

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

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Executive Summary

This chapter assesses how countries are managing current and future disaster risks, given knowledge of how risks are changing with observations and projections of weather and climate extremes [Table 3-2, 3.3], vulnerability and exposure [4.3] and impacts [4.4]. It focuses on the design of national systems for managing such risks, the roles played by actors involved in the system and the functions they perform, acknowledging that complementary actions to manage risks are also taken at local and international level as described in chapters five and seven.

National systems are at the core of countries' capacity to meet the challenges of observed and projected trends in exposure, vulnerability and weather and climate extremes (*high agreement, robust evidence*).

Effective national systems comprise of multiple actors from national and sub-national governments, private sector, research bodies, civil society and community-based organisations, playing differential but complementary roles to manage risk, according to their accepted functions and capacities. These actors work in partnership across temporal, spatial, administrative and social scales, supported by relevant scientific and traditional knowledge. Specific characteristics of national systems vary between countries and across scales depending on their socio-cultural, political and administrative environments and economic status. [6.2]

The national level plays a key role in governing and managing disaster risks because national government is central to providing risk management-related public goods as it maintains financial and organisational authority in planning and implementing these goods (*high agreement, robust evidence*). National governments are charged with the provision of public goods such as ensuring the economic and social well-being, safety and security of their citizens from disasters, including the protection of the poorest and most vulnerable citizens. They also control budgetary allocations as well as creating legislative frameworks to guide actions by other actors. Often, national governments are considered to be 'insurer of last resort'. In line with the delivery of public goods, national governments and public authorities 'own' a large part of current and future disaster risks (public infrastructure, public assets and relief spending). In terms of managing risk, national governments act as risk aggregators and by pooling risk, hold a large portfolio of public liabilities. This provides governments with the ability and responsibility to accurately quantify and manage risks associated with this portfolio, functions that are expected to become more important given projected impacts of climate change and trends in vulnerability and exposure. [6.2.1]

In providing such public goods, governments choose to manage disaster risk by enabling national systems to guide and support stakeholders to reduce risk where possible, transfer risk where feasible and manage residual risk, recognising risks can never be totally eliminated (*high agreement, robust evidence*). The balance between reducing risk and other disaster risk management strategies is influenced by a range of factors, including financial and technical capacity of stakeholders, robustness of risk assessment information, and cultural elements involving risk tolerance. [6.2.1, 6.2-6.5]

The ability of governments to implement disaster risk management responsibilities differs significantly across countries, depending on their capacity and resource constraints (*high agreement, robust evidence*). Smaller or less diversified vulnerable countries with a low tax base face critical challenges in providing the public goods associated with disaster risk management, and also in absorbing the losses caused by disaster events and providing relief and reconstruction assistance. [6.2.1] However, there is *limited evidence* to suggest any correlation between the type of governance system in a country (e.g. centralised or decentralised; unitary or federal) and the

effectiveness of disaster risk management efforts. There is *robust evidence* and *high agreement* to suggest that actions generated within and managed by communities with supporting government policies are generally most effective since they are specific and tailored to local environments. [6.4.2]

In the majority of countries, national systems have been strengthened by applying the principles of the Hyogo Framework for Action to mainstream risk considerations across society and sectors, although greater efforts are required to address the underlying drivers of risk and generate the political will to invest in disaster risk reduction (*high agreement, robust evidence*). The Hyogo Framework for Action has encouraged countries to develop and implement a systematic disaster risk management approach, and in some cases has led to strategic shifts in the management of disasters risks, with governments and other actors placing greater attention on disaster risk reduction compared to more reactive measures. This has included improvements in co-ordination between actors, enhanced early warning and preparedness, more rigorous risk assessments and increased awareness. However, there is *limited evidence* and *low agreement* to suggest improvements in integration between efforts to implement of the Hyogo Framework for Action, the United Nations Framework Convention on Climate Change and broader development and environmental policy frameworks. [6.4.2]

A set of factors can be identified that make efforts to systematically manage current disaster risks more successful (*all high agreement, robust evidence*). Systems to manage current disaster risk are more successful if:

- Risks are recognised as dynamic and are mainstreamed and integrated into development policies, strategies, and actions and into environmental management [6.3.1]
- Legislation for managing disaster risks is supported by clear regulations that are effectively enforced across scales and complemented by other sectoral development and management legislations where risk considerations are explicitly integrated [6.4.1]
- Disaster risk management functions are co-ordinated across sectors and scales and led by organisations at the highest political level [6.4.2]
- National development plans and sector plans include explicit considerations of disaster risk, countries adopt climate change adaptation policies and strategies, and translate these into action targeting vulnerable areas and groups [6.5.2]
- Risk is quantified and factored into national budgetary processes, and a range of measures including budgeting for relief expenditure, reserve funds, and other forms of risk financing have been considered or implemented [6.4.3]
- Decisions are informed by comprehensive information about observed changes in weather, climate and vulnerability and exposure, and historic disaster losses, using a diversity of readily available tools and guidelines [6.5.1]
- Early warning systems deliver timely, relevant, and accurate predictions of hazards, are developed and operationalised in partnership with the public and trigger effective response actions [6.5.1]
- Responses include a combination of hard infrastructure based options as well as soft longer term solutions such as building individual and institutional capacity and nature based investments, such as environment including conservation measures associated with for example forestry, river catchments, coastal wetlands and biodiversity. [6.5.2]

While there is robust evidence and high agreement on efforts to tackle current disaster risks, the assessment found *limited evidence* of cases where national disaster risk management systems and associated risk management measures had explicitly integrated knowledge of projected trends in vulnerability, exposure, and weather and climate extremes and uncertainties. The effectiveness of efforts to manage projected disasters risks at national level are dependent on a range of factors, including the effectiveness of the system for managing current risks, the ability of the system to flexibly respond to new knowledge, the availability of suitable data and the resources available to invest in longer-term risk reduction and adaptation measures. Developed countries are better equipped financially and institutionally to adopt explicit measures to effectively respond and adapt to projected changes in exposure, vulnerability, weather and climate extremes than developing countries, though all countries face challenges in assessing, understanding and then acting on these changes as well as uncertainties. [6.6.2, 6.6.4]

‘Low’ regrets measures for managing current disaster risks are starting points for addressing projected trends in exposure, vulnerability and weather and climate extremes, as they have the potential to offer

benefits now as well as lay the foundation for addressing projected changes (*high agreement, medium evidence*). The assessment considered such ‘low’ regrets options across a range of key sectors, with some of the most commonly cited measures associated with improvements to early warning systems, health surveillance, water supply, sanitation and drainage systems, climate proofing of major infrastructure and enforcement of building codes, better education and awareness and restoration of degraded ecosystems and nature conservation. Many of these ‘low regrets’ strategies also produce other co-benefits and help address other development goals, such as improvements in livelihoods, human well being and biodiversity conservation, and minimise the scope for maladaptation. Some low regrets options also may not always be optimal in every future scenario and recommended when uncertainties over future climate change directions are high. [6.3.1]

Ecosystem-based solutions in the context of changing climate risks can offer ‘triple-win’ solutions, as they can provide cost-effective risk reduction, support biodiversity conservation, and enable improvements in economic livelihoods and human well-being, particularly to the poor and vulnerable (*high agreement, robust evidence*). The assessment found that such ecosystem based adaptation strategies, including mangrove conservation and rehabilitation, integrated catchment management, sustainable forest and fisheries management, also minimise the scope for maladaptation. [6.5.2]

Insurance-related instruments are key mechanisms for helping households, business, and governments absorb the losses from disasters; but their uptake is unevenly distributed across regions and hazards, and often public private partnerships are required (*high agreement, robust evidence*). Disaster insurance and other risk transfer instruments covered about 20% of reported weather-related losses over the period 1980 and 2003. Distribution though is uneven with about 40% of the losses insured in high-income as compared to 4% percent of losses in low-income countries. Existing national insurance systems differ widely as to whether policies are compulsory or voluntary, and importantly how systems allocate liability and responsibility for disaster risks across society. With changing weather and extreme events, vulnerability and exposure, extended and innovative private-public sector partnerships are required to better estimate and price risk as well as develop robust insurance-related products, which may be supported in developing countries by development partner funds. [6.5.3]

Pooling of risk by and between national governments contributes to reducing the fiscal and socio-economic and consequences of disasters (*medium agreement, medium evidence*). As national governments hold a large portfolio of public liabilities (infrastructure, public assets and the provision of disaster relief), risk aggregation and pooling are expected to become more important given projected impacts of climate change and trends in vulnerability and exposure. In addition, particularly for small, low-income and highly exposed countries, risk transfer of public sector assets and relief expenditure recently has become a cornerstone of disaster risk reduction. Key innovative and promising applications recently implemented comprise sovereign insurance for hurricane risk, insurance for humanitarian assistance following droughts and intergovernmental risk pooling. [6.4.3, 6.5.3]

Flexible and adaptive national systems are better suited to managing projected trends in exposure, vulnerability and weather and climate extremes than static and rigid national systems (*high agreement, limited evidence*). Adaptive management brings together different scientific, social and economic information, experiences and traditional knowledge into decision-making through ‘learning by doing’. Multi-criteria analysis, scenario planning and flexible decision-paths offer options for taking action when faced with large uncertainties or incomplete information. National systems for managing disaster risk can adapt to climate change and shifting exposure and vulnerability by (i) frequently assessing and mainstreaming knowledge of dynamic risks, (ii) adopting ‘low’ regrets strategies, (iii) improving learning and feedback across disaster, climate and development organisations at all scales, (iv) addressing the root causes of poverty and vulnerability, (v) screening investments for climate change-related impacts to minimise scope for maladaptation, and (vi) increasing standing capacity for emergency response as climatic conditions change over time. [6.6.1, 6.6.2, 6.6.4]

6.1. Introduction

The socioeconomic impacts of disaster events can be significant in all countries, but low and middle income countries are especially vulnerable, and experience higher fatalities even when exposed to hazards of similar

magnitude (IFRC, 2010; Ibarraran et al, 2009; O'Brien et al, 2006; Thomalla et al, 2006). The number of deaths per cyclone event, for example, in the last several decades was highest in low income countries even though a higher proportion of population exposed to cyclones live in countries with higher income; 11 percent of the people exposed to hazards live in low human development countries, but they account for more than 53 percent of the total recorded deaths resulting from disasters (UNDP, 2004a). At the same time, while in absolute terms, the direct economic losses from disasters are far greater in high-income countries, middle and low-income states bear the heaviest burden of these costs in terms of damage relative to annual GDP (UNDP, 2004a; DFID, 2005; O'Brien et al, 2006; Kellenberg et al. 2008; Pelham et al, 2011). This burden has been increasing in the middle income countries, where the asset base is rapidly expanding and losses over the period from 2001-2006 amounted to about 1% of GDP. For the low income group losses totalled an average of 0.3% and for the high income countries amounted to less than 0.1% of GDP (Cummins and Mahul, 2009). In some particularly exposed countries, including many small island developing states, these wealth losses expressed as a percentage of GDP can be considerably higher, with the average costs over disaster and non-disaster years close to 10%, such as reported for Grenada and St. Lucia (World Bank/UN, 2010). In extreme cases, the costs of individual events can be as high as 200% of the annual GDP as experienced in the Polynesian island nation of Niue following cyclone Heta in 2004, or in the Hurricane Ivan event affecting Grenada in 2004 (McKenzie et al. 2005).

In terms of the macroeconomic and developmental consequences of high exposure to disaster risk, a growing body of literature has shown significant adverse effects in developing countries (Cochran, 1994; Otero and Marti 1995; ECLAC, 2002; ECLAC, 2003; 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. Amongst the reasons behind limited coping capacity of individuals, communities and governments are reduced tax bases and high levels of indebtedness, combined with limited household income and savings, a lack of disaster risk transfer and other financing instruments, little capital assets and limited social insurance.

This body of evidence emphasises that disasters can cause a setback for development, and even a reversal of recent development gains in the short- to medium-term, emphasising the point that disaster risk management is a development issue as much as a humanitarian one. 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 (Owens et al. 2003; Lal 2010). Consequently, disasters are seen as barriers for development, requiring *ex-ante* disaster risk reduction policies that also targets poverty and development (Ninno et al, 2003; Owens et al, 2003; Skoufias, 2003; Benson and Clay, 2004; Hallegatte et al, 2007; Raddatz, 2007; Cardona et al, 2010; IFRC, 2010). However, there is some literature that suggests that disasters may not always have a negative effect on economic growth and development and for some countries disasters may be regarded as rather a problem *of*, and not *for* development (Albala-Bertrand, 1993; Skidmore and Toya 2002; Caselli and Malhotra 2004; Hallegatte and Ghil 2007). Disasters have also been considered to increase economic growth in the short term as well as spur positive economic growth and technological renewal in the longer term, depending on the domestic capacity of nations to rebuild and the inflow of international assistance (Skidmore and Toya, 2002). This observation may be partially attributable to national accounting practices, which positively record reconstruction efforts but do not account for the immediate destruction of assets and wealth, in some cases (Skidmore and Toya 2002).

To better respond to the impacts of disasters on human livelihoods, environment and economies, national disaster risk management systems have evolved in recent years, guided in some cases by international instruments, particularly the Hyogo Framework for Action 2005-2015 and more recently as part of the adaptation agenda under the United Nations Framework Convention on Climate Change (UNFCCC) (see 7.3). Increasing knowledge, understanding and experiences in dealing with disaster risks has gradually contributed to a paradigm shift globally that recognises the importance of reducing risks by addressing underlying drivers of vulnerability and exposure, such as targeting poverty, improving human wellbeing, better environment management and adaptation to climate change and as well as responding to and rebuilding after disaster events (Yodmani, 2001; IFRC, 2004; Thomalla et al, 2006; ISDR, 2008a; Venton and LaTrobe, 2008; IFRC, 2010; Pelham et al, 2011). While governments cannot act alone, the majority are well placed and equipped to support communities and private sector to address disaster risks.

Yet recent reported experiences suggest that countries vary considerably in their responses, and concerns remain about the lack of integration of disaster risk management into sustainable development policies and planning as well as insufficient implementation at different levels (CCCD, 2008; UNFCCC, 2008b).

