and Polackova Brixi, 2004). In many particularly developing countries, government do not even explicitly plan for contingent liabilities, and rely on reallocating their resources following disasters, raise capital from domestic and international donations to meet infrastructure reconstruction costs.

[INSERT TABLE 6-2 HERE:
Table 6-2: Government liabilities and disaster risk (modified after Schick and Polackova Brixi, 2004).]

Rather than planning for or having contingency funds available post-disaster, countries also have tended to rely on development partner support. Knowing that such additional funds are usually forthcoming, it creates a serious moral hazard problem (see World Bank 2006 b). More recently, some developing countries that face large contingent liabilities in the aftermath of extreme events and associated financial gaps have begun to plan for contingent natural events. Countries such as Mexico, Colombia and many Caribbean countries now include contingent liabilities into their budgetary process and eventually even transfer their risks (Cardenas et al., 2007; Cummins and Mahul, 2009; Linnerooth-Bayer and Mechler, 2007; see Box 6-3). Similarly, many countries have started to also focus on improving human development conditions as an adaptation strategy for climate change and extreme events, particularly with the help of international agencies such as the World Bank. These deliberations are in line with the described *no* and *low regrets* strategies discussed in 6.3.1.1.

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Box 6-3. Case study: Mexico's Fund for Natural Disasters, FONDEN

Mexico lies within one of the world's most active seismic regions and in the path of hurricanes and tropical storms originating in the Caribbean Sea, Atlantic and Pacific Oceans. Mexico's population and economy is highly exposed to natural hazards and in the past severe disasters have created large fiscal liabilities and imbalances.

Given its high financial vulnerability, the Mexican Government passed a law in 1994 requiring federal, state and municipal public assets to be insured relieves the central government of having to pay for the reconstruction of public infrastructure, although the proper level of insurance particularly for very large events remained a concern. In 1996 the national government established a system of allocating resources into FONDEN (Fund For Natural Disasters) to enhance the country's financial preparedness for natural disaster losses. FONDEN 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's FONDEN budget item. FONDEN's objective is to prevent imbalances in the federal government finances derived from outlays caused by natural catastrophes.

The FONDEN program started well, although in recent years some concerns have been raised, particularly due to regular demands on the funds. Budgeted FONDEN resources have been declining in the last few years, demands on FONDEN's resources are becoming more volatile, and outlays have often exceeded budgeted funds, causing the reserve fund to decline. In 2005, after the severe hurricane season affecting large parts of coastal Mexico, the fund was finally exhausted. This has forced the Mexican Government to look at alternative insurance strategies, including hedging against natural disaster shocks, and government agencies at all levels providing their insurance protection independent of FONDEN, and the instrument should indemnify only losses that exceed the financial capacity of the federal, local or municipal government agencies. In 2006 Mexico became the first transition country to transfer part of its public sector natural catastrophe risk to the international reinsurance and capital markets, and in 2009 the transaction was renewed for another three years covering both hurricane and earthquake risk.

Source: based on Cardenas *et al*. 2007

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6.3.3. Practices including Methods and Tools

Governments, and other agencies working in the national system have developed a set of different practices for managing disaster risks. Practices involving risk assessment, information systems, hard and soft management options, risk transfer, public awareness, early warning, preparedness and response are all raised in this sub-section, which is divided into four sections related to those practices associated with building a culture of safety (6.3.3.1), reducing climate related risks (6.3.3.2), transferring and sharing residual risk (6.3.3.3) and managing the impacts (6.3.3.4).

6.3.3.1. Building a Culture of Safety

Building a culture of safety involves several strategies and activities that start with the assessment of risk factors and building information systems that provide relevant information for critical decision making. Early warning systems play a very relevant role in disaster management but, as stated in this section, also in long term planning because of their capability of generating relevant information of inadequate land use and planning, for example.in the same sense climate-adapted infrastructure, enhanced human development, ecosystems protection, risks transfer and sharing and managing the impacts of climate related disasters can play a fundamental role in building a culture and practice of human safety.

6.3.3.1.1. Assessing risks and maintaining information systems

As discussed in chapters 2 and 3, the first key step in managing risk is to assess and characterise it. In terms of risk factors, disaster risk commonly is 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 impacts, hazard analysis, studying exposure and vulnerability assessment. Responding to risks is dependent on the way risk-based information is framed in the context of public perception and management needs (See Chapter 5).

National governments have a fundamental role in providing good quality and context-specific risk information about, for example, the geographical distribution of people, assets, hazards, risks and disaster impacts and vulnerability to support disaster risk management (McBean, 2008). Good baseline information and robust time series information are key for long-term risk monitoring and assessments, not only for hazards but also for evaluating the evolution of vulnerability and exposure (McEntire and Myers, 2004; Aldunce and León, 2007). Regular updating of information about hazards, exposure and vulnerability is recommended because of the risk dynamics, especially today due to the affects of climate change on disaster risk and the associated uncertainty this creates (UNISDR, 2004; Prabhakar, 2008).

A key component in the risk assessment process is to determine the exposed elements at risk. This may relate to persons, buildings structures, infrastructure (e.g. water and sewer facilities, roads and bridges) or agricultural assets in harm's way, which can be impacted in case of a disaster event, and for national level assessments their aggregate values are of interest. Ideally, this would be based on national asset inventories, national population census, and other national information. In practice, collecting an inventory on assets and their values often proves very difficult and expensive due to the heterogeneity and sheer number of the examined elements (see Cummins and Mahul, 2009). In addition, risk management process would require identifying those elements of the social process that also contribute to vulernability – organisational and institutional strength, the status of national wealth and human development status of community at risk and capacity to respond to disasters (Cardona et al 2010 and Lavell 1998). Considerable progress has been made in the use of information (UNISDR, 2009). Nevertheless, in many countries this is not a regular practice and efforts to document impacts are started only after major disasters (UNISDRUNISDR, 2004; Prabhakar, 2008). Regular monitoring of vulnerability is also at nascent stage (Cardona, 2010;Dilley, 2005). Table 6-3 shows a sample of the kinds of information required for effective disaster risk management and climate change adaptation activities.

[INSERT TABLE 6-3 HERE:
Table 6-3: Information requirements for selected disaster risk reduction and climate change adaptation activities (adapted from Wilby, 2009).]

As to assessing and monitoring impacts and losses, country and context specific information, including baseline data about observations (different types of losses, weather data) from past events, are often very limited and of mixed quality (see Carter et al., 2007; Embrechts et al., 1997). Data records at best may date back several decades, and thus often would provide only one reference data point for extreme events, such as a 100 year event. Data on losses from extremes can also be systematically biased due to high media attention or unusual donor support (Sapir and Below, 2002). At times the data on losses are incomplete, as in the Pacific SIDS, because of limited capacity to systematically collect information at the time of disaster, or because of inconsistent methodologies and the costs of measures used (Chung 2009, Lal et al 2009).

Comparisons of disaster loss databases have shown significant variations in documented losses due to inconsistencies in the definition of key parameters and estimation methods used (Chung 2009, Lal 2010), emphasising the need to standardise parameter definitions and estimation methods (Guha-Sapir and Below, 2002; Tschoegl et al., 2006). For some countries, reasonable quality and quantity of information may exist on the direct impacts particularly where the reinsurance industry, consulting firms and multi-lateral financial institutions have worked together with the research communities. Limited information is generally available on socially relevant effects, such as the incidence of health effects post disaster as well as ecosystem impacts, which have not been well studied (Benson and Twigg 2005). Furthermore, the assessment of indirect and flow-on economic effects of disasters, such as on income generating sectors, and national savings needs greater attention, and can often be very useful to assess risks later on, using statistical estimation techniques (Embrechts et al. 1999), or catastrophe modeling approaches (Grossi and Kunreuther, 2005).

6.3.3.1.2. Promoting public awareness, including education and early warning systems

National governments create the environment and communication channels to develop and disseminate different kinds of information, for example, about hazards that affect different populations and preparedness for disaster response. For this, a robust and up-to date Early Warning Systems (EWS) is critical to not only reduce or mitigate the impacts of disasters, but to also provide timely warning to the agencies involved in preparing for and managing the risks of climate extremes and disasters and to the affected population for quick response (White et al., 2004; Aldunce and Neri, 2008; McBean, 2008). Traditionally, early warning systems had been interpreted narrowly as technological instruments for detecting and forecasting impending hazard events and for issuing alerts (NIDIS, 2007). This interpretation, however, does not clarify whether warning information is received by or helpful to the population it serves or actually used to reduce risks (UNISDR, 2006; NIDIS 2007). Governments maintain early warning systems to warn their citizens and themselves about, for example, impending climate- and weather-related hazards. “Early warnings” of potentially poor seasons to inform key actions for agricultural planning have been successful in producing proactive responses. This is reliant on close inter-institutional collaboration between national meteorological and hydrological services and agencies that directly intervene in rural areas, such as extension services, development projects and civil society organisations (Hammer, 2000; Meinke et al., 2001).

An effective early warning system delivers accurate, timely, and meaningful information dependably (UNISDR, 2005; Auld, 2008a; Basher, 2006; Wimbi, 2007). To be effective and complete, an early warning system typically comprises four interacting elements (UNISDR, 2006a; Basher, 2006): (i) generation of risk knowledge including monitoring and forecasting, (ii) surveillance and warning services, (iii) dissemination and communication and (iv) response capability. The success of an early warning system depends on the extent to which the warnings trigger effective response measures (van Aalst, 2009; Wimbi, 2009). Warnings can and do fail in both developing and developed countries due to inaccurate weather and climate forecasting, public ignorance of prevailing conditions of vulnerability, failure to communicate the threat clearly or in time, lack of local organization and failure of the recipients to understand or believe in the warning or to take suitable action (UNISDR, 2001; Auld, 2008). Warnings are received and understood by a complex target audience and are most relevant when conveyed to have meaning that is shared between those who issue the forecasts and the decision-makers they are intended to inform (Auld, 2008; Basher, 2006; UNISDR, 2006a). Because emergency responders, the media and the public often are unable to translate the scientific information on forecast hazards in warnings into risk levels and responses, early warning systems are most effective when they can identify and interpret the general impacts in simple and meaningful terms, prioritize the most dangerous hazards, assess potential contributions from cumulative and sequential events to risks and identify thresholds linked to escalating risks for infrastructure, communities and disaster response (Auld, 2008; UNISDR, 2006a).

Different hazards and different sectors often require unique preparedness, warnings and response strategies (UNISDR, 2006a; Basher, 2006; van Aalst, 2009). Some may represent singular extreme events, sequences or combinations of hazards. For example, the World Meteorological Organization (WMO), National Meteorological and Hydrological Services, World Health Organization (WHO), Food and Agriculture Organisation (FAO) and other United Nation partners recognize that combinations of weather and climate hazards can result in complex emergency response situations and are working to establish multi-hazard early warning systems for complex risks such as heat waves and vector-borne diseases (WMO, 2007; UNISDR, 2006a) and early warnings of locust swarms (WMO, 2007; WMO, 2004b; FAO, 2011). Some "creeping" hazards can evolve over a period of days to months; floods and droughts, for example, can result from cumulative or sequential multi-hazard events when accompanied by an inherent vulnerability (Auld, 2008a; Basher, 2006).

Understanding by the public and community organizations of their risk and vulnerabilities are critical but insufficient for risk management, requiring that early warning systems be complemented by preparedness programmes as well as land use and urban planning, public education and awareness programmes (UNISDR, 2006a; Basher, 2006; Wimbi, 2007). Public awareness and support for disaster prevention and preparedness is often high immediately after a major disaster event—such moments can be capitalized on to strengthen and secure the sustainability of early warning systems (Basher, 2006). It should be noted that such "policy windows" are seldom used without the pre-existence of a social basis for cooperation that in turn supports a collaborative framework between research and management.

The timing and form of climatic information (including forecasts and projections), and access to trusted guidance to help interpret and implement the information and projections in decision-making processes may be more important to individual users than improved reliability and forecast skill (Pulwarty and Redmond,1997; Rayner et al., 2001). Decision makers typically manage risks holistically, while scientific information is generally derived using reductionist approaches (Meinke et al, 2006). The net outcome can be a 'disconnect' between scientists and decision makers with the result that climate and hydro-meteorological information can be developed that, although scientifically sound, may lack relevance (Cash and Buizer, 2005; Meinke et al, 2006; Vogel and O'Brien, 2006; Averyst, 2010). Perceptions of irrelevance, inconsistency, confusion, or doubt can delay action (National Research Council, 2009). Some studies (Lowe, 2002; Meinke, 2006; Glantz, 2005; Feldman and Ingram, 2009) advise scientists and practitioners to work together to produce trustworthy knowledge that combines scientific excellence with social relevance. These studies suggest that decision support activities should be driven by users' needs, not by scientific research priorities, and that these user needs are not always known in advance, but should be identified collaboratively and iteratively in ongoing two-way communication between knowledge producers and decision makers (National Research Council 2009; Cash and Buizer, 2005). It has been suggested that this ongoing interaction, two-way communication, and collaboration allows scientists and decision makers to get to know each other, to develop an understanding of what decision makers need to know and what science can provide, to build trust and, over time, develop highly productive relationships as the basis for effective decision support (National Research Council, 2009; Feldman and Ingram, 2009; Averyst, 2010).

Since early warning information systems are multi-jurisdictional and multi-disciplinary, they usually require anticipatory coordination across a spectrum of technical and non-technical actors. National governments can play an important role in setting the high-level policies and supporting frameworks involving multiple organizations, in adopting multi-hazard and multi-stakeholder approaches and in promoting community based early warning systems (UNISDR, 2006b, Pulwarty et al, 2004). National governments can also interact with regional and international governments and agencies to strengthen early warning capacities and to ensure that warnings and related responses are directed towards the most vulnerable populations (UNISDR, 2006b). At the same time, national governments can also play an important role in supporting regions and sub-national governments in developing operational and response capabilities (UNISDR, 2006b; see 6.3.3.4).

6.3.3.2. Reducing Climate-Related Disaster Risk

National climate disaster risk reduction activities include a broad range of options that vary from safe infrastructure and building codes to those aimed to protect natural ecosystems, human development and, following extreme climate impact events, humanitarian focused actions. Each of these strategies can prove ineffective in isolation but effective in combination. These and other different options are addressed in the following sections, noticing how risk reduction and disaster response measures are increasingly being considered as good practices to deal with uncertainty and climate change.

6.3.3.2.1. Applying technological and infrastructure-based approaches

Climate change has the potential to negatively impact the safety of existing infrastructure, increase the frequency of weather-related disasters, increase premature weathering regionally, change engineering and maintenance practices and to alter building codes and standards where they exist (Wilby, 2007; Auld, 2008a; Stevens, 2009). With potential increases in extreme events regionally, small increases in climate extremes above regional thresholds have the potential to result in large increases in damages to all forms of existing infrastructure nationally and to increase disaster risks (Auld, 2008a; Coleman, 2002; Munich Re, 2005).

The need to address the risk of climate extremes and disasters in the built environment and urban areas, particularly for low- and middle-income countries, is one that is not fully appreciated by many national governments and the majority of development and disaster specialists (Moser and Satterthwaite, 2008; Rossetto, 2007). Low- and middle-income countries, which report close to three-quarters of the world's urban populations, are at greatest risk from extreme events and also have a far greater deficit in adaptive capacity than do high-income countries largely due to backlogs in protective infrastructure and services and limitations in urban government (Moser and Satterthwaite, 2008; Satterthwaite et al. 2007).

An inevitable result of potentially increased damages to infrastructure will be a dramatic increase in the national resources needed to restore infrastructure and assist the poor most affected by damaged infrastructure (Freeman and Warner, 2001). A study by the Australian Academy of Technological Sciences and Engineering (ATSE) concluded that national retrofit measures will be needed to safeguard existing infrastructure in Australia and new adaptation approaches and national codes and standards will be required for construction of new infrastructure (Stevens, 2008). Recommendations from this study call for: research to fill gaps on the future climate risks, comprehensive risk assessments for existing critical climate sensitive infrastructure, development of statistical information on future climate change events, investigation of the links between soft and hard engineering solutions and strengthened research efforts to improve the modelling of small-scale climate events (Stevens, 2008; Wilby, 2008; Auld, 2008a). The recommended national adaptation options to deal with projected impacts to the built environment range from deferral of actions pending development of new information to modification of infrastructure components according to national guidance, acceptance of residual losses, reliance on insurance and risk transfer instruments, formalized asset management and maintenance, new structural materials and practices, improved emergency services and retrofitting and replacement of infrastructure elements (Stevens, 2008; Wilby, 2007; Wilby et al, 2009; Auld, 2008a; Neumann, 2009).

The implementation of adequate national building codes that incorporate regionally specific climate data and analyses can improve resilience for many types of risks (World Water Council, 2009; Wilby et al, 2009; Auld, 2008a). Typically, infrastructure codes and standards in most countries use historical climate analyses to climate-proof new structures, assuming that the past climate will represent the future. For example, water related engineering structures, including both disaster- proofed infrastructure and services infrastructure (e.g. water supply, irrigation and drainage, sewerage and transportation), are all typically designed using analysis of historical rainfall records (Wilby and Dessai, 2010, Auld, 2008a). Since infrastructure is built for long life-spans and the assumption of climate stationarity will not hold for future climates, it is important that national climate change guidance, tools and consistent adaptation options be developed to ensure that climate change can be incorporated into infrastructure design (Stevens, 2008; Wilby et al, 2009; Auld, 2008b). While some government departments responsible for building regulations and the insurance industry are taking the reality of climate change very seriously, challenges remain on how to incorporate the uncertainty of future climate projections into engineering risk management and legislation, especially for elements such as extreme winds and extreme precipitation and its various phases (e.g. short and long duration rainfalls, freezing rain, snowpacks) (Wilby, 2010; Auld, 2008a; Sanders and. Phillipson, 2003; Lu, 2009). A few successful cases are emerging. In one example, the Canadian Standards Association (CSA) and its National Permafrost Working Group developed a Technical Guide, CSA Plus 4011-10, on "Infrastructure in Permafrost: A Guideline for Climate Change Adaptation" that directly incorporates climate change temperature projections from an ensemble of climate change models. This Guide factors in climate change projections of temperature and precipitation and risks from melting permafrost to foundations over the planned lifespans of the structure. The guide also suggested possible adaptation options, taking into account the varying levels of risks and the consequences of failure for foundations of structures, whether buildings, water treatment plants, utilidors, towers, tank farms, tailings ponds or other infrastructure (NRTEE, 2009; Canadian Standards Association, 2010; see Chapter 9 case study 9.x.x on vulnerable regions: The Arctic).

In developing countries, structures are often built using best local practices. But, problems can arise when the best local practices do not incorporate the use of national building standards or inadequately account for local climate conditions (Rossetto, 2007). While the perception in some developing countries is that national building codes and standards are too expensive, the implementation of incremental hazard-proof measures in building structures has proven in some countries to be relatively inexpensive and highly beneficial in reducing losses (ProVention, 2009; Rosetto, 2007; see Chapter 9 case studies 9.x.x). In reality, the most expensive component to codes and standards is usually the cost to implement national policies for inspections, knowledge transfer to trades and national efforts for their up-take and implementation (Rossetto, 2007). Bangladesh, for example, has implemented simple modifications to improve the cyclone-resistance of (non-masonry) kutcha or temporary houses, with costs that amounted to only 5 per cent of the construction costs (Lewis and Chisholm, 1996; Rossetto, 2007). Bangladesh is also developing national policies requiring that houses built following disasters include a small section of the replacement house that meets “climate proofing” standards and acts as a household shelter in the next disaster. In many countries, climate proofing guidelines and standards are applied to structures that are used as emergency shelters and for structures that form the economic and social lifeline of a society, such as its communications links, hospitals and transportation networks (Rossetto, 2007).

National support for land and water use planning that protects and enhances “green infrastructure” or natural buffers and defences can significantly reduce vulnerabilities for the built environment under current and future climate change. These ecosystem based adaptation approaches are discussed in section 6.3.3.2.3.

6.3.3.2.2. Promoting human development and secure livelihoods and reducing vulnerability

Vulnerabilities to climate related hazards and the options to reduce them vary between and within countries due to factors such as poverty, social positioning, geographic location, gender, age, class, ethnicity, ecosystem condition, community structure, community decision-making processes and political issues (Yodmani, 2001; UNISDR, 2009c). Policies and measures such as the establishment of a LDC fund, Special Climate Fund, Adaptation Fund, climate change Multi-Donor Trust Fund etc., have all been developed to address the special adaptation issues of these most vulnerable countries (see section 7.4.3 for more details). Within these countries, the most vulnerable are usually those who are least able to cope with climate hazards due to a paucity of skill-sets, resources and access to assets for adaptive capacity. Studies indicate that national policies can increase this capacity (Davies et al, 2009; Heltberg et al., 2009; UNISDR, 2009c).

The most vulnerable communities may require full scale assistance to protect lives, properties and livelihoods (UNISDR, 2009b). In many countries, including those in Africa, vulnerable communities suffer greater water stress, food insecurity, disease risks and loss of livelihoods (IPCC, 2007; FAO, 2008). Climate change may increase risks for waterborne diseases for many, requiring targeted assistance for health and water sanitation issues (Curriero, 2001; IPCC, 2007). Resilient housing and safe shelters will remain one of the key adaptation actions to protect the vulnerable from disasters and climate extremes, requiring national guidelines to ensure that new or replacement structures are built with flexibility to accommodate future changes (Rossetto, 2007; Auld, 2008). Small island states and low-lying countries may require support that relocates vulnerable groups to safer locations or other countries, all requiring a complex set of actions at the national and international levels (IPCC, 2007).

While there is a lot of rhetoric about targeting assistance to most vulnerable in the developing world, practical “on the ground” examples have been limited (Ayers and Huq, 2009). Nonetheless, some developing countries have implemented successful policies and plans. Nationally, good progress is being made in strengthening some disaster reduction capacities for disaster preparedness and early warning and response systems and in addressing some of the underlying risk drivers in many developing country regions and sectors (UNISDR, 2009c; also see Chapter 9 case study 9.x.x). For example, social safety nets and other similar national level programmes, particularly for poverty reduction and attainment of MDGs etc., have helped the poorest to reduce their exposure to current and future climate shocks (Davies et al, 2009; Heltberg et al., 2008). Some examples of social safety nets are cash transfers to the most vulnerable, weather-indexed crop insurance, employment guarantee schemes and asset transfers (Davies et al., 2009; CCCD, 2009). A national policy to help the vulnerable build assets should incorporate climate screening in order to remain resilient under a changing climate (UNISDR 2004; Davies et al., 2009; Heltberg et al., 2008). Other measures such as social pensions that transfer cash from the National level to vulnerable elderly people provide buffers against climate shocks (Davies et al, 2009; Heltberg et al., 2008). However, lack of capacity and good governance has remained a major barrier to efficient and effective delivery of assistance to most vulnerable (UNDP, 2007; Warner et al., 2009; CCCD, 2009c).

Many of the most vulnerable people who live below the International poverty line live and work in rural areas and are greatly impacted by disaster impacts (UNISDR, 2009c). Poor rural areas as well as many of the poor urban centers are often characterized by vulnerable housing, weak emergency services and infrastructure and a dependence on agriculture and other natural resources (UNISDR, 2009c; Reid et al, 2010). A high sensitivity to weather and climate variability combined with a lack of access to the necessary productive inputs for improved crop yields (e.g. productive land, seeds, fertilizer, irrigation, financial assets) means that rural poor in particular have low resilience to even the smallest weather irregularity (UNISDR, 2009c; IRI, 2006).

In reality, when faced with food scarcity, these poor populations often adopt maladaptive coping strategies that aggravate long-term disaster risks, such as overgrazing, deforestation, unsustainable extraction of water resources (UNISDR, 2009c; IRI, 2006). Short-term but limited strategies to minimize these risks include diversifying livelihoods to spread risk, farming in different ecological niches and building social networks to pool risks (UNISDR, 2009c). In the longer-term, climate change is expected to lead to more erratic food productivity and to even lower levels of output, requiring changes towards higher agricultural productivity, reduced production variability and agricultural systems that are more resilient to disruptive events (IPCC, 2007b; Stern et al, 2006; Cline, 2007; FAO, 2010; UNISDR, 2009c). This will require transformations in the management of natural resources and new climate-smart-agriculture policies, practices, tools and financing for food security, as outlined by the FAO (2010). FAO (2010) also developed carbon balance tools to assess greenhouse gas reduction impacts for these newly proposed food security and agriculture policies and practices, and these tools now being used in many countries. Other coping strategies include increased non-farm incomes, migration, government and other financial assistance, microfinance, social protection and index-based crop insurance (UNISDR, 2009c). The Sustainable Livelihoods Approach or Framework has been used internationally for rural and coastal development to holistically describe the variables that impact livelihoods locally and to define the capacity, assets (both natural and social) and policies required for sustainable living, poverty reduction and recovery from shocks (Allison and Horemans, 2005; Bennett, 2010). Chapters 2, 5 and 9 also discuss sustainable livelihood approaches that can be considered in building adaptive capacity and resilience to climate shocks in communities.

A crucial aspect in reducing vulnerability of climate-related risks among the most vulnerable - including food insecurity - is to make climate-related and climate change information available and accessible to decision-makers (IRI, 2006; Wilby et al., 2009; Washington et al., 2006), as discussed in section 6.3.3.1.1. developing countries in Africa, and particularly in the Sub-Saharan African economies, are especially susceptible to climate variability and change due to their predominately agrarian structure (IRI, 2006). Since food security crises in these countries are associated with climatic extremes, Sub-Saharan Africa currently represents the only region of the world where childhood malnutrition is actually increasing (IRI, 2006). There is growing recognition that better management of and responses to short and long-term climate risk in these countries will represent both a crucial step toward achieving the Millennium Development Goals and an opportunity to build some of the resilience for adaptation to the uncertainties of a changing future climate (IRI, 2006). Recent studies from Africa have shown that while climate information exists that could aid decision makers in making “no regret” adaptation decisions, this information is seldom incorporated into decisions (IRI, 2006; Ayers and Huq, 2009). In some cases, limited access to weather and climate forecasts in a timely manner also prevents the use of weather and climate information. The integration of climate information and services to support climate risk management of sensitive livelihoods will depend on effective use of communication infrastructure and networks to reach users, to facilitate climate awareness and education campaigns, and to receive feedback so that users can help shape the services they receive (IRI, 2006).

In many developing countries, one of the potential barriers for identifying the most vulnerable regions and people under future climate change is the limited human resource capacity to downscale global and regional climate projections to a scale suitable to support national level planning and programming process (Wilby et al., 2009; CCCD, 2009; Washington et al., 2006), and as discussed in section 3.2.3. Even when available, their use can be limited by a lack of understanding and interpretation on the degree to which these downscaled projections can highlight vulnerabilities.

National Adaptation Programme of Actions (NAPA) under the UNFCCC process have been able to assess the climate sensitive sectors and prioritize projects to address the most urgent adaptation issues of the most vulnerable regions, communities and populations in 49 least developed countries (UNCTAD, 2008). While the NAPA process has proven instrumental in increasing awareness of climate change and its potential impacts in LDCs, it can be limited by its tendency to focus on a project rather than a national programme approach to adaptation and risk reduction and by challenges in mainstreaming these plans into national developmental plans and strategies (CCCD, 2009; Satterthwaite et al, 2007). Concerns have been raised on means to fund NAPA activities and in some cases, potential donors may see the NAPA as little different from development plans, given that countries often fail to demonstrate incremental climate change benefits (UNFCCC, 2008; Satterhwaite et al, 2007). A key challenge is to ensure that NAPAs don't just become other policy documents, without translation into concrete support for adaptation (UNFCCC, 2008; Satterthwaite, 2007).

6.3.3.2.3. Investing in natural capital and ecosystem-based adaptation

Investment in sustainable ecosystems and environmental management has the potential to produce triple wins – reduction in underlying risk factors (UNISDRUNISDR, 2007, UNEP 2006, 2009 and Sudmeier-Rieux and Ash 2009), improved livelihoods, and conservation of biological diversity - through sustainable management of biological resources and, indirectly, through protection of ecosystem services (UNEP 2006, 2009; World Bank 2009).

Healthy, natural or modified, ecosystems (see Section 6.3.1 and Box 6-4) have a critical role to play in reducing risk of climate extremes and disasters (UNEP, 2009; Bebi, 2009; Dorren, 2004; Phillips and Marden, 2005; Sidle et al., 1985; SDR, 2005a, b; UNISDR, 2007, 2009; Colls et al., 2009; Sudmeier-Rieux and Ash 2009; Reid and Huq, 2005; Secretariat of the Convention on Biological Diversity, 2009; Lal 2010). Although the scientific evidence base relating to the role of ecosystem services in mitigating many disasters is nascent, investment in natural ecosystem management has long been used to reduce risks of disasters (see Box 6-4). Forests, for example, have been used in the Alps and elsewhere as effective mitigation measures against avalanches, rockfalls and landslides since the 1900s (Bebi, 2009; Dorren, 2004; Phillips and Marden, 2005; Sidle et al., 1985). The damage caused by wildfires, wind erosion, drought and desertification are be buffered by forest management, shelterbelts, greenbelts, hedges and other "living fences" (Dudley et al., 2010; ProAct, 2008). Mangroves could reduce 70-90% of the energy from wind generated waves in coastal areas, depending on the health and extent of the mangroves (UNEP, 2009), and depending on the width and age the mangrove stand can also contribute significantly to reducing damage from tsunamis (Yanagisawa et al. 2010).

