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)

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

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Executive Summary

This chapter examines the actors and functions that comprise national systems for managing the risks of climate extremes and disasters. It assesses how these systems can adapt to the challenges of changing hazards, risks and uncertainties associated with climate change and the trends in vulnerability and exposure highlighted in earlier chapters. This chapter recognizes that effective national systems involve actors playing differential but complementary roles according to their accepted functions and capacities across geographical scales, time and levels of society. These actors include national and sub-national governments, private sector, research, civil society and community-based organizations and communities, ideally working in partnership and harmony to cost effectively support people's efforts to reduce their risks and vulnerabilities. Well designed national systems would cover the full range of activities associated with managing climate extremes and disaster risks including supporting efforts to reduce risks, transfer risks and responding efficiently to disaster impacts as well as adapting to changing risk attributable to climate change and other factors. However, developed and developing countries alike consistently demonstrate their inability to tackle current disaster risks albeit to different degrees and this existing adaptation deficit must be tackled together with the new challenges posed by climate change. Governments at all scales play a crucial role achieving this aim.

In many countries national and sub-national government agencies initiate and lead many of the disaster risk management functions within their national system and play multiple roles in managing the risk of climate extremes and disasters. These functions include building and developing policy, regulatory and institutional frameworks that prioritize risk reduction; integrating disaster risk management with other policy domains like 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 (6.3.1.1 and 6.3.1.2, 6.3.1.3); providing goods and services necessary for management disaster risks and climate extremes, including research and public awareness related to disasters, education, training (6.2.5, 6.3.1.1), such as early warning systems (6.3.3.1.2), and measures to support the most vulnerable in the society(6.3.1.4). Some national systems might organise and allocate responsibilities for functions more formally; others are constituted by actors fulfilling functions where they see gaps (6.2.2; 6.2.3; 6.2.4; 6.2.5). Many systems are not adequately coordinated, harmonised and appropriately sequenced for effective risk management (6.2.1; 6.3.1; 6.3.2; 6.3.3).

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 (6.2.3; 6.2.4). The private sector, too, plays, an important role in managing disaster risk and adapting to climate change, particularly in the area of risk financing including insurance. While disaster insurances cover no more than a third of the global losses, and there are market failures and market gaps involved in the supply and demand for risk transfer instruments, risk financing mechanisms demonstrate substantial potential in both developed and developing world for absorbing a part of the financial burden of disasters (6.2.2, 6.3.2.2). It is though uncertain as to the extent to which the private sector could continue to play this role in the context of changing climate as they are often not willing to underwrite additional risks due to uncertainty and the presence of imperfect information, missing and misaligned markets and financial constraints. Innovative private-public sector

partnerships are being explored in both developed and developing countries, with funding support from development partners a critical variable in developing countries (6.3.3.4).

Globally, different combinations of methods and tools have been used by countries to address disaster risk management challenges, with varying degrees of success in developed as well as developing countries, including using deterministic and probabilistic risk assessment techniques (6.3.3.1.1), increasing preparedness for disasters through education, training and early warning systems (6.3.3.1.2), adopting technological and infrastructure options (6.3.3.2.1), and investing in natural capital and ecosystem based adaption (6.3.3.2.3). Globally, governments and the private sector are working to develop innovative ways to transfer risk as well as share risks (6.3.3.3). Governments with the help of development partners are also beginning to explore alternative ways of supporting disaster risk management by addressing the underlying drivers of vulnerability, including the targeting of pro-poor development strategies for the most vulnerable groups of society (6.3.3.2.2) and insuring public sector relief expenditure (6.3.3.3).

With climate change altering the frequency and magnitude of some extreme events and helping to create more extreme impacts through amplifying vulnerability and exposure and increasing uncertainty in some areas (see Chapters 3 and 4), the efficacy of national systems requires review to not only address the current gaps in disaster risk management but also the affects of climate change on future disaster risks.

Ideally, national systems for managing the risks from climate extremes and other disasters would need to be redesigned by fully integrating development, environmental and humanitarian dimensions, appropriately designing, coordinating and sequencing disaster risk reduction strategies, including social protection and climate change adaptation, and recalibrating the differential roles played by national and sub-national governments, private sectors and communities. No country, developed or developing, can achieve this instantaneously, but rather may progressively move towards such a system by aligning existing national disaster risk management systems to the challenges of more frequent and extreme events of higher intensity, growing uncertainty and changing patterns of vulnerability and exposure. This alignment could include making incremental changes to disaster risk management policies, enabling environments, plans and actions by adopting adaptive management and learning by doing to reflect changing climatic conditions, uncertainties and nonlinearity in climate change, improving information and knowledge, as well as building individual and institutional capacity within socio-ecological-economic systems to deal with shocks (6.4.2). Acknowledging pre-disaster efforts have a higher payoff than responding to post disaster events, addressing climate change would also require greater attention to tackling the underlying drivers of current and increasing vulnerability under changing climate by focusing on policy instruments that that bring disaster risk reduction and climate change adaption benefits amongst the poorest in the society (6.4.3) as well as promoting low-carbon development (6.4.4).

6.1. Introduction

The socioeconomic impacts of disasters can be significant in all countries, but low and middle income countries, and it is especially the vulnerable within these countries, that often suffer the most. For example, during the quarter century (1980-2004) over 95% of natural disaster deaths occurred in developing countries, and fatalities per event were higher by orders of magnitude in low-and middle-income countries compared with high-income countries and losses as a percentage of gross national income (GNI) were also highly negatively correlated with per capita income (see Munich Re, 2005). For example, low-income, small island development states, such as Samoa and Vanuatu, suffer an average economic loss during disaster years of 46% and 30% of their GDP respectively (Bettencourt et al 2006).

Many highly exposed developing countries often cannot raise sufficient capital to replace or repair damaged assets and restore livelihoods following major disasters due to a lack of insurance, combined with reduced tax bases, high levels of indebtedness and limited donor assistance, exacerbating the impacts of disaster shocks on poverty and development. Over the last years, a growing literature has shown important adverse macroeconomic and developmental impacts of natural disasters (Cochrane 1994; Otero and Marti, 1995; Benson, 1997a,b,c; Benson, 1998; Benson and Clay, 1998, 2000, 2001; ECLAC 1982, 1985, 1988, 1999, 2002; Murlidharan and Shah, 2001; Crowards, 2000; Charveriat, 2000; Mechler, 2004; 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. With exceptions, which consider disasters rather a problem of, but not for development (Albala-Bertrand, 1993, 2006; Caselli and Malhotra, 2004), this body of evidence proves that natural disasters can be a setback for development in the short- to medium-term. In turn, poor development status of communities and countries 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 (Lal et al 2009).

As a response to the impacts of disasters on countries' economies, on levels of poverty and broader development trajectories, many national governments have developed national systems for tackling climate extremes and disaster risks. These are desirable, not just as a response to the factors listed above, but also because governments have a responsibility and moral duty to their citizens and while they cannot act alone, the majority of governments are comparatively best equipped to tackle disaster risk. It is at national level that overarching development processes are generally put in place, albeit in varied forms and decisions on significant resource allocations occur (see Section 6.2.1 'role of national and sub-national government agencies in national systems'). National level governments are often called "insurers of last resorts" and "the most effective insurance instruments of society" (Priest 1996:225) as the governments are often the final entity that households and firms turn to in case of needs.

National level government also has the ability to mainstream consideration of extremes associated with climate variability and change into existing disaster risk management and development sectors, policies and plans. These include initiatives to assess risks and uncertainties, manage these across sectors, share and transfer risks and establish baseline information and research priorities (Prabhakar *et al*. 2008; Mechler 2004). In theory, national level institutions are best able to respond to the challenges of planned adaptation to extremes, 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 decisions often pertain to longer time horizons and are amenable to better appreciate key uncertainties and risks associated with climate change (Priest, 1996; Hallegate, 2009). In many cases, it is at this national level that national systems for adapting to climate change and changing disaster risks will emerge.