It is at national level that overarching development policies and legislative frameworks are formulated and implemented to create appropriate enabling environments to guide other stakeholders to reduce, share and transfer risks, albeit in different ways (Carter, 1992; Freeman et al, 2003). National level governments in developed countries are often the de facto “insurers of last resorts” and used to be considered the most effective insurance instruments of society (Priest, 1996). Governments also have the ability to mainstream risks associated with climate variability and change into existing disaster risk management and sectoral development, policies and plans, albeit to differing degrees depending on their capacity. These include initiatives to assess risks and uncertainties, manage these across sectors, share and transfer risks and establish baseline information and research priorities (Freeman et al, 2003; Prabhakar et al, 2008; Mechler, 2004). Ideally, national level institutions are best able to respond to the challenges of climate extremes, particularly given that when disasters occur they often surpass people’s and businesses’ coping capacity (OAS, 1991; Otero and Marti, 1995; Benson and Clay, 2002a, 2002b). National government are also better placed to appreciate key uncertainties and risks and take strategic actions, particularly based on their power of taxation (see 6.4.3, 6.5.3), although particularly exposed developing countries may be financially challenged to attend to the risks and liabilities imposed by natural disasters (Mechler, 2004; Cummins and Mahul, 2009; ISDR, 2011a)

Changes in weather and climate extremes and related impacts pose new challenges for national disaster risk management systems, which in many instances remain poorly adapted to the risks posed by existing climatic variability and extremes (Lavell, 1998; McGray et al, 2007; Venton and La Trobe, 2008; Mitchell 2010b). Nonetheless valuable lessons for advancing adaptation to climate change can be drawn from existing national disaster risk management systems (McGray et al 2007; Mitchell et al 2010b). Such national systems are comprised of actors operating across scales, fulfilling a range of roles and functions, guided by an enabling environment of institutions, international agreements and experience of previous disasters (Carter 1992 Freeman et al 2003). These systems vary considerably between countries in terms of their capacities and effectiveness and in the way responsibilities are distributed between actors. Countries also put differential emphasis on integration of disaster risk management with development processes and tackling vulnerability and exposure, compared with preparing for and responding to extreme events and disasters (Cardona et el 2010).

Recent global assessments of disaster risk management point to a general lack of integration of disaster risk management into sustainable development policies and planning across countries and regions, although progress has been made especially in terms of passing legislations, in setting up early warning systems and in strengthening disaster preparedness and response (ISDR, 2011b; Wisner, 2011; Amendola et al, 2008). Closing the gap between current provision and what is needed for tackling even current climate variability and disaster risk is a priority for national risk management systems and is also a crucial aspect of countries’ responses to projected climate change. With a history of managing climatic extremes, involving a large number of experienced actors across scales and levels of government and widespread instances of supporting legislation and cross-sectoral co-ordinating bodies [6.4.2], national disaster risk management systems offer a promising avenue for supporting adaptation to climate change and reducing projected climate-related disaster risks.

Accordingly, this chapter assesses the literature on national systems for managing disaster risks and climate extremes, particularly the design of such systems of functions, actors and roles they play, emphasising the importance of government and governance for improved adaptation to climate extremes and variability. Focussing particularly on developing country challenges, the assessment reflects on the adequacy of existing knowledge, policies and practices globally and considers the extent to which the current disaster risk management systems may need to evolve to deal with the uncertainties associated with and the effects of climate change on disaster risks. Section 6.2 characterises national systems for managing existing climate extremes and disaster risk by focusing on the actors that help create the system - national and sub-national government agencies, bi-lateral and multi-lateral organisations, private sector, research agencies, civil society and community-based organisations. Drawing on a range of examples from developed and developing countries, sections 6.3-6.5 describe what is known about the status of managing current and future risk, what is desirable in an effective national system for adapting to climate

change and what gaps in knowledge exist? The later part of the chapter is organised by the set of functions undertaken by the actors discussed in 6.2. The functions are divided into three main categories – those associated with planning and policies (section 6.3), strategies (section 6.4) and practices, including methods and tools (section 6.5) for reducing climatic risks. Section 6.6 reflects on how national systems for managing climate extremes and disaster risk can become more closely aligned to the challenges posted by climate change and development – particularly those associated with uncertainty, changing patterns of risk and exposure and the impacts of climate change on vulnerability and poverty. Aspects of Section 6.6 are further elaborated in chapter 8.

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

Managing climate-related disaster risks is a concern of multiple actors, working across scales from international, national and sub-national and community levels and often in partnership, to ultimately help individuals, households, communities and societies to reduce their risks (Twigg, 2004, Schipper, 2009; Wisner, 2011). Comprising of national and sub-national governments, private sector, research bodies, civil society and community-based organisations and communities, effective national systems would ideally have each actor performing to their accepted functions and capacities. Each actor would play differential but complementary roles across spatial and temporal scales, (ISDR, 2008a; Schipper, 2009; Miller et al, 2010) and would draw on a mixture of scientific and local knowledge to shape their actions and their appreciation of the dynamic nature of risk (see Figure 6-1). Given that national systems are at the core of country's capacity to meet the challenges of observed and projected trends in exposure, vulnerability and weather and climate extremes, this section assesses the literature on the roles played by different actors working within such national systems.

[INSERT FIGURE 6-1 HERE

Figure 6-1: National system of actors and functions for managing disaster risk and adapting to climate change.]

Figure 6-1 encapsulates the discussions to follow on the interface and interaction between different levels of actors, roles and functions, with the centrality of national organisations and institutions engaging at the international level and creating enabling environments to support actions across the country, supported by scientific information and traditional knowledge.

6.2.1. National and Sub-National Governments

The national level plays a key role in governing and managing disaster risks because national governments are central to providing risk management-related public goods as it maintains organisational and financial authority in planning and providing such goods. National governments have the moral and legal responsibility to ensure economic and social well-being, including safety and security, of their citizens from disasters (ISDR 2004). It is also argued that it is government's responsibility to protect the poorest and most vulnerable citizens from disasters, and to implement disaster risk management that reaches all (McBean 2008; O'Brien et al 2008; CCCD 2009). In terms of risk ownership, government and public disaster authorities "own" a large part of current and future extreme event risks and are expected to govern and regulate risks borne by other parts of society (Mechler 2004). Various normative literature sources support this. As one example, literature on economic welfare theory suggests that national governments are exposed to natural disaster risk and potential losses due to their three main functions: provision of public goods and services (e.g. education, clean environment and security), the redistribution of income, as well as stabilizing the economy (Musgrave 1959; Twigg 2004; White et al 2004; McBean 2008; Shaw et al 2009). The risks faced by governments include losing public infrastructure, assets and national reserves. National level government also redistributes income across members of society and thus are called upon when those are in need (Linnerooth-Bayer and Amendola 2000), or when members of society are in danger of becoming poor, and in need of relief payments to sustain a basic standard of living, especially in countries with low per capita income and/or have large proportions of the population in poverty (Cummins and Mahul 2009). Finally, it can be argued that governments are expected to stabilize the economy, e.g. by supply side interventions when the economy is in disequilibrium. National level governments 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, although the degree of compliance and ability

to honour those responsibilities by governments differs significantly across countries. Nonetheless, in the context of a changing climate, it is argued that governments have a particularly critical role to play in relation to not only addressing the current gaps in disaster risk management but also 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; also refer to chapter 3).

Different levels of governments – national, sub-national and local level - as well as respective sectoral agencies play multiple roles in addressing drivers of vulnerability and managing the risk of extreme events, although their effectiveness varies within a country as well as across them. They are well placed to create multi-sectoral platforms to guide, build and develop policy, regulatory and institutional frameworks that prioritize risk management (Handmer and Dovers, 2007; OECD 2009; ISDR, 2008c); integrate disaster risk management with other policy domains like development or environment management, which often are separated in different ministries (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 et al 2009) through education, training and research (Twigg, 2004; McBean, 2008; Shaw et al, 2009). Governments also allocate financial and administrative resources for disaster risk management, as well as provide political authority (Spence 2004; Twigg 2004; Handmer and Dovers 2007; CCCD 2009). Evidence suggests that successful disaster risk management is partly contingent on resources being made available at all administration level, but to date, insufficient policy and institutional commitments have been made to disaster risk management in many countries, particularly at local government level (Twigg, 2004; ISDR, 2009d). It is argued that governments also has an important role to guide and support 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., 2009).

6.2.2. *Private Sector Organizations*

The private sector plays a small, but increasingly important role in disaster risk management and adaptation and some aspects of disaster risk management may be suitable for non-government stakeholders to implement, albeit this would often effectively be coordinated within a framework created and enabled by governments. Three avenues for private sector engagement may be identified: (i) corporate social responsibility (CSR), (ii) Public Private Partnerships (PPP), and (iii) businesses model approaches. CSR involves voluntary-based advocacy and raising awareness by businesses for disaster risk reduction as well as involving funding support and the contribution of volunteers and expertise to implement risk management measures. PPPs focus on enhancing the provision of public goods for disaster risk reduction in joint undertakings between public and private sector players. The business model approach pursues the integration and alignment of disaster risk reduction with operational and strategic goals of an enterprise (Warhurst, 2006; Roeth, 2009). While CSR and PPP has received substantial attention, business model approaches remain rather untouched areas, one very important exception being the insurance industry as a supplier of tools for transferring and sharing disaster risks and losses.

In terms of business model approaches, insurance is a key sector. In exchange for pre-disaster premium payments, disaster insurance and other risk transfer instruments in 2010 covered about 30% of disaster losses overall (Munich Re 2011). In terms of weather-related events, for the period 1980 and 2003, insurance overall covered about 20% of the losses, yet the distribution according to country income groups is uneven with about 40% of the losses insured in high-income as compared to 4% percent in low-income countries (Mills, 2007). In developing countries, despite complexities and uncertainties involved on both supply and demand for risk transfer, risk financing mechanisms have been found to demonstrate substantial potential in for absorbing the financial burden of disasters (Pollner, 2000; Andersen, 2001; Varangis, Skees and Barnett, 2002; Auffret, 2003; Dercon, 2005; Linnerooth-Bayer et al, 2005; Hess and Syroka, 2005; World Bank, 2007; Skees et al, 2005; Cummins and Mahul, 2009; Hazell and Hess, 2010). There is, though, some uncertainty as to the extent to which the private sector would continue to play this role in the context of changing environment due to uncertainty and imperfect information, missing and misaligned markets and financial constraints (Smit et al, 2001; Aakre et al, 2010). Private insurers are concerned about changes in risks and associated risk ambiguity, i.e. the uncertainty about the chances induced by climate change in terms of

being potentially modified extreme event intensity and frequency. Accordingly, as climate change, and other drivers such as changes in vulnerability and exposure (see chapters 1,2,3) are projected to lead to changes in frequency and intensity of some weather risks and extremes, insurers may be less prepared to underwrite insurance for extreme event risks. Innovative private-public sector partnerships may thus be required to better estimate and price risk as well as develop robust insurance-related products, which may be supported in developing countries by development partner funds as well (see section 6.5.3 and case study 9.2.13).

Professional societies (such as builders and architects) and trade associations also play a key role in developing and implementing standards and practices for disaster risk reduction. These practices may include national and international standards and model building codes that are adopted in the regulations of local, state and national governments. Although the potential for private sector players in disaster risk reduction in sectors such as engineering and construction, information communication technology, media and communication as well as utilities and transportation seems large, *limited evidence* of successful private sector activity has been documented, owing to a number of reasons (Roeth, 2009). The business case for private sector involvement in disaster risk reduction remains unclear, hampering private sector engagement. Companies may also be averse to reporting activities which are fundamental to their business; and, in more community-focussed projects, companies often work with local non-governmental organisations and do not often report such efforts. Considering climate variability and change within the business model, companies may be an important entry point for disaster risk reduction, particularly in terms of guaranteeing global value chains in the presence of potentially large scale disruptions triggered by climate-related disasters. For example, the economic viability of the Chinese coastal zone - the economic heartland of China and home to many multinational companies producing a large share of consumer goods globally - is highly exposed to typhoon risk and will increasingly depend on well implemented disaster risk reduction mechanisms (Roeth, 2009).

6.2.3. *Civil Society and Community-Based Organizations*

At the national level, civil society organisations (CSO) and community based organisations (CBOs) play a significant role in developing initiatives to respond to disasters, reduce the risk of disasters and, recently, adapt to climate related hazards (see 5.1 for a discussion of ‘local’ and ‘community’ and 5.4.1 for the role of CBOs at local level). CSOs and CBOs are referred to here as the wide range of associations around which society voluntarily organizes itself, with CBO referring to those associations primarily concerned with local interests and ties. CSO and CBO initiatives in the field of disaster risk management, which may usually begin as a humanitarian concern, often evolve to also embrace the broader challenge of disaster risk reduction following community-focused risk assessment, including specific activities targeting education and advocacy, environmental management; sustainable agriculture; infrastructure construction, as well as increased livelihood diversification (McGray, et al., 2007, Care International 2008; Oxfam America 2008; Practical Action Bangladesh 2008; SEED 2008; Tearfund 2008; World Vision 2008).

Recently in some high risk regions there has been rapid development of national platforms of CSOs and CBOs that have been working together in order to push for the transformation of policies and practices related to disaster risk reduction. This is true in the case of Central America, where at least four platforms are functioning in the same number of countries, involving more than a hundred and twenty CSO and CBO’s (CRGR, 2007a). The efforts of these platforms have been aimed at advocacy, training, research and capacity building in disaster risk reduction. In Central America, the experience is that advocacy on climate policy construction has become a new feature of such platforms since 2007 (CRGR 2009). While beyond the scope of this chapter, on balance the majority of CSOs and CBOs focus efforts at the local level, trying to link disaster risk management with local development goals associated with water, sanitation, education and health for example (Lavell, 2009; GNDR 2009). Faith-based organisations are also influential in assisting local communities in disaster risk management, not only providing pastoral care in times of disasters but they also play an important role in raising awareness and training, with many international development partners often working with local church groups to build community resilience (see for example Gero et al 2011; Tearfund 2011; ADPC 2007).