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Box 6-4. Value of Ecosystem Services in Disaster Risk Management: Some Examples

1) In the Maldives, degradation of protective coral reefs necessitated the construction of artificial breakwaters at a cost of US$ 10 million per kilometre (Secretariat of the Convention on Biological Diversity, 2009).
2) In Viet Nam, the Red Cross began planting mangroves in 1994 with the result that, by 2002, some 12,000 hectares of mangroves had cost US$1.1 million for planting but saved annual levee maintenance costs of US$

7.3 million, shielded inland areas from a significant typhoon in 2000, and restored livelihoods in planting and harvesting shellfish (Reid and Huq, 2005; Secretariat of the Convention on Biological Diversity, 2009).

3) In the United States, wetlands are estimated to reduce flooding associated with hurricanes at a value of US$ 8,250 per hectare per year, and US$ 23.2 billion a year in storm protection services (Constanza et al., 2008).
4) In Sri Lanka Data from two villages in Sri Lanka that were hit by the Indian Ocean tsunami in December 2004 show that while two people died in the settlement with dense mangrove and scrub forest, up to 6,000 people died in the village without similar vegetation (World Bank, 2009)

Source: Sudmeier-Rieux and Ash (2009)

_____ END BOX 6-4 HERE _____

Investment in natural ecosystems also contributes significantly to reduction in GHG emissions, through practices such as Land Use, Land Use Change and Forestry (LULUCF) and through Reduced Carbon Emissions from Deforestation and Forest Degradation (REDD) or REDD+ (which additionally includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks) (UNEP, 2006; Secretariat of the Convention on Biological Diversity, 2009).

REDD and REDD+ related strategies can help generate alternative sources of income for local communities and provide much needed financial incentives to prevent deforestation (Angelsen, et al. 2009; Sudmeier-Rieux and Ash 2009; Reid and Huq, 2005; Secretariat of the Convention on Biological Diversity, 2009). Additional livelihood benefits are derived from the conservation and restoration of forest ecosystems and the services they support (International Union for the Conservation for Nature and Natural Resources and Stockhom Environment Institute et al. 2003; Longley and Maxwell 2003; Millennium Ecosystem Assessment 2005; SEEDS 2008).

With improvements on economic well being and associated human development conditions, vulnerability to risks of climate extremes and disasters are also expected to be reduced (Benson and Clay 2004; Lal and Singh et al. 2009). The extent to which ecosystems support such benefits though depends on a complex set of dynamic interactions of ecosystem related factors, as well as the intensity of the hazard (Sudmeier-Rieux and Ash, 2009) and institutional and governance arrangements (see various case studies in Angelsen, et al 2009). For example, coastal forests, stabilized sand dunes, mangroves and seagrasses are all known to reduce impact forces, flow depths and velocities of storm surges, but unless specifically protected, sand dunes are frequently used as building material, or flattened to enhance views for seaside resorts. (Baird et al. 2005; Balmford et al, 2008; Björk et al. 2008; IOC, 2009; Kaplan et al., 2009; Yanagisawa, 2009; Yanagisawa et al., 2010). Scientific understanding of the relationship between ecosystem structure and function and the reduction of risks associated with climate extremes and disaster risks is limited, though growing.

Some countries have begun to explicitly integrate ecosystem-based adaptation as a key strategy for addressing climate change, integrating such strategies in national and sectoral development planning (see Box 6-5).

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Box 6-5. Some Examples of Ecosystem-based Adaptation (EbA) Strategies and Disaster Risk Management Interventions Taking into Account the Role of Ecosystem Services

- Viet Nam has applied Strategic Environmental Assessments to land use planning projects and hydropower development for the Vu Gia-Thu Bon river basin (OECD, 2009; Secretariat of the Convention on Biological Diversity, 2009?).
- European countries affected by severe flooding, notably the U.K., the Netherlands and Germany, have made policy shifts to "make space for water" by applying more holistic River Basin Management Plans and Integrated Coastal Zone Management (EC, 2009; DEFRA, 2005;Wood et al. 2008).
- At the regional level, the Caribbean Development Bank has integrated disaster risk into its Environmental Impact Assessments for new development projects (UNISDR, 2009 and CDB and CARICOM, 2004).

- Under Amazon Protected Areas Program, Brazil has created over 30 million ha mosaic of biodiversity-rich forests reserve of state, provincial, private, and indigenous land, resulting in potential reduction in emissions estimated at 1.8 billion tons of carbon through avoided deforestation {World Bank, 2009).
- Swiss Development Cooperation's four year project in Muminabad, Tajikistan adopted an integrated approach to risk through reforestation and integrated watershed management (SDC, 2008).

______END BOX 6-5 HERE_______

Generally, ecosystem-based adaptation strategies, often referred to as 'soft' options, can be a more cost-effective adaptation strategy than hard infrastructures and engineering solutions, and produce multiple benefits. Many ecosystem-based options are often considerably more accessible to the rural poor (Sudmeier-Rieux and Ash2009). However, countries would need to overcome many challenges if they are to be successful in increasing investment in ecosystem-based solutions, including for example:

- Insufficient recognition of the economic and social benefits of ecosystem management under current risk situations, let alone under increased risks of climate change extremes and disasters (Vignola et al, 2009).
- Lack of interdisciplinary science and implementation capacity for making informed decisions associated with complex and dynamic systems (OECD, 2009; Leslie and McLeod, 2007).
- Lack of capacity to undertake careful assessments of alternative strategies to inform choices at the local level. Such assessments could provide total economic value of the full range of disaster-related ecosystem services, compared with alternative uses of the forested land such as in agriculture (see, e.g., Balmford, 2002).
- Where they exist, data and monitoring on ecosystem status and risk are often dispersed across agencies at various scales and are not always accessible at the sub-national or municipal level where land use planning decisions are made (UNISDR, 2009a).
- The mismatch in geographic scales and mandates between the administration and responsibilities for disaster reduction, and that of ecosystem extent and functioning, such as in water basin (OECD, 2009; Leslie and McLeod, 2007).

6.3.3.3. Transferring and Sharing 'Residual' Risks

Risk sharing and transfer mechanisms for individuals and businesses at the local level are discussed in section 5.5.2.2. This section sets out the role of national institutions, especially governments, in enabling and regulating practices at the local and regional scales. It also discusses the need on the part of some governments to transfer their risks.

Markets can often provide risk financing solutions, albeit partial ones given market failures and market gaps. Market mechanisms may work less well in developing countries, particularly because there is often little or no supply of insurance instruments. In such circumstances, governments may need to create enabling environments for the private sector to become more engaged or offer insurance themselves. Employing insurance and other risk financing instruments for helping to manage the vagaries of nature generally involves the building of public private partnerships in developing and in developed countries due to market failure, adverse selection and the sheer non-availability of such instruments (see Aakre et al., 2010). Because of such reasons, there is a role for governments to not only create enabling environment for private sector engagement, but also to regulate their activities. Some literature distinguishes between protection and promotion models, while acknowledging that in many instances hybrid combinations may contain elements of both (Hess and Hazell 2009). Protection relates to governments helping to protect themselves, individuals and business from destitution and poverty by providing ex post financial assistance, which however is taken out as an ex ante instrument as insurance before disasters. The promotion model relates to the public sector promoting more stable livelihoods and higher income opportunities by better helping businesses and households access risk financing, including micro-financing**.**

In many instances, insurance providers even in industrialized countries have been reluctant to offer region- or nation-wide policies covering flood and other hazards because of the systemic nature of the risks, as well as problems of moral hazard and adverse selection (Froot, 2001; Aakre, 2010). Insurance policies in Europe may be bundled with household insurance, or offered on a stand-alone basis; governments may pay a premium on behalf of the insured or governments may choose to (also) compensate post event; insurance may be compulsory (Prettenthaler et al., 2004; Schwarze, 2004; Aakre et al., 2010). Even where insurance markets do exist, there is a wide variety of schemes and penetration is never often much less than 100%. In some highly exposed countries, such as the Netherlands for flood risk, insurance is even virtually non-existent.

Because private insurers are often not prepared to fully underwrite the risks, many countries, including Japan, France, the US, Norway and New Zealand, have legislated public-private national insurance systems for natural perils with mandatory or voluntary participation of the insured as well as single hazard and comprehensive insurance. Also, in order to increase market penetration of non-traditional risks, such as in fledgling micro-insurance schemes, different strategies are being employed, including, as one example of pro-poor regulation in India shows, that insurers within their regular business segment reserve a certain quota for low income policies, effectively leading to a cross-subsidization of the micro-insurance industry (Mechler, Linnerooth-Bayer and Peppiatt, 2005).

Governments have a responsibility for a large portfolio of public infrastructure assets that are at risk to disasters. Moreover, most governments are obligated to provide post-disaster emergency relief and assistance to vulnerable households and businesses. Governments of developing countries typically finance their post-disaster expenses by diverting from their budgets or from already disbursed development loans, as well as by relying on new loans and donations from the international community (Mechler, 2004). In the past, these post-disaster sources of finance have often proven woefully inadequate to assure timely relief and reconstruction in developing countries. What is more, post-disaster assistance is not only often inadequate, but it can discourage governments and individuals from taking advantage of the high returns of preventive actions (Gurenko, 2003).

In wealthy countries, government insurance hardly exists at the national level and in Sweden insurance for public assets is illegal (Bayer and Amendola, 2000), although states in the US, Canada and Australia, regulated not to incur budget deficits, often carry cover for their public assets (Burby, 1991). As discussed earlier, this is consistent with Arrow and Lind Theorem, which suggests that governments can spread risk over its citizens, most usually by means of taxation; then, the expected and actual loss to each individual taxpayer is minimal due to the sheer size of the population. Second, a government's relative losses from disasters in comparison with its assets may be small if the government possesses a large and diversified portfolio of independent assets. Neither of this however, applies to small, low-income and highly exposed countries that have over-stretched tax bases and highly correlated infrastructure risks (OAS, 1991; Pollner, 2001; Mechler, 2004; Cardona, 2006; Linnerooth and Bayer, 2007; Mahul and Ghesquiere, 2007). Realizing the shortcomings of after-the-event approaches for coping with disaster losses, sovereign insurance may become an important cornerstone for tackling the substantial and increasing effects of natural disasters (Mahul and Ghesquiere, 2007).

A common recourse of action has been to insure public sector relief expenditure, and key applications have been in Mexico in 2006 and in the Caribbean with the Caribbean Catastrophe Risk Insurance Facility (CCRIF) (Cardenas et al., 2007; Ghesquiere, et al., 2006). These transactions are likely to set an important precedent for protecting highly exposed developing and transition country governments against the financial risks of natural catastrophes. Like national governments, donor organizations, exposed indirectly through their relief and assistance programs, too, have considered purchasing insurance. The World Food Programme, for example, purchased protection for its drought exposure in Ethiopia through index-based reinsurance (see case study in chapter 9).

Markets can often provide risk financing solutions, albeit partial ones given market failures and market gaps. Market mechanisms may work less well in developing countries, particularly because there is often little or no supply of insurance instruments. In such circumstances, governments may want to consider creating enabling environments for the private sector to become more engaged or offer insurance themselves as well as ensure financial oversight and monitoring of implemented schemes (Warner et al., 2009).

Employing insurance and other risk financing instruments for helping to manage the vagaries of nature generally involves the building of public private partnerships in developing and in developed countries due to market failure, adverse selection and the sheer non-availability of such instruments (see Aakre et al., 2010). Because of such reasons, there is a role for governments to not only create enabling environment for private sector engagement, but also to regulate their activities. For the development context, Hazell and Hess (2010) distinguish between protection and promotion models, while acknowledging that in many instances hybrid combinations may contain elements of both. Protection relates to governments helping to protect themselves, individuals and business from destitution and poverty by providing ex post financial assistance, which however is taken out as an ex ante instrument as insurance before disasters. The promotion model relates to the public sector promoting more stable livelihoods and higher income opportunities by better helping businesses and households access risk financing, including micro-financing**.**

In many instances, insurance providers even in industrialized countries have been reluctant to offer region- or nation-wide policies covering flood and other hazards because of the systemic nature of the risks, as well as problems of moral hazard and adverse selection (Froot, 2001; Aakre, 2010). As one example, insurance policies in Europe may be bundled with household insurance, or offered on a stand-alone basis; governments may pay a premium on behalf of the insured or governments may choose to (also) compensate post event; insurance may be compulsory (Prettenthaler et al., 2004; Schwarze, 2004; Aakre et al., 2010). Even where insurance markets do exist, penetration is often much less than 100%. In some highly exposed countries, such as the Netherlands for flood risk, insurance is even non-existent and government relief is dispensed in lieu (Botzen, W. and van den Bergh, J., 2008). In many developing countries, there is little in terms of insurance for disaster risks, yet novel index-based microinsurance solutions have been developed and are starting to show results (Hazell et al., 2010; Hazell and Hess, 2010) (see also ch.5 and ch.9 case study on risk financing).

Because private insurers are often not prepared to fully underwrite the risks, many countries, including Japan, France, the US, Norway and New Zealand, have legislated public-private national insurance systems for natural perils with mandatory or voluntary participation of the insured as well as single hazard and comprehensive insurance. Also, in order to increase market penetration of non-traditional risks, such as in fledgling micro-insurance schemes, different strategies are being employed, including, as one example of pro-poor regulation in India shows, that insurers within their regular business segment reserve a certain quota for low income policies, effectively leading to a cross-subsidization of the micro-insurance industry (Mechler *et* al. 2005).

Governments have a responsibility for a large portfolio of public infrastructure assets that are at risk to disasters. Moreover, most governments are obligated to provide post-disaster emergency relief and assistance to vulnerable households and businesses. As discussed above (see secion 6.3.2.3), post-disaster sources of finance have often proven woefully inadequate to assure timely relief and reconstruction and pre-disaster risk financing arrangements may be worth considering. Yet, in wealthy countries, government insurance hardly exists at the national level and in Sweden, insurance for public assets is illegal (Linnerooth-Bayer and Amendola, 2000), although states in the US, Canada and Australia, regulated not to incur budget deficits, often carry cover for their public assets (Burby, 1991). As discussed earlier, this is consistent with Arrow and Lind Theorem, which suggests that governments can spread risk over its citizens, most usually by means of taxation; then, the expected and actual loss to each individual taxpayer is minimal due to the sheer size of the population. Second, a government's relative losses from disasters in comparison with its assets may be small if the government possesses a large and diversified portfolio of independent assets. Neither of these conditions, however, applies to small, low-income and highly exposed countries (see section 6.3.2.3). Realizing the shortcomings of after-the-event approaches for coping with disaster losses, sovereign insurance may become an important cornerstone for tackling the substantial and increasing effects of natural disasters (Mahul and Ghesquiere , 2007).

A common recourse of action has been to insure public sector relief expenditure, and key applications have been in Mexico in 2006 and in the Caribbean with the Caribbean Catastrophe Risk Insurance Facility (CCRIF) (Cardenas et al., 2007; Ghesquiere, et al., 2006) (see Box 6-3 and ch.9 case study on risk financing). These transactions set an important precedent for protecting highly exposed developing and transition country governments against the financial risks of natural catastrophes. Like national governments, donor organizations, exposed indirectly through their relief and assistance programs, too, have considered purchasing insurance. The World Food Programme, for example, purchased protection for its drought exposure in Ethiopia through index-based reinsurance (see case study in chapter 9).

6.3.3.4. Managing the Impacts

Even in the rare circumstances where efforts outlined previously are all in place, there still needs to be investment in capacities to manage potential impacts as risk cannot be reduced to zero (Coppolla, 2007; Pelling, 2003; Wisner et al.2004). The scale of the disaster impact should ideally dictate the level and extent of response. Individual household capacities to respond to disasters may be quickly overwhelmed, requiring local resources to be mobilised (Del Ninno, 1998). When community-level responses are overwhelmed, regional or central government needs to be called upon (Copolla, 2007). Some events overwhelm national government capacities, and requires mobilisation of the international community of humanitarian responders (Fagen, 2008; Harvey, 2009). International responses pose the most complex management challenges for national governments, because of the diversity of actors that are involved and the multiple resources flows that are established (ALNAP, 2010a; Bennet, J, et al, 2006; Borton, 1993; Ramalingam, 2008). However, although humanitarian principles call for a proportionate and equitable response, in practice there are a few high-profile disasters that are over-resourced, with many more that are 'forgotten or neglected emergencies' (Slim, 2006; Walker et al. 2005). Despite the definition of international or national disasters as those where immediate capacities are overwhelmed, evaluations routinely find that most of the vital life-saving activities happen at the local level, led by households, communities and civil society (See Chapter 5, ALNAP, 2005; Hilhorst, 2003; Smillie, 2001, Telford and Cosgrave, 2006).

In terms of how responses are managed nationally, there are different models to consider (ALNAP, 2010b). Many countries now have some standing disaster management capacity (Interworks, 1998) and this should be considered distinct from national systems for managing disaster risk, commonly associated with 'national platforms' detailed in section 6.3.2. Examples of standing disaster management capacity include the Federal Emergency Management Agency in the US, Public Safety in Canada, National Disaster Management Authorities in India and Indonesia and the Civil Contingencies Secretariat in the UK. Comparative analysis of these structures shows that there are a number of common elements (Coppolla, 2007, Interworks, 1998). Countries with formal disaster management structures typically operate a system comprised of a National Disaster Committee, which works to provide high-level authority and ministerial coordination, alongside a National Disaster Management Office (NDMO) to lead the practical implementation of disaster preparedness and response (Interworks, 1998).

- National Committees are typically composed of representatives from different ministries and departments as well as the Red Cross/Red Crescent. They might also include donor agencies, NGOs and the private sector. The committee works to coordinate the inputs of different institutions to provide a comprehensive approach to disaster management.
- NDMOs usually act as the executive arm of the national committee. Focal points for disaster management, NDMOs are usually staffed by professional disaster managers NDMOs may be operational, or in large countries they may provide policy and strategic oversight to decentralised operational entities at federal or local levels.

Government ownership of the national disaster management function can vary with three models evident: It may reside with the presidential or prime ministerial offices, it may sit within a specific ministry, or it may be distributed across line ministries (Interworks, 1998). The way in which the international community is engaged in major emergencies is shaped by existing national capabilities and social contracts, with four possible response approaches (Chandran and Jones 2008; ALNAP, 2010b, see Table 6-4). Analysis based on these broad categories helps clarify the ways in which international agencies are mobilised to manage disaster impacts.

[INSERT TABLE 6-4 HERE:
Table 6-4: Typology of response.]

Details of the disaster management systems of two of the countries listed in Table 6-4 are outlined in Box 6-6.

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Box 6-6. National Disaster Management Systems of China and Kenya

China
The Government's disaster management process (called the 'disaster emergency response' in official documents) is a comprehensive system involving various central and local government sectors and covering the different phases of disasters preparedness, response and recover / rehabilitation. China has enacted more than 30 laws and regulations related to disaster management, including the Law on Earthquake Preparedness and Disaster Reduction. The national legislature adopted the Emergency Response Law on 30 August 2007 as the overall legal document governing all emergency responses in China, including disaster response.

Under the related law and regulations, the Government has established an emergency response system comprising three levels:

- The National Master Plan for Responding to Public Emergencies - an overall framework to be used at all levels of government to ensure public security and cope with public emergency events, including all disaster response activities.
- Five national thematic disaster response plans which outline the detailed assignment of duties and arrangements for major disaster response categories – natural disaster relief; flood and drought; earthquakes; geological disasters and very severe forest fires.
- Emergency response plans for 15 central Government departments and their detailed implementation plans and operation norms (UNESCAP, 2009).

Kenya
The government is working towards a national disaster management policy with the intention of preventing disasters and minimising the disruption they cause through taking steps to reduce risks. The policy will help enhance existing capacities by building resilience to hazard events, build institutional capacity, developing a well-managed disaster response system, reducing vulnerability and ensuring that disaster policy is integrated with development policy and poverty-reduction and takes a multi-sectoral, multi-level approach. The Ministry of State for Special Programmes will be responsible for the co-ordination of the disaster management policy and will promote integration and coordination of disaster management and will establish a national institute for disaster research to improve systematic monitoring and promotion of research.

The draft policy published in 2009 stressed the central role of climate change in any future sustainable planned and integrated National Strategy for Disaster Management. It sets out principles for effective disaster management, codes of conduct of different stakeholders, and provides for the establishment of an institutional framework that is legally recognized and embedded within the government structures. It stresses the importance of mobilising resources to enable the implementation of the policy, with provision of 2% of the annual public budget to a National Disaster Management Fund.

At the time of writing, this policy has not reached Parliament for discussion and approval (MOSSP, 2009, 2010).

_____ END BOX 6-6 HERE _____

Although the level of response and actors involved can vary considerably between disasters and countries (ALNAP, 2010a), the basic actions taken to manage disaster impacts remain the broadly the same across countries, and correspond closely to the different stages of the disaster timeline (see Table 6-5; Copolla, 2007). In general, disaster management employs immediate activities, needs assessments and the delivery of goods and services to meet requirements. The demand for water, food, shelter, sanitation, healthcare, security and – later on - education, employment, reconstruction and so on is balanced against available resources (Wisner and Adams, 2003).

[INSERT TABLE 6-5 HERE:
Table 6-5: Disaster Management Actions across the Disaster Timeline (adapted from Coppola, 2007 and ALNAP 2010a).]

Literature from the humanitarian community indicates that climate-related disasters are widely seen as playing a major role in the increasing the overall human impact of disasters and trends in disaster events are commonly attributed to climate change, even in the absence of robust scientific evidence (IASC, 2009a, IFRC 2009). As such, climate change is often cited as a reason for increasing pressure on both national and international disaster management capacities (Oxfam, 2007, IASC, 2009a, IASC, 2009b, HFP, 2007). Consequently, climate change-related considerations are increasingly featuring in literature on disaster management (Barret et al., 2007; IASC, 2009a, McGray, 2007, Mitchell and Van Aalst, 2008; Venton and La Trobe, 2008), although challenges remain in how climate information can be used as a direct guide to decision-making (IASC, 2009a).

The challenges of climate change calls for institutional changes to disaster management approaches that are far from trivial (Salter 1998), with such challenges including more appropriate policies and legislation; decentralization of capacities and resources; greater budgetary allocation; improved capacity building at the local level; and the political will to bridge the divide between disaster risk reduction activities and disaster management (Sanderson, 2000; UNISDR, 2005). Recent analyses of the need for greater innovation in international humanitarian responses (Ramalingam et al, 2009) present these shifts as among the most significant and important reforms the international system must undergo.

6.4. Aligning National Disaster Risk Management Systems to the Challenges of Climate Change and Development

As has been mentioned in the above, climate change presents multidimensional and fundamental challenges for national systems for managing the risks of climate extremes and disaster risks, including potential changes to the way society views, treats and responds to risks (Mitchell and Ibrahim 2010). As climate change is altering the frequency and magnitude of some extreme events (see Chapter 3) and contributing to trends in exposure and vulnerability (see Chapter 4), the efficacy of national systems requires review and realignment with the new challenges (Mitchell and Ibrahim 2010, Polack 2010, UNISDR GAR 2009). Literature suggests that the effectiveness of national systems for managing disaster risk in a changing climate will be improved if they integrate assessments of changing climate extremes and disasters into current investments, strategies and activities; seek to strengthen the adaptive capacity of all actors and address the causes of vulnerability and poverty recognising climate change as one such cause (UNISDR GAR 2009, Schipper 2009, Mitchell and Ibrahim 2010). In practice, this might require new alliances and hybrid organisations across government and potentially between countries, different actors to join the national system, new cross-sector relationships, a reallocation of responsibilities and resources across scales and new practices (Polack 2010, Hedger *et al*. 2010). As a compliment the available data, information and knowledge about the impact of climate change and disaster risk presented in chapter 2, 3 and 4, this section seeks to elaborate the key areas where realignment of national systems could occur – in assessing the effectiveness of disaster risk management in a changing climate (6.4.1), managing uncertainty and adaptive management (6.4.2) and in tackling poverty, vulnerability and their structural causes (6.4.3).

6.4.1. Assessing the Effectiveness of Disaster Risk Management in a Changing Climate

In order to align disaster risk management with the challenges presented by climate change, it is necessary to assess the effectiveness and efficiency of management options in a changing climate based on the best available information, recognising that this information is patchy at best. This section assesses the literature from both disaster risk management and climate change adaptation on the effectiveness of different options from an economics perspective. Studies framed around climate adaptation for developed and developing countries have focused on the costs of adaptation rather than impacts and damage costs as well as jointly considering costs and benefits (see UNFCCC, 2009; World Bank, 2009; EEA, 2007; ECA, 2009; Solomon 2007; Nordhaus, 2007; Parry, 2009; Agrawala and Fankhauser, 2008). National level studies in the EU, UK, Finland and the Netherlands, as well as in a larger number of developing countries, using the NAPA approach, have been conducted or are underway (Lemmen et al, 2008; MMM, 2005; Van Ierland, 2005; DEFRA, 2006; UNFCCC, 2009). Yet, the evidence base on the economic efficiency , that is benefits net of cost assessments, of adaptation remains limited and fragmented (Adger et al., 2007; Agrawala and Fankhauser, 2008; UNFCCC, 2009). In the disaster risk management literature, too, there have been few national level assessments focussing on economic efficiency of management responses (see World Bank, 1996; Benson 1998; Mechler (2004)). A recent report, taking an economic lense to DRR, goes as far as suggesting that governments should in many instances prioritize spending on early warning (such as for floods), critical infrastructure, such as water and electricity lifelines, as well as, within limits, *environmental buffers* such as mangroves, forests and wetlands (World Bank 2010).

Where assessments of costs and benefits of alternative options have been undertaken, most of these studies have focused on sea level risk and slower onset impacts on agriculture (UNFCCC, 2009; Agrawala and Fankhauser, 2008. Such studies have generally adopted deterministic impact metrics, which is problematic for disaster risk particularly in a environment where frequency and variability of extreme events is changing. On the other hand, assessments of variability in a changing climate are generally difficult to establish and mostly not available for many hazards (see Mechler *et al*., 2010).

Several different methods have been advocated for explicitly aligning disaster risk management with climate change considerations. A recent, risk-focused study (ECA, 2009) suggested the use of an adaptation cost curve approach, which organizes adaptation options around their cost benefit ratios. Interestingly, many of the options considered efficient are of what are considered to be “soft” options, such as reviving reefs, using mangroves as barriers and nourishing beaches. Clearly, many caveats and uncertainties apply to establishing such cost-curves, and this assessment, as one example, is based on asset losses rather than income-based outcomes and opportunity costs. Apart from proper cost benefit analyses, a selected number of studies using variants of a multi criteria approach have been conducted (see Van Ierland, 2005; Debels et al., 2007; de Bruin et al. (2009). Debels et al (2007) develop a multi-purpose index for a quick evaluation of adaptation practices in terms of proper design, implementation and post-implementation evaluation and apply it to cases in Latin America. De Bruin et al. (2009) describe a hybrid approach based on qualitative and quantitative assessments of adaptation options for flood risk in the Netherlands. For the qualitative part, stakeholders selected options in terms of their perceived importance, urgency and other elements. In the quantitative assessment costs and benefits of key adaptation options are determined. Finally using priority ranking based on a weighted sum of the qualitative and quantitative criteria suggests that in the Netherlands an integrated portfolio of nature and water management with risk based policies has particular high potential and acceptance. Overall, the costing and assessment of adaptation explicitly considering the risk based nature of extreme events remains incipient, and more work is desirable.

6.4.2. Managing Uncertainties and Adaptive Management in National Systems

Disasters associated with climate extremes are inherently complex, involving socio-economic as well as environmental and meteorological uncertainty. Population, social, economic and environmental change all influence the way in which hazards are experienced, through their impact on levels of exposure and on people’s sensitivity to hazards (Pielke Jr. et al. 2003). Uncertainty about the magnitude, frequency and severity of climate extremes is managed, to an extent, through the development of predictive models and early warning systems. Yet uncertainty pervades climate and weather models from the initial theoretical foundations to model parameters (Murphy et al. 2004; Stainforth et al. 2005). Early warning systems are also based on models and consequently there is always a probability of their success (or failure) in predicting events accurately, although the failure to heed early warning systems is also a function of social factors, such as trust in the information-providing institution, previous experience of the hazard, degree of social exclusion, and gender (see for example Drabek 1986; Drabek 1999). Enhanced scientific modelling and interdisciplinary approaches to early warning systems can address some of these uncertainties provided good baseline and time series information is available. Even where such information is available, there remain other uncertainties that influence the outcome of hazards. These relate to the capacity of ecosystems to provide buffering services, and the ability of systems to recover. Management approaches that take uncertainty into account include adaptive management and resilience, yet these approaches are not without their challenges (also see Chapter 8).