With this in mind, valuable lessons for advancing adaptation to climate change can be drawn from existing national systems for managing the risks from climate extremes and disasters. These systems are comprised of actors operating across scales, fulfilling a range of functions, guided by an enabling environment of institutions, international agreements and experience of previous disasters. 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. 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. Closing this adaptation deficit (Burton, 2004) 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 the extremes of climate variability, a stronger institutionalisation across scales, including to the local level, a greater number of experienced actors and more widespread instances of supporting legislation and cross-sectoral co-ordinating bodies, national systems for managing disaster risks and climate extremes offer a promising avenue for supporting adaptation to climate change.

However, despite significant recent progress in developing national systems and despite the burden of disasters imposed and increasingly recognized, measures to reduce the risks of disasters are still insufficiently taken, and there is, for the most part, a continued reliance on post disaster response and disaster management support. For example, countries, donors and international financial institutions allocate about 90% of their disaster management funds for relief and reconstruction and, only about 10% of the funds for disaster risk management (Tearfund, 2006). This low level of investment in preventing disasters can be explained inter alia by a lack of understanding and concrete evidence regarding the types and extent of the cost and benefits of measures to reduce disaster risk (Benson and Twigg, 2005). National level decision-makers generally seek information on the costs and benefits of disaster risk reduction and adaptation options in order to motivate and defend investments in these measures. Yet, only a very limited number of studies looking at sub-national level disaster risk reduction and adaptation measures have demonstrated that disaster prevention and adaptation can pay high dividends. Studies such as Mechler (2005) and MMC (2008) found that for every dollar invested in risk management broadly, two to four 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, measures to reduce disaster risk are faced with limited budgetary resources and many policy makers have been reluctant to commit significant funds for risk reduction. However, certainly internationally, they are happy to continue investing considerable funds into high profile, post-disaster response (Benson and Twigg, 2005).

While the current lack of emphasis on risk reduction compared to response highlights the inadequacies of existing systems, there are nevertheless a host of success stories and promising initiatives for managing and reducing the risks of climate extremes and disaster that provide valuable guidance for advancing adaptation to climate change. Accordingly, this chapter assesses the literature on national system for managing disaster risks and climate extremes, particularly the design of such systems and the actors and functions involved. It reflects on the adequacy of existing knowledge, policies and practices and considers the extent to which they will need to evolve to deal with the effects of climate change on disaster risks and uncertainties. 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, 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 possible in an effective national system and what gaps in knowledge exist. It is organised by the set of functions 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). 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, the impacts of climate change on vulnerability and poverty and the potential benefits of low-carbon, resilient forms of development. 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 everyone's business, from national and sub-national governments, private sector, research, civil society and community-based organizations and communities working in partnership to ultimately help individual households to reduce their risks and vulnerabilities (Twigg, 2004, ISDR 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 geographical scales, time and levels of society, supported by relevant scientific and traditional knowledge (ISDR, 2008). This section assesses 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 national disasters. 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, especially the most vulnerable (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 need to govern and regulate risks owned by other parts of society (Mechler, 2004).Recourse to various normative theories may be taken. 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). The risks faced by governments include the risk to losing public infrastructure and assets. National level government also generally redistribute 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 slipping into poverty, 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 need 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 generally 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; Christensen *et al.*, 2007).

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 countries. 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 (ISDR, 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 provide 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; Handmer and Dovers, 2007; CCCD, 2009). 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 Functions of the national disaster risk management systems*.

6.2.2. Private Sector Organisations

Some aspects of disaster risk management may be suited for non-government stakeholders to implement, albeit this would ideally be coordinated within a framework created by governments. Private sector already plays an important role in DRM and adaptation, particularly in the area of risk financing and insurance. Despite complexities and uncertainties involved on supply and demand for risk transfer, risk financing mechanisms have been found to demonstrate substantial potential in both developed and developing world 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, 2008; Cummins and Mahul, 2008; Hess and Hazell,,2009). The extent to which the private sector would continue to play this role in the context of changing environment is though unclear 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 often not prepared to underwrite insurance (Carpenter, 2000) the risks associated with variability and extreme events due to climate change, thus requiring innovative private-public sector partnerships supported by, in developing countries development partner funds as well (see Section 6.3.3.3 *Transferring and sharing 'residual risks')*.

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

Implementation of some disaster risk management initiatives may be more cost effectively delivered through civil society organizations, particularly where governments are weak, and or have limited resources to reach particularly the marginal and poor communities (Benson, 2001). Civil societies 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 (ISDR 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 Latin America, disasters provoked by hurricanes Georges and Mitch in 1997 and 1998, respectively; as well as the impacts of El Niño South Oscillation in the years 1997-1998, led several CSO to respond and assist affected communities (Lavell 2001, Girot, 2000). CSO initiatives in the field of disaster risk management while may usually begin as humanitarian concerns, but 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; SEEDS 2008; Tearfund 2008; World Vision 2008).

While effective at the local level, the biggest challenge for CSO though remains securing resources for replicating successful initiatives and scaling out geographically (Care International 2008; Oxfam America 2008; Practical Action Bangladesh 2008; SEEDS 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, for example in Bangladesh (Oxfam America 2008), and coordinating and linking local level efforts with sub-national government initiatives and macro-level plans during the specific project implementation, for example in India (SEEDS 2008). Much of civil society initiatives are though critically dependent on support from external bilateral and multilateral agencies.

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, Kinch 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 (ISDR 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.

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 three 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. 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. In addition, some agencies, particularly universities may be actively engaged in technical capacity building and training, or as in the case of largely civil societies in translating scientific evidence into adaptation practice, collating traditional knowledge, and lessons learnt for wider dissemination; or translating scientific information into user-friendly forms for community consumption (Sperling and Szekely 2005; Thomallaet 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 managing disaster risk is primarily a government's responsibility and governments have the potential to deliver and implement at the greatest scale.

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 having the primary responsibility of creating the enabling environment for other actors and its own agencies to reduce risk, share and transfer risk and manage residual risk. By drawing on 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 functions 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 (ISDR, 2009; CCCD, 2009). Since countries vary greatly in their political, cultural, socio-economic and hazards environments, disaster risk management and climate change adaptation plans and policies at the national scale will vary from country to country but will all need to consider the roles of sub-national and local actors (CCCD, 2009; ISDR, 2007). 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 and in mainstreaming climate change adaptation and disaster risk management into plans, policies and development paths (UNDP, 2002). 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 scale 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 and the timeframes within which these future impacts and disasters will occur that play an important role in their prioritization and adoption (Heltberg et al, 2008; World Bank, 2008b). For example, in countries and sectors with little capacity to deal with existing disasters or where the impacts of future changes remain highly uncertain, the planning and policy option of "no regrets" actions initially may offer the most realistic path for the future (UNDP, 2002; World Bank, 2008b; Heltberg et al, 2009). "No regrets" adaptation options imply that the benefits of the option are justified irrespective of whether the impacts to future climate change occur while "low regrets" options tend to "hedge" by dealing today with the uncertainties of the future changes through investments in research and outreach (Agrawala and van Aalst, 2008; OECD, 2009; Prabhakar et al, 2009). Improving the capacity of communities, governments or regions to deal with current climate vulnerabilities will likely also improve their capacity to deal with future climatic changes, particularly if such measures take a dynamic approach and can subsequently be adjusted to deal with further changes in climate risks and vulnerabilities (Sperling and Szekely, 2005).

Medium and high "regret" adaptation options include those that deal directly with the changing climate through plans and policies. These options are more likely to be considered when planning major large-scale projects where potential climate impacts are significant or irreversible and when the country has capacity to deal with the risk. The medium and high "regret" adaptation options include proactive planned adaptation to climate change and "triple-win" actions that have greenhouse gas reduction, disaster risk management, climate change adaptation and development synergies (Heltbert et al, 2009; Ribeiro et al, 2009; World Bank, 2008b). Many of these "win-win" options involve ecosystem management or ecosystem-based adaptation actions, sustainable land use and water planning, carbon sequestration, energy efficiency and energy and food self-sufficiency. In many cases, risk sharing can be considered a viable policy, including options 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, 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). Finally the option of "bearing the residual losses" is a choice for consideration when uncertainties over the direction of future climate change impacts are high, when capacity is very limited, adaptation options are currently not available or the impacts are low (Linnerooth-Bayer and Mechler, 2006; Heltberg et al, 2009; World Bank, 2010). All of these policy and planning options are particularly relevant at sectoral level where governments either define enabling environments for development projects to occur or define risks that are shared and transferred to be borne by different parts of society.