In several countries of Latin America, CSOs and CBOs are considered, by law, as part of national systems for civil protection (CRGR, 2007b, Lavell and Franco, 1996) though participation, with the exception of National Red

Cross/Red Crescent Societies, remains patchy (ISDR 2008c). In some countries, where governments are not able or willing to fulfill certain disaster risk management functions, such as training, supporting food security, providing adequate housing and preparedness, CSOs and CBOs have stepped in (Benson et al. 2001). While CSOs often face challenges in securing resources for replicating successful initiatives and scaling out geographically (Care International 2008; Oxfam America 2008; Practical Action Bangladesh 2008; SEED 2008; Tearfund 2008; World Vision 2008); sustaining commitment to work with local governments and stakeholders over long term and maintaining partnerships with local authorities (Oxfam America 2008), and coordinating and linking local level efforts with sub-national government initiatives and national plans during the specific project implementation (SEED 2008), they are particularly well positioned to draw links between disaster risk reduction and climate change adaptation given that such organisations are currently among the few to combine such expertise (Mitchell et al. 2010).

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 play a significant role in supplying financial, technical and in some cases, strategic support to government and non-government agencies to tackle the multifaceted challenges of disaster risk management and climate change adaptation in the context of national development goals (e.g. DFID 2011; AusAid 2009). Multilateral agencies are referred to here as international institutions with governmental membership that have a significant focus on development and aid recipient countries. Such agencies can include United Nations agencies, regional groupings (e.g. some European Union agencies) and multilateral development banks (e.g. World Bank, Asian Development Bank). Bilateral agencies (e.g. United Kingdom Department for International Development) are taken here as national institutions that focus on the relationship between one government and another. In the development sphere, this is often in the context of a richer government providing support to a poorer government. The role of international institutions, including bi-lateral and multi-lateral agencies, is discussed extensively in 7.3.

Bilateral and multi-lateral agencies have been key actors in advancing the mainstreaming of disaster risk reduction and climate change adaptation into development planning (Eriksen and Naess 2003; Klein et al. 2007; see 6.3). This has primarily been driven by a concern that development investments are increasingly exposed to climate and disaster-related risks and that climate change poses security concerns (Persson and Klein 2009; Harris 2009). As a result, such agencies are influencing development policy and implementation at national level as they require disaster and climate risk assessments and environmental screening to be conducted at different points in the project approval process and in some cases retrospectively when projects are already underway (Hammill and Tanner 2010; OECD 2009; Klein et al. 2007). A range of tools and methods have been developed, primarily by bilateral and multilateral agencies, to support such processes (Hammill and Tanner 2010; Klein et al. 2007).

While significant progress has been made in developing appropriate tools and methods for assessing and screening risk, many bilateral and multilateral agencies continue to address disaster risk management and climate change adaptation separately, and link with respective regional and national agencies in the context of distinct international instruments (Mitchell and Van Aalst 2008; Gero et al. 2010; Mitchell et al. 2010b). However, recent assessment suggest that the situation is improving, partially attributable to the process of authoring this Special Report and in the focus on risk management in the text of the Bali Action Plan (2007) and Cancun Agreement (2010) (Mitchell et al. 2010b; see 7.3.2.2 for more detail).

The diversity of national contexts requires bi-lateral and multi-lateral agencies to adopt different modalities to maximise the effectiveness of technical, financial and strategic support. For example, in the Pacific and the Caribbean, regional bodies (e.g. the Caribbean Disaster Emergency Management Agency) commonly operate as an intermediary, channelling resources to small island countries where it is not efficient for international agencies to establish a permanent adaptation or risk management-focused presence (Gero et al. 2010; Hay 2009). In countries with weak national institutions, bi-lateral and multi-lateral agencies commonly choose to channel resources through civil society organisations with the intention of ensuring resources reach the poorest and most vulnerable (Wickham et al. 2009). In such situations, co-ordination between agencies can be challenging and in certain circumstances can further reduce the risk management capacity of government organisations (Wickham et al. 2009). However, the broad trend is to maximise the support to national governments by seeking to improve national ownership of risk

management and adaptation processes and in that respect support national governments to lead national systems (Global Facility for Disaster Risk Reduction 2010; DFID 2011).

6.2.5. Research and Communication

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 data and information (Sperling and Szekely 2005; Thomalla *et al.*, 2006; CACCA, 2010) and traditional knowledge (Mercer *et al.*, 2007; Kelman *et al.*, 2011 and see Box 5-7) to inform not only communities-based decisions and policy makers who manage national approaches to disaster risk and climate change adaptation, but also amongst researchers who provide further analytical information to support such decisions.

Scientific and research organisations range from specialised research centres and universities, regional organisations, to national research agencies, multilateral agencies and CSOs playing differential roles, but generally continue to divide into disaster risk management or climate change adaptation communities. Scientific research bodies play important roles in managing climate extremes and disaster risks by: (a) supporting thematic programmes to study the evolution and consequences of past hazard events, such as cyclones, droughts, sandstorms and floods; (b) analysing time- and space-dependency in patterns of weather-related risks; (c) building cooperative networks for early warning systems, modelling, and long-term prediction; (d) actively engaged in technical capacity building and training; (e) translating scientific evidence into adaptation practice; (f) collating traditional knowledge and lessons learnt for wider dissemination, and (g) translating scientific information into user-friendly forms for community consumption (Aldunce and González, 2009; Sperling and Szekely, 2005; Thomalla *et al.*, 2006).

Disaster practitioners largely focus on making use of short-term weather forecasting and effective dissemination and communication of hazard information and responses (Thomalla *et al.* 2006). Such climate change expertise can typically be found in meteorological agencies, environment or energy departments, and in academic institutions (Sperling and Szekely 2005), while disaster risk assessments have been at the core of many multilateral and civil society organisations and national disaster management authorities (Sperling and Szekely 2005; Thomalla *et al.* 2006). Although progress has been reported in the communication and availability of scientific information, there is still a lack of, for example, sufficient local or sub-national data on hazards and risk assessments to underpin area specific disaster risk management (ISDR, 2009c; Chung 2009).

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

Given that learning will come from doing and in spite of differences, there are many ways that countries can learn from each other in prioritizing their climate and disaster risks, in mainstreaming climate change adaptation and disaster risk management into plans, policies and processes for development and in securing additional financial and human resources needed to meet increasing demands (UNDP, 2002; Thomalla *et al.*, 2006; Schipper, 2009). This sub-section will address frameworks for national disaster risk management and climate change adaptation planning and policies (6.3.1), the mainstreaming of plans and policies nationally (6.3.2) and the various sectoral disaster risk management and climate change adaptation options available for national systems (6.3.3), recognising the range of actors engaged in these processes as described in section 6.2.

6.3.1. Developing and Supporting National Planning and Policy Processes

National and sub-national government and statutory agencies 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; ONERC, 2009; Hammill and Tanner, 2010). When considering disaster risk management and adaptation to climate change actions, it is often the scale of the potential climate and disaster risks and impacts, the capacity of the governments or agencies to act, the level of certainty on future changes, the timeframes within which these future impacts and disasters will occur and the costs and consequences

of decisions that play an important role in their prioritisation and adoption (Heltberg et al, 2008; World Bank, 2008a; Wilby and Dessai, 2010).

The complexity and diversity of adaptation to climate change situations implies that there can be no single recommended approach for assessing, planning, and implementing adaptation options (Fussler, 2007; Lu, 2011; Hammill and Tanner, 2010). When the planning horizons are short and adaptation decisions only impact the next one or two decades, adaptation to recent climate variability and observed trends may be sufficient (Hallegatte, 2009; Wilby and Dessai, 2010; Lu, 2011). For long-lasting risks and decisions, the timing and sequencing of adaptation options and incorporation of climate change scenarios become increasingly important (OECD, 2009; Wilby and Dessai, 2010; Hallegatte, 2009). Studies suggest that the most pragmatic adaptation and disaster risk management options depend on the timeframes under consideration and the adaptive capacity and ability of the country or sectoral agencies to effectively integrate information on climate change and its uncertainties (McGray et al, 2007; Wilby and Dessai, 2010; Biesbroek et al, 2010; Juhola and Westerhoff, 2011; Krysanova *et al*, 2010). Given the various uncertainties at decision-making scales, studies suggests that adaptation actions based on information on the observed climate and its trends may be preferable in some cases while, in other cases with long-term irreversible decisions, climate change scenario-guided adaptation actions will be required (Wilby and Dessai, 2010; OECD, 2009; Auld, 2008b; Hallegatte, 2009; Krysanova *et al*, 2010). Climate change scenarios provide needed guidance for adaptation options when the direction of the climate change impacts are known and when the decisions involve long-term building infrastructure, development plans as well as actions to avoid catastrophic impacts from more intense extreme events (Hallegatte, 2009; Wilby and Dessai, 2010; Haasnoot et al, 2009).

In dealing with climate change and disaster risk uncertainties, many national studies identify gradations or categories of adaptation and disaster risk management planning and policy options (Kwadijk et al, 2010; Dessai and Hulme, 2007; Wilby and Dessai, 2010; Auld, 2008b; Mastrandrea et al, 2010; Hallegatte, 2009). These gradations in options range from climate vulnerability or resilience approaches, sometimes described as “bottom-up”, vulnerability, tipping point, critical threshold or policy-first approaches to climate modelling impact-based approaches, sometimes described as “top-down”, model or impacts-first, science-first, or classical approaches (as illustrated in Figure 6-2 and outlined in the sectoral option headings of Table 6-1 and described in Section 6.3.3). Although the bottom-up and top-down terms sometimes refer to scale, subject matter or policy (e.g., national versus local, physical to socio-economic systems), the terms are used here to describe the sequences or steps needed to develop adaptation and disaster risk management plans and policies at the national level. When dealing with long-term future climate change risks, the main differences between the scenarios-impacts-first and vulnerability-thresholds-first approaches lie in the timing or sequencing of the stages of the analyses, as shown in Figure 6-2 (Kwadijk *et al*, 2010; Ranger and Garbett-Shiels, 2011). Although this difference appears subtle, it has significant implications for the management of uncertainty, the timing of adaptation options and the efficiency of the policy-making (Dessai and Hulme 2007; Wilby and Dessai, 2010; Auld, 2008b; Lu, 2011; Kwadijk et al, 2010). For example, when the lifespan of a decision, policy or measure has implications for multiple decades or the decision is irreversible and sensitive to climate, the performance of adaptation and risk reduction options across a range of climate change scenarios become critical (Wilby and Dessai, 2010; Auld, 2008b; Kwadijk et al, 2010).

[INSERT FIGURE 6-2 HERE

Figure 6-2: Top-down scenario, impacts-first approach (left panel) and bottom-up vulnerability, thresholds-first approach (right panel) – comparison of stages involved in identifying and evaluating adaptation options under changing climate conditions. Source: Adapted from Kwadijk et al., 2010, and Ranger et al, 2010.]

Vulnerability-thresholds based approaches start at the level of the decision-maker, identify desired system objectives and constraints, consider how resilient or robust a system or sector is to changes in climate, assess adaptive capacity and critical “tipping points” / threshold points and then identify the viable adaptation strategies that would be required to improve resilience and robustness under future climate scenarios (Mastrandrea et al, 2010; Kwadijk et al, 2010; Wilby and Dessai, 2010; Hallegatte, 2009; Auld, 2008b; Urwin and Jordan, 2008). Vulnerability-thresholds approaches can be independent of any specific future climate condition.

Options that are known as “no regrets” and “low regrets” provide benefits under any range of climate change scenarios, although they may not be optimal for every future scenario, and are recommended when uncertainties

over future climate change directions and impacts are high (Dessai and Hulme, 2007; Hallegatte, 2009; Auld, 2008b; Kwadijk et al, 2010). These “low regrets” adaptation options typically include improvements to coping strategies or reductions in exposure to known threats (Wilby and Dessai, 2010, Kwadijk et al, 2010, Auld, 2008b), such as better forecasting and warning systems, use of climate information to better manage agriculture in drought-prone regions, flood-proofing of homesteads or interventions to ensure up-to-date climatic design information for engineering projects. The vulnerability-thresholds-first approaches are particularly useful for identifying priority areas for action now, assessing the effectiveness of specific interventions when current climate-related risks are not satisfactorily controlled, when climatic stress factors are closely intertwined with non-climatic factors, planning horizons are short, resources are very limited (i.e. data, expertise, time, and money) or uncertainties on future climate impacts is very large (Wilby and Dessai, 2010; Hallegatte, 2009; Agrawala and van Aalst, 2008; Prabhakar *et al*, 2009).

Vulnerability-thresholds-first approaches have sometimes been critiqued for the time required to complete a vulnerability assessment, for their reliance on experts and their largely qualitative results and limited comparability across regions (Kwadijk et al, 2010; Patt et al, 2005). Vulnerability-thresholds approaches can sometimes prove less suited for guiding future adaptation decisions if coping thresholds change, or if climate change risks emerge that are outside the range of recent experiences (e.g. successive drought years could progressively reduce coping thresholds of the rural poor by increasing indebtedness) (Wilby and Dessai, 2010; Auld, 2008b). McGray et al, 2007; Hallegatte, 2009; Agrawala and van Aalst, 2008; Auld, 2008b; Prabhakar et al, 2009).

The scenarios-impact-first approaches typically start with several climate change modelling scenarios and socio-economic scenarios, evaluate the expected impacts of climate change and subsequently identify adaptation and risk reduction options to reduce projected risks (Wilby and Dessai, 2010; Kwadijk et al, 2011; Mastrandrea et al, 2010). The scenarios-impacts-first approaches are most useful to raise awareness of the problem, to explore possible adaptation strategies and to identify research priorities, especially when current climate and disaster risks can be effectively controlled, when sufficient data and resources are available to produce state-of-the-art climate scenarios at the spatial resolutions relevant for adaptation and when future climate impacts can be projected reliably (Wilby et al, 2010; Kwadijk et al, 2010). Scenarios-impacts approaches depend strongly on the chosen climate change scenarios and downscaling techniques, as well as the assumptions on scientific and socioeconomic uncertainties (Kwadijk et al, 2010; OECD, 2009). Pure scenarios-impacts approaches may not be available on the spatial scales relevant to the decision-maker, may not be applicable for the purpose of the decision-maker and usually give less consideration to current risks from natural climate variability, to non-climatic stressors and to key uncertainties along with their implications for robust adaptation policies (Wilby and Dessai, 2010; Fussel, 2007). In practice, there are very limited examples of actual adaptation policies being developed and planned adaptation decisions being implemented based on scenarios-impacts approaches only (Fussel, 2007; Wilby and Dessai, 2010; Biesbroek et al, 2010).