Adaptive management has come to mean the testing of hypotheses through management action and the bringing together interdisciplinary science, experience and traditional knowledge into decision making through “learning by doing" (Walters 1997). In most cases it is implemented at the local or regional scale and there are few examples of its implementation at the national level. Proponents argue that effective adaptive management contributes to more rapid knowledge acquisition, better information flows between policy makers, and ensures that there is shared understanding of complex problems (Lee, 1993). Examples abound of adaptive management in ecosystem management (Johnson 1999; Ladson and Argent 2002) and in disaster risk reduction (Thompson and Gaviria, 2004; Tompkins, 2005; see Box 6-7). One of the main unresolved issues in adaptive management is how to ensure that scientists and engineers tasked with investigating adaptation and disaster risk management processes are able to learn and how this learning can be integrated into policy and practice. In the case of the restoration of the Florida Everglades a limiting factor to effective management is the unwillingness of some parts of society to accept short term losses for longer term sustainability of ecosystem services (Kiker et al. 2001). Investment in hurricane preparedness in New Orleans prior to Hurricane Katrina provides a contemporary example of science not being included in disaster risk decision making and planning (Congleton 2006; Laska 2004).

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Box 6-7. Building Resilience for Disasters in the Cayman Islands

The Cayman Islands (Tompkins et al. 2008) illustrates how factors such as flexibility, learning and responsive governance are helpful in managing risks. The National Hurricane Committee (NHC) manages hurricane disaster risk reduction in the Cayman Islands and is responsible for preparedness, response and recovery. Compared to other countries, the Cayman Islands have been successful in managing disaster risk. For example, in 2004 Hurricane Ivan (which was similar in magnitude to Hurricane Katrina that hit New Orleans in 2005) only caused two fatalities in the island. Key aspects that are relevant to built disaster resilience are flexibility, learning and adaptive governance (Adger *et al* 2005; Berkes, 2007), all are present in the case study. The NHC is a learning-based organization. It learns from its successes, but more importantly from mistakes made. Each year the disaster managers actively assess the previous year's risk management successes and failures. Every year the National Hurricane Plan is revised to incorporate this learning and to ensure that good practices are institutionalised. Evidence of adaptive governance can be observed, for example, in the changing composition of the NHC, their structure, network arrangements, funding allocation, and responsibilities. Policy makers are encouraged to design and to implement new initiatives, to make adjustments, and take motivated actions. Creating such space for experimentation, innovation, learning, and institutional adjustment is crucial for disaster resilience.

_____ END BOX 6-7 HERE _____

Testing new approaches to disaster risk management can only be undertaken effectively if the management institutions are scaled appropriately, where necessary at the local level (Berkes 2004), or at multiple scales with effective interaction (Gunderson and Holling 2002, Eriksen *et al*, 2011). For the management of climate extremes, the appropriate scale is influenced by the magnitude of the hazard and the affected area. Research suggests that increasing biological diversity of ecosystems allows a greater range of ecosystem responses to hazards, and this increases the resilience of the entire system (Elmqvist et al, 2003). Other research has shown that reducing non-climate stresses on ecosystems can enhance their resilience to climate change. This is the case for coral reefs (Hughes et al. 2003; Hoegh-Guldberg, et al., 2009), and rainforests (Malhi et al 2008). Managing the resources at the appropriate scale, e.g. water catchment or coastal zone instead of managing smaller individual tributaries or coastal sub-systems (such as mangroves), is becoming more urgent (Parkes and Horwitz 2009; Sorenson 1997)

Spare capacity within institutions has been argued to increase the ability of socio-ecological systems to address surprises or external shocks (Folke et al. 2005). McDaniels et al (2008) in their analysis of hospital resilience to earthquake impacts, agreed with this finding, concluding that key features of resilience include the ability to learn from previous experience, careful management of staff during hazard, daily communication and a willingness by staff to address specific system failures. The latter can be achieved through creating overlapping institutions with shared delivery of services/functions, and providing redundant capacity within these institutions thereby allowing a sharing of the risks (Low et al. 2003). Such redundancy increases the chances of social memory being retained within the institution (Ostrom 2005). However, if carefully managed, the costs to this approach can include fragmented policy, high transactions costs, duplication, inconsistencies and inefficiencies (Imperial 1999).

Nearly forty years of research, after the seminal paper published by Holling in 1973, have produced evidence of the impacts of aspects of resilience policy (notably adaptive management) on forests, coral reefs, disasters, and adaptation to climate change, however most of this has been at the local or ecosystem scale. There is still little evidence of the implementation of resilience policy at the national scale. Climate resilience as a development objective is difficult to implement, particularly as it is unclear as to what resilience means (Folke, 2006). Unless resilience is clearly defined and broadly understood, with measurable indicators designed to fit different local contexts and to show the success, the potential losers from this policy may go unnoticed, causing problems with policy implementation and legitimacy (Eakin et al. 2009). Please see the 'glossary' for the report's definition of resilience.

6.4.3. Tackling Poverty, Vulnerability, and their Structural Causes

Chapters 2 and 4 suggest that climate change may exacerbate vulnerability and exposure, which may potentially lead to more extreme impacts. This increases the urgency for disaster risk management systems to more effectively tackle the underlying drivers and root causes of poverty and vulnerability (UNISDR 2009), while also recognizing that climate change itself is one of these drivers; posing new challenges for considering the environmental and carbon emissions dimensions of disaster risk management activities (covered in section 6.4.4). As discussed in Chapter 2, underlying drivers and root causes of vulnerability and poverty include: inequitable development, declining ecosystems, lack of access to power, basic services, land and weak governance (UNISDR, 2009). Climate change adaptation and disaster risk reduction share similar interests in promoting measures to to reduce vulnerability – those which address inequity, promote secure livelihoods, act against discrimination, and increase access to power and resources, among others (Mitchell and Van Aalst 2008, Tanner and Mitchell 2008, Mitchell and Ibrahim 2010; Schipper 2009). However, strategies for tackling the risks of climate extremes and disasters, in practice, tend to focus on treating the symptoms of vulnerability, and with it risk, rather than the underlying causes, and these are not sufficiently embedded in sustainable development (Schipper 2009). The mid-term review of the HFA indicates that insufficient effort is being made to tackle the conditions which create risk (UNISDR 2010). This is despite a highly evolved awareness of the drivers of vulnerability to extreme events (Wisner *et. al*. 2004, CCCD 2009), highlighting a disconnect between disaster risk management and development processes that tackle the structural causes of poverty and vulnerability, and between knowledge and implementation at all scales (UNISDR 2009).

This raises questions about the alignment of current national risk management systems and poverty and vulnerability reduction approaches and to what extent climate change provides an opportunity to recreate this link in an innovative way (Soussan and Burton 2002). One option discussed in the literature that aims to recreate this link involves investing in and strengthening national social protection measures as discussed with reference to the local scale in chapter 5 (see table 5.4) and more broadly in Chapter 8. Other options include mainstreaming disaster risk management and climate change adaptation within poverty reduction strategies or strengthening local government and NGO capacity for community-based development in areas with concentrations of hard-to-reach, vulnerable populations (Tanner and Mitchell 2008; Mitchell and Van Aalst 2008).

6.4.4. Approaching Disaster Risk, Adaptation, Mitigation, and Development Holistically

Diverse and complex challenges of climate change call for a fundamental shift in how climatic risks are viewed, treated and responded to. Ideally, national systems for managing risks from climate extremes and disasters would need to be redesigned to fully integrate development, environmental and humanitarian dimensions, appropriately designing, coordinating and sequencing disaster risk reduction strategies, including social protection, and climate change adaptation. However no country, developed or developing, could afford to do this in the short term. A second best option would be to progressively move towards such a system by, in the first instance, aligning existing national disaster risk management systems to the trends in extreme events described in chapter 3, as well as by addressing the trends in exposure and the underlying drivers of vulnerability.

Strategies for mainstreaming climate change responses into national development planning and budgetary processes, and climate proofing at the sector level were discussed in Sections 6.2 and 6.3. In this section, the focus has been on the system level changes required to address uncertainty, in the form of explicitly assessing economic benefits, net of costs, of options for adaptation to changing risks associated with climate change, adaptive management, and linking poverty reduction and managing risks of climate extremes by focusing on social protection. None of these measures are likely to be easy to implement as actors and stakeholders at all levels of society are being asked to embrace risk as an inherent part of management; and continuously learn and modify policies, decision and actions taking into account new scientific information as they emerge and experiential lessons. A space that is poorly understood and more scientific work is needed to understand human beings perception of risks, their decision-making processes in the face of uncertainty and different stakeholder and human values, and then to translate these knowledges into governance arrangements and incentives for change. Other major transformational ideas such as focussing on low-carbon development strategies producing synergistic outcomes for climate change mitigation and adaptation is unclear. More research and experiments with different low carbon initiatives and their sensitivity to changing disaster risks are needed before firm conclusions can be drawn about their effectiveness.

Given the new information presented in this report, factoring in the impacts of climate change, including the associated changing disaster risks and uncertainties, and the need to tackle the drivers of vulnerability in to disaster risk management systems and finding synergistic climate change adaption and mitigation solutions will remain priorities for most countries.

6.5. Knowledge Gaps

The knowledge-base for the assessment of national systems for managing the risks of climate extremes and disasters, their practices and actors is evolving rapidly as more countries prioritise climate change related risk management within national and sub-national development and planning processes. At the same time, there are significant gaps in our knowledge about the specific ways that climate change is affecting and altering disaster risks and uncertainties (see chapters 3 and 4) and the associated impacts on the different dimensions of vulnerability and exposure that may exacerbate future disasters. Such uncertainty may be viewed by national level policy actors as a barrier to making policies, adopting legislation and targeting investments in managing disaster risks. However, as this chapter has shown, there is considerable experience of measures to respond to existing climate variability and disaster risk that can reduce the adaptation deficit, be viewed as ‘no regrets’ and not be dismissed as risking mal-adaptation to a changing climate (see section 6.3.1.3 for examples). Furthermore, it is important for understanding climate change, its effects on disaster risks and uncertainties, to build adaptive capacity and promote adaptive management and the compulsion to tackle the dual issue of vulnerability and poverty. It is equally important to understand their causes to be progressively integrated into, and used to realign and redesign, national systems for managing the risks of climate extremes and disasters. Experience of this happening and experience of creating national systems that integrate disaster risk, climate adaptation, environmental management and development more broadly is largely missing. In practice for national systems this would mean engaging a wider groups of communities of practice in planning, budgetary, policy design and investment decisions and implementation, connecting legislation and overarching national and sub-national committees associated with climate change to disasters and development more explicitly, and assembling robust information, expertise and decision-making systems that can recognise changing patterns of risk and uncertainty and respond accordingly. In order to gain such experience, this chapter has highlighted the following research priorities:

- How wise is the current trend to support decentralisation of disaster risk management functions to regional and local governments given the information requirements, changing risks and associated uncertainties of climate change? To what extent are efforts to build disaster risk management capacities at different scales creating sets of skills that prepare people and organisations for the new challenges that climate change poses (see section 6.3.2.2)?
- How are the roles and responsibilities of different actors working within national disaster risk management systems changing given the impacts of climate change? To what extent are the traditional functions associated with managing disaster risk being reshaped or redistributed as a result of climate change (see section 6.2)?

- Are systems that integrate a wider set of communities of practice and line ministries more efficient at reducing disaster risk or adapting to climate change than supporting a series of parallel efforts that place less emphasis on cross-sectoral co-ordination?
- What are the benefits and trade-offs of creating programmes and policies that seek to manage disaster risk, mitigate and adapt to climate change and reduce poverty simultaneously?
- To what extent do changing climate extremes and disaster risks present limits to low carbon growth? (Swart and Rees 2007).
- How to better monitor and demonstrate the successes (and failures) of managing risks due to climate variability and change as a means to provide more incentive for ex ante intervention as compared to the still dominant ex post stance taken for dealing with disasters.

Frequently Asked Questions (FAQs)

1) What constitutes a national system for managing risks and disasters associated with climate extremes?

A national system of disaster risk management ideally comprises of nation-wide multiple actors and stakeholders - national and sub-national government agencies, private sector, research bodies, international and regional non-government organizations, and community-based organizations and communities - working in partnership across all levels of society. These actors carry out differential but complementary roles according to their accepted functions and effectiveness and across spatial and temporal scales, to minimize exposure, reduce risks and vulnerabilities of communities and assets and assist communities to reduce their own exposures and risks, prepare them to respond quickly and efficiently to disaster events and residual risks and have capacity to rebuild and rehabilitate following disaster events.

2) What functions do key national systems' actors play in managing risks of climate related extreme events and disasters?

National and sub-national government agencies generally play multiple roles and functions in managing the risk of climate extremes and disasters. These vary between countries depending on the strength of the governments and their technical and budgetary capacity. The differential but complementary roles of national systems' actors can be categorized from a functions perspective into creating an enabling environment of policies, plans, legislation, organizational arrangements, coordination mechanisms; building knowledge and capacity to assess and identify risks and implement appropriate responses, including transferring and sharing risks through insurance and social safety nets; as well as generation and communication of information about hazards and risks, and appropriate responses.

These functions may include building and developing policy, regulatory and institutional frameworks that prioritize risk reduction; integrating disaster risk management with other policy domains, such as economic development or climate change adaptation; enabling different sectors and actors, as well as different levels of society, to be included in disaster risk management systems. Governments often also provide direct services for the management of disaster risks and climate extremes, including early warning systems, and measures to support the most vulnerable in society; research and public awareness related to disasters and training in subjects such as disaster preparedness and response. Certain aspects of disaster risk management in some countries may be suited to and delivered by non-government stakeholders, including the private sector, to implement; albeit this would most effectively be coordinated within a framework created by national and sub-national governments.

The private sector has traditionally played an important role in DRM, including risk financing and insurance, engineering and construction, information communication technology, media and communication. Under changing climatic environments the roles the private sector plays is changing including an enhance uptake of corporate social responsibility (CSR) in terms of advocacy and general awareness raising for DRR and involving humanitarian funding support and the contribution of volunteers and expertise; Public Private Partnerships (PPP) enhancing the provision of public goods for DRR in joint undertakings of public and private sector players; and businesses model approaches. Innovative risk sharing mechanism such as indexed catastrophic insurances and micro insurances for poverty alleviation and reducing risks through development efforts are also emerging private sector roles.

Civil Society and Community-based Organizations (CSO and CBOs) are part of national systems. Civil societies have provided humanitarian support and many other services including specific activities targeting education and advocacy, environmental management; sustainable agriculture; infrastructure construction, as well as increased livelihood. Their role in changing climate conditions is becoming even more critical as they largely operate on the ground with communities building their awareness and knowledge and capacity to understand their climatic risks, prepare for, respond to and rebuild after extreme events and disasters.

Bilateral and multilateral agencies are also major players in developing countries supplying financial and technical support to government and non-government agencies, as well as local communities and NGOs and CSOs, to tackle multifaceted challenges of disaster risk management. They vary in their approaches and modalities and support different aspects of risk management and climate change adaptation. Efforts in the past have generally focused on providing post disaster humanitarian and post disaster rehabilitation assistance, with almost 90% of their budget going towards disaster relief and reconstruction, and only less than 10% of the funds for preparedness and risk reduction. Recently the need for allocating resources also to disaster risk reduction assistance has been acknowledged, with increasing levels of resources, albeit still relatively small in comparison to budget allocation, identified for various disaster risk reduction efforts, including poverty reduction as a means of reducing risks and vulnerability.

Scientific and research organizations play important roles as well by undertaking research and assessments on subjects such as the evolution and consequences of past hazard events - cyclones, droughts, sandstorms and floods-; analyzing spatial and temporal patterns of weather-related risks; building cooperative networks for early warning systems, modeling, and long-term prediction; actively engaging in technical capacity building and training; transforming scientific evidence into adaptation practice; collating traditional knowledge and lessons learnt for wider dissemination, and translating scientific information into user-friendly forms for community consumption. The effectiveness of different actors and stakeholders in managing climate extremes and disasters risks is highly dependent on the policies, legislation and other enabling environments as well as the capacity of the stakeholders to proactively take steps. Also the availability and communication of robust and timely scientific information and traditional knowledge to all stakeholders and actors is key.

3) What can governments do to help reduce risk and manage residual risks of climate change related extremes and disasters?

Governments at all levels are well placed to provide the enabling environments in support of actors and stakeholders to cost effectively and equitably play their part in a multifaceted disaster risk management. National and sub-national governments can utilize a range of planning and policy options to create necessary enabling environments for government agencies, sub national and municipal governments, private sector and individuals to reduce exposure to hazards, reduce risks and manage residual risks of climate change related extremes and disasters. Planning and policy options range from targeting key underlying drivers and determinants of risks and vulnerability – such as poor human development status,; poor access to water and sanitation; unsustainable resource and environment use - to information generation and knowledge management; provision of private sector incentives to supply services such as insurance and microfinance; and coordination of post disaster response and rehabilitation efforts..

Governments can adopt longer term “no regrets” vulnerability options, which include some traditional disaster risk reduction (DRR) approaches to deal with the existing climate conditions and can be justified under all plausible future climate change scenarios, including no climate change. “No regret” actions would include interventions to enhance the provision and dissemination of climate information for agriculture in drought-prone regions, improvements to hazard warning and dissemination systems and updates to climatic design information for engineering codes and standards.

At the other end of the spectrum, some long-term, high implication planning issues involving large investments involve climate change impacts' studies and may also incorporate additional redundancies that account for the uncertainties of the future climate. Given the consequences, the potential irreversibility of decisions, significant investment costs and the long-lived nature of these national decisions, more climate information may be needed to treat the range of uncertainties for the future. In between these ranges lies a broad spectrum of activities with gradations of emphasis on vulnerability and impacts. In some cases, mal-adaptation can occur in the longer term when "no regret" actions for current climate vulnerabilities do not consider climate change impacts (e.g. changes to agricultural livelihoods to strengthen resilience today could undermine DRR gains over the longer term when climate change impacts on future flood risks are ignored).

Policies can also comprise of a range of financial instruments suitable under both current and future climate conditions. Key risk transfer options include insurance, micro-insurance and micro-financing, government disaster reserve funds and intergovernmental risk sharing. The latter two help to provide much needed relief, immediate liquidity after a disaster in regions where individual countries because of their size cannot have viable risk insurance schemes. They acan allow for more effective government response, provide some relief of the fiscal burden placed on governments due to disaster impacts and constitute critical steps in promoting more proactive risk management strategies and responses. The decision to bear residual losses is always in the background as due to financial and other constraints generally very low probability events cannot be fully adapted to and uncertainties over the directions of future climate change impacts can be high. Also, often, there are important constraints in terms of limited capacity or a small set of available adaptation options
.

When evaluating options, the scale of potential climate-related disaster risks, the capacity of governments or agencies to act, the level of certainty on future changes, the timeframes within which these future impacts and disasters will occur and finally the costs and consequences of decisions to be taken are key considerations in a government's prioritization and finally implementation. In terms of appropriate methods, cases with greater certainty in projecting future climate change impacts may better lend themselves for climate change impacts and modelling approaches while cases where a country's adaptive capacity is low or the uncertainties over future climate changes are high may be more suited to the "no regrets" and vulnerability-oriented approaches. All options are best implemented or mainstreamed through sectors and other policies and between sectors, including those for agriculture, water resources, infrastructure, health, land use, environment, early warning services, finance and planning, poverty reduction, educations, hydro meteorological science.

Given competing priorities and development goals, policy makers of national and sub-national governments may prefer to consider win-win outcomes that result in synergies for disaster risk reduction, climate change adaptation, greenhouse gas reduction and human development. An example involves ecosystem based adaptation, as healthy, natural or modified, ecosystems have a critical role to play in reducing risk of climate extremes and disasters. Although the scientific evidence base relating to the role of ecosystem services in mitigating many disasters is nascent, investment in natural ecosystem management has long been used to reduce risks of disasters. Sustainable land management, including reforestation and conservation of forests, reduces risk of landslides, avalanches, and floods. Wetland protection and other coastal ecosystem conservation serve to protect against coastal storm surges. Such ecosystem based adaption also contributes towards increased and sustainable economic opportunities, increased carbon sequestration and greenhouse gas mitigation in some cases. In many cases it can be more cost effectively replace or complement other adaptation actions like building expensive 'hard' infrastructure such as sea-walls and dykes. In an ecosystem based approach, in essence governments work towards streamlining their planning processes so that development, environmental management, disaster management and climate agendas are successfully combined.

4) How can countries integrate considerations of increasing risks of climate change related extremes and disasters to reduce risks, transfer and manage residual risks?

Countries can integrate or mainstream considerations of increasing risks of climate change related extremes and disasters into their plans, policies, strategies, programs, sectors and institutions in multiple ways and at all levels. A key challenge and opportunity in mainstreaming or implementing DRR and CCA actions lies in building bridges between current disaster risk management actions to deal with existing climate vulnerabilities and the additional and revised efforts needed for adaptation to future climate change. The ultimate challenge is the need for transformational change across the society where risk becomes a central component of social, economic and environmental development efforts, recognizing that it is the social processes which transform natural or technological phenomena into disasters and create and increase human vulnerability.

Several studies advocate a concurrent or twin-track approach to mainstreaming CCA and DRR, consisting of: (1) "bottom-up" approaches or vulnerability assessments of social and economic strategies for coping with present climate extremes and variability, as practiced by the DRR community and (2) "top-down" approaches using climate forecast tools and scenarios to evaluate sector-specific, incremental changes in risk over the next few decades. The combination of 'top-down' and 'bottom-up' options allows vulnerability and impacts approaches to be "mixed and matched" for the realities of different geographic scales, uncertainties and governance mechanisms
.

In many cases, these approaches can be combined by considering a range of climate change scenarios and impacts relative to critical vulnerability thresholds defined by decision-makers. In other cases, changing climate risks can be monitored and mainstreamed into decision-making through regularly updated revisions to hazard and vulnerability assessments. Redundancies can be incorporated into existing disaster management planning in order to strengthen against the unforeseen risks of the changing climate. When available, downscaled ensembles of future climate change and socio-economic scenarios, impact models, vulnerability assessments and their uncertainties can be incorporated or mainstreamed into national and sectoral plans.

Mainstreaming nationally across multiple sectors requires governance mechanisms and coordination that can cut across national and subnational government agencies and sectoral organizations and may best be realized if all areas of government are coordinated from the highest political and organizational level.

Mainstreaming DRR and CCA also requires good and relevant information being available to actors and stakeholders in the form that could be understood and acted upon. Good information includes not only scientific information about hazards and trends but also about the underlying ecological, social and economic drivers and determinants of risks and vulnerability, and appropriate responses. For example, increasing biological diversity of ecosystems allows a greater range of ecosystem responses to hazards, and this increases the resilience of the entire system. Research has shown that reducing non-climate stresses on ecosystems, such as coral reefs and rainforests can enhance their resilience to climate change. Moreover, intervention on the socio economical factors that trigger disasters implies reducing vulnerability that have to do with: low income, inappropriate technology, absence of land use planning, inappropriate education, lack of organization, institutional weakness and political willingness. Comprehensive considerations of the multifaceted determinants of increasing risks of climate change related extremes and disasters and responses required to reduce risks, transfer and manage residual risks suggest a need for relevant and appropriately sequenced multidisciplinary and experiential knowledge sets – natural hazard identification and patterns, risk construction processes, and evaluation and assessment.

Recent successful experiences suggest that the production and communication of relevant scientific and other knowledge to decision-makers and actors can be best be achieved by a co-generation of knowledge through scientists and researchers in collaboration with policy makers and other non-academic stakeholders. Collaboration between scientific disciplines, adopting transdisciplinary methodologies also helps generate a body of complementary and appropriately sequenced knowledge that generates synergistic outcomes.

5) What methods and tools are currently available to help develop a culture of resilience by assessing risks, reducing climate-related disaster risks through hard and soft options and transferring and sharing 'residual risks?

Information and knowledge is crucial for the development of different methods and tools that may help to reduce risks, improve the planning processes, help in the recovery process and improve the capabilities to adapt to a changing climate. Building a culture of resilience involves not only natural hazard identification and an understanding of the root causes of exposure, vulnerability and risk, but also the communication of knowledge to actors and decision-makers, designing residual risk preparedness procedures for effectively responding to disasters when they occur and finally an evaluation and assessment of adaptive learning.

Some examples of assessment methods, and tools are: climate change modeling, hazard zoning,"hot spot" mapping", national vulernability mapping and monitoring using vulnerability indices, easonal outlooks for preparedness planning. DRR options include early warning systems for fluvial, glacial, flood and tidal hazards; structural and non-structural flood controls, artificial draining of pro-glacial lakes, traditional rain and groundwater harvesting, and storage systems, long-range reservoir inflow forecasts and water demand management and efficiency measures.

National climate-related disaster risk reduction activities include a broad range of national options that vary from "hard" structural options for safer and future oriented national infrastructure and building codes, coastal defense practices, standards for maintenance of enhanced early warning systems to "soft" options that include policies for more rigorous land use planning, protection of natural ecosystems, human development, and financial instruments for promoting human development and disaster risk sharing and risk transfer (see Table 6-6).

[INSERT TABLE 6-6 HERE:
Table 6-6: Some examples of methods/tools/practices for assessing risks, reducing climate-related disaster risks, and transferring and sharing risks.]

"Hard" structural or engineering options include new and revised construction practices, implementation of adequate national building codes that incorporate regionally specific climate data and analyses to improve resilience for many types of risks. Since infrastructure is built for long life-spans and the assumption of climate stationarity will not hold for future climates, it is important that national climate change guidance, tools and consistent adaptation options be developed to ensure that climate change can be incorporated into these national infrastructure design standards. Meanwhile, challenges remain on how to incorporate the uncertainty of future climate projections into engineering risk management and legislation, especially for elements such as extreme winds and extreme precipitation. Examples are emerging where these challenges have been overcome successfully at the national level, for example, climate change related uncertainties are now incorporated into the national permafrost standard for Arctic regions of Canada and the design of cyclone-resistant temporary houses in Bangladesh.

Soft options for resilient infrastructure and communities include ecosystem-based adaptation strategies, which can prove to be more cost-effective adaptation strategies than hard engineering solutions alone and produce multiple benefits. Many ecosystem-based options are also more accessible to the rural poor and can support livelihoods. Land use planning and management that aims to protect and enhance functioning "green infrastructure" or natural buffers and defences such as wetlands, forests and natural drainage corridors can reduce vulnerabilities in the longer term. Index-based catastrophe insurance often linked to microfinance and microinsurance are some recent tools that have also proven successful in DRR. Hard structural options alone, without the support of soft ecosystem based services, private sector engagement and incentive based financing of DRR, may first prove to be very expensive in terms of construction and maintenance and then may not bring abut the expected benefits as they can lead to over-reliance on structures, which may fail catastrophically in large events.

For building resilience and reducing risk, information and knowledge needs to be translated into concrete actions, measures and tools to deal with disaster risk and climate change adaptation. Effective communication and public awareness for action is critical when trying to reduce risks and disaster losses and damages. Early Warning Systems are essential tools to promote both risk assessment and public awareness in order to promote a culture of resilience as they can deliver accurate, timely, and meaningful information. To be effective and complete, an early warning system should comprise of four interacting elements (i) generation of risk knowledge including monitoring and forecasting, (ii) surveillance and warning services, (iii) dissemination and communication and (iv) response capability. The success of an early warning system depends on the extent to which the warnings trigger effective response measures and how it promotes changes in planning and future policies.

6) How can governments facilitate increased engagement of the private sector in managing risks associated with climatic extremes and climatic variabilities?

The private sector has always been involved in disaster risk management particularly providing services such as post disaster engineering and construction, information communication technology, media and communication, utilities and transportation. But little evidence has been documented in relation to successful national systems level private sector engagement, with the exception of risk financing. There is scope for increased private sector involvement in DRR by creating increased awareness and understanding and highlighting a business case for private sector engagement, such as for guaranteeing global value chains in the face of disasters. There exists scope for innovative private-public sector risk financing partnerships in the supply of innovative risk financing instruments, although private insurers are often not prepared to fully underwrite disaster risks. In response to this reluctance, countries could, as many OECD countries including Japan, France, the US, Norway and New Zealand have done, legislate public-private national insurance systems for natural disasters with mandatory or voluntary participation of the insured. Within such partnerships, in a development context governments could follow a promotion model of pro-poor regulation to increase market penetration of non-traditional risk financing measures, such as through micro-insurance schemes. In India, for example, the government passed a regulation where insurers were made to reserve a certain quota of business for low income insurance policies within their regular business segment. This government legislation effectively led to the cross-subsidization of the micro-insurance industry and has helped the poor in rural communities access insurance against disasters.

References

Aaheim, A. & Schjolden, A., 2004. *An approach to utilise climate change impacts studies in national assessments. Global Environmental Change, 14,* 147-160.

Aakre, S., I. Banaszak, R. Mechler, D. Rübbelke, A. Wreford and H. Kalirai, 2010. Financial adaptation to disaster risk in the European Union. *Mitigation and Adaptation Strategies for Global Change* 15 (7): 721-736

Adger, W.N., 2000. Social and ecological resilience: are they related? *Progress in Human Geography, 24* (3), 347-364.