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

National planning and policies processes need to create an enabling environment where disaster risk management and climate change adaptation can be tightly linked with ongoing development efforts, involve stakeholders at all levels and spatial scales and create a culture of safety and resilience in everyday affairs (Mercer 2010; Litman 2008). Success will largely depend on the ability of national governments to align and integrate fiscal planning actions supporting disaster risk management and climate change adaptation and their ability to integrate climate risks into policies and into development decisions (ISDR 2009; Vogel 2009; Rosenzweig et al. 2007). Many studies indicate that one of the best ways to mainstream climate change into disaster risk management and development planning is to understand current climate impacts, consider potential impacts into the future and address both current and future impacts in development and risk reduction planning and policies (Prabhakar et al, 2009; UNDP, 2002; CCCD, 2009).

The existing barriers to managing the risks associated with current climate variability need to be addressed because it will help prepare for tackling the even greater barriers that may inhibit nations from addressing their future climate disaster risks (UNDP, 2002; UNDP, 2004). Some of the challenges to mainstreaming both disaster risk management and climate change adaptation into plans and policies, including risk assessments, early warning systems, sector risk management, insurance tools and public education, lie with government "silo" approaches, differing timeframes of interest for adaptation and risk reduction, the uncertainties of future climate scenarios as well as the need of each for relevant regional information on changing climate hazards and risks (Basher, 2009; ISDR, 2009; Wilby and Dessai, 2010). For example, environment or energy authorities as well as scientific institutions typically have responsibilities for climate change adaptation while authorities for disaster risk management reside with civil defence, disaster management or home affairs (Prabhakar et al, 2009; Thomalla, 2006; Sperling and Szekely, 2005). In many cases, disaster practitioners have focused largely on warning-response-relief approaches where technological advances in climate monitoring and short-term forecasting are linked to effective dissemination of climate hazard information and responses that at least save lives (Thomalla, 2006; Basher, 2009). Most disaster risk management planning currently aims to reduce disaster risks from existing climate hazards and vulnerabilities, sometimes little appreciating that the future may not be a repetition of the past hazards and risks (Dilley, 2005, Prabhaker et al, 2009). Yet, challenges remain in projecting future risks.

How can adaptation measures realize societal benefits now, and over coming decades, despite uncertainty about climate variability and change? Because future climate vulnerabilities and risks may change in unexpected directions, a range or ensembles of future climate change scenarios, and socio-economic scenarios along with impact models are needed to estimate the changing risks (UNFCCC, 2008; Prabhakar et al. 2009; Jones and Mearns, 2005; IPCC, 2007). However, this climate change scenario information is often not mainstreamed into adaptation planning (Wilby and Dessai, 2010; Wilby et al, 2009). This may be due to limitations to the availability of current climate hazards and risk information, a mismatch between climate model scales and the information needs of adaptation planners, access to dependable high-resolution regional climate change projections, a shortage of good quality climate data and methodologies for downscaling to decision-making scales, uncertainties in the climate scenarios themselves, the availability of relevant climate parameters from existing models and a shortage of information to guide understanding on the contribution that climate hazards make to risks, (Prabhakar et al, 2009; Basher, 2009; Wilby, 2009). Alternatives to these "top-down" or "scenario-led" approaches to adaptation are the 'bottom-up' methods that focus on reducing vulnerability to past and present climate variability and consider existing trends (Wilby and Dessai, 2010). These approaches include regular revisions of hazard and vulnerability assessments, use of redundancies, flexible planning and use of "precautionary" principles in policies and plans to deal with an increasingly uncertain and risky future climate (Dilley 2006; Auld, 2008b; Prabhakar et al, 2009; Baker, 2005; Wilby and Dessai, 2010 and see Section 6.4.2). While many developed countries are equipped to meet this challenge with national climate and socio-economic monitoring, climate models and analyses, redundancies and risk assessments, the situation is much less satisfactory in developing countries (Basher, 2009).

6.3.1.3. Developing Sector-Based Risk Management and Adaptation Approaches

National planning and policies are challenged in managing short-term climate variability while also ensuring different sectors and systems remain resilient and adaptable to changing extremes and risks over the long term (ISDR, 2007; Füssel, 2007; Wilby and Dessai, 2010). This challenge is to find the balance between the short-term "no regrets" actions to reduce immediate impacts with the longer-term actions needed to resolve underlying causes of vulnerability and to understand the nature of changing climate hazards (UNFCCC, 2008; OECD, 2009). "No regrets" policies and plans will continue to be important at the national scale and include funding, support to communities and local governments, declaring of disasters and seeking and coordinating international assistance when national capacity is overwhelmed (ISDR 2009; Sullivan et al 2009; Pande and Pande 2007). Longer term policies and plans include measures for the protection of ecosystem-based disaster-proofing services, built environment codes and standards that incorporate changing climatic design values, vulnerability assessments, zoning and land use management, preventive health care, alternative financial arrangement and public education (IPCC, 2007; Guzman, 2003; Prabhakar et al, 2009).

Achieving disaster risk reduction and climate change adaptation, while attaining human development goals requires a number of cross-cutting, inter-linked sectoral and development activities (Few et al, 2006; Thomalla et al, 2006). Linking risk reduction and adaptation policies and plans will require effective strategies within sectors as well as coordination between sectors. Climate change is far too big a challenge for any single ministry of a national government to undertake due to the coordination required among multiple sectors (CCCD 2009).

Table 6-1 provides examples of climate change adaptation and disaster risk management options that have been documented for sectors at the national scale, including governments, agencies and the private sector. These national level sectors and landscapes include: natural ecosystem management, agriculture and food security, fisheries, forestry, coastal zone management, water management, health, infrastructure including housing, cities and transportation, and energy. The sectoral risk reduction and adaptation options in the table are treated as a continuum of potential actions. How a particular policy and planning option fits in the continuum depends on the uncertainty of the climate risk, the capacity and willingness of the sector or country to act and the consequences and the timeframe needed to address the changing risks. As described in Section 6.3.1.1, these sectoral risk management and adaptation options are incremental and reinforce each other. For example, a specific option that deals with future climate risks in a sector will also need to consider the no and low regrets actions that deal with the current climate and uncertainties for the future climate (e.g. option 3 includes corresponding options under categories 1 and 2). The risk management and adaptation options for sectors at the national level can be categorized in the continuum and Table 6-1 as follows:

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

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

Several of the national level sectoral risk management and adaptation options outlined in Table 6-1 are described in the Chapter 9 case studies. These cases illustrate some of the realities and challenges that face developing, and developed countries in dealing with risk management and adaptation as well as the benefits and opportunities that can emerge, often at reasonable costs (see Section 9.1.1). In the majority of the Chapter 9 case studies, the starting point for risk management and adaptation are the options that address existing vulnerabilities to climate variability and extremes. For example, the case studies for cyclones, heat waves, floods, droughts and cities and settlements illustrate realized benefits from implementing "no regrets" all hazards Early Warning Systems, improved weather and climate predictions, better data collection and public education on hazards and response actions— irrespective of whether the country is developing and developed (see Chapter 9). The Bangadesh cylone case study, in particular, proves conclusively that (coastal) volunteer networks offer an effective mechanism for dissemination of warnings that allow time-critical responses on the ground and safe evacuation of vulnerable populations to cyclone shelters (see Chapter 9 case study 18). Many of the Chapter 9 case studies, including those for cyclones, heat waves, drought, sandstorms, floods and epidemics, demonstrate that preventative “no regrets” actions in the form of education campaigns, increased awareness of risks at the community level and the engagement of communities in emergency response and prevention actions are achievable and do provide significant payoffs at reasonable costs. The Chapter 9 case studies for cyclone, cities, coastal and SIDS further demonstrate the success of some developing countries in providing safe and climate-proof temporary infrastructure to their vulnerable populations, often as emergency refuges in the form of shelters, killas (raised earthen platforms for animals), or through reinforced sections of housing and upgraded building codes containing updated climatic design values (see Chapter 9.x.x case studies).