Increasingly, studies are recognizing that the scenarios-impacts and vulnerability-thresholds approaches are complementary and need to be integrated and that both can benefit from the addition of stakeholder and scientific input to determine critical thresholds for climate change vulnerabilities (Mastrandrea et al, 2010; Kwadijk et al, 2010; Wilby and Dessai, 2010; Haasnoot et al, 2009; Auld, 2008b). Critical thresholds (or adaptation tipping points) help in answering the basic adaptation questions of decision and policy makers: namely, what are the first priority issues that need to be addressed as a result of increasing disaster risks under climate change and when might these critical thresholds be reached (Kwadijk et al, 2010; Auld, 2008b; Mastrandrea et al, 2010; Haasnoot et al, 2009). The integration of scenarios-impacts and vulnerability-thresholds approaches provide guidance on the sensitivity of sectors and durability of options under different climate change scenarios (Kwadijk et al, 2010; Mastrandrea et al, 2010; Haasnoot et al, 2009). Integrated approaches that link changes in climate variables to decisions and policies and express uncertainties in terms of timeframes over which a policy or plan may be effective (i.e. roughly when will the critical threshold be reached) also provide valuable information for plans and policies and their implementation (Kwadijk et al, 2010; Mastrandrea et al, 2010; Haasnoot et al, 2009).

Regardless of the approaches used, it is important that uncertainty over future climate change risks not become a barrier to climate change risk reduction actions (Wilby and Dessai, 2010; Auld, 2008b; Hallegatte, 2009; Krysanova *et al*, 2010). In cases where climate change uncertainties remain high, countries may choose to increase or build on their capacity to cope with uncertainty, rather than risk maladaptation from use of ambiguous impact studies or no

action (McGray et al, 2007; Wilby and Dessai, 2010; Hallegatte, 2009). In order to reduce the risk of maladaptation into the future, some studies recommend the use of pro-adaptation and robust options to deal with climate change uncertainties (Hallegatte, 2009; Auld, 2008b; Wilby and Dessai, 2010). These robust options include actions that are reversible, flexible, less sensitive to future climate conditions (i.e. no and low regret) and can incorporate safety margins (e.g. infrastructure investments), employ ‘soft’ solutions (e.g. ecosystem services) and are mindful of actions being taken by others to either reduce greenhouse gases or adapt to climate change in other sectors (Hallegatte, 2009; Wilby and Dessai, 2010). Flexible options are those that provide benefits under a variety of climate conditions or reduce stress on affected systems to increase their flexibility (e.g. reducing pollution or demand on resources) (Hallegatte, 2009; Auld, 2008b; Wilby and Dessai, 2010).

Options that allow for incremental changes to, for example, infrastructure over time, or allow incorporation of future change, for example, support more flexible systems (OECD, 2009; Auld, 2008b; Hallegatte, 2009). Uncertainties over future risks can also be accounted for through “safety margin” or over-design strategies to reduce vulnerability and increase resiliency at low and sometimes null costs (Hallegatte, 2009; Auld, 2008b). These safety margin strategies have been used to manage future risks for sea level rise and coastal defences, for water drainage management and for investments in other infrastructure (Hallegatte, 2009). Given uncertainties, national policies may need to become more adaptable and flexible, particularly where national plans and policies currently operate within a limited range of conditions and are based on certainty (McGray et al, 2007; Wilby and Dessai, 2010). Without flexibility, rigid national policies may become disconnected from evolving climate risks and bring unintended consequences or maladaptation (Sperling and Szekely, 2005; Hallegatte, 2009). Rigid plans and policies that are irreversible and based on a specific climate scenario that does not materialize can result in future maladaptation and imply wasted investments or harm to people and ecosystems that can prove unnecessary.

Several studies indicate that national plans and policies for adaptation to climate change and disaster risk management tend to favour options that deal with the current or near-term climate risks and “win-win” options that satisfy multiple synergies for greenhouse gas reduction, disaster risk management, climate change adaptation and development issues (Fankhauser, 2010; Mitchell and Maxwell, 2010; Heltberg et al, 2009; Ribeiro et al, 2009; World Bank, 2008). Many of these “win-win” options include ecosystem-based adaptation actions, sustainable land and water use planning, carbon sequestration, energy efficiency and energy and food self-sufficiency. For example, the ecosystem management practices of afforestation, reforestation and conservation of forests offer co-benefits for disaster risk reduction from floods, landslides, avalanches, coastal storms and drought while contributing to adaptation for future climates, economic opportunities, increased biomass and carbon sequestration, energy efficiency, energy savings as well as energy and food self sufficiency (Thompson et al, 2009).

Disaster risk transfer options offer a viable adaptation response to current and future climate risks and include instruments such as insurance, micro-insurance and micro-financing, government disaster reserve funds, government-private partnerships involving risk sharing and new, innovative insurance mechanisms (Linnerooth-Bayer and Mechler, 2006; World Bank, 2010; European Commission, 2009a). Risk transfer options can provide much needed, immediate liquidity after a disaster, allow for more effective government response, provide some relief from the fiscal burden placed on governments due to disaster impacts, and constitute critical steps in promoting more proactive risk management strategies and responses (Arnold, 2008). The Chapter 9 case study 9.2.13 and Section 6.5.3 provide more detail on risk transfer options.

Even with risk transfer instruments and adaptation to climate change options in place, residual losses can be realized when extreme events—well beyond those typically expected—result in high impacts. In spite of the evidence, decisions to ignore increasing future risks and even current risks remain common, particularly when uncertainties over the directions of future climate change impacts are high, when capacity is initially very limited, adaptation options are not available or when the risks of future impacts are considered to be very low (Linnerooth-Bayer and Mechler, 2006; Heltberg et al, 2009; World Bank, 2010). The losses from deferring adaptation and disaster risk reduction actions are borne by all actors.

Table 6-1 outlines some of the adaptation to climate change and disaster risk management policy and planning options available nationally for selected sectors and described in the literature. Many of these options are

incremental actions that complement and reinforce each other. The actions are organised using the gradations of planning and policy options described in this section.

[INSERT TABLE 6-1 HERE

Table 6-1: National policies, plans and programs: selection of disaster risk reduction and adaptation to climate change options by selected sectors.]

6.3.2. *Mainstreaming Disaster Risk Management and Climate Change Adaptation into Sectors and Organizations*

National adaptation to climate change will involve stand-alone adaptation policies and plans as well as the integration or mainstreaming of adaptation measures into existing activities (OECD, 2009). Mainstreaming of adaptation and disaster risk management actions implies that national, sub-national and local authorities adopt, expand and enhance measures that factor disaster and climate risks into their normal plans, policies, strategies, programs, sectors and organisations (OECD, 2009; Few et al 2006; ISDR, 2008a; Biesbroek et al, 2010; CACCA, 2010).

In reality, it can be challenging to provide clear pictures of what mainstreaming is, let alone how it can be made operational, supported, and strengthened at the various national and sub-national levels (Olhoff and Schaer, 2010). Some studies indicate that the real challenge to mainstreaming adaptation is not planning but implementation (Tompkins et al, 2010; Biesbroek et al, 2010; Krysanova et al, 2010). Some of the barriers to implementation include lack of funding, limited budget flexibility, lack of relevant information or expertise, lack of political will or support and institutional silos (Preston et al, 2011; Krysanova et al, 2010). Studies indicate that effective plans, policies and programs for adaptation to climate change and disaster risk management need to go beyond identifying potential options to include better inventories of existing assets and liabilities for managing risk and specific actions for overcoming adaptation barriers (Preston et al, 2011; CIG 2007; Hulme et al. 2007; Adger et al. 2009; Haasnoot et al, 2009).

Recent studies investigating the success of existing adaptation plans and policies for Australia, United States, countries in Europe and major river basins in Africa and Asia, for example, indicate that there is a need for mainstreaming of adaptation into existing national policies and plans and a priority for capitalizing on “win-win” or options that take advantage of synergies with other national objectives (Preston et al, 2011; Tompkins et al, 2010; Biesbroek et al, 2010). The studies found that many strategies and institutions were focused to a greater extent on lower-risk actions dealing with science and outreach (knowledge acquisition) and capacity-building rather than moving forward on specific, more costly and difficult to implement adaptation and disaster risk management actions and managing at-risk public goods (Preston et al, 2011; Tompkins et al, 2010).

Preston et al (2011) found in their studies from Australia, United States and the United Kingdom (UK) that most national adaptation strategies were based on vulnerability assessments informed by broad international and national climate change guidance, rather than any consistent or systematic use of scenarios, and favoured bottom-up approaches for coordination across sectors and multiple government scales. Biesbroek et al, (2010) noted similar results for nine countries in Europe. Tompkins *et al* (2010) and Krysanova *et al* (2010) found that the sectors with the highest levels of adaptation implementation in the UK were those which tended to be most affected by current weather variability and extremes and that specific government initiatives had been successful in stimulating adaptation and disaster risk reduction (e.g, mandatory planning for flood-prone areas, ISO 14001). Tompkins et al (2010) also found that successful implementation frequently resulted from multiple triggers, that few of these adaptation actions were solely initiated in response to climate change, and that the relative impact of weather on core business and organisational culture encouraged an ability and willingness to proactively act on climate change information.

Adaptation to climate change and disaster risk management needs to typically identify more adaptation options than most countries can reasonably implement in the short term due to resource constraints, requiring that actions be prioritized (OECD, 2009; Krysanova et al, 2010). Initially, actions that remove the existing barriers to managing

disaster risks from today's climate variability can help to reduce the even greater barriers to managing future climate risks (UNDP, 2002; UNDP, 2004a; CCCD, 2009; Prabhakar et al, 2009; Tompkins et al, 2010). As a result, a key challenge, and an opportunity for mainstreaming adaptation and disaster risk management lies in building bridges between current disaster risk management actions for existing climate vulnerabilities and the additional revised efforts needed for future vulnerabilities (Few et al, 2006; Olhoff and Schaer, 2010; Wilby and Dessai, 2010; Krysanova et al, 2010).

An important prerequisite for informed decisions on adaptation to climate change and disaster risk management is that they should be based upon the best available information (OECD, 2009; Lu, 2011; Biesbroek et al, 2010). Preston et al. (2011) noted that many of the specific adaptation plans from Australia, United States and the UK indicated a need for improved gathering and sharing of climate and climate change science information prior to or in conjunction with the delivery of adaptation actions, perhaps reflecting a preference for delaying adaptation actions until greater certainty or better information on different adaptation actions was known. As noted in Chapter 3 (Section 3.2.3 and Box 3-2), many extreme events occur at small temporal and spatial scales, where climate change models, even when downscaled, cannot provide for simulation at such spatial and temporal resolutions. A number of studies also contend that increased and better information on climate change scenarios and projections and potential impacts will accomplish little on their own to mainstream and altering on-the-ground decisions, policies and plans unless the information provided can directly meet decision-maker's needs (Mastrandrea et al, 2010; Auld, 2008b; Wilby and Dessai, 2010; Stainforth et al, 2007; Haasnoot et al, 2009; Krysanova et al, 2010). Users require relevant climate risk information that is accessible, can be explained in understandable language, provides straight-forward estimates of uncertainties and is relevant or tailored to their management functions (Lu, 2011; Stainforth et al, 2007; Mastrandrea et al, 2010). Increasingly, studies are showing that this is best accomplished through sustained interactions between scientists and stakeholders and policy-makers, usually maintained through years of relationship- and trust-building (Mastrandrea et al, 2010; Lu, 2011; Wilby and Dessai, 2010).

Studies generally indicate that the most essential means for effectively mainstreaming both adaptation and disaster risk management nationally involve "whole of government" coordination across different levels and sectors of governance, including the involvement of a broad range of stakeholders (Few et al, 2006; Thomalla et al, 2006; OECD, 2009, also 6.4.2). In spite the strong interdependencies, governments have tended to manage these issues in their "silos" with environment or energy authorities and scientific institutions typically responsible for climate change adaptation while disaster risk management authorities may reside in a variety of national government departments and national disaster management offices (Prabhakar et al, 2009; Thomalla, 2006; Sperling and Szekely, 2005). Progress in planning for adaptation and developing and implementing strategies within government agencies usually depends on political commitment, institutional capacity and in some cases, on enabling legislation, regulations and financial support (Few et al, 2006; OECD, 2009; Krysanova et al, 2010, see 6.4). Nationally, studies indicate that it may be important to clearly identify a lead for disaster and climate risk reduction efforts where that lead has influence on budgeting and planning processes (Few et al, 2006; OECD, 2009). In some cases, countries and regions may be able to build on phases of raised awareness and increased attention to disaster risk in order to develop and strengthen their responsible institutions (Few et al, 2006; Krysanova et al, 2010).

While developed countries may be more financially equipped to meet many of the challenges of mainstreaming adaptation and disaster risk reduction into national plans and policies, the situation is often more challenging in developing countries (Basher, 2009; Krysanova et al, 2010). Nonetheless, there are examples from developing countries where adaptation to climate change and disaster risk management mainstreaming issues have been priorities for many years and significant progress in mainstreaming has been noted (e.g. the Caribbean Mainstreaming Adaptation to Climate Change (MACCC) project, which was implemented from 2004 to 2007; case studies 9.2.9 and 9.2.12). In other cases, international funding mechanisms such as the LDC (Least Developed Countries) Fund, the Special Climate Change Fund, Multi-donor Trust Fund (MDTF) on Climate Change and Pilot Programme for Climate Resilience (PPCR) under the Climate Investment Fund are making funding and resources available to developing countries to pilot and mainstream changing climate risks and resilience into core development and as an incentive for scaled-up action and transformational change, although needs exceed the availability of funds (O'Brien et al, 2008; Krysanova et al, 2010; see section 7.4.3.3, or 7.4.2 for additional discussion).