Adger, W.N., Agrawala, S., Mirza, M.M.Q., Conde, C., O'Brien, K., Pulhin, J., Pulwarty, R., Smit B. & Takahashi, K., 2007. Climate Change 2007. Assessment of Adaptation Practices, Options, Constraints and Capacity (pp 717- 743). In Parry, M.L., Canziani, O.F., Palutikof, J.P., Van Der Linde, P.J., & C.E. Hanson (Eds.), *Climate change 2007. Impacts adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

Adger, W.N., Hughes, T.P., Folke, C., Carpenter, S.R. & Rockstrom, J., 2005. Social-ecological resilience to coastal disasters. *Science , 5737*(309), 1036-1039.

Agrawala, S. & Fankhauser, S., 2008. Economic *aspects of adaptation to climate change. Costs, benefits and policy instrument*s. Paris: Organization for Economic Cooperation and Development (OECD).

Agrawala, S. AndVan Aalst, M., 2008. Adapting development cooperation to adapt to climate change. *Climate Policy, 8(3),* 183-193.

Albala-Bertrand, J., 2006. *The unlikeliness of an economic catastrophe: Localization & globalization (Working Papers 576).* London: Department Of Economics, Queen Mary University.

Albala-Bertrand, J.M., 1993. *Political economy of large natural disasters with special reference to developing countries*. Oxford: Clarendon Press.

Aldunce, P. & Leon, A., 2007. Opportunities for improving disaster management in Chile: A case study. *Disaster Prevention and Management, 16* (1), 33-41.

Aldunce, P., C. Neri, And P. Debels, 2008: Hacia La Evaluaciã³N De Prã¡Cticas De Adaptaciã³N Ante La Variabilidad Y El Cambio Climã¡Tico. In: Aplicaciã³N Del Ãndice De Utilidad De Prã¡Cticas De Adpataciã³N En La Evaluaciã³N De Dos Casos De Estudio En Amã©Rica Latina [Aldunce, P., C. Neri, And C. Szlafsztein (Eds.)]. Belem, Brazil, Pp. 87-105.

Allan, C. (2008). Can adaptive management help us embrace the Murray-Darling Basin's wicked problems? In Pahl-Wostl, C., Kabat P., & Moltgen, J. (Eds.)*, Adaptive and integrated water management: Coping with complexity and uncertainty (pp. 61-73).* Berlin Heidelberg: Springer.

Allen, K.M., 2006. Community-based disaster preparedness and climate adaptation: Local capacity-building in the Philippines. *Disasters, 30*(1), 81-101.
ALNAP (2005) Capacity Building amid Humanitarian Response, London: ALNAP
ALNAP (2010a) The State of the Humanitarian System: assessing performance and progress London: ALNAP
ALNAP (2010b) The role of national governments in international humanitarian response to disasters, Meeting Background Paper, 26th ALNAP Meeting http://www.alnap.org/pool/files/26-meeting-background-paper.pdf
Anderies, J.M., Janssen, M.A., & Ostrom, E., 2004. A framework to analyze the robustness of social-ecological systems from an institutional perspective. *Ecology and Society, 9*(1), 18.
Anderies, J.M., Janssen, M.A. & Walker, B.H., 2002. Grazing management, resilience and the dynamics of a fire-driven rangeland system. *Ecosystems, 5*(1), 23-44.
Anderies, J.M., Ryan, P. & Walker, B.H. 2006. Loss of resilience, crisis, and institutional change: lessons from an intensive agricultural system in southeastern Australia. *Ecosystems, 9*(6), 865-878.
Andersen, T. J., 2001. Managing Economic Exposures of Natural Disasters. Exploring Alternative Financial Risk Management Opportunities and Instruments. Washington DC, IDB.

Angelsen, A., Brockhaus, M., Kanninen, M., Sills, E., Sunderlin, W.D. & Wertz-Kanounnikoff, S., 2009. *Realising REDD: National strategy and policy options*. Indonesia: Center for International Forestry Research (CIFOR).
Apel, H., Thieken, A. H., Merz, B., & Blöschl,G., 2004. Flood risk assessment and associated uncertainty. *Natural Hazards and Earth System Sciences, (4)*, 295-308.
Arnell, N., 2004. Climate change and global water resources: SRES emissions and socio-economic scenarios. *Global Environmental Change, 14*(1), 31-52.
Arnell, N.W. & Delaney, E.K., 2006. Adapting to climate change: Public water supply in England and Wales. *Climatic Change, 78 (*2-4), 227- 255.
Arnold, M., 2008. *The role of risk transfer and insurance in disaster risk reduction and climate change adaptation* (policy brief). Stockholm:Commission on Climate Change and Development.
Arrow, K. and Lind, R., 1970. Uncertainty and the evaluation of public investment decisions. *The American Economic Review, 60*, 364-378.
Auffret, P., 2003b. Catastrophe Insurance Market in the Caribbean Region: Market Failures and Recommendations for Public Sector Interventions. World Bank Policy Research Working Paper 2963. Washington DC, World Bank.
Auld, H., 2008. Disaster Risk Reduction under current and changing climate conditions. *World Meteorological Organization Bulletin, 57*(2), 118-125.
Auld, H.E., 2008. Adaptation by design: The Impact of changing climate on infrastructure. *Journal of Public Works & Infrastructure, 3*, 276-288.
Auld, H., Maciver, D., & Klaassen, J., 2004. Heavy rainfall and waterborne disease outbreaks: The Walkerton example. *Journal of Toxicology and Environmental Health, Part A, 67*(20-220), 1879-1887.
Ayers, J.M. and Huq, S., 2009. The value of linking mitigation and adaptation: A case study of Bangladesh. *Environmental Management, 43*(5), 753-764.
Büchele, B., Kreibich, H., Kron, A., Thieken, A., Ihringer, J., Oberle, P., Merz, B. & Nestmann, F., 2006. Flood-risk mapping: Contributions towards an enhanced assessment of extreme events and associated risks. *Natural Hazards Earth System Sciences, 6*,485- 503.
Baird, A.H., Campbell, S.J., Anggoro, A.W., Ardiwijaya, R.L., Fadli, N., Herdiana, Y., Kartawijaya, T., Mahyiddin, D., Mukminin, A., & Pardede,S.T., 2005. Acehnese reefs in the wake of the Asian Tsunami. *Current Biology, 15*(21), 1926-1930.
Baker, R., Cannon, R., Bartlett, P., & Barker, I., 2005. Novel strategies for assessing and managing the risks posed by invasive alien species to global crop production and biodiversity. *Annals of Applied Biology, 2*(146), 177-191.
Balmford, A., Bruner, A., Cooper, P., Costanza, R., Farber, S., Green, R.E., Jenkins, M., Jefferiss, P., Jessamy, V., & Madden, J., 2002. Economic reasons for conserving wild nature. *Science, 297*(5583), 950-953.
Balmford, A., Rodrigues, A.S.L., Walpole, M., Ten Brink, P., Kettunen, M., Braat, L. & De Groot, R., 2008. *The economics of biodiversity and ecosystems: Scoping the science*. Cambridge, UK: The European Commission
Bank, W., 2003. *Financing rapid onset natural disaster losses in India: A risk management approach*. Washington, D.C.: The World Bank.

Barbier, E.B., 2009. *Rethinking the economic recovery: A global green new deal*. Report Prepared for the Economics and Trade Branch, Division of Technology, Industry and Economics. Geneva: United Nations Environment Programme (UNEP).
Barbier, E.B., Koch, E.W., Silliman, B.R., Hacker,S.D., Wolanski, E., Primavera, J., Granek, E.F., Polasky, S., Aswani, S., & Cramer, L.A., 2008. Coastal ecosystem-based management with nonlinear ecological functions and values. *Science, 319*(5861), 321-323.
Barrett, E., Murfitt, S., & Venton, P., 2007. *Mainstreaming the environment into humanitarian response: An exploration of opportunities and issues*. London: Environmental Resource Management Limited
Basher, R., 2006. Global early warning systems for natural hazards: Systematic and people-centered. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering, 364 (*1845), 2167-2182.
Basher, R., 2009. Climate sense. In: *WCC-3 Climate Sense* (pp. 212-214). Leicester: World Meteorological Organization (WMO).
Batima, P., Bat., Tserendash, S., Bayarbaatar L., Shiirev-Adya S., Tuvaansuren G., Natsagdorj, L., &. Chuluun, T., 2005. *Adaptation to climate change*. In: [Batima, P. & D. Tserendorj (Eds.) pp. 59-115.]. Ulaanbaatar, Mongolia: ADMON.
Bebi, P., Kulakowski, D., & Rixen, C., 2000. Snow avalanche disturbances in forest ecosystems -State of research and implications for management. *Forest Ecology and Management, 257*(9), 1883-1892. Benson, C. (1997). The economic impacts of natural disasters in Fiji. ODI Working Paper, Overseas Development Institute (ODI). **97**.
Bennett, J. et al (2006) *Coordination of international humanitarian assistance in tsunami affected countries,* Tsunami Evaluation Coalition (TEC)
Benson, C. (1997). The economic impacts of natural disasters in Philippines. ODI Working Paper, Overseas Development Institute (ODI). **99**.
Benson, C. (1997). The economic impacts of natural disasters in Vietnam. ODI Working Paper, Overseas Development Institute (ODI). **98**.
Benson, C. (1998). The cost of disasters. Development at risk? Natural disasters and the third world. J. Twigg. Oxford, Oxford Centre for Disaster Studies, UK National Coordinated Committee for the International Decade for Natural Disaster reduction (IDNR)**:** 8-13.
Benson, C. & Clay, E., 2004. *Understanding the economic and financial impacts of natural disasters*. Washington, D.C.: The World Bank. Benson, C. and E. Clay (2002). Disasters, Vulnerability, and the Global Economy. Building safer cities: The future of disaster risk. A. Kreimer, M. Arnold and A. Carlin. Washington, DC, The World Bank. Disaster Risk Management Series No. 3: 3-32.
Benson, C. & Clay, E. (2004). Understanding the Economic and Financial Impacts of Natural Disasters. Washington, DC., The World Bank. **4**.
Benson, C., Clay, E. et al. (2001). Dominica: Natural disasters and economic development in a small island state. Washington, DC., World Bank.
Benson, C. and Twigg, J. (2004). Measuring Mitigation: Methodologies for assessing natural hazard risks and the net benefits of mitigation — A Scoping Study. Geneva, The International Federation of Red Cross and Red Crescent Societies/The ProVention Consortium.
Benson, C., Twigg, J., et al. (2001). "NGO initiatives in risk reduction: An Overview." Disasters **25**(3): 199-215.
Berkes, F., 2002. *Cross-scale institutional linkages: Perspectives from the bottom up*. *In* Ostrom, E.E., T.E. Dietz, N.E. Dolsak, P.C. Stern, & S.E. Stonich (Eds.), *The drama of the commons*. Washington, D.C.: National Research Council.
Berkes, F., Colding, J., & Folke, C., 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications, 10*(5), 1251-1262.
Berkes, F., Folke, C., & Colding, J., 2000. *Linking social and ecological systems: Management practices and social mechanisms for building resilience*. Cambridge: Cambridge University Press.
Berkes, F. & Jolly, D., 2002. Adapting to climate change: Social-ecological resilience in a Canadian Western Arctic community. *Conservation Ecology, 5*(2), 18.
Berkes, F., 2007. Understanding uncertainty and reducing vulnerability: Lessons from resilience thinking. *Natural Hazards, 41*(2), 283-295.
Berry, P., 2007. *Adaptation options on natural ecosystems*. Report to the Financial and Technical Support Division. Bonn: United Nations Framework Convention on Climate Change (UNFCCC).

Betterncourt, S., Croad, R., et al. (2006). Not if But When: Adapting to natural hazards in the Pacific Islands Region. Sydney, The World Bank.
Bhattamshra, R. & Barret, C., 2008. *Community based risk management arrangements: an overview and implications for social fund programmes* (Discussion Paper No. 0830). Washington, D.C.: The World Bank.
Bhavnani, R., Owor, M, Vordzorgbe, S and Bousquet, F. (2008) 'Status of disaster risk reduction in the Sub-Saharan Africa region': January 2008, The World Bank
Biermann, F., 2007. Earth system governance as a crosscutting theme of global change research. *Global Environmental Change, 17*(3-4), 326-337.
Björk, M., Short, F., Mcleod, E., & Beer, S., 2008. *Managing seagrasses for resilience to climate change*. Gland: International Union for Conservation of Nature (IUCN).
Blaikie, P., Cannon, T., Davis, I., & Wisner, B., 1994. At risk–natural hazards, people's vulnerability and disasters. London: Routledge
Bogardi, J. & Brauch, H.G., 2005. UNEP-Towards an international environment organization. In Rechkemmer, A. (Ed.), *Global environmental change: A challenge for human security – defining and conceptualizing the environmental dimension of human security* (pp. 85-109). Nomos-Verl.-Ges.
Boonyabancha, S., 2009. Land for housing the poor- by the poor: Experiences from the Baan Mankong Nationwide Slum Upgrading Programme in Thailand. *Environment and Urbanization 21(2), 309-329*.
Borton, J. (1993) 'Recent Trends in the International Relief System', *Disasters* 17.3, September:187–201
Branco, A., Suassuna, J. & Vainsencher, S. A., 2005. Improving access to water resources through rainwater harvesting as a mitigation measure: The case of the Brazilian semi-arid region. *Mitigation and Adaptation Strategies for Global Change, 10(3),* 393-409
Brauch, H.G., 2005. *Threats, challenges, vulnerabilities and risks in environmental and human security*. Germany: Institute For Environment and Human Security, United Nations University.
Bravo Di Guenni, L., Cardoso, M., Goldammer, J., Hurtt, G., &. Mata, L. J, 2005. Ecosystems and human well-being: current state and trends: findings of the condition and trends working group of the Millennium Ecosystem Assessment. In Hassan, R.M., Scholes, R. & Ash, N. (Eds.), *Regulation of natural hazards: floods and fires*. Washington .D.C.: Island Press.
Brooks, N. & Adger, W.N., 2005. Adaptation policy frameworks for climate change: developing strategies, policies and measures. In Lim, B., Spanger-Siegfried, E., Burton I., Malone, E.L., & Huq S. (Eds.), *Assessing and enhancing adaptive capacity*. Cambridge: Cambridge University Press.
Brooks, N., Neil Adger, W., & Mick Kelly, P., 2005. The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation. *Global Environmental Change Part A, 15*(2), 151-163.
Bullock, A. & Acreman, M., 2003. The role of wetlands in the hydrological cycle. *Hydrology and Earth System Sciences, 7*(3), 358-389.
Burke, E., 2004. *Ambiguity and change: humanitarian NGOs prepared for the future*. A report prepared for World Vision, CARE, Save US, Mercy Corps, Oxfam USA, Oxfam GB, Catholic Relief Services.
Burroughs, R., 1999. When stakeholders choose: process, knowledge and motivation in water quality decisions. *Society & Natural Resources, 12(8),* 797-809.
Burton, I., Soussan, J., & Hammill, A., 2003. *Livelihoods and climate change. Combining Disaster Risk Reduction, natural resource management and climate change adaptation in a new approach to the reduction of vulnerability and poverty*. Canada: The International Institute for Sustainable Development.
Butler, C.D. & Oluoch-Kosura, W., 2006. Linking future ecosystem services and future human well-being. *Ecology and Society, 11*(1), 30.
Butt, T.A., Mccarl, B.A., Angerer, J., Dyke, P.T., & Stuth, J.W., 2005. The economic and food security implications of climate change in Mali. *Climatic Change, 68*(3), 355 - 378.
Campbell, A., Kapos, V., Chenery, A., Kahn, S.I., Rashid, M., Scharlemann, J.P.W., & Dickson, B., 2008. *The Linkages between Biodiversity and Climate Change Mitigation*. Cambridge, UK :UNEP World Conservation Monitoring Center.
Canada National Round Table on the Environment and the Economy (NTREE), 2009. *True North: Adapting Infrastructure to Climate Change in Northern Canada* (Working Paper p.146). Ottawa: NTREE.
Canadian Standards Association (CSA), 2010: *Infrastructure in permafrost: A guideline for climate change adaptation. A technical guide, Plus 4011-10*. Mississauga : CSA.
Cardenas, V., Hochrainer, S., Mechler, R., Pflug, G., Linnerooth-Bayer, J., 2007. Sovereign financial disaster risk management: The case of Mexico. *Environmental Hazards, 7*(1), 40-53.

Cardona, O., 2006. Measuring vulnerability to natural hazards: Towards disaster resilient societies. In Birkmann, J. (Ed.), *A system of indicators for disaster risk management in the Americas*. Tokyo: United Nations University Press.
Cardona, O., 2009, *Indicators of disaster risk and risk management- Program for Latin America and the Caribbean: Summary Report (*3rd Ed) (p. 50). Washington D.C.: Inter-American Development Bank.
Cardona, O., 1996. Environmental degradation, risks and urban disasters. In *Environmental Management and Disaster Prevention: Two Related Topics* (pp. 19-19-58). Lima: La Red.
Cardona, O. D., M. G. Ordaz, et al. (2010). "Disaster risk form a macroeconomics perspective: a metric for fiscal vulnerability evaluation." Disasters **34**(4): 1064-1083.
CARE International, 2008. Linking Disaster Risk Reduction and poverty: Good practices and lessons learnt. In: International Strategy for Disaster Reduction (ISDR) (Ed.), *Community preparedness for emergencies helps poverty* (pp. 6-10). Geneva: International Strategy for Disaster Reduction (ISDR).
Caribbean Development Bank & CARICOM, 2004: *Sourcebook on the integration of natural hazards into environmental impact assessment (NHIA-EIA Sourcebook)*. Bridgetown: Caribbean Development Bank
Carpenter, G. and M. Saito, 2000. Managing the financial impacts of natural disaster losses in Mexico: Government options for risk financing and risk transfer. Washington, DC, Finance, Private Sector & Infrastructure Department, Environmental & Social Sustainability Department, Mexico Country Office, Latin & the Caribbean Region, World Bank.
Carreño *M. L.*, *Cardona, O. D.* & *Barbat A. H.,* 2007. A disaster risk management performance index. *Journal of Natural Hazards, 41*(1), 1-20.
Carson, R., 1962. *Silent spring*. Boston: Houghton Mifflin
Carter, T.R., Jones, R.N., Lu, X., Bhadwal, S., Conde, C., Mearns, L.O., O'neill, B.C., Rounsevell, M. & Zurek, M.B. (2007). New assessment methods and the characterisation of future conditions. In Parry, M.L., Canziani, O.F., Palutikof, J.P., Van Der Linden, P.J., & Hanson, C.E (Ed.), *Climate change 2007: Impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change* (pp.133-171). Cambridge: Cambridge University Press.
Carter, M., Little, P., Mogues, T., & Negat, W., 2006. *Shocks, sensitivity and resilience: Tracking the economic impacts of environmental disaster on assets in Ethiopia and Honduras*. Washington, D.C.: The International Food Policy Research Institute.
Carter, W. N. (1992). Disaster management: a disaster manager's handbook.
Caselli, F. and P. Malthotra (2004). Natural disasters and growth: from thought experiment to natural experiment. Washington DC, IMF.
Cash, D.W. & Moser, S.C., 2000. Linking global & local scales: Designing dynamic assessment and management processes. *Global Environmental Change, 10*(2), 109-120.
Chandran, R. and Jones, B. (2008) *Concepts and Dilemmas of State Building in Fragile Situations: from fragility to resilience*, OECD/DAC Discussion Paper
Changnon, S.A., 2003. Shifting economic impacts from weather extremes in the United States: A result of societal changes, not global warming. *Natural Hazards, 2* (29), 273-290.
Chhatre, A. & Agrawal, A., 2009. Trade-offs and synergies between carbon storage and livelihood benefits from forest commons. *Proceedings of the National Academy of Sciences,* 106 (42), 17667 - 17670.
Charveriat, C. (2000). Natural disasters in Latin America and the Caribbean: an overview of risk. Washington, DC, Inter-American Development Bank.
Chitekwe, B., 2009. Struggles for urban land by the Zimbabwe Homeless People's Federation, *Environment and Urbanization 21* (2), 347-366.
Christensen, J. H. And Christensen, O.B., 2003. Severe summertime flooding in Europe. *Nature, 421*, 805- 806
Christensen, J. H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Koli, W.-T. Kwon, R. Laprise, V.M. Rueda, L. Mearns, C.G. Menã©Ndez, J. Rã¤Isã¤Nen, A. Rinke,A.Sarr And P.Whetton, 2007: Climate Change 2007: The Physical Science Basis. Contribution Of Working Group I To The Fourth Assessment Report Of The Intergovernmental Panel On Climate Change. In: Regional Climate Projections [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor And H.L. Miller (Eds.)]. Cambridge University Press, Cambridge, Pp. 847-940.
Chung, J. (2009). Situation analysis for strengthening disaster information management systems in Fiji: baseline data preparedness and assessment methodologies. A report prepared for the Fiji Government and Pacific Disaster Risk Management Partnership Suva, Fiji, ISDR and SOPAC.

Cochran, H. C. (1994). Disaster, indebtedness and faltering economic growth. 9th International Seminar on Earthquake Prognosis, September 9-23. San Jose, Costa Rica Hazards Assessment Laboratory, Colorado State University, Boulder.
Colls, A., Ash N., & Ikkala N., 2009. *Ecosystem-based adaptation: A Natural Response to Climate Change*. Gland: International Union for Conservation of Nature (IUNC).
Comerio, M.C., 2004. Public policy for reducing earthquake risks: A US perspective. *Building Research & Information, 32*(5), 403-413.
Commission on Climate Change and Development, (CCD) 2009. *Closing the gaps: disaster risk reduction and adaptation to climate change in developing countries* (Final Report). Stockholm: Ministry for Foreign Affairs
Commoner, B., 1972. *The closing circle: nature, man, and technology*. New York: Alfred Knopf
Congleton, R.D., 2006. The story of Katrina: New Orleans and the political economy of catastrophe. *Public Choice,* 127(1), 5-30.
Coppola, DP (2007) Introduction to international disaster management, Butterworth-Heinemann
Corrales, W. & Miquilena, T., 2009. *Disasters in developing countries sustainable development: A conceptual framework for strategic action* (Global Assessment Report). Geneva: ISDR.
Costanza, R., Daly, H., Folke, C., Hawken, P., Holling, C.S., Mcmichael, A.J., Pimentel, D., & Rapport, D., 2000. Managing our environmental portfolio. *Bioscience, 50*(2), 149-155.
Costanza, R., Pérez-Maqueo, O., Martinez, M.L., Sutton, P., Anderson, S.J., & Mulder, K., 2008. The value of coastal wetlands for hurricane protection. *Ambio, 37*(4), 241-248.
Crabbé, P. & Robin, M., 2006. Institutional adaptation of water resource infrastructures to climate change in eastern Ontario. *Climatic Change, 78*(1), 103 -133.
Crowards, T., 2000. *Comparative vulnerability to natural disasters in the Caribbean*. Barbados: Caribbean Development Bank.
Cummins, J., & Mahul,O., 2009: *Catastrophe risk financing in developing countries: Principles for public intervention*. Washington D.C.: The World Bank.
Curriero, F.C., Patz, J.A., Rose, J.B., & Lele, S., 2001. The association between extreme precipitation and waterborne disease outbreaks in the United States, 1948-1994. *American Journal of Public Health, 91*(8), 1194-1199.
Cutter, S.L., 2003. The vulnerability of science and the science of vulnerability. *Annals of the Association of American Geographers, 93(1),* 1-12.
Cutter, S.L. & Emrich, C.T., 2006. Moral hazard, social catastrophe: The changing face of vulnerability along the hurricane coasts. *The Annals of the American Academy of Political and Social Science, 604*(1), 102-112.
Danter, K.J., Griest, D.L., Mullins, G.W., & Norland, E., 2000. Organizational change as a component of ecosystem management. *Society & Natural Resources, 13*(6), 537-547.
Dasilva, J., Garanganga, B., Teveredzi, V., Marx, S.M., Mason, S.J., & Connor, S.J., 2004. Improving epidemic malaria planning, preparedness and response in Southern Africa. *Malaria Journal, 3*(1), 37.
Davis, K. (Ed.), 2004. *Technology dissemination among small-scale farmers in Meru Central District of Kenya: Impact of group participation*. USA: University of Florida
De Bruin, K., Dellink, R., & Agrawala, S., 2009. *Economic aspects of adaptation to climate change: Integrated assessment modeling of adaptation costs and benefits* (Environment Working Paper No. 6). Paris: Organization for Economic Cooperation and Development (OECD).
De Roo, A., Barredo, J., Lavalle, C., Bodis, K., & Bonk, R., 2007. Digital terrain modeling. development and applications in a policy support environment. Series: Lecture notes in geoinformation and cartography. In: Peckham, R. & Jordan, G. (Eds.), *Potential flood hazard and risk mapping at Pan-European scale*. Berlin: Springer
Debels, P., Szlafsztein, C., Aldunce, P., Neri, C., Carvajal, Y., Quintero-Angel, M., Celis, A., Bezanilla, A, & Martinez, D, 2009. IUPA: A tool for the evaluation of the general usefulness of practices for adaptation to climate change and variability. *Natural Hazards, 50*(2), 211-233.
Del Ninno, C. (2001) The 1998 floods in Bangladesh: disaster impacts, household coping strategies, and response, IFPRI Research Report 122
Department for Environment, Food and Rural Affairs (DEFRA), 2001. *National appraisal of assets at risk from flooding and coastal erosion*. Final Report. London: DEFRA.
Department for Environment, Food and Rural Affairs (DEFRA), 2005. *Making space for water. Taking forward a new government strategy for flood and coastal erosion risk management in England*. London: DEFRA

Dercon, S. 2005. Risk, insurance, and poverty: A review. In Dercon, S. (Ed.) (2005). Insurance Against Poverty. A study prepared by the World Institute for Development Economics Research of the United Nations University (UNU-WIDER). Oxford: Oxford University Press

Deutsche Gesellschaft Für Technische Zusammenarbeit (GTZ), German Committee for Disaster Reduction, DKKV. & U.O. Bayreuth, 2005. *Linking Poverty Reduction and Disaster Risk Management*. Eschborn: GTZ

Department for International Development (DFID), 2004. *Disaster Risk Reduction: A development concern: A scoping study on links between disaster risk reduction, poverty and development*. London: DFID.

Department for International Development (DFID), 2009. *Eliminating world poverty: building our common future*. London: The Stationery Office.

DFID (2005). Natural disaster and disaster risk reduction measures: A desk review of costs and benefits. UK, Department for International Development.

Dheri S. K., 2004: Disaster Management Preparedness: A Plan For Action. http://www.gisdevelopment.net/application/natural_hazards/overview/nho0018a.htm

Diagne, K. & Ndiaye, A., 2009. Disaster risk reduction: Cases from urban Africa. In: *integrated disaster risk and environmental health monitoring: Greater Accra Metropolitan area, Ghana* (pp. 151-172). London: Earthscan.

Dietz, T., Dolsakm, N., Ostrom, E., & Stern, P. (Eds.), 2002. *The drama of the commons (*pp 3–35). Washington, D.C: National Academy Press

Dietz, T., Ostrom, E., & Stern, P.C., 2003. The struggle to govern the commons. *Science, 302*(5652), 1907-1912.

Dilley, M., 2006. Risk identification: A critical component of disaster risk management. *World Meteorological Organization Bulletin, 55*(1), 13-20.

Dilley, M., R.S. Chen, U. Deichmann, A.L. Lerner-Lam, M. Arnold, J. Agwe, P. Buys, O. Kjekstad, B. Lyon, And G. Yetman, 2005. *Natural Disaster Hotspots: A Global Risk Analysis* (p. 145). USA: The World Bank and Columbia University.

Dimas Alonzo, R., 2003. *Flood warning system of La Masica Municipality*. Stockholm: Global Water Partnership.

Dodman, D., Hardoy, J., & Satterthwaite, D., 2008. *Urban development and intensive and extensive risk*. London: International Institute for Environment and Development(IIED)

Dolan, A.H., & Walker, I.J., 2003. Understanding vulnerability of coastal communities to climate change related risks. In: *Journal of Coastal Research, SI 39* (Proceedings of the 8th International Coastal Symposium). Itajaí, SC – Brazil.

Dorren, L.K.A., Berger, F., Imeson, A.C., Maier, B., & Rey, F., 2004. Integrity, stability and management of protection forests in the European Alps. *Forest Ecology and Management, 195 (*1-2), 165-176.

Dovers, S.R. & Mobbs, C.D., 1997. Frontiers in ecology: building the links. In Klomp, N. & Lunt, I. (Eds.), *An alluring prospect? Ecology and the requirements of adaptive management* (pp. 39-52). Oxford: Elsevier Science

Drabek 1986; Drabek, T. E. (1986) Human system responses to disaster : An inventory of sociological findings, Springer- Verlag New York.