A theme threading through many of the case studies and evident in almost all of the sectoral options in Table 6-1 is the benefit that a combination of hard and “soft” engineering or Ecosystem-based Adaptation (EbA) solutions offers in building resilient communities. EbA, integrated water and coastal resource management and land use management approaches all recognize that the natural environment and ecosystems need to be conserved and protected or restored in order to provide critical ecosystem services to reduce climate vulnerabilities for sectors and national economies. For example, the Chapter 9 case studies for sandstorm, flood, drought, cyclones, epidemics and heat wave events provide practical illustrations of beneficial EbA, water and land use practices that have been proven to work in reducing disaster risks (see Chapter 9, case study 9.x.x). The cases also illustrate the realities and significant challenges inherent in developing and implementing national scale risk management and climate change adaptation options, including lack of climate and weather data, lack of institutions and systems to effectively disseminate weather warnings and to efficiently respond to them, insufficient finances, imbalances in funding spent on disaster relief and reconstruction compared to risk reduction, institutional fragmentation and other barriers to the assignment of responsibilities for appropriate disaster and preventative responses.

The case studies in Chapter 9 also highlight a real shortage of examples where risk reduction and adaptation options have been implemented for future climate change risks and uncertainties. In the Arctic, SIDS and coastal regions case studies where climate change impacts are already a reality, some adaptation options are being considered and implemented (e.g. national standards and guidelines for foundations in Canadian permafrost zones) but many more adaptation solutions are needed (NRTEE, 2009; CSA, 2010; also see Chapter 9, case study 9.x.x). Overall, dealing with future climate change risks will require more flexibility to accommodate changes in the frequency and magnitude of extreme impacts over time as well as a continuous re-evaluation of risks and re-adjustment of risk management and adaptation plans and policies (Sperling and Szerkely, 2005; IPCC, 2007). Climate change will mean that further precautions and more preventative adaptation options will be needed. For example, in some cases involving hard engineering, it may mean a need to increase safety factors to ensure that infrastructure can withstand future increases in critical thresholds for extremes, such as peak winds and extreme rainfalls (Auld, 2008a; Sperling and Szerkely, 2005; World Bank, 2008b; World Water Council, 2009).

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). Together these elements form the subject of this section, which is divided into three subsections: (a) legislation and compliance mechanisms, (b) organisational arrangements and distribution of responsibilities across scales, (c) finance and budget allocation. At the start of this section, it is important to recognise the variation between countries in governance capacity for managing the risks and uncertainties of changing climate extremes also cuts across this section. 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 remarkably 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 (cf. 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 (ISDR 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 (UN-ISDR 2005), 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)

_____ END BOX 6-1 HERE _____

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 (ISDR 2005 *review of national submissions*), especially as experience suggests legislation must 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 (ISDR 2005, Pelling and Holloway 2006).

Improving risk management legislation in the context of climate change likely means stronger synergy with land-use planning and environmental protection laws, and the integration of environmental management principles into existing legislation (UN-ISDR 2007, 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 will likely require cross-sectoral coalitions. Evidence from the Philippines cited in Chapter 9, 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 (ISDR 2007). With no formal evaluation of National Platform, there is little evidence to suggest whether or not such multi-sectoral co-ordination mechanisms lead to more effective disaster risk management.

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 [UN-ISDR GAR 2009], despite calls to involve climate change focal points/organisations into National Platforms (ISDR 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).

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 (Guy 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; Bayer, Pflug and Mechler, 2005; Hochrainer, 2006; Ghesquiere and Mahul, 2007; Cummins and Mahul, 2008). 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, 2008).

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 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.]

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, 2008; Linnerooth-Bayer and Mechler, 2008; see Box 6-2). 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 6-2. 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 remains a concern (World Bank, 2000). 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

_____ END BOX 6-2 HERE ______

6.3.3. Practices including Methods and Tools

Governments, and other agencies working in the national system have developed a set of good, and not so good, practices for managing disaster risk. Practices involving risk assessment, hard and soft management options, risk transfer, public awareness and early warning are all raised in this sub-section, which is divided into those practices associated with building a culture of safety (6.3.3.1), risk reduction (6.3.3.2), risk sharing and transfer (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 assessing risks, providing and communicating reliable and adequate information to serve as the basis for planning interventions as well as generally raising public awareness of risks.

6.3.3.1.1. Assessing risks and maintaining information systems

The first key step in managing risk is to assess and characterise risk. In terms of risk drivers, disaster risk commonly is defined by three factors: 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 framed in the context of public perception and management needs (See Chapter 5). The technical aspects of risk may be characterized in terms of deterministic and probabilistic assessments of their likelihood (see Box 6-3).

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Box 6-3. Deterministic and Probabilistic Risk Assessment

Two distinct approaches have been used to assess risks and what actions to take – a deterministic assessment of extremes focussing on certain *design events* such as a 100 year event and probabilistic risk assessments taking the whole probability distribution of events into account (see Freeman et al., 2001; Apel et al., 2004; Mechler, 2004; World Bank, 2004; Hall, Sayers and Dawson, 2005; Cardona et al., 2007; Hochrainer, 2006; Feyen, Barredo and Dankers, 2009; Mechler et al., 2010). Although difficult and sometimes not feasible, a probabilistic approach is to preferred. In terms of outcomes, disaster risk is commonly defined as the probability of potential impacts affecting people, assets or the environment (Smith, 1996), thus ideally, probabilistic information is generated framing risk in terms of loss exceedance curves indicating the probability of losses such as for a 50 , 100, 200 year event. While they are complex and require some technical expertise, probabilistic approaches are well suited to inform key decisions and represent uncertainty, which is particularly important when considering catastrophic events with potentially large impacts but small probabilities of occurrence. Deterministic approaches on the other hand ignore the presence of aleatoric (natural) uncertainty and provide only partial information.

_____ END BOX 6-3 HERE ______

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 (ISDR, 2004; Prabhakar, 2008). Considerable progress has been made in the use of information (ISDR, 2009). Nevertheless, in many countries this is not a regular practice and efforts to document impacts are started only after major disasters (ISDR, 2004; Prabhakar, 2008). 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.]

As to 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 (eg 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 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).

As to addressing the different components of risk, hazard analysis involves determining the nature of hazard(s) affecting a certain area with specific intensity, duration, and frequency in order to derive a stochastic representation of the hazard. Climate change, shown to already affect extreme weather-related events in frequency and severity (IPCC, 2007, Solomon et al., 2007), needs to be first and foremost factored into such an analysis. Climate models have been assessed and currently are not good at reproducing spatially explicit climate extremes due to limited data and inadequate (coarse) resolution (Goodess et al., 2003). Hence, projections of extreme events for future climate are highly uncertain and often are important hindrances to robustly projecting sudden onset of risk, such as flood risk, while drought risks, which are slower onset phenomena more strongly characterised by boundary conditions, can better be projected on average (Christensen and Christensen, 2002; Kundzewicz et al., 2006). The severity and duration of drought and it's occurrence in combination with increasing aridity are not well understood. When projecting risks into a future it is important to address the non-stationarity exhibited by the system in order not to underestimate the risk (Milly et al., 2008). Although there have been several articles criticizing the assumption of stationarity, it is not apparent what alternative methods should be used. However failure to account for changes in baseline conditions may lead to the following consequences: (i) early warnings may become unreliable and therefore will lose the trust enjoyed by the stakeholders at risk (Oloruntoba, 2005), (ii) risk management strategies may become inefficient and obsolete as strategies are based on past risk not adequately reflecting expected future changes (Pflug and Römisch, 2007); (iii) natural resource management policies may not appropriately refer to newly hazard prone areas, and therefore the number of those exposed to hazards may increase (Vari and Ferencz, 2007).

Apart from the climate change component, vulnerability and exposure will also change over time, and these aspects of the risk triangle are often not considered equally (see Hochrainer and Mechler, 2010). 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 (ADPC 2000; World Bank, 2004), 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, 2007).