6.3.3. Sector-Based Risk Management and Adaptation

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

Sector-based organisations and departments play a central role in national decision-making and are a logical focus for adaptation actions (McGray et al, 2007; Biesbroek et al, 2010). The impacts of changing climate risks in one sector, such as tourism, can affect other sectors and scales significantly, especially since sectoral linkages operate both vertically and horizontally. Sector plans, policies and programs are linked vertically from national to local levels within the same sector as well as horizontally across different sectors at the same level (Urwin and Jordan, 2007; CCCD, 2009; UNFCCC, 2008b; Biesbroek et al, 2010). While the case and need for integration across sectors and levels may be clear, the issue of how to integrate or mainstream nationally across multiple sectors and multiple levels still remains challenging, requiring governance mechanisms and coordination that can cut across governments and sectoral organisations (UNFCCC, 2008b; CCCD, 2009; Biesbroek *et al*, 2010; ONERC, 2009, ISDR, 2005). Typically, multi-sector integration tends to deal with the broader national scale (e.g. entire economy or system) and aims to be as comprehensive as possible in covering several affected sectors, regions and issues (UNFCCC, 2008b). Studies from organisations and academia indicate that effective adaptation and risk reduction coordination between all sectors may only be realized if all areas of government are coordinated from the highest political and organisational level (CCCD, 2009; Schipper and Pelling, 2006; Prabhaker, 2009; UNFCCC, 2008b). Even when “political champions” at the highest levels encourage mainstreaming across sectors and Departments, competing national priorities will remain an impediment to progress.

Table 6-1 (Section 6.3.1) outlines adaptation to climate change and disaster risk management options for several selected sectors. As the table indicates, adaptation and disaster risk management approaches for many development sectors benefit jointly from ecosystem based adaptation and integrated land, water and coastal zone management actions. For example, conservation and sustainable management of ecosystems, forests, land use and biodiversity have the potential to create win-win disaster risk protection services for agriculture, infrastructure, cities, water resource management, food security. It can also create synergies between climate change adaptation and mitigation measures (CCCD, 2009; CBD, 2009), as well as produce many co-benefits that address other development goals, including improvements in livelihoods and human well being, particularly to the poor and vulnerable, and biodiversity conservation, and are discussed further in Section 6.5.2.3 and in studies 9.2.3, 9.2.4, 9.2.5, 9.2.7, 9.2.8 and 9.2.9. Likewise, water resource, land and coastal zone management options deal with many sectors and issues and jointly provide disaster risk management and adaptation solutions, as mentioned in the case studies 9.2.6 and 9.2.8 (CCCD, 2009; Urwin and Jordan, 2007; UNFCCC, 2008b; WWAP, 2009; WHO, 2003). Human health is a cross-cutting issue impacted by actions taken in many sectors, as indicated in Table 6-1 and discussed in case studies 9.2.2 and 9.2.7.

6.4. Strategies including Legislation, Institutions, and Finance

National systems for managing the risks of extreme events and disasters are shaped by legislative provision, compliance mechanisms, the nature of cross-stakeholder bodies and financial and budgetary processes that allocate resources to actors working at different scales. These elements help to create the technical architecture of national systems and are often led by national government agencies. However non-technical dimensions of good governance, such as the distribution and decentralisation of power and resources, processes for decision-making, transparency and accountability are woven into the technical architecture and are significant factors in determining the

effectiveness of risk management systems and actions (UNDP, 2004b; UNDP, 2009). These technical and non-technical aspects of risk governance vary between countries as governance capacity varies (and as detailed in section 6.3, are critical in shaping investment in particular adaptation and disaster risk management options). Accordingly risks can be addressed through both formal and informal governance modes and institutions in all countries (Jaspars and Maxwell, 2009), but a clear correlation between particular risk governance models and specific political-administrative contexts is difficult to identify (ISDR, 2011a). The balance between formal or informal, or technical and non-technical risk governance strategies depends on the economic, political and environmental contexts of individual countries or scales within countries, and the culture of managing risks (Menkhaus, 2007; Kelman, 2008).

6.4.1. Legislation and Compliance Mechanisms

Disaster risk management legislation commonly establishes organisations and their mandates, clarifies budgets, provides (dis)incentives and develops compliance and accountability mechanisms (UNDP, 2004b; Llosa and Zodrow, 2011). Creating and improving legislation for disaster risk reduction was included as a priority area in the Hyogo Framework for Action (ISDR, 2005) and the majority of countries – in excess of 80% - now have some form of disaster risk management legislation (ISDR, 2005; Bhavnani et al, 2008). Legislation continues to be considered as an important component of effective national disaster risk management systems (UNDP, 2004b; ISDR, 2011a) as it creates the legal context of the enabling environment in which others, working at different scales, can act, and it helps to define people’s rights to protection from disasters, assistance and compensation (Pelling and Holloway, 2006). Multi-stakeholder, cross-sector bodies for co-ordinating disaster risk management actions and implementing the Hyogo Framework for Action, known commonly as National Platforms, are seen as key advocacy routes for achieving new and improved legislation (ISDR, 2005; ISDR 2007b). Where National Platforms are less prevalent or less well organised, literature suggests that regional disaster management bodies are viewed as responsible for advancing legislation (ISDR, 2007b; 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 adaptation options (Llosa and Zodrow, 2011; UNDP, 2009; see case study 9.2.12 on legislation).

There have been few detailed cross-comparative studies that assess the extent to which legislation in different countries is oriented towards managing uncertainty and reducing disaster risk compared with disaster response (Llosa and Zodrow, 2011). Limited evidence suggests that legislation in some high and middle-income countries (such as the UK, USA and Indonesia) has led to a focus on building institutional capacity to help create resilience to disasters at different scales, but even in such cases a strongly reactive culture is retained when observing the system as a whole (UNDP, 2009; O’Brien and Read, 2005, O’Brien, 2006 and 2008; O’Brien and O’Keefe, 2010). This has been attributed to lack of political will and insufficient financial and human resources for disaster risk reduction (O’Brien 2006 and 2008). Additionally few studies have assessed whether disaster risk management legislation includes provision for the impact of climate change on disaster risk or whether aspects of managing disaster risk are included in other complimentary pieces of legislation (case study 9.2.12; Llosa and Zodrow, 2011), though there are also a very limited number of normative studies on these aspects (Llosa and Zodrow, 2011). 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 and (c) promote the view that reducing disaster risk is everyone’s responsibility (case study 9.2.12; UNDP, 2004b, Llosa and Zodrow, 2011).

Viet Nam has taken steps to integrate disaster risk management into legislation across key development sectors, including 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 Holloway 2006). Case study 9.2.12, in examining legislation development processes in the Philippines and South Africa, highlights a number of components of effective disaster risk management legislation. An Act needs to be: (a) comprehensive and overarching, (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. Box 6-1 supplements these cases with reflections on the process that led to the creation of disaster risk management legislation in Indonesia.

_____ START BOX 6-1 HERE _____

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 considered successful due to the following factors:

- **Strong, visible professional networks** - Professional networks born out of previous disasters meant a high level of trust and willingness to co-ordinate and 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 supportive **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 disaster risk reduction) was influenced by the international focus, through the HFA, on disaster risk reduction.
- 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, 2004b; 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 2004b). A lack of financial, human or technical resources and capacity constraints present significant obstacles to full implementation, especially as experience suggests legislation should be implemented continuously from national to local level and is contingent on strong monitoring and enforcement frameworks and adequate decentralisation of responsibilities and human and financial resources at every scale (Pelling and Holloway 2006; UNDP 2004b). In some countries, building codes, for instance, are often not implemented properly because of a lack of technical capacity and political will of officials concerned (UNDP, 2004b). Where enforcement is unfeasible, accountability for disaster risk management actions is extremely challenging – this supports the need for an inclusive, consultative process for discussing and drafting the legislation (ISDR, 2007b; UNDP, 2004b). Effective legislation 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).

6.4.2. *Coordinating Mechanisms and Linking across Scales*

As the task of managing the risks of changing climate conditions and climate extremes and disasters cuts across the majority of sectors and involves a wide range of actors, multi-stakeholder and cross-government mechanisms are commonly cited as preferred way to ‘organise’ disaster risk management systems at national level (ISDR, 2005; ISDR, 2007b; see 6.3.3); as well as for addressing the challenges associated with adaptation to climate change (ONERC 2009). The Hyogo Framework for Action terms these ‘National Platforms’ defined as a ‘generic term for national mechanisms for co-ordination and policy guidance on disaster risk reduction that are multi-sectoral and inter-disciplinary in nature, with public, private and civil society participation involving all concerned entities within

a country' (ISDR, 2005). In some countries such coordinating mechanisms are referred to by other names (Gero et al. 2010; Hay 2009), but essentially perform the same function. 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 2007b). Evaluations and reflections on the effectiveness of National Platforms for delivering results on the Hyogo Framework for Action and on disaster risk management more broadly indicate widely varying results (ISDR, 2007c; GTZ/DKKV, 2007; ISDR, 2008c; ISDR/DKKV/Council of Europe 2008; Sharma, 2009). An assessment in Asia found National Platforms struggling to obtain the legal mandate to secure full participation of stakeholders, particularly NGOs, difficulty in obtaining sustainable funding sources and challenges associated with translating intent into implementation (Sharma, 2009). On the other hand, pockets of evidence exist where National Platforms have succeeded in generating senior political commitment for disaster risk reduction, in strengthening integration of disaster risk reduction into national policy and development plans and in establishing institutions and programmes on disaster risk management with engagement from academic, media and the private sector (Sharma, 2009; ISDR, 2008c). This assessment found only a limited number of genuinely independent studies on the effectiveness of National Platforms, with evidence particularly weak in Africa and elsewhere.

While the evidence again suggests significant differences between countries, on balance, national co-ordination mechanisms for adaptation to climate change and disaster risk management remain largely disconnected, although evidence suggests that the trajectory is one of improvement (Mitchell *et al*, 2010b; National Platform for Kenya, 2009 this is discussed in chapter 1). Benefits of improved co-ordination between adaptation to climate change 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 paucity 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 adaptation to climate change in national planning and budgetary processes (Few *et al*, 2006; Mitchell and Van Aalst 2008; Mitchell *et al*, 2010b) (see Box 6-2).

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

Kenya's National Platform is situated under the Office of the President and has made significant achievements in co-ordinating multiple stakeholders, but is constrained by limited resources and lack of budgets for disaster risk reduction in line ministries (National Platform for Kenya, 2009). Some key constraints of the national system are recognised as being difficulties in integrating disaster risk reduction in planning processes in urban and rural areas and lack of data on risks and vulnerabilities at different scales (Few *et al*, 2006). In this regard, Nairobi has experienced periods of drought and heavy rains in the last decade, prompting action to reduce exposure and vulnerability to what is perceived as changing hazard trends (ActionAid, 2006). Increasing exposure and vulnerability has resulted from a rapid expansion of poor people living in informal settlements around Nairobi, leading to houses of weak building materials being constructed immediately adjacent to rivers and blocking natural drainage areas. While data and co-ordination systems are still lacking, the Government of Kenya has established the Nairobi Rivers Rehabilitation and Restoration Programme (African Development Bank Group, 2010), designed to install riparian buffers, canals and drainage channels, while also clearing existing channels. The Programme also targets the urban poor with improved water and sanitation, paying attention to climate variability and change in the location and design of wastewater infrastructure and environment monitoring for flood early warning (African Development Bank Group, 2010). This demonstrates the kind of options for investments that can be achieved in the

absence of a fully fledged nationally co-ordinated disaster management system and in the absence of complete multi-hazard, exposure and vulnerability data sets.

_____ END BOX 6-2 HERE _____

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 (see 6.2.1); sources suggest that decentralization can be an effective risk management strategy, especially in support of community-based disaster risk management processes (Global Network of Civil Society Organisation, 2009; Mitchell and Van Aalst, 2008; Scott and Tarazona, 2011). However, there are few studies that critically examine the effectiveness of decentralisation of disaster risk management in detail (Twigg, 2004; Scott and Tarazona 2011; Tompkins *et al*, 2008). One such study of four countries: Colombia, Mozambique, Indonesia and South Africa found that effective decentralisation of disaster risk reduction can be constrained by (a) low capacity at local level, (b) funds dedicated to disaster risk reduction often being channelled elsewhere, (c) the fact that decentralisation does not automatically lead to more inclusive decision-making processes, (d) an appreciation that decentralised systems face significant communications challenges and (e) knowledge that robust measures for ensuring accountability and transparency are vital for effective disaster risk management but are often missing (Scott and Tarazona, 2011). It appears that 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). 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).

6.4.3. Finance and Budget Allocation

Governments in the past have ignored catastrophic risks in decision-making, implicitly or explicitly exhibiting risk-neutrality (Mechler, 2004). This is consistent with the Arrow Lind theorem (Arrow and Lind 1970), according to which a government may be well equipped to efficiently (i) pool risks as it possesses a large number of independent assets and infrastructure so that the aggregate risk converges to zero, and/or (ii) spread risk across the taxpaying population base, so that per-capita risk accruing to risk-averse household converges to zero. In line with this theorem, due to their ability to spread and diversify risks, governments are sometimes termed ‘the most effective insurance instrument of society; (Priest 1996). Accordingly, it has been deduced that, although individuals are risk-averse [to disasters risk], governments can take a risk-neutral approach. However, the experiences of highly exposed countries suggest otherwise and have led to a recent paradigm shift and critical re-evaluation of governments being ‘risk neutral’ to being risk averse and managing disaster risks. Many highly exposed developing and developed countries (especially in the wake of the recent financial crisis) have very limited economic means, rely on small and exhausted tax bases, have high levels of indebtedness and are unable to raise sufficient and timely capital to replace or repair damaged assets and restore livelihoods following major disasters. This can lead to increased impacts of disaster shocks on poverty and development (OAS, 1991; Linnerooth-Bayer *et al.*, 2005; Hochrainer, 2006; Mahul and Ghesquiere, 2007; Cummins and Mahul, 2009). Exposed countries thus have had to rely on donors to ‘bail’ them out after events, although ex-post assistance usually only provides partial relief and reconstruction funding, and such assistance is also often associated with substantial time lags (Pollner, 2000; Mechler, 2004).

Furthermore, extreme events that are associated with large losses may lead to important economic flow on effects (see 4.6) causing depressed incomes and reduced ability to share the losses. Consequently, a risk neutral stance in dealing with catastrophic risk (implying the consideration of risk broadly in terms of means - the statistical expectation - is sufficient), may not be suitable for exposed developing countries with limited diversification of their economies or small tax bases. Accordingly, assessing and managing risks over the whole spectrum of probabilities is gaining momentum (Cardenas *et al*, 2007; Cummins and Mahul, 2009). As OAS, 1991 suggests: “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). Also, in more developed economies, less pronounced but still considerable effects imposed by events linked to climate variability can be identified. This has been 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 (Mechler et al., 2010).