Drabek, T. E. (1999) Understanding disaster warning responses, The Social Science Journal, 36, 515-523.

Dubois, J.L., Mahieu, F.R., & Poussard, A., 2002. *Social sustainability as a component of human development*. Proceedings of workshop poverty, social capital and development, Von Hugel Institute, St. Edmunds' College, Cambridge University, Cambridge, UK.

Dudley, N., Stolton, S., Belokurov, A., Krueger, L., Lopoukhine, N., Mackinnon, K., Sandwith, T., & Sekhran, N., 2010. Natural solutions: Protected areas helping people cope with climate change. Gland, Washington D.C. and New York, USA: IUCN, WCPA, TNC, UNDP, WCS, The World Bank and WWF.

Dumas, P. & Hallegatte, S., 2009. *Think again: higher elasticity of substitution increases economic resilience*. Milan: Fondazione Eni Enrico Mattei.

Dynes, R.R., 1994. Community emergency planning: False assumptions and inappropriate analogies. *International Journal of Mass Emergencies and Disasters, 12*(2), 141-158.

Eakin, H., Tompkins, E.L., Nelson, D.R., & Anderies, J.M., 2009. Adapting to climate change: Thresholds, values, governance. In Adger, W.N., Lorenzoni, I. &. Karen, L.O.B (Eds.), *Hidden costs and disparate uncertainties: Trade-offs involved in approaches to climate policy* (pp. 212-226). Cambridge: Cambridge University Press.

Ebi, K.L., 2008. Adaptation costs for climate change-related cases of diarrhoeal disease, malnutrition, and malaria in 2030. *Globalization and Health, (4),* 9. Doi:10.1186/1744-8603

Ebi, K.L., Kovats, R.S., & Menne, B., 2006. An approach for assessing human health vulnerability and public health interventions to adapt to climate change. *Environ Health Perspectives 114*(12): Doi:10.1289/Ehp.8430.

Ebi, K.L., Lewis, N.D., & Corvalan, C., 2006: Climate variability and change and their potential health effects in Small Island States: Information for adaptation planning in the health sector. *Environ Health Perspectives 114*(12): Doi:10.1289/Ehp.8429.

Embrechts, P., Klüppelberg, C., and Mikosch, T. , 1997. Modelling extremal events for insurance and finance. Berlin: Springer.

European Commission, 2005 (EC). *European Union Solidarity Fund* - Annual Report 2004 Com/2005/0709 Brussels: EC.

European Commission (EC), 2007. *Adapting to climate change in Europe- Options for EU Action*. Green Paper, Commission of the European Communities. Brussels: EC.

European Commission (EC), 2007. *Addressing the challenge of water scarcity and droughts in the European Union*. Brussels: EC.

European Commission (EC), (2007, June 29). *Climate change: Europe must take adaptation measures to lessen impacts of current and future warming*. Press Release Ip/07/979. Brussels: EC.

European Commission (EC), 2009. *Adapting to climate change in Europe -options for EU Action*. White Paper. Brussels: EC.

European Commission (EC), 2009. Technical Report - 2009 – 040, Guidance Document No. 24. River Basin Management. In: *A changing climate, common implementation strategy for the water framework*. Directive (2000/60/EC). Brussels: EC

ECLAC (2002). Handbook for establishing the socio-economic and environmental effects of natural disasters. Mexico City, United Nations, Economic Commission for Latin America and the Caribbean (ECLAC) and International Bank for Reconstruction and Development (The World Bank).

ECLAC (2003). Handbook for establishing the socio-economic and environmental effects of natural disasters. Santiago, Chile, United Nations, Economic Commission for Latin America and the Caribbean (ECLAC) and International Bank for Reconstruction and Development (The World Bank). 111.

Economics of Climate Adaptation Working Group, 2009. *Shaping climate-resilient development: A framework for decision-making study*. Washington, D.C.: The World Bank

European Environment Agency (EEA), 2007: *Climate change: The cost of inaction and the cost of adaptation*. Technical Report. Copenhagen: EEA.

Elmqvist, T., Folke, C., Nyström, M., Peterson, G., Bengtsson, J., Walker, B., & Norberg, J., 2003. Response diversity, ecosystem change, and resilience. *Frontiers in Ecology and the Environment, 1*(9), 488-494.

Fagen, P. (2008) *Natural disasters in Latin America and the Caribbean: National, regional and international interactions*, HPG Working Paper, Overseas Development Institute

Füssel, H. & Klein, R., 2006. Climate change vulnerability assessments: An evolution of conceptual thinking. *Climatic Change, 75*, *301-329*.

Food and Agriculture Organization (FAO), 2008. Climate change adaptation and mitigation in the food and agriculture sector: In: *Technical background document from the expert consultation held on 5 to 7 March 2008 (*Paper presented at Climate change, energy and food). Rome: FAO

Food and Agriculture Organization (FAO), 2006. *Third session of the sub-committee on aquaculture: Committee on Fisheries (CoFI)* (4-8 September).New Delhi: FAO

Food and Agriculture Organization (FAO), 2007: Building adaptive capacity to climate change: policies to sustain livelihoods and fisheries. New Directions in Fisheries – A Series of Policy Briefs On Development Issues, 0816.

Food and Agriculture Organization (FAO), 2008. *Challenges for sustainable land management for food security in Africa*. 25th Regional Conference for Africa, Nairobi, Kenya.

Food and Agriculture Organization (FAO), 2008. *Climate change for fisheries and aquaculture*. (Technical background document from the expert consultation). Rome: FAO

Food and Agriculture Organization (FAO), 2009. *Seed security for food security in the light of climate change and soaring food prices: Challenges and opportunities* (Report of the twenty first session of the Committee on Agriculture*)*. Rome: FAO

Few, R., Brown, K., & Tompkins, E.L., 2007. Public participation and climate change adaptation: Avoiding the illusion of inclusion. *Climate Policy,* 7(1), 46-59.

Few, R., Osbahr, H., Bouwer, L.M., Viner, D., & Sperling, F., 2006. *Linking climate change adaptation and disaster risk management for sustainable poverty reduction* (Synthesis report). Washington, D.C: Vulnerability and Adaptation Resource Group

Feyen, L., Barredo, J. I., Dankers, R., 2009. Water and urban development paradigms. Towards an integration of engineering, design and management approaches. In Feyen, J., Shannon, K., Neville, M. (Eds.), *Implications of global warming and urban land use change on flooding in Europe*. London: Taylor & Francis Group.
Fischer, J., Peterson, G.D., Gardner, T.A., Gordon, L.J., Fazey, I., Elmqvist, T., Felton, A., Folke, C., & Dovers, S., 2009. Integrating resilience thinking and optimization for conservation. *Trends in Ecology & Evolution, 24*(10), 549-554.
Fischer, S., & Easterly,W., 1990. The economics of the Government budget constraint. *The World Bank Research Observer, 5,* 127-142.
Fischer, G., Tubiello, F., Vanvelthuizen, H., & Wiberg, D., 2007. Climate change impacts on irrigation water requirements: Effects of mitigation, 1990–2080. *Technological Forecasting and Social Change, 74*(7), 1083 - 1107.
Floodsite, 2006: *Guidelines for socio-economic flood damage evaluation*. www.floodsite.net
Folke, C., 2006. Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environmental Change, 16*(3), 253-267.
Folke, C., Hahn, T., Olsson, P., & Norberg, J., 2005. Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources, 30*, 441-473.
Forbes, K. & Broadhead, J., 2007. *The Role of coastal forests in the mitigation of Tsunami impacts*. Bangkok: Food and Agriculture Organization (FAO).
Freeman, P., Martin, L. A., et al. (2003). Disaster risk management: National systems for the comprehensive management of disaster risk and financial strategies for natural disaster reconstruction. Washington, DC, Sustainable Development Department, Inter-American Development Bank.
Freeman, P. K., Martin, L., Mechler, R., Warner, K &.Hausman, P, 2002. *Catastrophes and development, integrating natural catastrophes into development planning*. Washington D.C.: World Bank.
Freeman, P.K. & Warner, K., 2001. *Vulnerability of infrastructure to climate variability: How does this affect infrastructure lending policies*? Washington, D.C.: World Bank and Provention Consortium.
Froot, K. A., 2001. The market for catastrophe risk: A clinical examination. Journal of Financial Economics 60: 529-571.
Fuente, A.D.L. & Dercon, S., 2008. *Disasters, growth and poverty in Africa: Revisiting the microeconomic evidence*. Geneva: International Strategy for Disaster Reduction (ISDR)
Füssel, H., 2007. Adaptation planning for climate change: Concepts, assessment approaches, and key lessons. *Sustainability Science, 2*(2), 265 - 275.
Gallopin, G.C., 1991. Human dimensions of global change: Linking the global and the local processes. *International Social Science Journal, 43*(4), 707-718.
Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy, 31 (*8-9), 1257-1274.
Genus, A. & Coles, A.M., 2008. Rethinking the multi-level perspective of technological transitions. *Research Policy, 37*(9), 1436-1445.
Ghesquiere, F., Mahul, O., Forni, M., Gartley, R., 2006. Caribbean Catastrophe Risk Insurance Facility:A solution to the short-term liquidity needs of small island states in the aftermath of natural disasters, www.aidandtrade.org, IAT03-13/3.
Global Facility for Disaster Reduction and Recovery, 2009: *Integrating disaster reduction into the fight against poverty*. (Annual Report 2009). Washington D.C.: Global Facility for Disaster Reduction and Recovery.
Global Network of Civil Society Organisations for Disaster Reduction, 2009. *Clouds but little rain. Views from the frontline: A Local Perspective of progress towards implementation of the Hyogo Framework for Action*. Teddington: Global Network of Civil Society Organizations for Disaster Reduction.
Goodess, C.M., Hanson, C., Hulme, M., Osborn, T.J., 2003. Representing climate and extreme weather events in integrated assessment models: A review of existing methods and options for development. *Integrated Assessment, 4*, 145-171.
Groot, R., Kuikman, P., Nillesen,E., 2007: *A qualitative assessment of climate adaptation options and some estimate of adaptation costs*. Routeplanner Projects 3, 4, 5 in Ark Programme.
Grossi, P. and H. Kunreuther, Eds.., 2005. Catastrophe Modeling: A New Approach to Managing Risk. New York: Springer.

Guha-Sapir, Debarati and Regina Below, 2002. Quality and accuracy of disaster data: a comparative analysis of three global datasets. Working document prepared for Disaster Management Facility. Washington, DC: World Bank

Guimaraes, P., Hefner, F.L., & Woodward, D.P., 1993. Wealth and income effects of natural disasters: An econometric analysis of hurricane Hugo. *Review of Regional Studies, 23*, 97-114.

Gunderson, L., 1999. Resilience, flexibility and adaptive management--antidotes for spurious certitude? *Conservation Ecology, 7*(1), 7.

Gunderson, L. & Holling, C.S., 2002. *Panarchy synopsis: understanding transformations in human and natural systems*. Washington DC: Island Press

Gurenko, E., 2004. *Catastrophe risk and reinsurance: A Country risk management perspective*. London: Risk Books.

Guzman, E.M.D., 2003. *Towards total disaster risk management approach*. Japan: Asian Disaster Reduction Center and United Nations Office for the Coordination of Humanitarian Affairs.

Gwimbi, P., 2007. The effectiveness of early warning systems for the reduction of flood disasters: Some experiences from cyclone induced floods in Zimbabwe. *Journal of Sustainable Development in Africa, 9*(4), 152-169.

Haines, A., Kovats, R.S., Campbell-Lendrum, D., & Corvalan, C., 2006. Climate change and human health: impacts, vulnerability and public health. *Public Health, 120*(7), 585-596.

Hall, J.W., Sayers, P.B., & Dawson, R.J., 2005. National-scale assessment of current and future flood risk in England and Wales. *Natural Hazards, 36*, 147-164.

Hallegatte, S., 2009. Strategies to adapt to an uncertain climate change. *Global Environmental Change, 19*(2), 240-247.

Hallegatte, S. & Ghil, M., 2007. *Endogenous business cycles and the economic response to exogenous shocks*. Milan: Fondazione Eni Enrico Mattei,

Hallegate, S. and M. Gill (2007). Endogenous business cycles and the economic response to exogenous shocks. Milan, Fondazione Eni Enrico Mattei. **Working Paper 20.2007**.

Halsnæs, K. & Verhagen, J., 2007. Development based climate change adaptation and mitigation-Conceptual issues and lessons learned in studies in Developing countries. *Mitigation and Adaptation Strategies for Global Change, 12*(5), 665-684.

Hammer, K., Arrowsmith, N., & Gladis, T., 2003. Agrobiodiversity with emphasis on plant genetic resources. *Naturwissenschaften 2003*; *90*(6):241-250.

Handmer, J.W., Dovers, S., & Downing, V., 1999. Societal vulnerability to climate change and variability. *Mitigation and Adaptation Strategies for Global Change,* 4(3-4), 267-281.

Handmer, J. & Dovers, S., 2007. *Handbook of disaster and emergency policies and institutions*. London: Earth Scan

Hardoy, J. & Pandiella, G., 2009. Urban poverty and vulnerability to climate change in Latin America. *Environment and Urbanization, 21*(1), 203-224.

Harvey, D., 1996. *Justice, nature and the geography of difference*. Oxford: Blackwell.

Harvey, P (2009) *Towards good humanitarian government: The role of the affected state in disaster response*, Humanitarian Policy Group, Overseas Development Institute

Hasan, A., 2009. *Land, CBOs and the Karachi circular railway* (pp. 331-345). *London:* International Institute for Environment and Development (IIED).

Hasan, A., 2009. *Migration, small towns and social transformation in Pakistan* (Vol. 21). London: International Institute for Environment and Development (IIED).

Hassan, R.M., Scholes, R., & Ash, N., 2005. *Ecosystems and human well-being: current state and trends: Findings of the condition and trends working group of the Millennium Ecosystem Assessment*. Washington, D.C.: Island Press.

Hazell, P. and U. Hess, 2010. Drought insurance for agricultural development and food security in dryland areas. Food Security (2): 395–405. DOI 10.1007/s12571-010-0087-y

Hedger, M. & Cacouris, J., 2008. *Separate streams? Adapting water resources management to climate change*. Teddington: Tearfund.

Heller, P., 2005. *Understanding fiscal space*. Washington, D.C.: International Monetary Fund.

Heltberg, R., Jorgensen, S.L., & Siegel, P.B., 2008. *Climate change, human vulnerability, and social risk management*. Washington, D.C.: World Bank.

Heltberg, R., Siegel, P.B., & Jorgensen, S.L., 2009. Addressing human vulnerability to climate change: toward a 'no-regrets' approach. *Global Environmental Change, 19*(1), 89 – 99

Hess, U. and H. Syroka, 2005. Weather-based Insurance in Southern Africa. The Case of Malawi. Washington DC, World Bank.
Hesse M. (Von), Kamiche, J., & Torre, D.L., 2008: *In-depth review of mainstreaming risk reduction into public investment in Latin America*. Germany: GTZ, UNDP.
Hilhorst, D. (2003) 'Unlocking Disaster Paradigms: An Actor-oriented Focus on Disaster Response', Abstract submitted for Session 3 of the Disaster Research and Social Crisis Network Panels of the 6th European Sociological Conference, Murcia, Spain, 23–26 September.
Hoegh-Guldberg, P. O., J. Mumby, A. J. Hooten, R. S. Steneck, P. Greenfield, E. Gomez, D. R. Harvell, P. F. Sale, A. J. Edwards, K. Caldeira, N. Knowlton, C. M. Eakin, R. Iglesias-Prieto, N. Muthiga, R. H. Bradbury, A. Dubi, and M. E. Hatziolos, 2008. Coral adaptation in the face of climate change. Science 320 (5874), 315
Hyogo Framework for Action (HFA), 2005. *The Hyogo Framework for Action 2005-2015: Building the resilience of nations and communities to disasters*. Hyogo: HFA
Hochrainer, S., 2006. *Macroeconomic risk management against natural disasters*. Wiesbaden: Deutscher Universita Ts-Verlag.
Hodgson, R., 1995. Housing Improvements: Disaster response or hazard mitigation? *Built Environment, 21*(2/3), 154-163.
Hodgson, R. & Carter, M., 1999. Natural disaster management. In Ingleton, J. (Ed.), *Some lessons for a national approach to building for safety in Bangladesh (*pp160-162). Leicester: Tudor Rose.
Hodgson, R.L.P., 2000. Village infrastructure to cope with the environment. In Seraj, S.M., Hodgson, R.L.P., & Ahmed, K.I. (Eds.), The *Exeter workshops*. Dhaka: Housing & Hazard Group
Hoeppe, P. & Gurenko, E.N., 2006. Scientific and economic rationales for innovative climate insurance solutions. *Climate Policy, 6*(6), 607-620.
Holling, C.S., 1973. Resilience and stability of ecological systems. *Annual Review of Ecology and Systematics, 4*(1), 1-23.
Holling, C.S., 2001: Understanding the complexity of economic, ecological, and social systems. *Ecosystems, 4*(5), 390-405.
Holling, C.S., 2004. From complex regions to complex worlds. *Ecology and Society, 9*(1), 11.
Holling, C.S. & Stephen, S., 1995. *Barriers and bridges to the renewal of ecosystems and institutions*. New York: Columbia University Press
Howden, S.M., Soussana, J.F., Tubiello, F.N., Chhetri, N., Dunlop, M., & Meinke, H., 2007. Adapting agriculture to climate change. *Proceedings of the National Academy of Sciences of the United States of America,* 104(50), 19691-19696.
Huffman, G.J., Adler, R.F., Stocker, E., Bolvin, D.T., & Nelkin, E.J., 2002. *Analysis of TRMM 3-hourly multi-satellite precipitation estimates computed in both real and post-real time*. Combined preprints CD-ROM, 83RD AMS annual meeting. Paper p4.11 in 12th conf. on sat. Meteor. and Oceanog., 9-13 Feb. 2003, Long Beach, Califonia.
Huffman, G.J., Bolvin, D.T, Nelkin, E.J., Wolff, D.B., Adler, R.F., Gu, G., Hong, Y., Bowman, K.P., & Stocker, E.F., 2007. The TRMM Multisatellite Precipitation Analysis (TMPA): Quasi-Global, Multiyear, Combined-Sensor Precipitation Estimates At Fine Scales. *Journal of Hydrometeorology, 1*(8), 38-55.
Hughes, T.P., Baird, A.H., Bellwood, D.R., Card, M., Connolly, S.R., Folke, C., Grosberg, R., Hoegh-Guldberg, O., Jackson, J.B.C., & Kleypas, J., 2003. Climate change, human impacts, and the resilience of coral reefs. *Science, 301 (*5635), 929.
Hulme, M., Barrow, E.M., Arnell, N.W., Harrison, P.A., Johns, T.C., Downing, T.E., 1999. Relative impacts of human-induced climate change and natural climate variability. *Nature, 397*, 688-691.
Humanitarian Futures Programmes (2007) Dimensions of Crisis Impacts: Humanitarian Needs by Dimensions of Crisis Impacts: Humanitarian Needs by 2015', Working Paper, Kings College London
Hyll, *W*., Türk, A., *Vetters*, *N*. (*2004*). *Flood risk*. *Workpackage* Ökonomische Aspekte TP 05. Projektendbericht. Wiesbaden*:* Lebensmittelministerium.
IASC (2009a) Addressing the Humanitarian Challenges of Climate Change Regional and National Perspectives
Preliminary Findings from the IASC Regional and National Level Consultations, IASC online at http://www.humanitarianinfo.org/iasc/downloaddoc.aspx?docID=4862&type=any
IASC (2009b) Letter from the IASC Principals to Yvo de Boer, Executive Secretary of the United Nations Framework Convention on Climate Change, IASC http://www.humanitarianinfo.org/iasc/downloaddoc.aspx?docID=4838&type=any

ICHARM, 2009. *Global trends in water-related disasters: An insight for policymakers, international centre for water hazard and risk management*. World Water Assessment Programme. Paris: UNESCO.
International Institute for Environment and Development (IIED), 2009. *Climate change and the urban poor: risk and resilience in 15 of the world's most vulnerable cities*. London: IIED
IFRC (2008) Bridging the gap: integrating climate change and disaster risk reduction, IFRC
IFRC (2009) Focus on early warning, early action, World Disasters Report 2009 http://www.ifrc.org/publicat/wdr2009/index.asp
Immerzeel, W.W., Droogers, P., De Jong, S.M., & Bierkens, M.F.P., 2009. Large-scale monitoring of snow cover and runoff simulation in Himalayan river basins using remote sensing. *Remote Sensing of Environment, 113*(1), 40-49.
Imperial, M.T., 1999. Institutional analysis and ecosystem-based management: The institutional analysis and development framework. *Environmental Management, 24*(4), 449-465.
Inter-Agency Standing Committee (IASC), 2009. *Addressing the humanitarian challenges of climate change. Regional and national perspectives* (Case studies on climate change adaptation). Geneva: IASC
Inter-Agency Standing Committee (IASC), 2009. *Addressing the humanitarian challenges of climate change: regional and national perspectives*. Preliminary Findings from the IASC Regional and National Level Consultations. Geneva: IASC.
Intergovernmental Oceanographic Commission (IoC), 2009: Manuals And Guides 52. In: *Tsunami risk assessment and mitigation for the Indian Ocean; Knowing your Tsunami risk – and what to do about it*. Paris: UNESCO
Intergovernmental Panel on Climate Change (IPCC) Working Group II, 2001. *Climate change 2001. Impacts, adaptation, and vulnerability. Summary for policymakers* (Report approved at the sixth session of Intergovernmental Panel on Climate Change 13-16 February, 2001). Geneva: IPCC
Intergovernmental Panel on Climate Change (IPCC), 2007. *Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change* (Pp. 976). Cambridge: Cambridge University Press.
Intergovernmental Panel on Climate Change (IPCC), 2007. Contribution of working group II to the fourth assessment report of the Intergovernmental Panel on Climate Change. In: *Adaptation and vulnerability (*pp. 315-357). Cambridge: Cambridge University Press.
Intergovernmental Panel on Climate Change (IPCC), 2007: Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the IPCC. In Parry, M.L., Canziani, O.F., Palutikof, J.P., Van Der Linden, P.J., Hanson, C.E. (Ed.), *Summary for policymakers* (pp. 7-22). Cambridge: Cambridge University Press
International Federation of the Red Cross (2004). World Disasters Report 2004: Focus on Community Resilience. . J. Walter., Geneva: International Federation of Red Cross and Red Crescent Societies.
International Federation of the Red Cross (2010). World Disasters Report 2010: Focus on urban risk D. McLean, Geneva: International Federation of Red Cross and Red Crescent Societies.
International Federation of Red Cross and Red Crescent Societies (IFRC), 2008: *Early warning, early action and evaluation of the IFRC Central and West Africa Zone flood preparedness*. Geneva: IFRC
International Federation of Red Cross and Red Crescent Societies (IFRC), 2009: World *Disasters Report*: *Focus on early warning, early action*. Geneva: .IFRC.
International Federation of Red Cross and Red Crescent Societies (IFRC), 2007. *Climate Guide*. Geneva: .IFRC.
International Federation of Red Cross and Red Crescent Societies (IFRC), 2000: *World Disasters Report*. Geneva: IFRC
International Federation of Red Cross and Red Crescent Societies (IFRC), 1995. *Code of conduct for International Red Cross and Red Crescent. Movement and NGOS in disaster relief: List of signatories*. Geneva: IFRC
International Strategy for Disaster Reduction (ISDR), 2001. *Disaster risk reduction 2007; Global review, Global platform for disaster risk reduction*. Geneva: ISDR
International Strategy for Disaster Reduction (ISDR), 2001. *Early Warning Issues: A Discussion Paper* Geneva: ISDR
International Strategy for Disaster Reduction (ISDR), 2006. *Developing early warning systems: A checklist* (The conclusions of the third international conference on early warning, 27-29 March 2006, Bonn, Germany). Geneva: ISDR
International Strategy for Disaster Reduction (ISDR), 2007. *Words into action: A guide for implementing the Hyogo framework*. Geneva: ISDR.

International Strategy for Disaster Reduction (ISDR), 2009. *Adaptation to climate change by reducing disaster risks: Country practices and lessons*. Geneva: ISDR.
International Strategy for Disaster Reduction (ISDR), 2004. *Living With Risk: A global review of disaster reduction initiatives* pp. 429, 126. Geneva: ISDR.
International Strategy for Disaster Reduction (ISDR), 2007. *Building disaster resilient communities: good practices and lessons learned*. Geneva: ISDR
International Strategy for Disaster Reduction (ISDR), 2009. *Applying disaster risk reduction for climate change adaptation: country practices and lessons*. Geneva: ISDR
International Strategy for Disaster Reduction (ISDR), 2008: *Climate change and Disaster Risk Reduction* (Briefing Note 01). Geneva: ISDR
International Strategy for Disaster Reduction (ISDR), 2009. *Risk and poverty in a changing climate* (Global Assessment Report on disaster risk reduction). Geneva: ISDR
International Strategy for Disaster Reduction (ISDR), 2009. *Recommendations of national platforms to the chair and participants of the second session of the global platform for disaster risk reduction*. Geneva: ISDR.
International Strategy for Disaster Reduction (ISDR), 2010. *Local governments and disaster risk reduction, good practices and lessons learned*. Geneva: ISDR. ISDR (2004). Living with Risk: a global review of disaster reduction initiatives. Geneva, United Nations International Strategy for Disaster Reduction.
International Strategy for Disaster Reduction (ISDR), 2007. *Building Disaster Resilient Communities: Good Practices and Lessons Learned*. Geneva, Switzerland, United Nations International Strategy for Disaster Reduction.
International Strategy for Disaster Reduction (ISDR), 2008. *Linking disaster risk reduction and poverty: Good practices and lessons learnt*. Geneva, Switzerland, Global Network of NGOs for Disaster Risk Reduction.
International Strategy for Disaster Reduction (ISDR), 2009. *Global Assessment Report on Disaster Risk Reduction*. Geneva, Switzerland, United Nations
Interworks (1998) Model for a National Disaster Management Structure, Preparedness Plan, and Supporting Legislation, UNOCHA Disaster Management Training Programme http://ocha.unog.ch/drptoolkit/PreparednessTools/IL%20Frameworks/Models%20for%20Institutional%20structures%20and%20legislation,%20DMTP,%20InterWorks,1998.pdf
Iremil, E.T. & Yayos Co, J., 2009. Community-driven land tenure strategies: The experience of the homeless people's federation of the Philippines. *Environment and Urbanization, 21*(2), 415-441.
Jaspers, S. & Shoham, J., 2000. Targeting the vulnerable: A review of the necessity and feasibility of targeting vulnerable households. *Disasters, 23*(4), 359-372.
Jerneck, A. & Olsson, L., 2008. Adaptation and the poor: Development, resilience and transition. *Climate Policy, 8*(2), 170-182.
Johnson, B.L., 1999. Introduction to the special feature: Adaptive management—scientifically sound, socially challenged. *Conservation Ecology, 3*(1), 10.
Jones, R. & Mearns, L., 2005. Adaptation policy frameworks for climate change: Developing strategies, policies and measures. In Lim, B. & Spanger-Siefried, E. (Eds.), *Assessing future climate risks* (pp. 119-144). Cambridge: Cambridge University Press.
Jones, R.N., 2004. *Managing climate change risks*. Paris: Organization for Economic Cooperation and Development (OECD).
Kagiannas, A., Askounis, D., Anagnostopoulos, K., & Psarras, J., 2003. Energy policy assessment of the Euro-Mediterranean Cooperation. *Energy Conversion and Management, 44*(16), 2665-2686.
Kamal-Heikman, S., Derry, L.A., Stedinger, J.R., & Duncan, C.C., 2008. A simple predictive tool for lower Brahmaputra river basin monsoon flooding. *Earth Interactions, 21*(11), 1-11.
Kaplan, M., Renaud, F.G., & Lüchters, G., 2009. Vulnerability assessment and protective effects of coastal vegetation during the 2004 Tsunami in Sri Lanka. *Natural Hazards and Earth System* Sciences, 9, 1479-1494.
Kasperson, J. X &. Kasperson, R. E., (2001*). Summary of international workshop n vulnerability and global environmental change, (17-19 May 2001)*. Stockholm: Stockholm Environment Institute (SEI).
Katoch, A., 2007: Effective Response Reduces Risks. *Humanitarian Exchange Magazine, Issue 38*
Katz, R. & Brown, G.B., 1992: Extreme events in a changing climate: Variability is more important than averages. *Climatic Change, 21,* 289-302.
Kay, R. & Adler, J, 2005. *Coastal planning and management (*2[nd] Ed, *pp*. 380). New York: Routledge.