The third building block of risk, vulnerability, refers to the susceptibility of the exposed elements to incur damages and follow on impacts (ADPC, 2000; UNISDR, 2008). For managing risk, vulnerability is a key component, yet it is the most elusive of three drivers of risks due to a lack of standardized definitions. The challenge in assessing vulnerability is to build on the rigour of (more narrowly focussed) risk assessments and contribute to the complex scientific, institutional, and policy processes necessary for effectively assessing and reducing vulnerability to climate change (Birkmann, 2006).

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. For this, a robust and up-to date Early Warning Systems (EWS) is critical to not only mitigate the impacts of disasters, but to also provide timely warning to the agencies involved in 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). Early warning systems have 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 actually used to reduce risks (UNISDR, 200; 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 and on time (ISDR, 2005; Auld, 2008; Basher, 2006; Wimbi, 2007). Warnings buy the time needed in advance of hazards to evacuate populations, reinforce infrastructure, reduce potential damages or prepare for emergency response (Auld, 2008). To be effective and complete, an early warning system needs to comprise four interacting elements (ISDR, 2006a; Basher, 2006): (i) generation of risk knowledge including montoring 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 (ISDR, 2001; Auld, 2008). Warnings must be received and understood by a complex target audience and need to have a meaning that is shared between those who issue the forecasts and the decision-makers they are intended to inform (Auld, 2008; Basher, 2006; ISDR, 2006a). Because emergency responders and the public often are unable to translate the scientific information on forecast hazards in warnings into risk levels and responses, future work is needed that can identify general impacts, 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; ISDR, 2006a).

Different hazards and different sectors often require unique preparedness, warnings and response strategies (ISDR, 2006a; Basher, 2006; van Aalst, 2009). Some may represent singular extreme events, sequences or combinations of hazards. The World Meteorological Organization (WMO), National Meteorological and Hydrological Services and UN 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 deadly heat waves and vector-borne diseases (WMO, 2007; ISDR, 2006a) and early warnings of locust swarms (WMO, 2007; WMO, 2004b). 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, 2008; 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 (ISDR, 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 prexistence 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).

Early warning information systems are multi-jurisdictional and multi-disciplinary, requiring anticipatory cooordination across a spectrum of technical and non-technical actors. National governments play critical roles in setting the high-level policies and supporting frameworks to facilitate multiple organizational and community networks that sustain early warning systems to issue national hazard warnings and identify and diffuse successful approaches (ISDR, 2006b, Pulwarty et al, 2004). National governments need to 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 (ISDR, 2006b). At the same time, national governments have a role in supporting regions and sub-national governments in developing operational and response capabilities (ISDR, 2006b; see 6.3.3.4).

6.3.3.2. Reducing Climate-Related Disaster Risk

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, in extremes, humanitarian focused actions. 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

The built environment of both developing and developed countries will be impacted significantly by climate change (Wilby, 2007; Auld, 2008a; Stevens, 2009). Climate change has the potential to 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 (Auld, 2008a). With potential increases in extreme events regionally, it is expected that small increases in climate extremes above regional thresholds will have the potential to bring large increases in damages to all forms of existing infrastructure (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 governments and the majority of development and disaster specialists (Moser and Satterthwaite, 2008; Rossetto, 2007). Low- and middle-income countries, with close to three-quarters of the world's urban population, are at greatest risk from extreme events and also have a far greater deficit in adaptive capacity than do high-income countries because of backlogs in protective infrastructure and services and limitations in urban government (Moser and Satterthwaite, 2008; Satterthwaite et al. 2007).

An inevitable result of the increased damages to infrastructure from climate change and disasters will be a dramatic increase in the resources needed to restore infrastructure and assist the poor who will be most affected by damaged infrastructure (Freeman and Warner, 2001). A study by the Australian Academy of Technological Sciences and Engineering (ATSE) concluded that retrofit measures will be needed to safeguard existing infrastructure in Australia and new adaptation approaches will be required for construction of new infrastructure (Stevens, 2008). The recommendations from this study as well as those from other countries recognize the need for: research to fill gaps on the future climate, 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 adaptation options to deal with projected impacts to the built environment range from deferral of actions pending new information to modification of infrastructure components, 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).

Planning for safe structures is a key disaster risk management and adaptation approach towards reducing vulnerabilities today and into the future. The implementation of adequate building codes incorporating 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, relying on the assumption 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 designed using analysis of historical rainfall records, assuming that the past climate will represent the future (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 climate change guidance, tools and adaptation options be developed to ensure that climate change can be incorporated into infrastructure design (Stevens, 2008; Wilby et al, 2009; Auld, 2008b).

Many climate change studies advocate a twin-track approach of: (1) "bottom-up" vulnerability assessments of strategies to cope with present climate extremes and variability, and, (2) "top-down" approaches to develop climate change tools and scenarios to evaluate sector-specific, incremental changes in risk over the next few decades (Wilby et al, 2009; Auld, 2008b). Although the "top-down" approach of using climate scenarios for impact assessment has grown steadily since the 1990s, uptake of such information into adaptation decision-making is lagging (Wilby et al, 2009). Some tools are becoming available to account for changing climate risks. These tools include the avoidance of high-risk areas through more stringent development controls, allocation of green space for urban cooling and flood attenuation, appropriate building design and climate sensitive planning, new hard engineering codes and standards with increased uncertainty/safety factors and climate change guidance and incorporation of climate change into engineering practices especially for flood defences and water supply systems (Wilby, 2007; Auld, 2008a; Neumann, 20009). To address ongoing climate change in the Arctic, the Canadian Standards Association released a national Guide in 2010 to deal with climate change risks in melting permafrost regions by incorporating results from an ensemble of climate change models into risk assessment and risk management methodologies (NRTEE, 2009; Canadian Standards Association, 2010; see Chapter 9 case study 9.x.x on vulnerable regions: The Arctic). Overall, prioritization of required adaptation actions for the built environment will need to account for existing and future vulnerabilities, the variable lifecycles of structures and replacement and maintenance cycles (Auld, 2008a).

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 building standards or inadequately account for local hazards (Rossetto, 2007). While the perception in some developing countries is that 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). For example, Bangladesh 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). 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 their up-take and implementation (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).

Land and water use planning to protect and enhance "green infrastructure" or natural buffers and defences for the built environment can reduce vulnerabilities to current and future climate change. For example, stormwater management or urban flood management approaches (*references from Canberra, Florida, Japan and Malaysia*) have been developed over the last decades using soft and hard engineering approaches to overcome flash floods and poor water quality in natural systems in rapidly urbanised areas. Current flood proofing of the existing infrastructure, including modification of existing structures and their operations and maintenance, is expected to incorporate projected extreme rainfalls from an ensemble of climate models into design criteria. While some countries' authorities, such as 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 predictions, especially for elements such as extreme winds and extreme precipitation and its various phases (e.g. short and long duration rainfalls, freezing rain, snowpacks), into formal legislation (Wilby, 2010; Auld, 2008a; Sanders and. Phillipson, 2003)

6.3.3.2.2. Promoting human development and secure livelihoods and reducing vulnerability

Vulnerabilities to climate related hazards vary between and within countries due to factors such as poverty, social positioning, geographic location, gender, age, class, ethnicity, community structure, community decision-making processes and political issues (Yodmani, 2001). Between countries, 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 needs of these most vulnerable countries (see Section 7.4.3 for more details). Within countries, the most vulnerable are usually those least able to cope with climate hazards due to limited adaptive capacity and policies are needed to increase this capacity (Davies et al, 2009; Heltberg et al., 2009).

The most vulnerable communities in poor countries may require full scale assistance to protect lives, properties and livelihoods (ISDR, 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). For example, climate change is likely to 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 as one of the key priorities 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 so far remained limited (Ayers and Huq, 2009). Nonetheless, some developing countries have implemented successful policies and plans. 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 (UN-ISDR 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, 2009).

A crucial aspect in reducing vulnerability of climate-related risks - including food insecurity - is to make climate-related and climate change information available and accessible to decision-makers (Wilby et al., 2009; Washington et al., 2006). The use of climate information in the national planning and programming process is still in its infancy. A recent 'gap analysis' in Africa showed that while climate information exists that could aid decision makers in making 'climate smart' decisions, this information is seldom incorporated (Ayers and Huq, 2009). In many developing countries, one of the potential barriers for identifying the most vulnerable regions and people under future climate change is the limited capacity to downscale global and regional climate projections to a scale needed to support national level planning and programming process (Wilby et al., 2009; CCCD, 2009; Washington et al., 2006).