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 through certain and annually recurrent events. Those liabilities are of explicit (as recognized by law or contract), or implicit nature (moral obligations) (see Table 6-2). Yet, governments are not good at planning for contingencies even for probable events, let alone improbable events. Explicit, contingent liabilities deal with the reconstruction of infrastructure destroyed by events, whereas implicit obligations are associated with providing relief – commonly considered as a moral liability for governments (Polackova Brix and Mody, 2002). In many countries, governments do not explicitly plan for contingent liabilities, and rely on reallocating their resources following disasters and by raising capital from domestic and international donations to meet infrastructure reconstruction needs and costs.

[INSERT TABLE 6-2 HERE

Table 6-2: Government liabilities and disaster risk.]

More recently, some developing and transition countries that face large contingent liabilities in the aftermath of extreme events and associated financial gaps have begun to plan for and consider contingent natural events (also see 6.5.3). Mexico, Colombia and many Caribbean countries now include contingent liabilities in their budgetary process and eventually even transfer some of these risks (Cardenas et al., 2007; Cummins and Mahul, 2009; Linnerooth-Bayer and Mechler, 2007; see Box 6-3). Similarly, many countries have also started to 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.

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

Mexico is exposed to natural hazards due to its location 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. There have been many disaster events and in the past severe hurricane disasters (in addition to earthquakes) have created large fiscal liabilities and imbalances (Cardenas *et al.* 2007). Given high perceived financial vulnerability to disasters, in 1994, the Mexican Government passed a law, which required federal, state and municipal public assets to be insured. This was intended to relieve the central government of the obligation of having to pay for the reconstruction of public infrastructure, although the adequate level of insurance particularly for very large events remained a concern. As a next step, in 1996 the national government established a system of allocating resources for disaster spending (FONDEN) in order to enhance the country's financial preparedness for disaster losses and prevent imbalances in the federal government finances derived from outlays caused by catastrophes. FONDEN serves as last-resort funding for uninsurable losses, such as emergency response and disaster relief expenditure. In addition to this budgetary program, in 1999 a reserve fund was created, which accumulates the surplus of the previous year's FONDEN budget item (Cardenas *et al.* 2007). After the initial phase that was characterized by spending in line with requirements caused by disaster events, one concern for the disaster management authorities became the regular demands on the funds in non-disaster years. As a consequence, budgeted FONDEN resources were declining while demands on FONDEN's resources were becoming more volatile, and outlays 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 forced the Mexican Government to look at alternative risk financing strategies, which included hedging against disaster shocks, government agencies at all levels providing their insurance protection independent of FONDEN, and that FONDEN itself should only indemnify 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 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 (Cardenas *et al.* 2007).

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6.5. Practices including Methods and Tools

With some success and with many challenges, countries are increasingly adopting a diverse range of approaches, methods and tools to manage disaster risk and adapt to a changing climate, with the attention of building a safe, secure society. This section discusses efforts made in building a culture of safety (6.5.1), which includes methods associated with assessing and communicating risk; in reducing climate-related disaster risks (6.5.2); in transferring and sharing residual risks (6.5.3) and in managing the impacts of disasters holistically (6.5.4) as disaster risks can never be reduced to zero. Accordingly, it is important to recognise that the approaches, methods and tools discussed here are complementary, often overlapping and can be pursued simultaneously. Whereas the Summary for Policymakers of this report includes a visual representation of the range of such approaches (Figure SPM-2), the figure presented here (Figure 6-3) includes a version tailored to incremental action at the national level.

[INSERT FIGURE 6-3 HERE

Figure 6-3: Complementary response measures to observed and projected disaster risks supported by respective institutional and individual capacity for making informed decisions.]

Figure 6-3 characterises the range of risk management and adaptation options open to stakeholders involved in national systems for managing disaster risk. Such options exist along a continuum of action, with choices between different options being dependent on the quality of information and how it is communicated, the findings of risk assessments, the culture of risk management/acceptability of risk and on capacities and resources. In practice, different options will likely be pursued simultaneously and will have a high degree of co-dependence.

6.5.1. Building a Culture of Safety

Building a culture of safety involves several strategies and activities that start with the assessment of risk factors and developing information systems that provide relevant information for critical decision-making. It also involves understanding the large variety of beliefs and core value systems for, which will help determine decisions made by different actors and stakeholders. A key ingredient is appropriate public education and awareness-raising and as such, early warning systems play an important role in managing residual risk as they can provide timely warnings to exposed communities and thus can promote action for a quick response. Time series empirical data used to generate risk assessments, including those contributing to early warnings, is also critical for long term planning because of its relevance in generating appropriate information about adequate land use planning for example to reduce climatic risks. As examples, in the same sense, analysed information about climate-adapted infrastructure, enhanced human development, ecosystems protection, risks transfer and sharing and managing the impacts of climate-related disasters, can play fundamental role in building a culture and practice of human safety.

6.5.1.1. Assessing Risks and Maintaining Information Systems

As discussed widely in chapter 1, the first key step in managing risk is to assess and characterise it. In terms of risk factors, disaster risk is commonly defined by three elements: the hazard, exposure of elements, and vulnerability (Swiss Re, 2000; Kuzak, 2004; Grossi and Kunreuther, 2005; CACCA, 2010). Thus, understanding risk involves observing and recording hazards and hazard analysis, studying exposure and drivers of vulnerability and vulnerability assessment. Responding to risks is dependent on the way risk-based information is framed in the context of public perception and risk management needs.

Given the ‘public good’ nature of much of disaster related information (Benson and Clay, 2004), 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 are also necessary because of the dynamic nature of disaster risk, especially due to the effects of climate change and the associated uncertainty this creates (ISDR, 2004; Prabhakar, 2008; CACCA, 2010).

A key component in the risk assessment process is to determine exposed elements at risk. This may relate to persons, buildings, infrastructure (e.g. water and sewer facilities, roads and bridges), agricultural assets, livelihoods, ecosystems, natural infrastructure, and ecosystem services in harm's way, which can be impacted in case of a disaster event. For national level assessments, their aggregate values are of interest. Ideally, this would be based on national asset inventories, national population census, and other national information. In practice, collecting an inventory on assets and their values often proves very difficult and expensive due to the heterogeneity and sheer number of the examined elements (see Cummins and Mahul, 2009). In addition, risk management process require identifying those elements of the social process that also contribute to vulnerability – such as organisational and economic capacities, human development status of communities at risk and capacity to respond to disasters (Cardona *et al.*, 2010 and Lavell, 1996); as well as assessing the impacts following disaster events (ECLAC 2003; Benson and Clay, 2004). Considerable progress has been made in the generation and use of such information including in some developing countries (ISDR 2009c; Benson and Clay, 2004). Nevertheless, in many countries this is not a regular practice and efforts to document impacts are started only after major disasters (Prabhakar, 2008). Regular monitoring of vulnerability is also at nascent stage (Cardona *et al.*, 2010; Dilley, 2006). Table 6-3 shows a sample of the kinds of information required for effective disaster risk management and adaptation to climate change activities.

[INSERT TABLE 6-3 HERE

Table 6-3: Information requirements for selected disaster risk management and adaptation to climate change activities.]

Country and context specific information on disaster impacts and losses, 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 (see 3.2.1). Data on losses from extremes can also be systematically biased due to high media attention (Guha-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, 2010).

International disaster impact databases are available, such as the EM-DAT database of the Centre for the Epidemiology of Disasters (CRED) in Brussels, Desinventar maintained by a network of scientists involved in studying disasters in Latin America (Red de Estudios Sociales en Prevención de Desastres en América Latina - LA RED) as well as databases by reinsurers such as Munich Re. Comparisons of international and national disaster loss databases have shown significant variations in documented losses due to inconsistencies in the definition of key parameters and estimation methods used. This emphasises the need to standardise parameter definitions and estimation methods (Guha-Sapir and Below, 2002; ECLAC, 2003; 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 of disasters, such as the incidence of health effects after a disaster as well as the impacts on ecosystems, which have not been well studied (Benson and Twigg 2004). Furthermore, the assessment of indirect disaster impacts on social or economic systems, such as on income generating sectors and national savings, needs greater attention (ECLAC 2003; Benson and Clay, 2004). Such information can often also be very useful in order to assess risks by using statistical estimation techniques (Embrechts *et al.* 1997) or catastrophe modelling approaches (Grossi and Kunreuther, 2005).

6.5.1.2. Preparedness: Risk Awareness, Education, and Early Warning Systems

National governments create the environment and communication channels to develop and disseminate different kinds of information on, for example, the hazards that affect different populations and preparedness for disaster response. Numerous studies indicate that a robust and up-to-date Early Warning Systems (EWS) plays a critical role in reducing the impacts of potential disasters and enable populations to protect lives and some property and infrastructure (White et al., 2004; Aldunce and León, 2007; McBean, 2008; Rogers and Tsirkunov, 2010) and as illustrated in the Chapter 9 case study 9.2.11.

Traditionally, early warning systems have been interpreted narrowly as technological instruments for detecting and forecasting impending hazard events and for issuing alerts (Rogers and Tsirkunov, 2010). However, this interpretation does not clarify whether warning information is received by or helpful to the population it serves or actually used to reduce risks (Basher, 2006; Rogers and Tsirkunov, 2010). As noted in the Chapter 9 case study 9.2.11, the HFA 2005-2015 stated a need for more than just accurate predictions, stressing that early warning systems should be '*people centered*' and that warnings need to be '*timely and understandable to those at risk*' and to include '*guidance on how to act upon warnings*' (ISDR, 2005).

Governments also maintain early warning systems to warn their citizens and themselves about impending creeping climate- and weather-related hazards. For example, 'early warnings' of potentially poor seasons have been successful informing key actions for agricultural planning on longer time scales and for producing proactive responses (Meinke et al, 2006; Vogel and O'Brien, 2006). Case study 9.2.11 provides examples of early warning systems for short response hazards as well as for creeping hazards operating on time scales from weeks to seasonal. This case study also highlights the possibility of using weather and climate predictions for timeframes longer than a few days to provide advanced warning of extreme conditions has been only a very recent development. Studies indicate that successful early warning systems are reliant on close inter-institutional collaboration between national meteorological and hydrological services and the agencies that directly intervene in rural areas, such as extension services, development projects and civil society organisations (Meinke et al., 2006; Vogel and O'Brien, 2006; Rogers and Tsirkunov, 2010).

An effective early warning system delivers accurate, timely, and meaningful information dependably with its success dependent on whether the warnings triggered effective responses (ISDR, 2005; Auld, 2008a; Basher, 2006; Gwimbi, 2007; van Aalst, 2009; Rogers and Tsirkunov, 2010). Warnings fail in both developing and developed countries for a number of reasons, including inaccurate weather and climate forecasting, public ignorance of prevailing conditions of vulnerability, failure to communicate the threat clearly or in time, lack of local organisation and failure of the recipients to understand or believe in the warning or to take suitable action (ISDR, 2006; Rogers and Tsirkunov, 2010; Auld, 2008a). To be effective and complete, an early warning system typically comprises four interacting elements (ISDR, 2006; Basher, 2006): (i) generation of risk knowledge including monitoring and forecasting, (ii) surveillance and warning services, (iii) dissemination and communication and (iv) response capability. Warnings are received and understood by the target audience and are most relevant when conveyed to have meaning that is shared between those who issue the forecasts, local knowledge and the decision-makers they are intended to inform (Auld, 2008a; Basher, 2006; ISDR, 2006; case study 9.2.2). Because emergency responders, the media and the public often are unable to translate the scientific information on forecast hazards in warnings into risk levels and responses, early warning systems are most effective when their users can identify and interpret the general warning messages into simple and relevant local impacts and actions (e.g. flash flood warning and the need to evacuate areas at risk), 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, 2008a; ISDR, 2006).

Different hazards and different sectors often require unique preparedness, warnings and response strategies (ISDR, 2006; Basher, 2006; van Aalst, 2009). For example, the needs and responses behind a warning of a drought or a tornado or cyclone or fire are very different. Some hazards may represent singular extreme events, sequences or compound combinations of hazards while other hazards can be described as "creeping" or accumulations of events (or non-events). For example, the World Meteorological Organisation (WMO), National Meteorological and Hydrological Services, World Health Organisation (WHO) and Food and Agriculture Organisation (FAO) and

others recognize that combinations of weather and climate hazards can result in complex emergency response situations and are working to establish multi-hazard early warning systems for complex risks such as heat waves and vector-borne diseases (WMO, 2007; ISDR, 2006) and early warnings of pests and food safety threats and disease outbreaks (e.g. prediction of a potential desert locust crisis) (WMO, 2007; WMO, 2004; FAO, 2010). Other “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, especially when accompanied by an already existing vulnerability, while other hazards such as accumulated precipitation can lead to critical infrastructure failure (Auld, 2008a; Basher, 2006; Rogers and Tsirkunov, 2010). Section 3.1.3 provides more detail on compound, multiple and creeping hazards.

Studies indicate that an understanding by the public and community organisations of their risks and vulnerabilities are critical but insufficient for risk management and that early warning systems need to be complemented by preparedness programmes as well as public education and awareness programmes (ISDR, 2006a; Basher, 2006; Gwimbi, 2007; Rogers and Tsirkunov, 2010). This requires systematic linkages and integration between early warning systems and contingency planning processes (Pelham et al, 2011). For example, a significant long-term social protection programme known as the Productive Safety Net Programme (PSNP) was implemented in Ethiopia in 2007 in response to experiences from a series of drought-related disaster responses during the late 1990s and early 2000s (Pierro and Desai, 2008; Conway and Schipper, 2011). The aim of the Programme was to shift institutional approaches away from just emergency responses and into more sustainable livelihood approaches involving asset protection and food security. Under this Programme, millions of people in ‘chronically’ food insecure households in rural Ethiopia received resources from the PSNP through cash transfers or food payments for their participation in labour-intensive public works projects with a particular focus on environmental rehabilitation (Conway and Schipper, 2011). The case study on drought (9.2.3) also emphasises the importance of proactive steps in the form of drought preparedness and mitigation, and improved monitoring and early warning systems.

Some studies indicate that public awareness and support for disaster prevention and preparedness are often high immediately after a major disaster event and that such moments can be capitalized on to strengthen and secure the sustainability of, for example, early warning systems (Basher, 2006; Rossetto, 2007). It should be noted that such windows require the pre-existence of a social basis for cooperation which, in turn, supports a collaborative framework between research and management (Pelham et al, 2011; Rossetto, 2007; Tompkins et al, 2008).