Kelly, P.M. & Adger, W.N., 2000. Theory and practice in assessing vulnerability to climate change and facilitating adaptation. *Climatic Change, 47,* 325-352.
Kesavan, P.C. & Swaminathan, M.S., 2006. Managing extreme natural disasters in coastal areas. *Philosophical transactions, R. Soc. A Mathematical, Physical and Engineering Sciences, 364* (1845) 2191-2216.
Keskitalo, E.C.H. &. Kulyasova, A.A, 2009. The role of governance in community adaptation to climate change. *Polar Research, 28*(1), 60-70.
Kiker, C.F., Milon, J.W., & Hodges, A.W., 2001. Adaptive learning for science-based policy: The everglades restoration. *Ecological Economics, 37*(3), 403-416.
Kirshen, P., 2007. *Adaptation options and costs in water supply* Report to the UNFCCC Secretariat, Financial and Technical Support Division. Bonn: UNFCC
Klein, R.J.T., Nicholls, R.J., Ragoonaden, S., Capobianco, M., Aston, J., & Buckley, E.N., 2001. Technological options for adaptation to climate change in coastal zones. *Journal of Coastal Research, 17*(3), 531-543.
Klein, R.J.T., Nicholls, R.J. & Thomalla, F., 2003. Resilience to natural hazards: how useful is this concept? *Global Environmental Change Part B: Environmental Hazards, 5(*1-2), 35-45.
Kok, M., Metz, B., Verhagen, J., & Van Rooijen, S., 2008. Integrating development and climate policies: National and international benefits. *Climate Policy,* 8(2), 103-118.
Kreps, G., 1992. Hazard management and emergency planning: Perspectives on Britain. In Parker, D. and Handmer, J., (Eds.), *Foundations and principles of emergency planning and Management* (pp. 159-174). London: James and James
Kundzewicz, Z.W., Radziejewski, M., Pinskwar, I., 2006. Precipitation extremes in the changing climate of Europe. *Climate Research, 31*, 51-58.
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*. London: Risk Books, 41-64
La Trobe, S. & Venton, P., 2003. *Natural disaster risk reduction: The policy and practice of selected institutional donors*. Teddington: Tearfund.
La Trobe, S. & Davis, I., 2005. *Mainstreaming disaster risk reduction: A tool for development organizations*. Teddington: Tearfund.
Ladson, A.R. & Argent, R.M., 2000. Adaptive management of environmental flows: Lessons for the Murray-Darling Basin from three large North American rivers. *Australian Journal of Water Resources, 5*(51), 89-101.
Lal, P. N. (2010). "Vulnerability to natural disasters: an economic analysis of the impact of the 2009 floods on the Fijian sugar belt." Pacific Economic Bulletin **25**(2): 62-77.
Larsen, K. & Gunnarsson-Östling, U., 2009. Climate change scenarios and citizen-participation: Mitigation and adaptation perspectives. In: Constructing sustainable futures. *Habitat International, 33*(3), 260-266.
Larsen, P.H., Goldsmith, S., Smith, O., Wilson, M.L, Strzepek, K., Chinowsky P., & Saylor, B., 2008. Estimating future costs for Alaska public infrastructure at risk from climate change. *Global Environmental Change,* 18(3), 442-457.
Laska, S., 2004. What if hurricane Ivan had not missed New Orleans? *Natural Hazards Observer, 29*(2), 5-6
Laska, S., 2008. What if hurricane Ivan had not missed New Orleans? *Sociological Inquiry, 78*(2), 174-178.
Laukkonen, J., Blanco, P.K., Lenhart, J., Keiner, M., Cavric, B., & Kinuthia-Njenga, C., 2009. Combining climate change adaptation and mitigation measures at the local level. *Habitat International, 33*(3), 287-292.
Lavell, A., 2003. *La gestión local Del riesgo*: *Nociones y precisiones en torno al concepto y la práctica*. Guatemala: CEPREDENAC – PNUD
Lavell, A., 2004. Mapping Vulnerability: Disasters, development, and people. In: *The lower Lempa River Valley, El Salvador: risk reduction project* [Bankoff, G., G. Frerks, And D. Hilhorst(Eds.) pp. 67-82]. London, Earthscan.
Lavell, A., Karremans, J., & Lima, P. 2009. *Local Disaster Risk Reduction: Lessons from the Andes*. Lima: Proyecto Predecan
Lavell, A., 1996. Environmental degradation, risks and urban disasters. In: *Issues and concepts: towards the definition of a research agenda (*pp. 19-19-58). Lima: La Red.
Lavell, A., 2009. Incorporando la gestiãn del riesgo de desastres en la inversiãn publica, Comunidad Andina, Lima.
Lavell, A., 2009. *Unpacking climate change adaptation and disaster management: Searching for the links and differences: A conceptual and epistemological critique and proposal*. Bogota: FLACSO.
Lavell, A. & Franco, E., 1996. *Estado, sociedad y gestiãn de loes desastres en america latina: en busqueda del paradigma perdido*. Bogota: La Red

Lee, K., 1993. Compass and gyroscope. Island Press, Covelo. California. USA

Lee, K.N., 1994. *Compass and gyroscope: Integrating science and politics for the environment*. Washington D.C.: Island Press.

Lemmen, D., Warren, F., Lacroix, J., Bush, E., 2008. *From impacts to adaptation: Canada in a changing climate 2007*. Natural Resources Canada. Ottawa: Government of Canada

Leslie, H.M. & Mcleod, K.L., 2007. Confronting the challenges of implementing marine ecosystem-based management. *Frontiers in Ecology and the Environment, 5*(10), 540-548.

Levy, M., Babu, S., Hamilton, K., Rhoe, V., Catenazzi, A., Chen, Reid, W.V., Sengupta, D., &Ximing, C., 2005. Ecosystems and human well-being: current state and trends: Findings of the condition and trends working group of the Millennium Ecosystem Assessment. In Hassan, R.M., Scholes, R., &. Ash, N. (Eds.), *Ecosystem conditions and human well-being* (pp. 123-164).Washington D.C.: Island Press.

Lewis, J. & Chisholm, M.P., 1996. Cyclone-resistant Domestic construction in Bangladesh. In: Hodgson, R.L.P., S.M. Seraj, J.R. Choudhury (Eds.), *Implementing proceedings of hazard-resistant housing, proceedings of the first international housing and hazards workshop to explore practical building for safety solutions*, 3–5 December 1996, Dhaka, Bangladesh.

Linnerooth-Bayer, J. & Amendola, A., 2000. Global change, catastrophic risk and loss spreading. *The Geneva Papers on Risk and Insurance, 25*(2), 203-219.

Linnerooth-Bayer, J. & Mechler, R., 2007. Disaster safety nets for developing countries: Extending public-private partnerships. *Environmental Hazards, 7*, 54-61.

Linnerooth-Bayer, J. & Mechler, R., 2006. Insurance for assisting adaptation to climate change in developing countries: A proposed strategy. *Climate Policy* 6 (6):621–636.

Linnerooth-Bayer, J., Mechler, R., &. Pflug, G, 2005. Refocusing disaster aid. *Science, 309(*5737), 1044-1046.

Lisø, K.R., Aandahl, G., Eriksen, S., & Alfsen, K., 2003. Preparing for climate change impacts in Norway's built environment. *Building Research & Information,* 31(3-4), 200-209.

Litman, T., 2008. Creating safe and healthy communities. *Environments: A Journal of Interdisciplinary Studies, 35*(3), 21-43.

Loewenson, R. & Whiteside, A., (2001, 25-27). *HIV/AIDS: Implication for poverty reduction* (United Nations Development Programme Policy Paper for the UN General Assembly special session on HIV/AIDS). New York: United Nations Development Programme (UNDP).

Longley, C. & Maxwell, D., 2003. Livelihoods, chronic conflict and humanitarian response: A review of current approaches. *Natural Resource Perspectives, 89*, 1-6.

Low, B., Ostrom, E., Simon, C., & Wilson, J., 2003. Navigating social-ecological systems: Building resilience for complexity and change. In Berkes, F., Colding, J., & Folke, C., (Eds.), *Redundancy and diversity: Do they influence optimal management? (*pp. 83-114). Cambridge: Cambridge University Press.

Lowe, R., 2003. Preparing the built environment for climate change. *Building Research and Information, 31*(3-4), 195-199.

Lugeri, N., Genovese, E., Lavalle, C., Barredo, J.I., Bindi, M., Moriondo,M., 2007. An assessment of weather-related risks in Europe. JRC IES EUR 23208 EN.

Luna, E.M., 2001. Disaster mitigation and preparedness: The case of NGOS in the Philippines. *Disasters, 25*(3), 216-226.

Luterbacher, U., 2004: Environmental change and its implications for population migration. In Unruh, J.D., Krol, M.S. & Kliot, N. (Eds.), *Migration, land use and climate change*. Berlin*:*Springer

Magor, J.I., Ceccato, P.C., Dobson, H.M., Pender, J., & Ritchie, L., 2007. Preparedness to prevent desert locust plagues in the Central Region. FAO EMPRES Central Region Program. Rome: Food and Agriculture Organization (FAO).

Mahul, O. & Ghesquiere, F., 2007. *Sovereign natural disaster insurance for developing countries: A paradigm shift in catastrophe risk financing* (Policy Research Working Paper 4345). Washington D.C.: World Bank.

Mahul, O. & Stutley, C., 2010. Government support to agricultural insurance: Challenges and options for developing countries. Washington D.C.: World Bank

Malhi, Y., Roberts, J.T., Betts, R.A., Killeen, T.J., Li, W., & Nobre, C.A., 2008. Climate change, deforestation and the fate of the Amazon. *Science, 319(*5860), 169-172.

Maréchal, K., 2007. The economics of climate change and the change of climate in economics. *Energy Policy, 35*(10), 5181- 5194.

Marulanda, Mabel C., Cardona, Omar D., & Barbat, Alex H., 2010. Revealing the socioeconomic impact of small disasters in Colombia using the Desinventar database. *Wiley-Blackwell , 34*(2), 552-570.
Maskrey, A., 1989. *Disaster mitigation: A Community Based Approach*. Oxford: Oxfam.
Maskrey, A., Buescher, G., Peduzzi, P., & Schaerpf, C., 2007. *Disaster risk reduction: 2007 Global Review*. Consultation edition prepared for the Global Platform for Disaster Risk Reduction first session, Geneva, Switzerland.
Maskrey, A., 1994. Viviendo en Riesgo: Comunidades vulnerables y prevención de desastres en América Latina. In: "Comunidad y Desastre en América Latina: Estrategias deIntervención in Lavell (Pp.25-56). Bogotá: FLACSO/La Red/ CEPREDENAC.
Maskrey, A., 1996: *Terremotos En El Tropico Humedo:La Gestion De Los Desastres Del Alto Mayo, Peru (1990-1991), Limon, Costa Rica (1991) Y Atrato Medio, Colombia (1992)*. Bogota: La Red
Maskrey, A., 2009. Disaster mitigation: A Community Based Approach, Oxfam Publications.
Matin, N. & Taher, M., 2001. The changing emphasis of disasters in Bangladesh NGOs. *Disasters, 25*(3), 227-239.
Mcbean, G.A., 2008. Role of prediction in sustainable development and disaster management. *Springer- Hexagon Series on Human and Environmental Security and Peace, 3*,929-938.
Mccarl, B.A., 2007. *Adaptation options for agriculture, forestry and fisheries* (A Report to the UNFCCC Secretariat Financial and Technical Support Division). Bonn: UNFCCC
Mccay, B.J., 2002: The drama of the commons. In Ostrom, E., Dietz, T.E., Dolsak, N.E., Stern, P.C., Stonich, S.E., & Weber, E.U., (Eds.), *Emergence of institutions for the commons: contexts, situations, and events* (Pp. 361-402). Washington D.C.: National Academy Press.
McDaniels, T., S. Chang, D. Cole, J. Mikawoz, and H. Longstaff. 2008. Fostering resilience to extreme events within infrastructure systems: characterizing decision contexts for mitigation and adaptation. *Global Environmental Change: Human and Policy Dimensions* **18**:310-318.
Mcentire, D.A., 2000. Sustainability or invulnerable development? Proposals for the current shift in paradigms. *Australian Journal of Emergency Management, 15*(1): Pp. 58-61.
Mcentire, D.A. & Myers,V, 2004. Preparing communities for disasters: Issues and processes for government readiness. *Disaster Prevention and Management, 13*(2), 140-152.
McGray, H., & Hammill, A., Bradley, R., Schipper, E.L., & Parry, J.E., 2007. *Weathering the storm: Options for framing adaptation and development* (p. 66). Washington, D.C.: World Resources Institute.
McKenzie, E., B. Prasad, et al. (2005). Economic Impact of Natural Disasters on Development in the Pacific Volume I. Suva, Fiji, SOPAC and USP.
Mclain, R.J. & Lee, R.G., 1996. Adaptive Management: Promises and pitfalls. *Environmental Management, 20*(4), 437-448.
Mcmichael, A.J., Campbell-Lendrum, D.H., Corvalán, C.F., Ebi, K.L., Githeko, A., Scheraga, J.D., & Woodward, A., 2003. *Climate change and human health: risks and responses* (p. 397). Geneva: World Health Organization (WHO).
Mechler, R. (2005). Cost-benefit analysis of natural disaster risk management in developing countries: A manual, GTZ.
Mechler, R., 2004. *Natural disaster risk management and financing disaster losses in developing countries*. Germany: Verlag Versicherungswirtsch.
Mechler, R., 2005. *Cost-benefit analysis of natural disaster risk management in developing countries*. Germany: Deutsche Gesellschaft Fur Technische Zusammenarbeit (GTZ).
Mechler, R., Hochrainer, S., Aaheim, A., Kundzewicz, Z., Lugeri, N., Moriondo, M., Salen, H., Bindi, M., Banaszak, I., Chorynski, A., Genovese, E., Kalirai, H., Linnerooth-Bayer, J., Lavalle, C., Mcevoy, D., Matczak, P., Radziejewski, M., Rübbelke, D., Schelhaas, M.-J., Szwed, M., Wreford,A., 2010: Making climate change work for us: European perspectives on adaptation and mitigation strategies. In M. Hulme, H.N. (Ed.), *A risk management approach for assessing adaptation to changing flood and drought risks in Europe* (pp. 200-229). Cambridge: Cambridge University Press
Mechler, R., & Weichselgartner, J., 2003. Disaster loss financing in Germany- The case of the Elbe River floods 2002 (Interim Report IR-03-021). Luxemburg: International Institute for Applied Systems Analysis (IIASA)
Meehl, G.A., Zwiers, F., Evans, J., Knutson, T., Mearns, L., & Whetton, P., 2000. Trends in extreme weather and climate events: Issues related to modeling extremes in projections of future climate change. *Bulletin of the American Meteorological Society, 81*(3), 427-436.

Meinke, H., Nelson, R., Kokic, P., Stone, R., Selvaraju, R., & Baethgen W., 2006. Actionable climate knowledge: From analysis to synthesis. *Climate Research, 33*(1), 101.
Mercer, J., 2010. Disaster Risk Reduction or climate change adaptation: Are we reinventing the wheel? *Journal of International Development, 22*(2), 247-264.
Merz, B. & A.H. Thieken (2004). Flood risk analysis: Concepts and challenges. *Österreichische Wasser- Und Abfallwirtschaft 56*(3-4): 27-34.
Millenium Ecosystem Assessment, 2005. *Ecosystems and human well-being: Synthesis*. Washington D.C.: Island Press
Mills, E., 2006. Testimony to the National Association of Insurance Commissioners. The Role of NAIC in responding to climate change. *UCLA Journal of Environmental Law and Policy, 26*(1), 129-168
Mills, E., 2005. Insurance in a climate of change. *Science, 309 (*5737), 1040-1044.
Mills, E., 2007; 2007: Synergisms Between Climate Change Mitigation And Adaptation: An Insurance Perspective. Mitigation and Adaptation Strategies for Global Change, 12(15), 809-842.
Milly, P. C. D., Betancourt, J., Falkenmark, M., Hirsch, R. M., Kundzewicz, Z. W., Lettenmaier, D. P., Stouffer,R.J., 2008. Stationarity is dead: Whither water management? *Science, 319*, 573-574.
Mirza, M.M.Q., Dixit, A., & Nishat, A., 2003. Special issue on flood problems and management in South Asia: Preface. *Natural Hazards, 28*(1), 85-99.
Mitchell, T and van Aalst,M (2008) Convergence of Disaster Risk Reduction and Climate Change Adaptation: A Review for DFID
Miyan, M.A., 2003. *Knowledge based area development*. Dhaka: International University of Business Agriculture and Technology (IUBAT).
Mizina, S.V., Smith J.B., Gossen E., Spiecker, K.F., Witkowski,S.L., 1999. An evaluation of adaptation options for climate change impacts on agriculture in Kazakhstan. *Mitigation and Adaptation Strategies for Global Change, 4,* (1), 25-41.
MMC (2005). Natural hazard mitigation saves: An independent study to assess the future savings from mitigation activities: Volume 2 Study Documentation. Washington, DC, Mutihazard Mitigation Council**:** 144.
Moench, M., R. Mechler, et al. (2007). Guidance note on the costs and beneftis of disaster risk reduction. A report prepared for ISDR High Level Platform on disaster risk reduction, June 4-7, 2007. Geneva, ISDR.
Möller, I., 2006. Quantifying saltmarsh vegetation and its effect on wave height dissipation: Results from a UK East Coast Saltmarsh. *Journal of Estuarine, Coastal and Shelf Science, 69(*3-4), 337-351.
Moritz, M.A. & Stephens, S.L. 2008. Fire and sustainability: Considerations for California's altered future climate. *Climatic Change, 87*, 265-271.
Mortimore, M.J. & Adams, W.M., 2001. Farmer adaptation, change and crisis in the Sahel. *Global Environmental Change, 11*(1), 49-57.
Moser, C. & D. Satterthwaite, 2008. *Towards pro-poor adaptation to climate change in the urban centers of low- and middle-income countries*. London: International Institute for Environment and Development (IIED).
MOSSP, Government of Kenya, (2010) DRAFT NATIONAL POLICY FOR DISASTER MANAGEMENT IN KENYA http://www.kecosce.org/downloads/DRAFT_DISASTER_MANAGEMENT_POLICY.pdf
MOSSP, Government of Kenya (2010) Presentation on 11-12 May 2010 by Abach W. Namaa, Assistant Secretary http://www.disasterriskreduction.net/fileadmin/user_upload/drought/docs/05%20DRR%20Framework%20Kenya%20MoSSP%20-%20NATIONAL%20POLICY%20ON%20DISASTER%20MANAGEMENT.pdf
Muller, M., 2007. Adapting to climate change: Water management for urban resilience. *Environment and Urbanization, 19*(1), 99-113.
Multihazard Mitigation Council (MMC), 2005: *Natural hazard mitigation saves: An independent study to assess the future savings from mitigation activities* (Volume 2-study documentation). Washington, D.C.: Multihazard Mitigation Council.
Munich Re, 2005. *Short Annual Report 2005: Paving the way for opportunities*. Germany: Munich Re Group.
Munich Re, 2010. Topics Geo natural catastrophes 2009: analyses, assessments, positions. Munich: Munich Re.
Murlidharan, T. L., Shah, H.C., 2001. *Catastrophes and macro-economic risk factors: An empirical study*. Conference On 'Integrated disaster risk management: Reducing socio-economic vulnerability'. Luxemburg: International Institute for Applied Systems Analysis (IIASA).
Murphy, James M., David M. H. Sexton, David N. Barnett, Gareth S. Jones, Mark J. Webb, Matthew Collins & David A. Stainforth 2004: Quantification of modelling uncertainties in a large ensemble of climate change simulations. NATURE, Nature, Vol 430. pp 768-772

Musgrave, R.A., 1959. *The theory of public finance*. New York: McGraw Hill.
Neufeldt, H., Wilkes, A., Zomer, R.J., Xu, J., Nang'ole, E., Munster, C., & Place, F., 2009. *Trees on farms: Tackling the triple challenges of mitigation, adaptation and food security* (Policy Brief 07). Kenya: World Agroforestry Centre.
Neumann, J., 2009. *Adaptation to climate change: Revisiting infrastructure norms* (p.12). Washington, D.C.: Resources for the Future.
Neumann, J.E. & Price, J.C., 2009. *Adapting to climate change: The public policy response: Public infrastructure* (Resources for the Future *Report)*. Washington D.C.: Resources for the Future.
Nicholls, R.J., 2007. *Adaptation options for coastal areas and infrastructure: An Analysis for 2030*. Report to the United Nations Framework Convention on Climate Change. Bonn: UNFCC.
Nicholls, R.J., Wong, P.P., Burkett, V., Codignotto, J., Hay, J., Mclean, R., Ragoonaden, S., & Woodroffe, C.D., 2007. *Climate change 2007: Impacts, adaptation, and vulnerability*. Contribution of Working Group II to the fourth Assessment Report of the Intergovernmental Panel on Climate Change. [Parry, M.L., Canziani, M.L., Palutikof, J.P., Van Der Linden, P., & Hanson, C.E., (Eds.)]. Cambridge: Cambridge University Press.
Nicholls, R.J., Wong, P.P., Burkett, V., Codignotto, J., Hay, J., Mclean, R., Ragoonaden, S., & Woodroffe, C.D., 2007. Climate change 2007: Impacts, adaptation, and vulnerability. Contribution of Working Group II to the fourth Assessment Report of the Intergovernmental Panel on Climate Change. In: Parry, M.L., Canziani, M.L., Palutikof, J.P., Van Der Linden, P., & Hanson, C.E. (Eds.), *Coastal Systems and Low-Lying Areas*. Cambridge: Cambridge University Press
Ninno, C. D., P. A. Dorosh, et al. (2003). "Public policy, markets and household coping strategies in Bangladesh; Avoiding a food security crisis following the 1998 floods." World Developmetn **31**(7): 1221-1238.
Noji, E.K., 1997. *The public health consequences of disasters*. USA: Oxford University Press.
Nordhaus, W.D. & Boyer, J., 2000. *Warming the world. economic models of global warming*. Cambridge, MA: MIT Press.
Nordhaus, W., 2006. The Economics of Hurricanes in the United States. Cambridge, MA: National Bureau of Economic Research.
Noy, I., 2009. The macroeconomic consequences of disasters. *Journal of Development Economics, 88*(2), 221-231.
Nyström, M. & Folke, C., 2001. Spatial resilience of coral reefs. *Ecosystems, 4*(5), 406-417.
O'brien, G., O'keefe, P., Rose, J., & Wisner, B., 2006. Climate change and disaster management. *Disasters, 30(*1), 64-80.
O'brien, K., Sygna,, L., Leichenko, R., Adger, W.N., Barnett, J., Mitchell, T., Schipper, L., Tanner, T., Vogel, C., & Mortreux, C., 2008. *Disaster Risk Reduction, climate change adaptation and human security (p*.76). Norway: University Of Oslo
OAS (1991). Primer on Natural Hazard Management in Integrated Regional Development Planning. . Washington DC, Organisation of American Studies.
Organization for Economic Cooperation and Development (OECD), 2009. *Policy guidance on integrating climate change adaptation into development Co-Operation*. Paris: OECD
Okuyama, Y. & Chang, S.E.L., 2004. *Modeling spatial and economic impacts of disasters*. Germany: Springer Verlag.
Okuyama, Y., 2009. *Critical review of methodologies on disaster impacts estimation*. Background paper for World Bank Report: Economics of Disaster Risk Reduction. Washington, D.C.: The World Bank.
Olsen, J.R., 2006. Climate change and floodplain management in the United States. *Climatic Change, 76*(3-4), 407-426.
Olsson, P. & Folke, C., 2001. Local ecological knowledge and institutional dynamics for ecosystem management: A Study of lake Racken watershed, Sweden. *Ecosystems,* 4(2), 85-104.
Organization of American States (OAS), 1991. *Primer on natural hazard management in integrated regional development planning*. Washington, D.C.: OAS
Ostrom, E., 1986. An agenda for the study of institutions. *Public Choice, 48*(1), 3-25.
Ostrom, E., 2005. *Understanding Institutional Diversity*. Princeton, N. J.: Princeton University Press.
Otero, R.C. & Marti, R.Z., 1995. *The impacts of natural disasters on developing economies: Implications for the international development and disaster community* (pp.11-40). Disaster prevention for sustainable development: economic and policy issues. Washington D.C.: The World Bank.
Otero, R. C. and R. Z. Marti (1995). The impacts of natural disasters on developing economies: Implications for the international development and disaster community. Disaster Prevention for Sustainable Development:

Economic and Policy Issues. . M. Munasinghe and C. Clarke. Washington DC, The International Bank for Reconstruction and Development/The World Bank: 11-40.
Owens, T., H. Hoddinott, et al. (2003). "Ex-Ante actions and ex-post public responses to drought shocks: Evidence and simualtions from Zimbabwe." World Development **31**(7): 1239-1255.
Oxfam America, 2008. Linking Disaster Risk Reduction and poverty: Good practices and lessons learnt. In International Strategy for Disaster Reduction (Ed.), *National Network for DRR helps Curb Poverty (*pp. 11-14). Geneva: International Strategy For Disaster Reduction (ISDR).
Oxfam (2007) Climate alarm: disasters increase as climate change bites, Oxfam Briefing Paper 108 Available at http://www.oxfam.org.uk/resources/policy/climate_change/downloads/bp108_weather_alert.pdf
Pã©Rez Albela, L., 2006: Incorporaciã³N Del Anã¡Lisis Del Riesgo En Los Procesos De Planificaciã³N E Inversiã³N Pãºblica En America Latina Y El Caribe, Comunidad Andina And Gtz, Lima,Peru .
Paavola, J., Adger, W.N., 2002. *Justice and adaptation to climate change* (Tyndall Centre for Climate Change Working Paper 23). Norwich: University of East Anglia
Pahl-Wostl, C., 2007. Transitions towards adaptive management of water facing climate and global change. *Water Resources Management, 21,* 49-62.
Palutikof, J.P., Agnew, M.D., & Hoar, M.R., 2004. Public perceptions of unusually warm weather in the UK: Impacts, responses and adaptations. *Climate Research, 26*(1), 43-59.
Pande, R. & Pande, R.K., 2007. Financial mechanism for the relief expenditure in India: Some Observations. *Disaster Prevention and Management, 16*(3), 353-360.
Parkes, M.W & Horwitz, P., 2009. Water, ecology and health: Ecosystems as settings for promoting health and sustainability. *Health Promotion International, 24*(1), 94.
Parmesan, C. & Yohe, G., 2003. A globally coherent fingerprint of climate change impacts across natural systems. *Nature, 421*(6918), 37-42.
Paton, D., Millar, M, & Johnston, D., 2001. Community resilience to volcanic hazard consequences. *Natural Hazards, 24*(2), 157-169.
Patz, J.A., Campbell-Lendrum, D., Holloway, T., & Foley, J.A., 2005. Impact of regional climate change on human health. *Nature, 438*(7066), 310-317.
Patz, J.A., Mcgeehin, M.A., Bernard, S.M., Ebi, K.L., Epstein, P.R., Grambsch, A., Gubler, D.J., Reither, P., Romieu, I., Rose, J.B., Samet, J.M., & Trtanj, J., 2000. The potential health impacts of climate variability and change for the United States: Executive Summary of the report of the health sector of the U.S. National Assessment. *Environmental Health Perspectives,* 108(4), 367-376.
Pelling, M., 2003. *The vulnerability of cities: natural disasters and social resilience*. London: Earthscan.
Pelling, M. & Wisner, B., 2009. Disaster Risk Reduction: Cases from urban Africa. In: *Urbanization and Disaster Risk Reduction in Africa* (pp. 3-3-68). London: Earthscan.
Pelling, M (ed) (2003) Natural disasters and development in a globalizing world, Routledge: London
Perez, R.T., Amadore, A., & Feir, R.B., 1999. Climate change impacts and responses in the Philippines coastal sector. *Climate Research, 12,* 97-107.
Phillips, C. & Marden, M., 2005. Landslide hazard and risk. In Glade, T., M. Anderson, & M.J. Crozier(Eds.), *Reforestation schemes to manage regional landslide risk* (pp. 517-548). Sussex: John Wiley and Sons Ltd.
Pielke Jr, R.A. & Rubiera, J., Landsea, C, Fernández, M.L., & Klein, R., 2003. Hurricane vulnerability in Latin America and the Caribbean: Normalized damage and loss potentials. *Natural Hazards Review, 4*, 101-114.
Pollner, J., 2000. Managing catastrophic risks using alternative risk financing & insurance pooling mechanisms. Washington DC, World Bank.
Pope, V.D., Gallani M.L., Rowntree. P.R. & tratton, R.A., 2000. The impact of new physical parameterisations in the Hadley Centre Climate Model: Hadam3. *Climate Dynamics, 16*, 123-146.
Prabhakar, S.V.R.K., Srinivasan, A., & Shaw, R., 2009. Climate change and local level Disaster Risk Reduction planning: Need, opportunities and challenges. *Mitigation and Adaptation Strategies for Global Change,* 14(1), 7-33.
Practical Action Bangladesh, 2008. Linking Disaster Risk Reduction and poverty: good practices and lessons learnt. In International Strategy for Disaster Reduction) (Ed.), *Risk reduction boosts livelihood security in disaster-prone District*. Geneva: International Strategy for Disaster Reduction (ISDR).
Priest, G.L., 1996. The government, the market, and the problem of catastrophic loss. *Journal of Risk and Uncertainty, 12*(2), 219-237.