A process has already been initiated in many countries to establish a solid information base and support the prioritization of adaptation needs for the most vulnerable populations. For example, National Adaptation Programme of Actions (NAPA) have been able to assess the climate sensitive sectors and prioritize projects to address the urgent adaptation needs of the most vulnerable regions, communities and populations in 49 least developed countries (UNCTAD, 2008).

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 (UNISDR, 2007, UNEP 2006, 2009 and Sudmeier-Rieus and Ash 2009), improved livelihood 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 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; ISDR, 2007, 2009; Colls et al., 2009; Sudmeier-Rieux and Ash 2009; Reid and Huq, 2005; Secretariat of the Convention on Biological Diversity, 2009). Investment in natural ecosystem has long been used to reduce risks of disasters. Forests, for example, have been used in the Alps and elsewhere as effective mitigation measures against avalanches, rockfalls and landslides (Bebi, 2009; Dorren, 2004; Phillips and Marden, 2005; Sidle et al., 1985). The damage caused by wildfires, wind erosion, drought and desertification can 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). Investment in natural ecosystem can also contribute significantly to reduction in GHG emissions, through practices such as Land Use, Land Use Change and Forestry or LULUCF and through Reduced Carbon Emissions from Deforestation and Forest Degradation or REDD (UNEP, 2006; Secretariat of the Convention on Biological Diversity, 2009).

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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 devastating Asian tsunami in 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)

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REDD and REDD+ related strategies can help generate alternative sources of 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), and improve their livelihoods. Livelihood benefits are derived from protection of natural ecosystem and goods and services they support and conservation of biological diversity (International Union for the Conservation for Nature and Natural Resources, 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, Singh et al. 2009). The extent to which ecosystems support such benefits though depends on a complex set of dynamic interaction 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, while the protective effects against tsunami waves and storm surges is more dependent on factors such as coastal bathymetry, coastal forest and mangrove stand density (Baird et al. 2005; Balmford et al, 2008; Björk et al. 2008; IOC, 2009; Kaplan et al., 2009; Yanagisawa, 2009). Scientific relational understanding between ecosystem health and the reduction of risks associated with climate extremes and disaster risks is though limited. There are nonetheless, many examples where countries have rehabilitated natural ecosystems, that demonstrate the nature of economic benefits that natural ecosystems provide in reducing risks to disasters (Reid and Huq, 2005; Secretariat of the Convention on Biological Diversity, 2009 (see Box 6-4).

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 Successes

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 (ISDR, 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).

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Generally, EbA strategies, often referred to as 'soft' options, can be more cost-effective CCA strategy than hard infrastructures and engineering solutions, and produce multiple benefits. EbA options are often more easily accessible to the rural poor (Sudmeier-Rieux, 2009). But countries would need to overcome many challenges if countries are to be successful in increasing investment in nature 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 and inter-ministerial coordination and planning for EbA which may follow administrative, rather than geographical boundaries such as watersheds (OECD, 2009; Leslie and McLeod, 2007).
- Lack of capacity to undertake careful assessments of alternative strategies to inform choices at the micro level. Such assessments could provide total economic value of *in situ* conservation compared with alternative uses of the forested land such as in agriculture (see eg Balmford 2002). Such assessments can help between *in situ* conservation and *ex-situ* conservation strategies, for example, species relocation, assisted migration, captive breeding, and *ex-situ* storage of genetics or germplasm, may be less cost effective than *in-situ* conservation actions (Convention on Biological Diversity's Ad Hoc Technical Expert Group (Secretariat of the Convention on Biological Diversity, 2009).
- Data and monitoring on ecosystem conditions 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 (ISDR, 2009a).
- Absence of tools to assess and monitor impact of climate change on biodiversity and ecosystem (Secretariat of the Convention on Biological Diversity, 2009).

6.3.3.3. Transferring and Sharing 'Residual' Risks

Risks can be reduced at all levels using many different measures, yet some residual risks will remain due to physical, financial and other constraints. Implicitly, residual risk is borne after an event when people use their personal savings or governments use their tax revenue (the latter often also called ex post loss financing). Ex ante risk financing occurs when risk is considered explicitly before disaster events using risk sharing and transfer instruments. The relevance and role of such ex ante and ex post mechanisms for national level strategies for managing extreme events is demonstrated by a substantial body of literature (e.g., Jaffee and Russell, 1997; Van Schoubroeck, 1997; Kunreuther, 1998, 2000; Froot, 1999; Von Ungern-Sternberg, 2002; Lane, 2004; Schwarze and Wagner, 2004; Mills, 2009; Aakre et al., 2010; Hochrainer, Bayer and Mechler, 2010). Risk financing as an important pre-event risk management tool for developing and emerging economies has been discovered, applied and analyzed over the last ten years, as reflected by a growing body of literature (eg., Pollner, 2000; Andersen, 2001; Varangis, Skees and Barnett, 2002; Auffret, 2003; Dercon, 2005; Linnerooth-Bayer, Mechler and Pflug, 2005; Hess and Syroka, 2005; World Bank, 2007; Skees, 2008; Cummins and Mahul, 2008; Hess and Hazell,,2009). Finally the role of risk financing for climate change was first covered a decade ago, but has only lately received growing attention (e.g., Doherty, 1997; Tol, 1998; IPCC, 2001; Mills, 2005; AOSIS, 2007; MCII, 2008; Linnerooth-Bayer, Bals and Mechler, 2008).

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. Hess and Hazell (2009) 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). 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 (see 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, 2001). 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; Ghesquiere and Mahul, 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 (Ghesquiere and Mahul, 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).

6.3.3.4. Managing the Impacts

Risk reduction strategies cannot completely eliminate the impact of extreme climate events (Katoch, 2007).and the impacts of climate-related disasters still need to be managed even if the practices detailed above are executed perfectly. Moreover, the immediate post-disaster period and those associated with rehabilitation and reconstruction often provide significant opportunities to put in place new systems, policies and practices with the intention of reducing future disaster risk and adapting to climate change.

Climate related disasters have played a major role in the increasing human impact of overall disasters, according to the IFRC (2009), and undoubtedly have put a strong pressure on humanitarian organizations and national governments. Table 6-4 shows that in the 1999-2008 period near 97% of affected persons were attributed to disasters provoked by drought, floods, heat waves or other climate related hazards. The remaining 3% were affected by geological related disasters, especially earthquakes and volcanic eruptions (IFRC, 2009). When assessing economical losses the trend stays the same, with geological-related disasters accounting for only 21.8% of total damages and climate related disasters accounting for 78.2% of the same total (IFRC, 2009).Considering the present trends of risk and climate change, the humanitarian costs will probably even rise in the near future, some estimations point out that increase could range from a 32% due to changes in frequency of disasters, to upwards of a 1600% increase when an increase in intensity of disasters is taken into account (Webster, et al., 2008).

[INSERT TABLE 6-4 HERE:
Table 6-4: Total number of people reported affected, by type of phenomenon and by year (1999 to 2008), in thousands.]

In practice, national governments rely on humanitarian organizations, usually integrated in the national systems, for dealing with the human toll of disasters. One of the major actors in the humanitarian scene are, undoubtedly, the Red Cross and the Red Crescent, and they are also addressing the challenges posed by disaster risk reduction and climate change impacts very seriously, as well as another large practitioners of the humanitarian field (IASC, 2009; IFRC, OCHA and WFP, 2009; Red Cross/Red Crescent, 2007). A comprehensive review of experiences at the national level pointed out at six components of the so called "good climate risk management": (a) climate risk assessment: assessing priorities, and planning follow-up; addressing the consequences: (b) integrating climate change in programs and activities; (c) raising awareness; (d) establishing and enhancing partnerships; (e)international advocacy: shaping the global response to climate change; and (f) documenting and sharing experiences and information (Red Cross/Red Crescent, 2007).