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 (Gwimbi, 2007; Rogers and Tsirkunov, 2010; Pulwarty and Redmond, 1997; Rayner et al., 2005). Decision makers typically manage risks holistically, while scientific information is generally derived using reductionist approaches (Meinke et al, 2006). The net outcome can be a ‘disconnect’ between scientists and decision makers with the result that climate and hydro-meteorological information can be developed that, although scientifically sound, may lack relevance to the decision-maker (Cash and Buizer, 2005; Meinke et al, 2006; Vogel and O’Brien, 2006; Averyst, 2010). Perceptions of irrelevance, inconsistency, confusion, or doubt can delay action (National Research Council, 2009). Some studies (Lowe, 2003; Meinke, 2006; Glantz, 2005; Feldman and Ingram, 2009) advise scientists and practitioners to work together to produce trustworthy knowledge that combines scientific excellence with social relevance, a point also emphasised in the case study 9.2.2 on fire. These studies suggest that decision support activities should be driven by users’ needs, not by scientific research priorities, and that these user needs are not always known in advance, but should be identified collaboratively and iteratively in ongoing two-way communication between knowledge producers and decision makers (National Research Council, 2009; Cash and Buizer, 2005). It has been suggested that this ongoing interaction, two-way communication, and collaboration allows scientists and decision makers to get to know each other, to develop an understanding of what decision makers need to know and what science can provide, to build trust and, over time, develop highly productive relationships as the basis for effective decision support (National Research Council, 2009; Feldman and Ingram, 2009; Averyst, 2010).

Since early warning information systems are multi-jurisdictional and multi-disciplinary, they usually require anticipatory coordination across a spectrum of technical and non-technical actors. National governments can play an important role in setting the high-level policies and supporting frameworks involving multiple organisations, in

adopting multi-hazard and multi-stakeholder approaches and in promoting community based early warning systems (Basher, 2006, Pulwarty et al, 2004; ISDR, 2010). National governments can also interact with regional and international governments and agencies to strengthen early warning capacities and to ensure that warnings and related responses are directed towards the most vulnerable populations (Basher, 2006; ISDR, 2010). At the same time, national governments can also play an important role in supporting regions and sub-national governments in developing operational and local response capabilities (Basher, 2006; ISDR, 2010; see Section 6.5.4). In Japan and the Mekong region, for example, in addition to using early warning system based on extensive flood modelling exercise, the emergency basin level management relies on the flood mitigation capacity of paddy fields (Masumoto et al., 2006; 2008).

6.5.2. Reducing Climate-Related Disaster Risk

National climate-related disaster risk reduction activities include a broad range of options that vary from safe infrastructure and building codes to those aimed to enhance and protect natural ecosystems, support human development and even ‘build back better’ following a disaster. Each of these strategies can prove minimally effective in isolation but highly effective in combination. These and other different options, along with their limitations (e.g. lack of information and understanding, human resource capacity, scientific requirements, financing) are addressed in the following sub-sections, noting how risk reduction measures are increasingly being considered as good practices to promote adaptation to climate change.

6.5.2.1. Applying Technological and Infrastructure-Based Approaches

Climate change has the potential to directly and indirectly impact the safety of existing infrastructure, to alter engineering and maintenance practices and will require changes to building codes and standards where they exist (Wilby, 2007; Auld, 2008b; Stevens, 2008; Bourrelie et al, 2000; Füssel, 2007; Hallegatte, 2009). The changing climate also has the potential regionally to increase premature deterioration and weathering impacts on the built environment, exacerbating vulnerabilities to climate extremes and disasters and negatively impacting the expected and useful lifespans of structures (Auld, 2008b, Stewart et al, 2011; Larsen et al, 2008). As noted in case study 9.2.8 (Chapter 9), people living with un-adapted and inadequate infrastructure and housing will be more at risk to climate change.

With projected increases in the magnitude and/or frequency of some extreme events in many regions (see Chapter 3), small increases in climate extremes above thresholds or regional infrastructure “tipping points” have the potential to result in large increases in damages to all forms of existing infrastructure nationally and to increase disaster risks (Auld, 2008b; Coleman, 2002; Munich Re, 2005, Kwadijk et al, 2010; Mastrandrea et al, 2010; Larsen et al, 2008). Since infrastructure systems, such as buildings, water supply, flood control, and transportation networks often function as a whole or not at all, an extreme event that exceeds an infrastructure design or ‘tipping points’ can sometimes result into widespread failure and a potential disaster (Ruth and Coelho, 2008; Haasnoot et al, 2009). For example, a break in a water main, dyke or bridge can impact other systems and sectors and render the regional system incapable of providing needed services (Ruth and Coelho, 2008). These infrastructure thresholds or adaptation “tipping points” become important when considering sensitivities to climate change and adaptation and disaster risk reduction options for the future (see 6.6.1 for further discussion on thresholds and management of climate change uncertainties). Infrastructure thresholds refer here to the critical climate conditions where technical, economic, spatial or societal acceptable limits are exceeded and the current built environment system is no longer future climate proof (i.e. it fails, requiring proactive adaptation actions and changes to infrastructure codes, standards and management processes) (Haasnoot et al, 2009; Kwadijk et al, 2010; Auld, 2008b; Mastrandrea et al, 2010).

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 always fully appreciated by many national governments and development and disaster specialists (Moser and Satterthwaite, 2008; Rossetto, 2007). Low- and middle-income countries, which report close to three-quarters of the world’s urban populations, are at greatest risk from extreme

events and also have far less capacity than do high-income countries largely due to backlogs in protective infrastructure and services and limitations in urban government (Moser and Satterthwaite, 2008; Satterthwaite et al. 2007a). Rapid growth and expansion in urban areas, particularly in developing countries, can outpace infrastructure development and lead to a lack of infrastructure services for housing, sewerage systems, effective transportation and emergency response and increased vulnerability to weather and climate extremes (Birkmann et al., 2011; Satterthwaite et al. 2007). These impacts from the changing climate will be particularly severe for populations living in poor-quality housing on illegally occupied land, where there is little incentive for investments in more resilient buildings or infrastructure and service provision (Birkmann *et al*, 2011; Satterthwaite et al, 2007a; Freeman and Warner, 2001). Case study 9.2.8 provides further discussion on best adaptation and risk management practices for cities and their built environment.

An inevitable result of potentially increased damages to infrastructure will be a dramatic increase in the national resources needed to restore infrastructure and assist the poor affected by damaged infrastructure (Freeman and Warner, 2001). A study by the Australian Academy of Technological Sciences and Engineering (ATSE) concluded that national retrofit measures will be needed to safeguard existing infrastructure in Australia and new adaptation approaches and national codes and standards will be required for construction of new infrastructure (Stevens, 2008). Recommendations reported from this study call for: research to fill gaps on the future climate risks, comprehensive risk assessments for existing critical climate sensitive infrastructure, development of information and supporting tools (e.g. non-stationary extreme value analysis methods) 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, 2007; Auld, 2008b).

The recommended national adaptation options to deal with projected impacts to the built environment range from deferral of actions pending development of new climate change information to modification of infrastructure components according to national guidance, acceptance of residual losses, reliance on insurance and other risk transfer instruments, formalised asset management and maintenance, mainstreaming into environmental assessments, new structural materials and practices, improved emergency services and retrofitting and replacement of infrastructure elements (Stevens, 2008; Wilby and Dessai, 2010; Auld, 2008b; Neumann, 2009; Bourrelie et al, 2000; Haasnoot et al, 2009; Hallegatte, 2009; Kwadijk et al, 2010).

Strategic environmental assessment approaches, such as those recommended by the Organisation for Economic Cooperation and Development (OECD) and many national environmental assessment agencies, offer an effective means for ensuring mainstreaming adaptation to climate change and disaster risk management, as well as GHG reduction practices, into policies, and planning for new programs on infrastructure and systems (OECD, 2006; Benson, 2007). Environmental impact assessment approaches can reduce the risks of environmental degradation from a project and reduce future disaster risks from the current and changing climate conditions (Benson, 2007). For long-lived infrastructure or networks, studies recommend consideration of likely climate change impacts that will potentially affect the planned useful life of the infrastructure system (e.g. seasonal variability in water flows, temperatures, incidence of extreme weather events) (OECD, 2006; Neumann, 2009; Auld, 2008b; NRTEE, 2009; Boshier et al, 2007; Larsen et al, 2008).

The implementation of adequate national building codes that incorporate up-to-date regionally specific climate data and analyses can improve resilience of infrastructure for many types of weather-related risks (WC, 2009; Wilby et al, 2009; Auld, 2008b). Typically, infrastructure codes and standards in most countries use historical climate analyses to climate-proof new structures, assuming that the past climate can be extrapolated to 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 atypically designed using analysis of historical rainfall records (Wilby and Dessai, 2010, Auld, 2008b; Ruth and Coelho, 2007; Hallegatte, 2009; Haasnoot et al, 2009). Since infrastructure is built for long life-spans and the assumption of climate stationarity will not hold for future climates, it is important that national climate change guidance, tools and consistent adaptation options be developed to ensure that climate change can be incorporated into infrastructure design (Stevens, 2008; Wilby et al, 2009; Auld, 2008b; Hallegatte, 2009). While some government departments responsible for building regulations and the insurance industry are taking the reality of climate change very seriously, challenges remain on how to incorporate the uncertainty of future climate projections into engineering risk

management and into codes and standards, especially for climate elements such as extreme winds and extreme precipitation and its various phases (e.g. short and long duration rainfalls, freezing rain, snowpacks) (Wilby and Dessai, 2010; Hallegatte, 2009; Kwadijk et al, 2010; Auld, 2008b; Sanders and Phillipson, 2003; Lu, 2011; Haasnoot et al, 2009). Recent advances in characterizing the uncertainties of climate change projections, in regionalisation of climate model outputs and in the application and mainstreaming of integrated top-down, bottom-up approaches for assessing impacts and adaptation options (6.3.1 and 6.3.2) will help to ensure that infrastructure and technology can be better adapted to a changing climate. Chapter 3 (3.2.3, 3.3 and 3.4) provides further details on scientific advances for the construction, assessment and communication of climate change projections, including a discussion on recent advances in the development of regionalisation or downscaling techniques and approaches used to quantify uncertainties in climate change model outputs.

Some implementation successes are emerging. In one example, discussed in case study 9.2.10, the Canadian Standards Association (CSA) and its National Permafrost Working Group developed a Technical Guide, CSA Plus 4011-10, on “Infrastructure in Permafrost: A Guideline for Climate Change Adaptation” that directly incorporated climate change temperature projections from an ensemble of climate change models. This CSA Guide factors considered climate change projections of temperature and precipitation and incorporated risks from warming and thawing permafrost to foundations over the planned life spans of the structure (Grosse et al, 2011; NRTEE, 2009; Canadian Standards Association, 2010; Hayley and Horne, 2008; Smith et al, 2010). The guide suggested possible adaptation options, taking into account the varying levels of risks and the consequences of failure for foundations of structures, whether buildings, water treatment plants, towers, tank farms, tailings ponds or other infrastructure (NRTEE, 2009; Canadian Standards Association, 2010; see Chapter 9 case study 9.2.10). Similarly, working with the Canadian meteorological service, engineering associations and national water stakeholder associations, the Canadian Standards Association has also developed an initial rainfall Intensity-Duration-Frequency (IDF) Guideline for water practitioners with adaptation guidance (CSA Plus 4013-10).

In developing countries, structures are often built using prevalent local practices, which may not reflect best practices from disaster risk reduction or adaptation perspectives. These prevalent local practices usually do not include the use of national building standards or adequately account for local climate conditions (Rossetto, 2007). While the perception in some developing countries is that national building codes and standards are too expensive, experience in 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; 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 national efforts for their up-take and implementation (Rossetto, 2007). Bangladesh, for example, has implemented simple modifications to improve the cyclone-resistance of (non-masonry) kutchra or temporary houses, with costs that amounted to only 5 per cent of the construction costs (Lewis and Chisholm, 1996; Rossetto, 2007). Bangladesh is also developing national policies requiring that houses built following disasters include a small section of the replacement house that meets “climate proofing” standards and acts as a household shelter in the next disaster. In many countries, climate proofing guidelines and standards are applied to structures that are used as emergency shelters and for structures that form the economic and social lifeline of a society, such as its communications links, hospitals and transportation networks (Rossetto, 2007).

Many studies advocate that technical and infrastructure solutions are not the only way of adapting to changing climates and that “soft solutions” such as financial tools, land use planning and ecosystem conservation or soft engineering approaches are also needed (McEvoy et al, 2010; Hallegatte, 2009; Auld, 2008b; Adger et al, 2007; Nicholls et al, 2008). Land and water use planning, use of bioshields as natural buffers, soft defences and green or “soft engineering” are complementary adaptation options, described further in Section 6.5.2.3 and in the Chapter 9 case studies 9.2.1 and 9.2.8.

6.5.2.2. Human Development and Vulnerability Reduction

Vulnerabilities to climate-related hazards and the options to reduce them vary between and within countries due to factors such as poverty, social positioning, geographic location, gender, age, class, ethnicity, ecosystem condition, community structure, community decision-making processes and political issues (Yodmani, 2001; Yamin et al,

2005; Halsnaes and Traerup, 2009). Overall, studies indicate that the extent of the vulnerability to climate variability and climate change is shaped by both the dependence of the national economy and livelihoods on climate-sensitive natural resources and the resilience or robustness of the country's social institutions to equitable distribution of resources under climate change (Virtanen et al, 2011; Brooks et al, 2009; Ikeme, 2003). The poorest regions are often characterized by vulnerable housing, weak emergency services and infrastructure and a dependence on agriculture and other natural resources (Manuel-Navarrete et al, 2006; Ikeme, 2003; Reid *et al.*, 2010).