Priest, G. (1996). "The government, the market, and the problem of catastrophic loss." *Journal of Risk and Uncertainty* 12: 219-237.

PROACT Network, 2008. *Environmental management, multiple Disaster Risk Reduction and climate change adaptation benefits for vulnerably communities*. Switzerland: PROACT Network.

Provention, 2009. Cities and resilience. In: *Climate policy brief from cities and resilience dialogue* September 28-29. 2009, Bangkok, Thailand.

Quarantelli, E.L., 1998. *Major criteria for judging disaster planning and managing their applicability in developing societies* (Disaster research center preliminary paper) USA: University Of Delaware,

Rahaman, M. & Varis, O., 2005. Integrated water resources management: Evolution, prospects and future challenges. *Sustainability: Science, Practice and Policy, 1*(1), 15-21.

Rahel, F.J. & Olden, J.D., 2008. Assessing the effects of climate change on aquatic invasive species. *Conservation Biology: The Journal of the Society for Conservation Biology, 22*(3), 521-533.

Ramalingam, B et al (2008) Exploring the science of complexity: ideas and implications for international development and humanitarian efforts, ODI Working Paper 285, ODI: London

Ramalingam, B et al, (2009) Innovations in International Humanitarian Action, London: ALNAP

Ramalingam, B and Barnett, M (2010) The Humanitarian's Dilemma, London: ODI

Reduction, R. And S. John, 2007: Humanitarian Practice Network (Hpn).

Reid, H. & Huq, & S., 2005. Tropical forests and adaptation to climate change: In search of synergies. In Robledo, C., Kanninen, M., & Pedroni, L. (Eds.), *Climate change - Biodiversity and livelihood impacts*. Indonesia: Center for International Forestry Research (CIFOR).

Revi, A., 2008. *Climate change risk: An adaptation and mitigation agenda for Indian cities*. London: International Institute for Environment and Development (IIED).

Ribeiro, M., Losenno, C., Dworak, T., Massey, E., Swart, R., Benzie, M. & Laaser, C., 2009. *Design of guidelines for the elaboration of regional climate change adaptations strategies* (Study for European Commission). Vienna: Ecologic Institute.

Robledo, C., Kanninen, M., & Pedroni, L. (Eds.), 2005. *Tropical forests and adaptation to climate change: In search of synergies (*pp. 186.). Indonesia: Center for International Forestry Research.

Roeth, Helen. 2009. The Development of a Public Partnership Framework and Action Plan for Disaster Risk Reduction in Asia. Bangkok: UNISDR.

Roling, N.G. And M.A.E. Wagemakers, 1998: *Facilitating sustainable agriculture: participatory learning and adaptive management in times of environmental uncertainty*. Cambridge University Press, Cambridge.

Rosenzweig, C. & Parry, M., 1994. Potential impact of climate change on world food supply. *Nature, 36*, 133- 138.

Rosenzweig, C., Major, D.C., Demong, K., Stanton, C., Horton, R., & Stults,V., 2007. Managing climate change risks in New York City's water system: Assessment and adaptation planning. *Mitigation and Adaptation Strategies for Global Change, 12*(8), 1391- 1409.

Rosenzweig, C. & Tubiello, F.N., 2007. Adaptation and mitigation strategies in agriculture: An analysis of potential synergies. *Mitigation and Adaptation Strategies for Global Change, 12*(5), 855-873.

Rossetto, T., 2007. *Construction design, building standards and site selection: Tools for mainstreaming Disaster Risk Reduction*. Geneva: Provention Consortium,

Roy, M., 2009. Planning for sustainable urbanization in fast growing cities: Mitigation and adaptation issues addressed in Dhaka, Bangladesh. *Habitat International, 33*(3), 276-286.

Så,Ota, H., 2000: Water Management In Poland. University Of Cracow, Institute Of Meteorology and Water Management, Cracow, Polland.

Sabatier, P.A., 1986. Top-down and bottom-up approaches to implementation research: A critical analysis and suggested synthesis. *Journal of Public Policy, 6*(1), 21-48.

Salter, J. (1998). Risk management in the emergency management context. Australian Journal of Emergency Management 13, 22-28.

Sanderson, I (2000) Cities, disasters and livelihoods, Environment and Urbanization October 2000 vol. 12 no. 2 93-102

Sarukhán, J. & Whyte, A., 2005. *Ecosystems and human well-being* (Synthesis report, Millennium Ecosystem Assessment). Geneva: World Health Organization

Satterthwaite, D., 2007. *Adaptation options for infrastructure in developing countries*. A report to the UNFCCC Financial and Technical Support Division. Bonn: UNFCC

Satterthwaite, D., Huq, S., Pelling, M., Reid, H., &. Lankao, P.R, 2007. *Adapting to climate change in urban areas*. London: International Institute for Environment and Development (IIED).
Satterthwaite, D., 2007. *The transition to a predominantly urban world and its underpinnings* (pp. 1-91). London: International Institute for Environment and Development (IIED).
Satterthwaite, D., 2009. *Getting land for housing; what strategies work for low-income groups? (*pp. 299-307). London: International Institute for Environment and Development (IIED).
Satterthwaite, D., Huq, S., Reid, H., Pelling, M., & Romero Lankao, P., 2009. *Adapting to climate change in urban areas: The possibilities and constraints in low- and middle-income nations (*pp. 3-3-47). London: Earthscan.
Save the Children (2007) Legacy of disasters: The impact of climate change on children, Save the Children Humanitarian Policy Brief, London
Scawthorn, C., Blais, H., Seligson, E., Tate, Miflin, E., Thomas, W., Murphy, J., Jones, C., 2006. HAZUS-MH flood loss estimation methodology I: Overview and flood hazard characterization. *Natural Hazards Review, 7* (2):60-71.
Scawthorn, C., Blais, H., Seligson, E., Tate, Miflin, E., Thomas, W., Murphy, J. & Jones.C., 2006. HAZUS-MH flood loss estimation methodology II. Damage and loss assessment. *Natural Hazards Review, 7* (2):72-81.
SCBD, 2009. *Connecting biodiversity and climate change mitigation and adaptation* (Report of the second ad hoc technical expert group on biodiversity and climate change p.126). Montreal: United Nations Convention on Biological Diversity (UNCBD).
Schär C, Vidale Pl, Lüthi D, Frei C, Häberli C, Liniger Ma, Appenzeller C. 2004. The role of increasing temperature variability in European summer heatwaves. *Nature 427*(6972), 332-336
Schick, A.and Polackova Brixi, H. (eds.), 2004. Government at Risk. World Bank and Oxford University Press, Washington DC.
Schwarze and Wagner, 2004. In the aftermath of Dresden: New directions in German flood insurance, *The Geneva Papers on Risk and Insurance* **29** (2) (2004), pp. 164–168.
Scoones, I., 1999. New ecology and the social sciences: What prospects for a fruitful engagement? *Annual Review of Anthropology, 28*(1), 479-507.
Scott, C. & Thompson, A., 2005. Measuring psychodermatological distress: The construction of the skin shame scale (SSS). *Psychology & Health, 20,* 242-242.
Secretariat of the Convention on Biological Diversity, 2009. *Connecting biodiversity and climate change mitigation and adaptation*. Report of the second ad hoc technical expert group on biodiversity and climate change. Montreal: United Nations Convention on Biological Diversity (UNCBD).
Seed, 2008. Linking Disaster Risk Reduction and poverty: Good practices and lessons learnt. In International Strategy for Disaster Reduction (Ed.), *Reducing risk in poor urban areas to protect shelters, hard-won assets and livelihoods* (pp. 20-22). Geneva: International Strategy For Disaster Reduction (ISDR).
Sen, A., 1999. *Development as freedom*., New York: Alfred Knopf
Seraj, S.M. & Ahmed, K.I., 2004. *Building safer houses in rural Bangladesh*. Bangladesh: University of Engineering & Technology, Pp. 244.
Shaw, R., Takeuchi, Y., & Rouhban, B., 2000. Landslides "Disaster Risk Reduction. In Sassa, K.A.C., Paolo (Ed.), *Education, capacity building and public awareness for disaster reduction* (pp. 499-515). Berlin: Springer-Verlag
Shepherd, G., 2004: *The Ecosystem approach: Five steps to implementation*. Gland: The World Conservation Union (IUCN).
Shepherd, G. (Ed.), 2008. *The Ecosystem approach: Learning from experience*. Gland: The World Conservation Union (IUCN)
Shugart, H., Sedjo, R., &. Sohngen, B, 2003. *Forests and global climate change: Potential impacts on U.S. forest resources (*p. 64.). Arlington: Pew Center on Global Climate Change
Sidle, R.C., Pearce, A.J., O'loughlin, C.L., & Union, A.G., 1985. *Hillslope stability and land use*. Washington, D.C.: American Geophysical Union.
Skees, J., Varangis, P., Larson, D.F., Siegel, P., 2005. Can financial markets be tapped to help poor people cope with weather risks? In Dercon, S. (Ed.) 2005. Insurance Against Poverty. Oxford: Oxford University Press.
Skidmore, M. and H. Toya (2002). "Do natural disasters promote long run growth?" Economic Inquiry **40**(4): 664-687.
Skoufias, E. (2003). "Economic crises and natural disasters: Coping strategies and policy implications." *World Development* 13(7): 1087-1102.

Slim, H (2006) 'Global welfare: A realistic expectation for the international humanitarian system?' in ALNAP, *ALNAP Review of Humanitarian Action: Evaluation Utilisation*. London: Overseas Development Institute. Available at: www.alnap.org/publications/RHA2005/rha05_Ch1.pdf

Smillie, I (2001), *Patronage or Partnership: Local capacity building in humanitarian crises,* Kumarian Press, Bloomfield

Smit, B., Burton, I., Klein, R.J.T., Street, R., 1999. The science of adaptation: A framework for assessment. *Mitigation and Adaptation Strategies for Global Change, 4*, 199-213.

Smit, B.,Pilifosova, O., Burton, I., Challenger, B., Huq, S., Klein, R., Yohe, G., 2001. Adaptation to climate change in the context of sustainable development and equity. Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change, McCarthy, J.J., Canziani, O.F., Leary, N.A., Dokken, D.J. and White, K.S. (Eds.), Cambridge University Press, Cambridge, 879-906

Smith, A., Stirling, A., & Berkhout, F., 2005. The governance of sustainable socio-technical transitions. *Research Policy, 34*(10), 1491-1510.

Smith, C.L., Lindley, S.J., Levermore, G.J., &. Lee, S.E, 2009. A GIS-based decision support tool for urban climate risk analysis and exploration of adaptation options, with respect to urban thermal environments. In: *proceedings of the seventh international conference on urban climate*, 29 June - 3 July 2009, Yokohama, Japan.

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M.,Miller, H.L. (Eds.) 2007. *Climate Change 2007: The Physical Science Basis. Contribution Of Working Group I To The Fourth Assessment Report Of The Intergovernmental Panel On Climate Change*. Cambridge: Cambridge University Press.

Songsore, J., 2009. Disaster Risk Reduction: cases from urban Africa. In: *Integrated disaster risk and environmental health monitoring: Greater Accra Metropolitan Area, Ghana* (pp.69-90). London: Earthscan

Sorensen J. 1997. National and international efforts at Integrated Coastal Management: Definitions, achievements, and lessons. Coastal Management 25: 3-41.

Sorooshian, S., Bales, R., Hartmann, H.C., & Pagano, T.C., 2002. Confidence builders: Evaluating seasonal climate forecasts from user perspectives. *Bulletin of the American Meteorological Society, 83*(5), 683-698.

Spence, R., 2004. Risk and regulation: Can improved government action reduce the impacts of natural disasters? *Building Research & Information*, 32(5), 391-402.

Sperling, F. & Zzekely, F., 2005. *Disaster risk management in a changing climate, vulnerability and adaptation*. Discussion paper prepared for the world conference on disaster reduction - reprint with addendum on conference outcomes. Washington, D.C.: Vulnerability and Adaptation Resource Group (VARG).

Spittlehouse, D.L. & Stewart, R.B., 2003. Adapting to climate change in forest management. *Journal of Ecosystems and Management, 4*, 7-17.

Stainforth, D.A., T. Aina, C. Christensen, M. Collins, N. Faull, D. J. Frame, J. A. Kettleborough, S. Knight, A. Martin, J. M. Murphy, C. Piani, D. Sexton, L. A. Smith, R. A. Spicer, A. J. Thorpe & M. R. Allen 2005: Uncertainty in predictions of the climate response to rising levels of greenhouse gases NATURE | VOL 433 | 27 JANUARY 2005.

Stankey, G.H., Clark, R.N., & Bormann, B.T., 2005. *Adaptive management of natural resources: Theory, concepts, and management institutions* (p.73). USA: U.S. Department Of Agriculture, Forest Service.

Stefanski, R & Sivakumar, M.V.K., 2009. Impacts of sand and dust storms on agriculture and potential agricultural applications of a SDSWS. IOP Conf. Series. *Earth and Environmental Science 7*, 012016.

Stern, N.H., 2006. *The Stern review: The economics of climate change*. Cambridge: Cambridge University Press.

Stevens, L., 2008. *Assessment of impacts of climate change on Australia's physical infrastructure* (pp. 53). Australia: Academy of Technological Sciences and Engineering (ATSE).

Stockle, C.O., Donatelli, M., Nelson,R., 2003. Cropsyst, a cropping systems simulation model. *European Journal for Agronomy, 18* (3), 289-307.

Stratus Consulting, 2003. The Economic Value of Current and Improved Weather Forecasts to US Households. Report prepared for NOAA.

Stringer, L.C., Dyer, J.C., Reed, M.S., Dougill, A.J., Twyman, C., & Mkwambisi, D., 2009. Adaptations to climate change, drought and desertification: Local insights to enhance policy in Southern Africa. *Environmental Science & Policy, 12*(7), 748-765.

Sudmeier-Rieux, K. & Ash, N., 2009. Environmental guidance note for Disaster Risk Reduction. Gland: International Union for Conservation of Nature (IUCN).

Sudmeier-Rieux, K., Masundire, H., Rizvi, A., & Rietbergen, S., 2006. *Ecosystems, livelihoods and disasters: an integrated approach to disaster risk management (p 58)*. Gland: International Union for Conservation of Nature (IUCN).

Sullivan, J., Parras, B., Marie, R.S., Subra, W., Petronella, S., Gorenstein, J., Fuchs-Young, R., Santa, R.K., Chavarria, A., Ward, J., & Diamond, P., 2009. Public talks and science listens: A community-based participatory approach to characterizing environmental health risk perceptions and assessing recovery needs in the wake of hurricanes Katrina and Rita. *Environmental Health Insights, 3,* 37-51.

Swart, R. & Raes, F., 2007. Making integration of adaptation and mitigation work: Mainstreaming into sustainable development policies. *Climate Policy, 7*(4), 288-303.

Swiss Development Cooperation (SDC), 2008. *Natural disaster risk management in Muminabad*. SDC Project Fact Sheet CARITAS. Switzerland: SDC

Swiss Development Cooperation (SDC), 2009: *SDC Guidelines on Disaster Risk Reduction*. Switzerland: University of Berne

SwissRe, 2000b. Storm over Europe. An underestimated risk. Zurich, Swiss Reinsurance Company.

Tarik-Ul-Islam, M. & Ferdousi, S., 2007. Renewable energy development – Challenges for Bangladesh. *Energy & Environment, 18*(3-4), 421-430.

Tearfund, 2008. Linking Disaster Risk Reduction and poverty: Good practices and lessons learnt. In: International Strategy for Disaster Reduction (Ed.), *Livelihood initiatives helps poor women build community resilience* (pp. 45-50). Geneva: International Strategy for Disaster Reduction.

Telford, J. and Cosgrave, J (2006) *Joint evaluation of the international response to the Indian Ocean tsunami: synthesis report,* Tsunami Evaluation Coalition

Thomalla, F., Cannon, T., Huq, S., Klein R.J.T, & Schaerer, C., 2006. *Mainstreaming adaptation to climate change in coastal Bangladesh by building civil society alliances*. Stockholm: Stockholm Environment Institute

Thomalla, F., Downing, T., Spanger-Siegfried, E., Han, G., & Rockstrom, J., 2006. Reducing hazard vulnerability: towards a common approach between Disaster Risk Reduction and climate adaptation. *Disasters 30*(1), 39-48.

Thomas, D.S.G. & Twyman, C., 2005. Equity and justice in climate change adaptation amongst natural-resource-dependent societies. *Global Environmental Change Part A, 15*(2), 115-124.

Thompson, M. & Gaviria, I., 2004. Weathering the storm: Lessons in risk reduction from Cuba. Boston, M.A.: Oxfam

Thorne, C., Evans, E., & Penning-Rowsell, E. (Eds.), 2006: *Future flooding and coastal erosion risks* (p. 350). London: Thomas Telford.

Tippett, J., Searle, B., Pahl-Wostl, C., & Rees, Y., 2005. Social learning in public participation in river basin management- early findings from HarmoniCOP European case studies. *Environmental Science & Policy, 8*(3), 287-299.

Tompkins, E.L., 2005. Planning for climate change in small islands: Insights from national hurricane preparedness in the Cayman Islands. *Global Environmental Change Part A, 15*(2), 139-149.

Tompkins, E.L., Lemos, M.C., & Boyd, E., 2008. A less disastrous disaster: Managing response to climate-driven hazards in the Cayman Islands and NE Brazil. *Global Environmental Change, 18*, 736-745.

Tschoegl, L., 2006. "An Analytical Review of Selected Data Sets on Natural Disasters and Impacts." UNDP/CRED Working PaperPrettenthaler et al., 2004;

Tsing, A.L., Brosius, J.P., & Zerner, C., 1999. Assessing community-based natural-resource management. *Ambio,* 28(2), 197-198.

Turner, B.L., Kasperson, R., Matson, P., Mccarthy, J.J., Corell, R., Christensen, L., Eckley, N., Kasperson, J., Luers, A., Martello, M., Polsky, C., Pulsipher, A., Schiller, A., 2003. A framework for vulnerability analysis in sustainability science. *PNAS, 100*, 8074-8079.

Twigg, J., 2004. *Disaster Risk Reduction: mitigation and preparedness in development and emergency programming* (p 3650). London: London: Humanitarian Practice Network, Overseas Development Institute.

UNBconnect, 2009. *Climate change adaptation project targeting vulnerable people in 5 coastal districts* . Bangladesh: UNBconnect.

United Nations Development Programme (UNDP), 1999. *The Human Development Report*. CD-ROM, statistical data base, human development and climate change, the encyclopedia of earth. New York: UNDP.

United Nations Development Programme (UNDP), 2002. A Climate risk management approach to disaster reduction and adaptation to climate change. In: *Proceedings of UNDP expert group meeting*, June 19 - 21, 2002, Havana, Cuba.

United Nations Development Programme (UNDP), 2004. *Reducing disaster risk: A challenge for development* (p. 146). New York: UNDP.
United Nations Development Programme UNDP (2004). *Reducing disaster risk: A challenge for development*. New York: UNDP.
UNDP & WHO, 2009. *The energy access situation in developing countries, a review focusing on the least developed countries and Sub-Saharan Africa*. New York: UNDP.
United Nations Environment Programme (UNEP), 2006. *In the front line: Shoreline protection and other ecosystem services from mangroves and coral reefs*. Geneva: UNEP.
United Nations Environment Programme (UNEP), 2009. *Global green new deal: Policy brief*. Nairobi: Division of Early Warning and Assessment, UNEP.
United Nations Environment Programme (UNEP), 2009. *The role of ecosystem management in climate change adaptation and Disaster Risk Reduction*. Issues paper prepared for the global platform for Disaster Risk Reduction. Geneva: UNEP.
UNESCAP (2009) Case Study: The National Disaster Management System Of China And Its Response To The Wenchuan Earthquake Http://Www.Unescap.Org/Idd/Events/Cdrr-2009/Cdr_2e.Pdf
United Nations Framework Convention on Climate Change (UNFCCC), 2006. *Application of environmentally sound technologies for adaptation to climate change*. Bonn: UNFCCC
United Nations Framework Convention on Climate Change (UNFCCC), 2006. *Technologies for adaptation to climate change*. Adaptation, technology and science programme of the UNFCCC. Bonn: UNFCCC.
United Nations Framework Convention on Climate Change (UNFCCC), 2008. *Disaster Risk Reduction strategies and risk management practices: Critical elements for adaptation to climate change*. Bonn: UNFCCC.
United Nations Framework Convention on Climate Change (UNFCCC), 2008. *Integrating practices, tools and systems for climate risk assessment and management and strategies for disaster risk reduction into national policies and programmes*. Bonn: UNFCCC.
United Nations Framework Convention on Climate Change (UNFCCC), 2009. *Advance report on recommendations on future financing options for enhancing the development, deployment, diffusion and transfer of technologies under the convention* (With a note by the Chair of the Expert Group on Technology Transfer). Bonn: UNFCCC.
United Nations Framework Convention on Climate Change (UNFCCC), 2009. *Potential costs and benefits of adaptation options: a review of existing literature* (Technical Paper). Bonn: UNFCC
UNISDR, 2008. Private Sector Activities in Disaster Risk Reduction. Good Practices and Lessons Learned. United Nations
UNISDR (2005) *Hyogo Framework for Action 2005-2015,* Building the resilience of nations and communities to disasters, International Strategy for Disaster Reduction
UNISDR (2009) Giving Risk Reduction a Regional Dimension http://www.preventionweb.net/files/9923_GFDRRTrack1GivingRiskReductionaRegi.pdf
Uribe, A., Sakai, S., Cuervo, J., Franklin, H., Girot, P., Mora-Castro, S., Ferraté, L., Perez, I., Clark, C., & Bender, S., 1999. *Reducing vulnerability to natural hazards: Lessons learned from hurricane Mitch*. A strategy paper on environmental management presented at the Inter-American Development Bank consultative group meeting for the reconstruction and transformation of Central America. Stockholm: Inter-American Development Bank.
Urwin, K. & Jordan, A., 2008. Does public policy support or undermine climate change adaptation? Exploring policy interplay across different scales of governance. *Global Environmental Change, 18*(1), 180-191.
Van Aalst, M., 2009: Climate sense. In World Meteorological Organization (Ed.), *Early warning, early action*. Geneva: World Meteorological Organization (WMO).
Van Aalst, M.K., Cannon, T., & Burton, I., 2008. Community level adaptation to climate change: The Potential role of participatory community risk assessment. *Global Environmental Change, 18*(1), 165-179.
Vanbuskirk, R., 2006. Analysis of long-range clean energy investment scenarios for Eritrea, East Africa. *Energy Policy,* 34(14), 1807 -1817.
Varangis, P., Skees, J.R., Barnett, B.J., 2002. Weather Indexes for Developing Countries. in B. Dischel (Ed.). *Climate Risk and the Weather Market*, Risk books, London, 279-294.
World Bank/United Nations, 2010. Natural Hazards, UnNatural Disasters. The Economics of Effective Prevention. Washington DC: World Bank.
Vargas, J., 2002. Políticas públicas *para la reducción de la vulnerabilidad frente a los desastres naturals* (Pp. 48). Santiago De Chile.

Venter, O., Laurance, W.F., Iwamura, T., Wilson, K.A, Fuller, R.A., & Possingham, H.P., 2009. Harnessing carbon payments to protect biodiversity. *Science, 326(*5958), 1368.
Venton, P. and LaTrobe, S. (2008). Linking climate change adaptation and disaster risk reduction. Tweddington, UK, Teafund.
Venton, P and La Trobe, S (2008) *Linking Climate Change Adaptation and Disaster Risk Reduction*, Tearfund Report, Tearfund: London http://www.tearfund.org/webdocs/Website/Campaigning/CCA_and_DRR_web.pdf
Vetter, S., 2009. Drought, change and resilience in South Africa's arid and semi-arid rangelands. *South African Journal of Science, 105(*1-2), 29-33.
Vignola, R., Locatelli, B., Martinez, C. & Imbach, P., 2009. Ecosystem-based adaptation to climate change: What role for policy-makers, society and scientists? *Mitigation and Adaptation Strategies for Global Change,* 8(14), 691-696.
Vogel, C., 2009. Business and climate change: Initial explorations in South Africa *Climate and Development, 1*(1), 82 - 97.
Von Boemcken, M. & Krieger, N., 2006. Early Warning-Early Action.
Von Hesse, M. And D.L. Torre, 2009: *Reducción del Riesgo Ámbito Local: Lecciones desde la de Desastres en el Subregión Andina* (pp5-84). Lima: Comunidad Andina.
Walker, B., Carpenter, S., Anderes, J., Abel, N., Cumming, G., Jansen, M., Lebel, L., Norberg, J., Perereson, G, Pichard, R., 2002. Resilience management in social-ecological systems: A working hypothesis for a participatory approach. *Conservation Ecology, 6*(1), 14.
Wall E., S., B., 2005. Climate Change adaptation in light of sustainable agriculture. *Journal of Sustainable Agriculture, 27*(1), 113-123.
Walters, C., 1986. *Adaptive management of renewable resources*. New York: Macmillan.
Walters, C., 1997. Challenges in adaptive management of Riparian and coastal ecosystems. *Conservation Ecology, 2*(1), 1.
Walters, C.J. & Hilborn, R., 1978. Ecological optimization and adaptive management. *Annual Review of Ecology and Systematic, 9*(1), 157-188.
Warmsler, C., 2004. Managing urban risk: Perceptions of housing and planning as a tool for reducing disaster risk. *Global Built Environment Review ,4* (2), 11-28.
Warner, K., Ranger, N., Surminski, S., Arnold, M., Linnnerooth-Bayer, J., Michel-Kerjan, E., Kovacs, P., & Herweijer, C., 2009. *Adaptation to climate change: Linking Disaster Risk Reduction and insurance* (p. 18). Geneva: International Strategy for Disaster Reduction Secretariat (ISDR).
Wastell, D.G., 2006. Information systems and evidence-based policy in multi-agency networks: The micro-politics of situated innovation. *The Journal of Strategic Information Systems, 15*(3), 197-217.
Watkins, K., 2008. *Fighting climate change, human solidarity in a divided world*. Human Development Report 2007/2008. New York: United Nations Development Programme.
Watkins, K., Fu, H., Fuentes, R., Ghosh, A., Giamberardini, C., Johansson, C., Kuonqui, C., Montes, A., Stewart, D., &. Ugaz, C, 2005. *International cooperation at a crossroads: Aid, trade and security in an unequal world*. Human Development Report 2005. New York: United Nations Development Programme (UNDP).
Webster, M., Ginnetti, J., Walker, P., Coppard, D., & Kent R., 2008. The humanitarian costs of climate change. Medford: Feinstein International Center.
Webster, M., Ginnetti, J, Walker, P., Coppard, D., & Kent, R., 2009. The humanitarian costs of climate change. *Environmental Hazards, 2*(8), 149-163.
Weih, M., 2004. Intensive short rotation forestry in boreal climates: Present and future perspectives. *Canadian Journal of Forest Research, 34(*1369), 1378.
West, J., 2007. Workshop on climate change, humanitarian disasters and international development: *Linking vulnerability, risk reduction and response capacity*. In: Proceedings of CICERO, GECHS and University Of Oslo, 27 April 2007, Oslo, Norway.
White, P., Pelling M., Sen, K., Seddon, D., Russell, S. & Few, R., 2004. *Disaster Risk Reduction: A development concern. A scoping study on links between disaster risk reduction, poverty and development* (p. 74). United Kingdom: Department for International Development (DFID).
Wilby, R.L., 2007. A review of climate change impacts on the built environment. *Built Environment, 33*(1), 31-45.
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 the UK Department for International Development). UK: DFFID.