Different efforts made under the framework of climate change adaptation are increasingly including preparedness and response measures such as training, equipment, EWS, health protection, natural resource development, environmental management and livelihoods protection, for example (IASC, 2009; Barret et al., 2007; McGray, 2007). The use of climate information has been another field in which humanitarian efforts have been undertaken, nevertheless, serious challenges remain in the use of climate information in humanitarian decision-making for example: forecasts give only probabilities, not certainties, leaving disaster managers to use their own criteria to interpret seasonal forecasts and its implications on operations; and second, the further in advance a forecast is made, the less accurate it is likely to be so, at the end, the preparedness period is always short and uncertain. (IASC, 2009).

Case studies are showing an important shift in the humanitarian sector from the preparedness-response approach to the disaster risk reduction and climate change adaptation approaches, at the same time, adaptation projects are also including preparedness and response components (IASC, 2009a). At the national level these trends are evident in different programs of international cooperation and humanitarian organizations as well as in the growing involvement of national governments in disaster response, risk reduction and climate change adaptation (ISDR, 2009). But despite the obvious progress done in its field, there are also big problems and challenges that have been identified when evaluating the disaster preparedness and response capabilities: lack of appropriate policies and legislation; decentralization of capacities and resources; insufficient budgetary allocation; capacity building at the local level; lack of political will to include disaster risk reduction activities in traditional emergency response programs (UNISDR, 2004; ISDR, 2009).

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. As climate change is altering the frequency and magnitude of some extreme events and helping to create more extreme impacts through amplifying vulnerability and exposure and increasing uncertainty in some areas (see Chapters 3 and 4), the efficacy of national systems requires review and realignment with the new challenges. At minimum, national systems must begin to integrate the assessments of climate impacts and changing disaster risks and uncertainties into current investments, strategies and activities, seek to strengthen longer term capacity of all actors to adapt to climate change and address the drivers of vulnerability and poverty, recognising climate change as a key driver (UN-ISDR GAR 2009; Schipper 2009). In practice, this might require new alliances across government and potentially between countries, different actors to join the national system, a reallocation of responsibilities and resources across scales and new practices. 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 must occur – in assessing the effectiveness of disaster risk management in a changing climate (6.4.1), managing uncertainty and adaptive management (6.4.2), tackling poverty, vulnerability and their structural causes (6.4.3) and supporting the transition to a low carbon form of development that appreciates the implications of changing disaster risks (6.4.4)

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 very few national level assessments focussing on economic efficiency of management responses (see World Bank, 1996; Benson 1998; Mechler (2004)),

Where such 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 a multi criteria approach have been conducted (see Van Ierland, 2005; de Bruin et al. (2009). 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 modeling 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.

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 (Thomson and Gaviria, 2004; Tompkins, 2005). 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 fed 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).

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). 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; and 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 (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 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 to show the success, the potential losers from this policy may go unnoticed, causing problems with policy implementation and legitimacy (Eakin et al. 2009).

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, something that so far it has struggled to do (UN-ISDR 2010), 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 (ISDR, 2009) .Climate change adaptation and disaster risk reduction share a common goal in seeking to reduce vulnerability – addressing inequity, promoting secure livelihoods, discrimination, and increasing access to power and resources, among others (Mitchell and Van Aalst 2008, Tanner and Mitchell 2008, Schipper 2009). However, strategies for tackling the risks of climate extremes and disasters adaptation and disaster risk management used 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 (UN-ISDR 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 social protection/welfare/safety net measures within national development programmes designed to tackle the causes of poverty and vulnerability while also addressing risk in a changing climate at the same time (Davies et al. 2008, see Box 6-6).

_____ START BOX 6-6 HERE _____

Box 6-6. Linking Disaster Risk Reduction, Climate Change Adaptation, and Transformative Social Protection

Adaptive Social Protection (ASP) is the combination of social protection (SP), disaster risk reduction (DRR) and climate change adaptation (CCA) in policy and practice as a means to promote climate and disaster-resilient livelihoods in developing countries. Social protection is the set of all initiatives, both formal and informal, that provide social assistance to extremely poor individuals and households; social services to groups who need special care or would otherwise be denied access to basic services; social insurance to protect people against the risks and consequences of livelihood shocks; and social equity to protect people against social risks such as discrimination or abuse (Devereux and Sabates-Wheeler 2004). ASP recognises that the disciplinary concepts and knowledge sets from the thematic areas of SP, DRR and CCA have their own strengths and weaknesses, and work to maximise the advantages that each brings to poverty and vulnerability reduction among the poorest and most vulnerable (Davies et al. 2008; Davies et al. 2009; Cyprik 2009; Heltberg et al. 2009; Heltberg and Siegel 2008). This is important given the requirement to significantly scale up vulnerability-reducing programmes and projects in response to climate change and shifting disaster risk in a way that maximises development impact whilst avoiding duplication of effort on the ground. Importantly, merging a transformative version of social protection (Devereux and Sabates-Wheeler 2006), which recognises that poverty and vulnerability cannot be tackled through resource transfers alone and without addressing underlying issues of disempowerment and inequality, with disaster risk management and climate change adaptation provides a framework to sustainably tackle the drivers and root causes of disaster risk. Table 6-5, shows the benefits of different social protection measures for disaster risk reduction and climate change adaptation (Davies *et al*. 2009).

[INSERT TABLE 6-5 HERE:
Table 6-5: Examples of Social Protection Measures that bring disaster risk management and climate change adaptation benefits among the poorest in society.]

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6.4.4. Low Carbon Development and Disaster Risk

Carbon-intensive development produces greenhouse gases that contribute to climate change. Continued focus on this type of development will only accelerate the changing of the climate and climate extremes experienced (Yamin et al. 2005) and exacerbate vulnerability. The search for linkages between adaptation and mitigation has been going for many years, yet there are still few examples of the general benefits from addressing climate change adaptation and mitigation jointly as opposed to separately (Klein et al 2007). Few of these examples focus on disaster risk reduction and fewer still are initiated and managed at the national scale. Klein et al (2007) cite the use of air conditioning as a risk reducing strategy in heatwaves; the use of afforestation that stabilizes soils; managing urban heat islands through green roves and trees for shade as examples of joint action on adaptation and mitigation that also aligns with national disaster risk management systems. Proponents of low carbon, climate resilient growth suggest that there are developmental (and hence adaptation) benefits from pursuing domestic emissions reduction policies (Ayres and Huq, 2009). Kok et al. (2008) provide examples of how developmental gains can be made through greenhouse gas emissions reduction. They argue that energy security can be enhanced through hydro-power and suggest that a large scale hydro-power scheme could improve energy supply across southern Africa. Further they highlight the health improvements seen after the switch to biofuelled vehicles in Brazil (Kok et al. 2008).

Low carbon climate resilient development could be an effective strategy for some countries in land use planning, water management and urban planning, although in most cases greater benefits may be found by addressing adaptation and mitigation separately (Swart and Rees, 2007). Swart and Rees (ibid) nonetheless recommend identifying synergies between adaptation and mitigation wherever possible to reduce the need for later trade-offs between the two policies. In South African rangelands drought is a recurrent problem. Restoration of the rangelands could provide enhanced resilience to drought, however the agricultural policy currently in place is unlikely to deliver this, as there are multiple other interests that need to be addressed requiring land reform (Vetter, 2007). Institutional and social barriers to learning and change present a significant hurdle to potential advances in adaptation and mitigation initiatives that generate risk reduction benefits (Dietz et al. 2003). A first step to achieving this is to clearly document the risk reducing benefits from joint action on adaptation and mitigation. Specifically, under what conditions these co-benefits arise, and where national intervention (through for example, education and knowledge transfer, payments or penalties, and regulation) can deliver these co-benefits.