Wilby, R.L. &. Dessai, S, 2010. Robust adaptation to climate change. *Weather, 65*(7), 180-185.
Wilby, R.L., Troni, J., Biot, Y., Tedd, L., Hewitson, B.C., Smith, D.M. & Sutton, R.T., 2009. A review of climate risk information for adaptation and development planning. *International Journal of Climatology, 29*(9), 1193-1215.
Wilches-Chaux, G., 1993. Los Desastres No Son Naturales. In: *La Vulnerabilidad Global* (pp. 9-50). Bogota: Tercer Mundo Editores.
Wilches-Chaux, G., 2007. *ENSO What? La Red guide to getting radical with ENSO Risks*. Bogota: ARFO Editores.
Wiley, L. And L. Gostin, 2009. The international response to climate change: An agenda for global health. Georgetown Law Faculty Publications research Paper No. 1489524, *302 J. Am. Med. Assn. 1218*.
Walker, P. Wisner, B., Leaning,J and Minnear, L (2005) 'Smoke and mirrors: deficiencies in disaster funding', *British Medical Journal Volume* 330, Volume 330, Number 7485 29 January 2005.
Wisner, B. and Adams, J., eds. (2003) *Environment Health in Emergencies and Disasters*. Geneva: WHO (for WHO/ IFRC/ UNHCR), 2003, http://www.who.int/water_sanitation_health/hygiene/emergencies/emergencies2002/en/
Wisner, B., Blaikie, P., Cannon, T., Davis, I. (2004) *At Risk: Natural Hazards, People's Vulnerability and Disasters*, 2nd Edition, Routledge, London.
Wisner, B., Blaikie, P., Cannon, T., and Davis, I., 2004. *At risk: natural hazards, people's vulnerability and disasters* (2nd Ed). London: Routledge.
Wisner, B. & Adams, J., 2003. *Environmental health in emergencies and disasters: A practical guide*. Geneva: World Health Organization.
Wood, A.P. & Van Halsema, G.E., 2008. *Scoping agriculture, wetland interactions: Towards a sustainable multiple-response strategy* (FAO Water Reports) Rome: Food and Agriculture Organization.
World Bank, 2009. *Convenient solutions to an inconvenient truth: Ecosystem-based approaches to climate change*. Washington D.C.: The World Bank
World Bank, 1996. *Argentina flood protection project* (Staff Appraisal Report 15354). Washington DC: World Bank.
World Bank, 2000. *Cities, seas and storms: Managing change in Pacific Island Economies*. Washington DC: World Bank.
World Bank, 2001. *A revised forest strategy for the World Bank group*. Washington DC: World Bank.
World Bank, 2003. *Protecting new health facilities from natural disasters: Guidelines for the promotion of disaster mitigation*. Washington D.C.: World Bank.
World Bank, 2004. *Grenada, hurricane Ivan: preliminary assessment of damages*. Washington D.C.: World Bank.
World Bank 2004. *Natural disasters: Counting the cost*. Washington, DC: The World Bank
World Bank, 2005. *Managing agricultural production risk*. Washington DC: World Bank.
World Bank, 2006. *Hazards of nature, risks to development*: *An IEG evaluation of World Bank assistance for natural disasters*. World Bank Independent Evaluation Group. Washington D.C.: World Bank.
World Bank, 2006. *Not if but when: Adapting to natural hazards in the Pacific Islands Region*. Sydney: World Bank.
World Bank, 2007. The *Caribbean Catastrophe Risk Insurance Initiative*. Results of preparation work on the design of a Caribbean Catastrophe Risk Insurance Facility. Washington D.C.: World Bank.
World Bank, 2008. *The economics of adaptation to climate change: methodology report*. Washington D.C.: World Bank.
World Bank, 2008. *World Development Report; agriculture for development*. Washington D.C.: World Bank.
World Bank, 2009. *Global economic prospects 2009.Commodities at the crossroads*. Washington D.C.: World Bank.
World Bank, 2010. *Mainstreaming Adaptation to climate change in agriculture and natural resources management projects*. Washington D.C.: World Bank.
World Health Organization (WHO), 2003. *Climate change and human health - risks and responses: summary*. Geneva: WHO
World Health Organization (WHO), 2005. *Health and climate change: the "now and how": a policy action guide*. Copenhagen: WHO Regional Office for Europe.
World Health Organization (WHO), 2008. *Protecting health from climate change: global research priorities*. Geneva: WHO

World Health Organization (WHO), 2008. *Improving public health responses to extreme weather / Heat-Waves - Euroheat*. . Copenhagen: WHO Regional Office for Europe.

World Health Organization (WHO), 2005. *Health and climate change: The "now and how*". (A Policy Action Guide). Copenhagen: WHO Regional Office for Europe.

World Meteorological Organization (WMO), 2009. *Progress report on the implementation of the global observing system for climate in support of the* UNFCCC 2004-2008, GCOS Secretariat. Geneva: WMO

World Meteorological Organization (WMO), 2004. *Report of the expert meeting on meteorological information for locust control, 18-20 October 2004*. Geneva: WMO

World Meteorological Organization (WMO), 2007: WMO Press Release 781. In: *WMO to provide guidance for heat health warning system*. Geneva: WMO

World Vision, 2008. Linking Disaster Risk Reduction and poverty: Good practices and lessons learnt. In: *Reducing vulnerabilities and poverty through disaster mitigation* (pp. 15-19). International Strategy for Disaster Reduction (Ed.). Geneva: International Strategy for Disaster Reduction (ISDR).

World Water Assessment Programme (WWAP), 2009. *Water in a changing world*. The United Nations world water development report. Paris*:* UNESCO / London: Earthscan.

World Water Council (WWC), 2009. *Water Supply and Sanitation*. France: WWC

WSSD, 2002. *Report of the World Summit on Sustainable Development*.

Yamin, F., Rahman, A. & Huq, S., 2005. Vulnerability, adaptation and climate disasters: A conceptual overview. *IDS Bulletin, 36*(4), 1-14.

Yanagisawa, H., Koshimura, S., Goto, K., Miyagi, T., Imamura, F., Ruangrassamee, A., & Tanavud, C., 2009. The reduction effects of mangrove forest on a Tsunami based on field surveys at Pakarang Cape, Thailand and numerical analysis. *Estuarine, Coastal and Shelf Science, 81*(1), 27-37.

Yodmani, S., 2001. Disaster risk management and vulnerability reduction: Protecting the poor. In: *Proceedings of Asia and Pacific Forum on Poverty,* 5–9 February 2001, Manila, Philippines.

Yodmani, S. (2001). Disaster risk management and vulnerability reduction: Protecting the poor. *Asia and Pacific Forum on Poverty: Reforming policies and institutions for poverty reduction*. 5-9 February, Manila, Philippines

Young, G., Zavala, H., Wandel, J., Smit, B., Salas, S., Jimenez, E., Fiebig, M., Espinoza, R., Diaz, H., and Cepeda, J., 2010. Vulnerability and adaptation in a dryland community of the Elqui Valley, Chile. *Climatic Change, 98*(1), 245-276.

Younger, M., Morrow-Almeida, H.R., Vindigni, S.M., & Dannenberg, A.L., 2008. The built environment, climate change, and health: Opportunities for co-benefits. *American Journal of Preventive Medicine, 35*(5), 517-526.

Table 6-1: National policies, plans, and programs: selection of disaster risk management and adaptation options.

Sector/ Response	**Manage residual risks**	**Transfer of risks**	**"No regrets" or climate proof actions**	**Preparing for climate change by reducing uncertainties** ***('No regrets' options plus…)***	**Reduce future climate change risks** ***("Reducing uncertainties" options plus...)***	**'Win-win' for GHG reduction, adaptation, risk reduction and development benefits**
Natural Ecosystems and Forestry	▪ Replace lost ecosystem services through additional hard engineering, health measures [6] ▪ Restore loss of damaged ecosystems [6] ▪ Reduce forest harvesting and provide incentives for alternate livelihoods [6]	▪ Micro-funding and insurance to compensate for lost livelihoods [5] ▪ Investments in additional insurance, government reserve funds for increased risks due to loss of protective ecosystem services [5]	▪ Use of Ecosystem-based Adaptation (EbA) or "soft engineering"; Financial recognition of EbA; Integrate DRR and climate into Integrated Coastal Zone and Water Resources Management; forest, land-use Management; Conserve, enhance resilience of ecosystems; restore protective ecosystem services [1] ▪ Adaptive forest management Forest fire management, controlled burns; Agroforestry; biodiversity [2]	▪ Synergies between UNFCCC and Rio Conventions (e.g. UN CBD); avoid perverse incentives in conventions [3] ▪ Research on climate change-ecosystem-forest links; climate and ecosystem prediction systems, climate change projections; Monitor ecosystem and climate trends [3] ▪ Incorporate ecosystem management into NAPAs and DRR plans [3]	▪ CCA interventions to maintain ecosystem resilience; corridors, assisted migrations; Plan EbA for climate change [4] ▪ Seed, genetic banks; new genetics; tree species improvements to maintain ecosystem services in future [4] ▪ Changed timber harvest management, new technologies, new uses to conserve forest ecosystem services [4]	▪ Afforestation reforestation, conservation of forests, wetlands and peatlands, increased biomass; LULUCF; REDD [7] ▪ Incentives, Sequestration of carbon; sustainable bio-energy; energy self – sufficiency[7]
Agriculture and Food Security	▪ Changed livelihoods and relocations in regions with climate sensitive practices [12]	▪ Improved access to crop, livestock and income loss insurance, (e.g. weather	▪ Food security via sustainable land and water management, training; Efficient water use, storage; Agro-forestry; Protection shelters,	▪ Increased agriculture-climate research and development [10] ▪ Research on climate tolerant crops, livestock; Agrobiodiversity for	▪ Adaptive agricultural practices for new climates, extremes [12] ▪ New and enhanced agricultural weather, climate prediction services [11]	▪ Energy efficient and carbon sequestering practices; Training; Reduced use of chemical

	▪ Emergency stock and improved distribution of food and water [12]	derivatives) [13] ▪ Micro-funding and micro-insurance [13] ▪ Subsidies, tax credits [13]	crop and livestock diversification; Improved supply of climate stress tolerant seeds; Integrated pest, disease management [8] ▪ Climate monitoring; Improved weather predictions; Disaster management, crop yield and distribution models and predictions [9]	genetics [10] ▪ Integration of climate change scenarios into national agronomic assessments [11] ▪ Diversification of rural economies for sensitive agricultural practices [10]	▪ Food emergency planning; Distribution and infrastructure networks [12] ▪ Diversify rural economies [12]	fertilizers [14] ▪ Promote Bio-gas from agri-waste and animal excreta[14] ▪ Agroforestry [14]
Coastal Zone and Fisheries	▪ Enhance emergency preparedness measures for changed extremes, including evacuations [16] ▪ Relocations of communities, infrastructure [16] ▪ Exit fishing; alternate livelihoods [19]	▪ Enhance insurance for coastal regions and resources; Fisheries insurance [21] ▪ Government reserve funds [21]	▪ EbA; Integrated Coastal Zone Management ICZM; Combat salinity; alternate drinking water availability; soft and hard engineering [15] ▪ Strengthen institutional, regulatory and legal instruments; Setbacks [16] ▪ Marine Protected Areas, monitoring fish stocks, alter catch quantities, effort, timing; Salt-tolerant fish species [17] ▪ Climate risk reduction planning; Hazard delineation; Improve weather forecasts, warnings, environmental prediction [16]	▪ CC projections for coastal management planning; Develop modelling capacity for coastal zone-climate links; Climate-linked ecological and resource predictions; Improved monitoring, geographic and other databases for coastal management [18] ▪ Monitor fisheries; Selective breeding for aquaculture, fish genetic stocks; research on saline tolerant crop varieties [19]	▪ Incorporate CCA, sea-level rise into ICZM, coastal defences; [18] ▪ Hard and “soft” engineering for CCA; Resilient vessels and coastal facilities [16] ▪ Manage for changed fisheries, invasives [19] ▪ Inland lakes: Alter transportation and industrial practices, Soft and hard engineering [20]	▪ Promote renewable energy; conservation, energy self-sufficiency (especially for offshore islands, coastal regions) [22] ▪ Offshore renewable energy for alternate incomes and aquaculture habitat [22]

Water resources	▪ National preparedness and evacuation plans [24] ▪ Enhanced health infrastructure [24] ▪ Transport, engineering; temporary consumable water taking permits [24] ▪ Food , water distribution, alternate livelihoods [24]	▪ Public-private partnerships; Economics for water allocations beyond basic needs [26] ▪ Mobilize financial resources and capacity for technology and EbA [26] ▪ Insurance for infrastructure	▪ Implement Integrated Water Resource Management (IWRM), national water efficiency, storage plans [23] ▪ Effective surveillance, prediction, warning and emergency response systems; Better disease and vector control, detection and prediction systems; better sanitation; Awareness and training on public health [24] ▪ Adequate funding, capacity for resilient water infrastructure and water resource management; Improved institutional arrangements, negotiations for water allocations [23]	▪ Develop prediction, climate projection and early warning systems for flood events and low water flow conditions; Research and downscaling for hydrological basins [24] ▪ Multi-sectoral planning for water; Selective decentralization of water resource management (e.g. catchments and river basins); joint river basin management (e.g. bi-national) [23]	▪ National water policy frameworks, IWRM incorporate CCA [25] ▪ Investments in hard and soft infrastructure considering changed climate; river restoration [25] ▪ Improved weather, climate, hydrology-hydraulics, water quality forecasts for new conditions [24]	▪ Integrated water efficiency and renewable hydro power for CCA [23]
Infra-structure, Housing, Cities, Transport-ation, energy	▪ Relocation [28] ▪ Evacuation planning; Contingency plan for transport during extreme events [28] ▪ Climate	▪ Infrastructure insurance and financial risk management [29] ▪ Insurance for energy facilities, interruption [29]	▪ Building codes, standards with updated climatic values; Climate resilient infrastructure (and energy) designs; Training, capacity, inspection,	▪ Improved downscaling of CC information; Maintain climate data networks, update climatic design information; Increased safety/uncertainty factors in codes and standards; Develop	▪ Codes, standards for changed extremes; [30] ▪ Publicly funded infrastructure and post-disaster reconstruction to include CCA [30] ▪ New materials, engineering approaches; Flexible	▪ Implement energy and water efficient GHG reductions, DRR and adaptation synergies [29] ▪ Scale up, market penetration for renewable energy

	resilient shelter construction [28] ▪ Promote energy security; Distributed energy generation and distribution [29]	▪ Innovative risk sharing instruments [29] ▪ Government reserve funds [29]	enforcement; Monitoring for priority retrofits (e.g. permafrost) [27] ▪ Legal alternatives to shanty settlements, sanitation [27] ▪ Strengthen early warning systems, hazard awareness; Improved weather warning systems; Disaster resilient building components (rooms) in high risk areas; heat-health responses [28] ▪ Integrate urban planning, engineering, maintenance [27] ▪ Redundant, diversified energy systems; Maintenance; Self-sufficiency, clean energy technologies for national energy plans, MEA goals (bio-gas, solar cooker); Promote renewable energy in remote and vulnerable regions; Promote appropriate energy mixes nationally [29]	CCA tools [28] ▪ Research on climate, energy and built environment interface, including flexible designs, redundancy; Forensic studies of failures (adaptation learning), Improved maintenance [27] ▪ Investments for sustainable energy development; Cooperation on trans-boundary energy supplies (e.g. wind energy at times of peak wind velocity) [29]	use structures; Asset management [30] ▪ Hazard mapping; Zoning and avoidance; Prioritized retrofits, abandon the most vulnerable; Soft engineering services [30] ▪ Design energy generation, distribution systems for CCA; Switch to less risky energy systems, mixes; Embedd sustainable energy in DRR and CCA planning [29]	production; Increased hydroelectric potential; Sustainable biomass; “Greener” distributed community energy systems [29]
Health	▪ National plan for heat and extremes	▪ Extend and expand health insurance	▪ Community/urban planning, building standards and	▪ Research on climate-health linkages and CCA options; Develop	▪ New food and water security, distribution systems; air quality	▪ Promote use of clean renewable energy and water

	emergencies; New disease detection and management systems; Better land and water use management to reduce health risks; Enhanced prediction and warning systems for new risks [32]	coverage to include new and changed weather and climate risks [33] ▪ Government reserve funds [33] ▪	guidelines; cooling shelters; safe health facilities; Retrofits for vulnerable structures; Health facilities designed using updated climate information [31] ▪ Strengthen surveillance, health preparedness; Early warning weather-climate-health systems, heat alerts and responses; Capacity for response to early warnings; Prioritize disaster risks; Disaster prevention and preparedness; Public education campaigns; Food security [31] ▪ Strengthen disease surveillance and controls; Improve health care services, personal health protection; Improve water treatment/sanitation; Water quality regulations; Vaccinations, drugs, repellants; Development of rapid diagnostic tests [31] ▪ Monitor air and water quality; regulations; urban planning [31]	new health prediction systems for emerging risks; Research on landscape changes, new diseases and climate; Urban weather-health modelling [31] ▪ Education, Disaster prevention and preparedness [31]	regulations, alternate fuels [32] ▪ New warning and response systems; Predict and manage health risks from landscape changes; Target services for most at risk populations [32] ▪ Climate proofing, refurbish/ maintain national health facilities and services; Address needs for additional health facilities and services; Design for climate change; Alternate energy for improved air quality [32]	sources; increase energy efficiency; Air quality regulations; Clean energy technologies to reduce harmful air emissions (e.g. cooking stoves) [34]

END NOTES

[1] Adger et al, 2005; Barbier, 2009; Colls et al, 2009; FAO, 2008a; UNISDR, 2007; UNISDR, 2009; MA, 2005; SCBD, 2009; Shepherd, 2008, Shepherd, 2004; UNEP, 2009; World Bank, 2010.
[2] FAO, 2007; Neufeldt et al, 2009; Shugart et al, 2003;.Spittlehouse and Stewart 2003, Weih, 2004.
[3] Colls et al, 2009; FAO, 2008a; SCBD, 2009; Rahel and Olden, 2008; Robledo et al, 2005; OECD, 2009; SCBD, 2009; UNEP, 2009; UNFCCC, 2006.
[4] Berry, 2007; FAO, 2007; FAO, 2008a; FAO, 2008b; OECD, 2009; Leslie and McLeod, 2007; SCBD, 2009.
[5] CCCD, 2009; Coll et al, 2009; FAO, 2008b; ProAct, 2008; UNFCCC, 2006.
[6] Chhatre and Agrawal, 2009; FAO, 2008b; Reid and Huq, 2005; SCBD, 2009;
[7] FAO, 2008a; Reid and Huq, 2005; SCBD, 2009; UNEP, 2006; Venter et al, 2009;
[8] Arnell 2004; Branco et al., 2005; Campbell et al, 2008; FAO, 2008a; FAO, 2009; Fischer et al. 2006; Howden et al, 2007; IPCC, 2007; UNISDR, 2009; McGray et al, 2007; Neufeldt et al., 2009; Romano, 2003; SCBD, 2009; World Bank, 2009.
[9] FAO, 2007; Hammer et al, 2003; IPCC, 2007; UNISDR, 2009; McCarl, 2007; Taggarwal et al, 2006; UNFCCC, 2006; World Bank, 2009.
[10] FAO, 2007; Campbell et al, 2008; CCCD, 2009; IPCC, 2007; World Bank, 2009.
[11] FAO, 2007, IPCC, 2007; World Bank, 2009.
[12] Butler and Oluoch-Kosura, 2006; Butt et al, 2005; CCCD, 2009; Davis, 2004; FAO, 2006; FAO, 2007; FAO, 2008a; Howden et al, 2007; McCarl, 2007; Romano, 2003; World Bank, 2009.
[13] CCCD, 2009; FAO, 2007; IPCC, 2007; UNISDR, 2009; World Bank, 2009.
[14] Batima et al. 2005; FAO, 2007; Rosenzweig and Tubiello, 2007.
[15] Adger et al, 2005; Kay and Adler, 2005; Kesavan and Swaminathan, 2006.
[16] Adger et al, 2005; FAO, 2008b ; Kesavan and Swaminathan, 2006; Klein et al, 2001; Nicholls, 2007; UNFCCC, 2006a.
[17] FAO, 2007; FAO 2008b; IPCC, 2007; Rahel and Olden, 2008; UNFCCC, 2006.
[18] Adger et al, 2005; Dolan and Walker, 2003; FAO, 2008b; Nicholls, 2007b; Thorne et al, 2006; UNFCCC, 2006b; World Bank, 2010.
[19] FAO, 2008b; Kesavan and Swaminathan, 2006;Rahel and Olden, 2008.
[20] FAO, 2007; IIED, 2009.
[21] FAO, 2007; Nicholls, 2007.
[22] FAO, 2008b; UNFCCC, 2006a.
[23] Branco et al, 2005; CCCD, 2009; Hedger and Cacourns, 2008; ICHARM, 2009; IPCC, 2007; Klijn et al., 2004; Mills, 2007; Olsen, 2006; Rahaman and Varis, 2005; World Bank, 2009; WSSD, 2002; WWAP, 2009.
[24] Arnell and Delaney, 2006; Auld et al, 2004; CCCD, 2009; DaSilvia et al, 2004; Hedger and Cacouris, 2008; Mills, 2007; Muller, 2007; Thomalla et al., 2006; UNFCCC, 2006b; UNFCCC, 2009; WHO, 2003; World Water Council, 2009; WWAP, 2009.
[25] CCCD, 2009; Crabbe and Robin, 2006; Hedger and Cacourns, 2008; IPCC 2007; Rahaman and Varis, 2005; WWAP, 2009.
[26] Few et al, 2006; Kirshen, 2007; Mills, 2007; Rahaman and Varis, 2005; Warner et al, 2009; WWAP, 2009.
[27] Auld, 2008; Auld, 2008a ; Hodgson and Carter, 1999; IPCC, 2007; Lowe, 2003; Mills, 2007; NRTEE, 2009; ProVention, 2009; Satterthwaite, 2007; Rosetto, 2007; Wamsler, 2004; World Bank, 2000; World Bank, 2008; World Water Council, 2009.
[28] Auld, 2008; Auld, 2008a ; Auld, 2008b; Lewis and Chisholm, 1996; Mills, 2007; Neumann, 2009; ProVention, 2009; Rosetto, 2007; UNFCCC, 2006.
[29] Auld, 2008a ; IPCC, 2007; Islam and Ferdousi, 2007; Kagiannas et al, 2003; Marechal, 2007; Mills, 2007; Neumann, 2009; Robledo er al, 2005; UNDP/WHO, 2009; VanBuskirk, 2006; Warner et al, 2009; Younger et al, 2008.
[30] Auld, 2008a; Freeman and Warner, 2001; Mills, 2007; Neumann, 2009; NRTEE, 2009; ProVention, 2009; Stevens, 2008; Younger et al, 2008.
[31] Auld et al, 2004; Auld, 2008a; CCCD, 2009; Curriero et al, 2001; DaSilvia et al, 2004; Ebi et al, 2006b; Haines et al, 2006; Patz et al, 2000; Patz et al, 2005; UNFCCC, 2006; WHO, 2003; WHO, 2005; WHO, 2008; World Bank, 2003..
[32] CCCD, 2009; Ebi et al, 2006b; Ebi, 2008; Haines et al, 2006; Patz et al, 2005; Younger et al, 2008; UNFCCC, 2006a; WHO, 2003; WHO, 2005.
[33] Mills, 2005; Mills, 2006.
[34] Haines et al, 2006; Younger et al, 2008.

Table 6-2: Government liabilities and disaster risk.

Liabilities	**Direct**: obligation in any event	**Contingent**: obligation if a particular event occurs
Explicit: Government liability recognized by law or contract	Foreign and domestic sovereign borrowing, expenditures by budget law and budget expenditures	States guarantees for non-sovereign borrowing and public and private sector entities, reconstruction of public infrastructure
Implicit : A 'moral' obligation of the government	Future recurrent costs of public investment projects, pensions and health care expenditure	Default of sub-national government as public or private entities provide disaster relief.

Source: Modified after Schick and Polackova Brixi, 2004

Table 6-3. Information requirements for selected disaster risk reduction and climate change adaptation activities.

Activities	**Information needs**
Cross-cutting	
Climate change modelling	Time series information on climate variables, air and sea surface temperatures and circulation patterns, green house gas levels, rainfall and precipitation measures.
Hazard zoning and "hot spot" mapping	Inventories of landslide, flood, drought, cyclone occurrence and impacts at district level; human development indicators
Relief payments	Dense network of rain gauges to calculate meteorological drought indices; household surveys of resource access
Seasonal outlooks for preparedness planning	Seasonal climate forecast model; sea surface temperatures; remotely sensed and *in situ* measurements of snow cover/depth, soil moisture, vegetation growth; teleconnection indices; monthly rainfall-runoff; crop yields; epidemiology
A system of risk indicators: reflecting macro and financial health of nation, social and environmental risks, human vulnerability conditions; and strength of governance (Cardona et al. 2010)	Macroeconomic and financial impacts (DDI) Measures of social and environmental risks (LDI) Measures of vulnerability conditions reflected in exposure in disaster-prone areas, socioeconomic fragility and a lack of social resilience in general. Measures of organisational, development and institutional strengths (RMI)
Flood risk management	
Early warning systems for fluvial, glacial and tidal hazards	Real-time meteorology and water-level telemetry; rainfall and tidal surge forecasts; remotely sensed snow, ice and lake areas; rainfall-runoff model
Structural and non-structural flood controls	Inventories of pumps, drainage and defence works; land use maps for hazard zoning; post disaster plan; climate change allowances for structures; floodplain elevations
Artificial draining of pro-glacial 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; teleconnection indices; 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; metering and survey effectiveness of demand management

Source: Adapted from Wilby (2009)

Table 6-4: Typology of response.

States where there is an existing or emerging social contract with its citizens, by which the state undertakes to assist and protect them in the face of disasters, and there is a limited role for international agencies, focusing on advocacy and fundraising	• China post-Sichuan earthquake • Chile post-2010 earthquake • USA post-Hurricane Katrina • Australia during 2010 floods
States that have a growing capacity to respond and request international agencies to supplement their effort in specific locally owned ways, through filling gaps in national capacities or resources	• Indonesia post-Earthquake • India post-Bihar floods • Mozambique post-2008 floods
States that have limited capacity and resources to meet their responsibilities to assist and protect their citizens in the face of disasters, and which request international assistance to cope with the magnitude of a disaster, resulting in a fully-fledged international response	• Haiti post-2010 earthquake • Bangladesh post Cyclone Sidr • Uganda post-2009 floods • Kenya 2009 drought
States that lack the will to negotiate a resilient social contract, including assisting and protecting their citizens in times of disaster. These pose significant challenges, and pose the greatest challenge; and involve a combination of direct delivery and advocacy	• Myanmar post-Cyclone Nargis • DRC post-Goma volcano • Zimbabwe

Table 6-5: Disaster management actions across the disaster timeline.

	Pre-disaster	**Immediate post-disaster**	**Recovery**
Disaster Management Actions	• Warning and evacuation • Pre-positioning of • resources and supplies • Last minute mitigation and preparedness measures	• Search and rescue • Emergency medical treatment • Damage and Needs Assessment • Provision of services – water, food, health, shelter, sanitation, social services, security • Resumption of critical infrastructure • Coordination of response • Donation management	• Transitional shelter in form of temporary housing or long-term shelter • Demolition of critically damaged structures • Repair of less seriously damaged structures • Clearance, removal and disposal of debris • Rehabilitation of infrastructure • New construction • Social rehabilitation • 'Building back better' to reduce future risk • Employment schemes • Reimbursement for losses • Reassessment of risks

Adapted from Coppola, 2007 and ALNAP 2010a

Table 6-6: Some examples of methods/ tools/ practices for assessing risks, reducing climate-related disaster risks and transferring and sharing risks.

Methods/Tools/Practices	Examples
Mainstreaming climate change considerations in development and disaster risk management	• Adaptation across project/community; ii) sector regulation and compliance; and or iii) policy and planning level (short- and mid-term policy making and planning at sub-national level and national strategic development planning in Cook Islands and Federated States of Micronesia {ADB, 2005 #2669}. • Swiss Development Cooperation's four year project in Muminabad, Tajikistan adopted an integrated approach to risk through reforestation and integrated watershed management (SDC, 2008). (see also chapter 8)
"Hard Options"	
Structural and non-structural flood controls	• Early warning and flood control systems for Mozambique (chapter-9)
Artificial draining of pro-glacial lakes	• The Tsho Rolpa glacial lake project in Nepal (Sperling and Szekely, 2005 (chapter-9)
Protection of natural ecosystems	• Forests, used in the Alps as effective mitigation measures against avalanches, rockfalls and landslides since the 1900s(Bebi, 2009; Dorren, 2004; Phillips and Marden, 2005; Sidle et al., 1985
Building code	• Permafrost standard for Arctic regions of Canada • Simple modifications to improve the cyclone-resistance of (non-masonry) kutcha or temporary houses in Bangladesh (Lewis and Chisholm, 1996; Rossetto, 2007
Coastal defence practices	• Artificial breakwaters in Maldives (Secretariat of the Convention on Biological Diversity, 2009)
Traditional rain and groundwater harvesting	• Marshall Islands, Bangladesh, Japan
"Soft Options"	
Ecosystem based adaptation	• Planting Mangroves in Viet Nam for coastal protection (Reid and Huq, 2005) • Application of holistic River Basin Management Plans and Integrated Coastal Zone Management (EC, 2009; DEFRA, 2005;Wood et al. 2008). • Brazil, under Amazon Protected Areas Program, Brazil has created over 30 million ha mosaic of biodiversity-rich forests reserve of state, provincial, private, and indigenous land, resulting in potential reduction in emissions estimated at 1.8 billion tons of carbon through avoided deforestation {World Bank, 2009).
Risk sharing and transfer	• Index-based reinsurance in Ethiopia for protection for its drought exposure under the World Food Program (chapter-9) • Supporting Index-based microinsurance in Bolivia • Insuring public relief expenditure in Mexico and the Caribbean region (Cardenas et al, 2007; Ghesquiere, et al 2006
Information and Communication	
Early warning and communication	• Cyclone warning system in Bangladesh (Paul 2009) • Early warning systems based on medium-range and seasonal forecasts across Europe and West Africa (Bartholmes et al. 2008; Tall et al. 2010)
Disaster Deficit Index (DDI) using integrated science, economics, social processes and traditional knowledge and expert knowledge	• Monitoring disaster risk and vulnerability in 19 Latin American countries (Cardona, et al 2010)