6.4.5. Conclusion: 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 more frequent and extreme events of higher intensity and uncertainty, as well as by addressing the underlying drivers of vulnerability e.g. poor economic well being and social inequalities

Strategies for mainstreaming climate change 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 transformative 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. Research Priorities

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 subnational 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, see Section 6.4).
- 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

1) What constitutes a national system for managing risk associated with climate extremes and disasters *(S 6.1 Introduction)*, and how does it differ from 'national level' of managing risks of climate change related extremes and disasters? (*S. 6.2.1).*
2) What are the respective roles of governments (national and subnational), private sector, communities, and development partners in addressing the risks of climate change related extreme events and disasters? (*S 6.2.1 – 6.2.4).*
3) Under what conditions is the private sector likely to be willing (or not willing) to share in the risks of climate change related extreme events and disasters and assist communities to minimise their burden of disaster management costs? (*S 6.2.2 and S 6.3.3.3).*

4) What can government (national and subnational) policy makers do, domestically, to help reduce risk and manage residual risks of climate change related extremes and disasters?(*S 6.3.1 – 6.3.2; S6.4.1-6.4.5).*
5) How can countries integrate considerations of increasing risks of climate change related extremes and disasters to reduce risks, transfer risks and manage residual risks? (*S 6.3.1-6.3.2; S 6.4.1-6.4.2).*
6) What methods and tools are currently available to help develop a culture of resilience (S 6.3.3.1); reduce climate-related disaster risks though hard and soft options (S 6.3.3.2), and transferring and sharing 'residual risks? (S 6.3.3.3).
7) What is 'Ecosystem based Adaptation' to climate change and what role can it play in providing triple win outcomes? (*S 6.3.3.2.3).*
8) What best practice examples are currently available to demonstrate the value of integrating disaster risk reduction and climate change adaptation in a country? (*S 6.4.1 – 6.4.2).*
9) What is 'adaptation deficit' in relation to current risk management, how will this be affected under climate change? (*S. 6.1.2); and what could be* done to transform current disaster risk management system into a system that addresses 'adaptation def*icit'* and meets the challenges of climate change? (*S 6.3.1-6.3.2 6.4.1-6.4.5).*
10) How can communities and countries become climate smart in an environment of limited baseline information about climate change? (S 6.3.3.1; S6.4.2).

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

Sector/ Response	**No regret actions**	**Reduce uncertainties** ***('No regrets' options plus…)***	**Reduce climate change risks** ***("Reducing uncertainties" options plus...)***	**Transfer of risks**	**Managing residual risks**	**'Triple win' - GHG reduction, adaptation, risk reduction and development benefits**
Natural Ecosystems and Forestry	▪ 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]	▪ 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]	▪ 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]	▪ 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	▪ Food security via sustainable land and water management, training; Efficient water use, storage; Agro-forestry; Protection shelters, crop and livestock diversification; Improved supply of climate stress tolerant seeds; Integrated pest, disease	▪ Increased agriculture-climate research and development [10] ▪ Research on climate tolerant crops, livestock; Agrobiodiversity for genetics [10] ▪ Integration of climate	▪ Adaptive agricultural practices for new climates, extremes [12] ▪ New and enhanced agricultural weather, climate prediction services [11] ▪ Food emergency planning;	▪ Improved access to crop, livestock and income loss insurance, (e.g. weather derivatives) [13] ▪ Micro-funding and micro-	▪ Changed livelihoods and relocations in regions with climate sensitive practices [12] ▪ Emergency	▪ Energy efficient and carbon sequestering practices; Training; Reduced use of chemical fertilizers [14]

	management [8] ▪ Climate monitoring; Improved weather predictions; Disaster management, crop yield and distribution models and predictions [9]	change scenarios into national agronomic assessments [11] ▪ Diversification of rural economies for sensitive agricultural practices [10]	Distribution and infrastructure networks [12] ▪ Diversify rural economies [12]	insurance [13] ▪ Subsidies, tax credits [13]	stock and improved distribution of food and water [12]	▪ Promote Bio-gas from agri-waste and animal excreta[14] ▪ Agroforestry [14]
Coastal Zone and Fisheries	▪ 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]	▪ Enhance insurance for coastal regions and resources; Fisheries insurance [21] ▪ Government reserve funds [21]	▪ Enhance emergency preparedness measures for changed extremes, including evacuations [16] ▪ Relocations of communities, infrastructure [16] ▪ Exit fishing; alternate livelihoods [19]	▪ 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	▪ 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	▪ 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	▪ 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	▪ Public-private partnerships; Economics for water allocations beyond basic needs [26] ▪ Mobilize financial resources and capacity for	▪ National preparedness and evacuation plans [24] ▪ Enhanced health infrastructure [24] ▪ Transport, engineering; temporary consumable	▪ Integrated water efficiency and renewable hydro power for CCA [23]

	for resilient water infrastructure and water resource management; Improved institutional arrangements, negotiations for water allocations [23]	water resource management (e.g. catchments and river basins); joint river basin management (e.g. bi-national) [23]	quality forecasts for new conditions [24]	technology and EbA [26] ▪ Insurance for infrastructure	water taking permits [24] ▪ Food , water distribution, alternate livelihoods [24]	
Infra-structure, Housing, Cities, Transport-ation, energy	▪ Building codes, standards with updated climatic values; Climate resilient infrastructure (and energy) designs; Training, capacity, inspection, 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]	▪ Improved downscaling of CC information; Maintain climate data networks, update climatic design information; Increased safety/uncertainty factors in codes and standards; Develop 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]	▪ Codes, standards for changed extremes; [30] ▪ Publicly funded infrastructure and post-disaster reconstruction to include CCA [30] ▪ New materials, engineering approaches; Flexible 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]	▪ Infrastructure insurance and financial risk management [29] ▪ Insurance for energy facilities, interruption [29] ▪ Innovative risk sharing instruments [29] ▪ Government reserve funds [29]	▪ Relocation [28] ▪ Evacuation planning; Contingency plan for transport during extreme events [28] ▪ Climate resilient shelter construction [28] ▪ Promote energy security; Distributed energy generation and distribution [29]	▪ Implement energy and water efficient GHG reductions, DRR and adaptation synergies [29] ▪ Scale up, market penetration for renewable energy production; Increased hydroelectric potential; Sustainable biomass; "Greener" distributed community energy systems [29]
Health	▪ Community/urban planning, building standards and guidelines; cooling shelters;	▪ Research on climate-health linkages and CCA options; Develop	▪ New food and water security, distribution systems; air quality	▪ Extend and expand health insurance	▪ National plan for heat and extremes	▪ Promote use of clean renewable

	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]	coverage to include new and changed weather and climate risks [33] ▪ Government reserve funds [33]	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]	energy and water sources; increase energy efficiency; Air quality regulations; Clean energy technologies to reduce harmful air emissions (e.g. cooking stoves) [34]

TABLE 6-1 NOTES:

[1] Adger et al, 2005; Barbier, 2009; Colls et al, 2009; FAO, 2008a; ISDR, 2007; ISDR, 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; ISDR, 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; ISDR, 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; ISDR, 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 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
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: Total number of people reported affected, by type of phenomenon and by year (1999 to 2008), in thousands.

Type of disaster/Years	**1999**	**2002**	**2006**	**2008**	**Total**	**Percentages**
Subtotal climato-, hydrometeorological Disasters	*295,236*	*710,524*	*138,586*	*166,606*	*2,606,736*	*96.8*
Subtotal geophysical Disasters	*6,890*	*1,130*	*4,237*	*47,351*	*87,233*	*3.2*
Total natural disasters	**302,126**	**711,654**	**142,823**	**213,957**	**2,693,969**	**100**

Source: Based on IFRC, 2009

Table 6-5: Examples of social protection measures that bring disaster risk management and climate change adaptation benefits among the poorest in society.

SP measure	**SP instruments**	**Adaptation and DRR benefits**
Provision (coping strategies)	– social service protection – basic social transfers (food/cash) – pension schemes – public works programmes	– protection of those most vulnerable to climate risks, with low levels of adaptive capacity
Preventive (coping strategies)	– social transfers – livelihood diversification – weather-indexed crop insurance	– prevents damaging coping strategies as a result of risks to weather-dependent livelihoods
Promotive (building adaptive capacity)	– social transfers – access to credit – asset transfers/protection – starter packs (drought/flood resistant) – access to common property resources – public works programmes	– promotes resilience through livelihood diversification and security to withstand climate related shocks – promotes opportunities arising from climate change
Transformative (building adaptive capacity)	– promotion of minority rights – anti-discrimination campaigns – social funds	– transforms social relations to combat discrimination underlying social and political vulnerability