Many vulnerable communities already suffer greater water stress, food insecurity, disease risks and loss of livelihoods, which have the potential to increase under climate change. (Virtanen et al, 2011; Brooks et al, 2009; Manuel-Navarrete et al, 2006; Halsnaes and Traerup, 2009). For example, climate change may increase the risks of waterborne diseases, requiring targeted assistance for health and water sanitation issues (Curriero, 2001; Brooks et al, 2009). Small island states and low-lying countries may require support to relocate vulnerable groups to safer locations or other countries, all requiring a complex set of actions at the national and international levels (Manuel-Navarrete et al, 2006; McGranahan et al, 2007). Other studies indicate that resilient housing and safe shelters will remain a key adaptation action to protect vulnerable people 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; Ikeme, 2003; Auld, 2008b; Manuel-Navarrete et al, 2006). Under climate change, it is expected that food security issues among vulnerable populations will become more impacted by climate variability, erratic rainfall and more frequent extreme events (IRI, 2006; Ikeme, 2003; Brooks et al, 2009; Halsnaes and Traerup, 2009; and regional studies through global partnerships, such as the Consultative Group on International Agricultural Research). When faced with food scarcity, vulnerable populations sometimes adopt maladaptive coping strategies such as overgrazing, deforestation and unsustainable extraction of water resources that aggravate long-term disaster risks, (Brooks et al, 2009; Bunce et al, 2010).

Studies indicate that the greatest losses in suitable agricultural cropland due to climate change are likely to be in Africa, particularly sub-Saharan Africa (FAO, 2010; Ikeme, 2003). Assessing food security issues in this vulnerable area requires consideration of multiple socio-economic and environmental variables, including climate (Virtanen et al, 2011; Verdin et al, 2005). In sub-Saharan Africa, where large and widely dispersed populations depend on rain-fed agriculture and pastoralism, climate monitoring and forecasting are important inputs to food security analysis and assessments. Since conventional climate and hydro-meteorological networks in these areas are sparse and often report with significant delays, there is a growing need for increased capacity in rainfall observations, forecasting, data management and modelling applications (Verdin et al, 2005; FAO, 2010; Heltberg et al, 2009). Studies indicate a need for rainfall observation networks to be expanded, to incorporate satellite information and for data management systems to be improved, tailored forecast information to be disseminated and used by decision-makers and for more effective early warning systems that can integrate seasonal forecasts with drought projections as inputs for hazards, food security and vulnerability analysis (Heltberg et al, 2009; FAO, 2010; Verdin et al, 2005). Other short-term but limited strategies to minimize food security risks include diversifying livelihoods to spread risk, farming in different ecological niches, building social networks, productive safety net and social protection schemes and risk pooling at the regional or national level to reduce financial exposure (FAO, 2010; Brooks et al 2009; Heltberg et al, 2009; Halsnaes and Traerup, 2009). Specific longer term strategies to address the increasing risks, particularly given uncertainties, include land rehabilitation, terracing and reforestation, measures to enhance water catchment and irrigation techniques, improvements to infrastructure quality for better access to markets and the introduction to drought-resistant crop varieties (Heltberg et al, 2009; Halsnaes and Traerup, 2009).

In the longer-term, studies indicate that increasing food security risks under climate change will require higher agricultural productivity, reduced production variability and agricultural systems that are more resilient to disruptive events (Stern, 2006; Cline, 2007; FAO, 2010; Halsnaes and Traerup, 2009). This implies transformations in the management of natural resources, new climate-smart-agriculture policies, practices and tools, better use of climate science information in assessing risks and vulnerability, and financing for food security (FAO, 2010; Ericksen et al, 2010; Brooks et al, 2009). Other coping strategies may include increased non-farm incomes, migration, government and other financial assistance, microfinance, social protection, other safety nets, and various insurance products (FAO, 2010; Barrett et al, 2007; Heltberg et al, 2009). The Sustainable Livelihoods Approach or Framework has been used internationally for rural and coastal development to holistically describe the variables that impact livelihoods locally and to define the capacity, assets (both natural and social) and policies required for sustainable

living, poverty reduction and recovery from disasters (Brocklesby and Fisher, 2003; Yamin et al, 2005; Allison and Horemans, 2005). Chapters 2 (2.3.1, 2.4.3.1 and 2.6.1), 5 (5.2.3.2 and 5.4) and 9 (9.3.4.1, case study 1 and 2, 9.3.7) also discuss sustainable livelihood approaches that can be considered in building adaptive capacity and resilience to climate hazards and climate change.

Early identification of populations at risk can enable timely and appropriate actions needed to avert widespread impacts. Reliable and detailed information on the current and future climates and their impacts can play an important role in the recognition of the need to adapt and the successful evolution of effective adaptation strategies (Ikeme, 2003; Heltberg et al, 2009; Wilby et al., 2009; Verdin et al, 2005; and as discussed in section 6.5.1). Some studies claim that one of the potential barriers for identifying the most vulnerable regions and people in developing countries under future climate change is the limited human resource capacity regionally to downscale global and regional climate projections to a scale suitable to support national level planning and programming process (Wilby et al., 2009; CCCD, 2009; Ikeme, 2003; Verdin et al, 2005). Not all of the climate variables of importance for development can be projected and downscaled with confidence, particularly given that many development activities are especially sensitive to changes in climate extremes (Agrawala and van Aalst, 2008). Even when downscaled results are available, their use can be limited by a lack of understanding and interpretation on how these downscaled projections can be translated to highlight vulnerabilities with certainty (Agrawala and van Aalst, 2008; Heltberg et al, 2009). Agrawala and van Aalst (2008) argue that development practitioners and climate scientists should join forces to make climate information more accessible, relevant and usable.

Because the risks posed by climate change can affect the long-term efficiency with which development resources can be invested and development objectives achieved, studies indicate that it remains important to integrate or mainstream disaster risk management and climate change adaptation into a range of development activities (Agrawala and van Aalst, 2008; Heltberg et al, 2009; Halsnaes and Traerup, 2009; Mitchell et al. 2010). Lack of awareness within the development community of the many implications of climate change and limitation on resources for implementation are frequently cited reasons for difficulties in mainstreaming adaptation and disaster risk management (Agrawala and van Aalst, 2008; Heltberg et al, 2009, also see 6.3.2). Adaptation to climate change and disaster risk management actions can be considered to be successfully mainstreamed when they reduce the vulnerability of susceptible populations to existing climate variability and are also able to strengthen the capacity of the population to prepare for and respond to further changes (Yamin et al, 2005; Manuel-Navarrete et al, 2006; Mertz et al, 2009). Studies indicate that national policies can increase this capacity (Heltberg et al., 2009; Ikeme, 2003). 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 and risk reduction issues of vulnerable countries (see 7.4.2 or 7.4.3.3 for more details).

In spite of recommendations to target assistance to most vulnerable in the developing world, practical “on the ground” examples have been limited (Ayers and Huq, 2009; Heltberg et al, 2009; Yamin et al, 2005). Nonetheless, some developing countries have implemented successful policies and plans. Nationally, good progress is being made in strengthening some disaster reduction capacities for disaster preparedness and early warning and response systems and in addressing some of the underlying risk drivers in many developing country regions and sectors (ISDR, 2009c; Manuel-Navarrete et al, 2007). For example, social safety nets and other similar national level programmes, particularly for poverty reduction and attainment of the Millennium Development Goals, have helped the poorest to reduce their exposure to current and future climate hazards (Yamin et al, 2005; Tanner and Mitchell 2008; Heltberg et al., 2009). Some examples of social safety nets are cash transfers to the most vulnerable, versions of weather-indexed crop insurance, employment guarantee schemes and asset transfers (CCCD, 2009; Yamin et al, 2005; also see 6.6.3). A national policy to help the vulnerable build assets should incorporate climate screening in order to remain resilient under a changing climate (ISDR 2004; Heltberg et al., 2009; Tanner and Mitchell, 2008). Other measures such as social pensions that transfer cash from the national level to vulnerable people provide some buffers against climate hazards (Davies et al, 2008; Heltberg et al., 2009). However, lack of capacity and good governance has remained a major barrier to efficient and effective delivery of assistance to the most vulnerable (Warner et al., 2009; CCCD, 2009; Yamin et al, 2009; Heltberg et al, 2009).

National Adaptation Programme of Actions (NAPA) under the UNFCCC process have helped least developed countries assess the climate sensitive sectors and prioritize projects to address the most urgent adaptation issues of

the most vulnerable regions, communities and populations.. The NAPA process has proven instrumental in increasing awareness of climate change and its potential impacts in the poorest countries. The proposed adaptation projects under the NAPA usually cover small areas and address a few components within a given sector with a view to addressing urgent and immediate needs. The choice of projects is based on the urgency of the actions as well as cost-effectiveness in cases where delays would increase the costs of later addressing the issue. Assessment of completed NAPAs show different national and regional priority sectors such as health, food security, infrastructure, coastal zone and marine ecosystem, insurance, early warning and disaster management, terrestrial ecosystem, education and capacity building, tourism, energy, water resources and cross sectoral areas. The NAPA process forms a good basis for developing medium-and-long-term adaptation plans and policies. The capacity within NAPA teams and the subsequent networks that are created are proving very useful in the design of broader national adaptation plans (UNFCCC, 2011a and 2011b).

6.5.2.3. Investing in Natural Capital and Ecosystem-Based Adaptation

Ecosystem-based adaptation, which integrates the use of biodiversity and ecosystem services into an overall adaptation strategy, can be cost-effective strategy for responding to effects of weather and climate extremes (SCBD, 2009). It is generally agreed that investment in sustainable ecosystems and environmental management has the potential to also provide improved livelihoods and increased biodiversity conservation (Bouwer, 2006; Coll, 2009; McGray et al, 2007; Sudmeier-Rieux and Ash, 2009; UNEP, 2010; UNEP, 2006; World Bank, 2009; SCBD, 2009).

Healthy, natural or modified, ecosystems (see Section 6.3.1 and Box 6-4) have a critical role to play in reducing risk of climate extremes and disasters (UNEP, 2009b; Bebi *et al.*, 2009; Dorren *et al.*, 2004; Phillips and Marden, 2005; Sidle et al, 1985; ISDR, 2005; ISDR, 2007a, b; ISDR, 2009a, b; Colls et al., 2009; Sudmeier-Rieux and Ash, 2009; Reid and Huq, 2005; Secretariat of the Convention on Biological Diversity, 2009; Lal 2010). Although the scientific evidence base relating to the role of ecosystem services in reducing sensitivity of natural systems to weather and climate extremes and reducing vulnerabilities to many disasters is nascent, investment in natural ecosystem management has long been used to reduce risks of disasters (see Box 6-4). Forests, for example, have been used in the Alps and elsewhere as effective risk reducing measures against avalanches, rockfalls and landslides since the 1900s (Bebi et al, 2009; Dorren et al, 2004; Phillips and Marden, 2005; Sidle et al, 1985). The damage caused by wildfires, wind erosion, drought and desertification are reported to have be buffered by forest management, shelterbelts, greenbelts, hedges and other “living fences” (Dudley et al., 2010; ProAct, 2008). Mangrove replanting has been used as a buffer against cyclones and storm surges, with reports of 70-90% reduction in energy from wind generated waves in coastal areas (UNEP, 2006) and reduction in the number of deaths from cyclones (Das and Vincent, 2009) , depending on the health and extent of the mangroves. Many sectoral examples are provided in Table 6-1, which also provide evidence of the value of ecosystem services in disaster risk reduction and adaption to climate change (see also 6.5.2.1).

_____ START BOX 6-4 HERE _____

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

- In the Maldives, degradation of protective coral reefs necessitated the construction of artificial breakwaters at a cost of US\$ 10 million per kilometre (SCBD, 2009).
- 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; SCBD, 2009).
- 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 (Costanza et al., 2008).
- In Orissa, India, a comparison of the impact of the 1999 super cyclone on 409 villages in two tahsils with and without mangroves, show that villages that had healthy strand of mangroves suffered significantly less loss of lives than those without (or limited areas) healthy mangroves, even though all villages had the benefit of early warnings and accounting for other social and economic variables (Das and Vincent, 2009).

_____END BOX 6-4 HERE _____

The extent to which ecosystems support such benefits though depends on a complex set of dynamic interactions of ecosystem related factors, as well as the intensity of the hazard (Sudmeier-Rieux and Ash, 2009; UNEP, 2006) and institutional and governance arrangements (see various case studies in Angelsen, et al 2009). Scientific understanding of the relationship between ecosystem structure and function and the reduction of risks associated with weather and climate extremes is limited, though growing.

Investment in natural ecosystems also contributes significantly to reduction in GHG emissions, through practices such as Land Use, Land Use Change and Forestry (LULUCF) and through Reduced Carbon Emissions from Deforestation and Forest Degradation (REDD) or REDD+, which additionally includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks) (UNEP, 2006; SCBD, 2009). Mangrove ecosystems, for example, are important sources of carbon sequestrators and stores, as well as provide buffer against weather and climate extremes, biodiversity values and livelihood benefits discussed above, containing amongst the highest carbon pools - 1060-2020 t CO₂/ha or an annual C-sequestration of 6.32 t CO₂/ha (Murray et al, 2010). Investment in natural ecosystems, through REDD and REDD+ related strategies, can generate alternative sources of income for local communities and provide much needed financial incentives to prevent deforestation (Angelsen, et al. 2009; Sudmeier-Rieux and Ash 2009; Reid and Huq, 2005; SCBD, 2009; Murray et al 2010), as well as provide additional livelihood benefits from the conservation and restoration of forest ecosystems and the services they support (Longley and Maxwell, 2003; Millennium Ecosystem Assessment, 2005; Murray et al, 2010; SEEDS, 2008; Sudmeier-Rieux and Ash, 2009).

Some countries have begun to explicitly consider ecosystem based solutions for climate change mitigation and or adaptation risks associated with weather and climatic extremes as an integral element of national and sectoral development decisions (see Box 6-5).

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Box 6-5. Some examples of Ecosystem-Based Adaptation Strategies and Disaster Risk Management Interventions Taking into Account the Role of Ecosystem Services

- Viet Nam has applied Strategic Environmental Assessments to land use planning projects and hydropower development for the Vu Gia-Thu Bon river basin, including climatic disaster risks (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 and Van Halsema, 2008; ONERC 2009).
- At the regional level, the Caribbean Development Bank has integrated weather and climatic disaster risks into its Environmental Impact Assessments for new development projects (ISDR, 2009c and CDB and CARICOM, 2004).
- Under Amazon Protected Areas Program, Brazil has created over 30 million ha mosaic of biodiversity-rich forests reserve of state, provincial, private, and indigenous land, resulting in potential reduction in emissions estimated at 1.8 billion tons of carbon through avoided deforestation (World Bank, 2009).
- Swiss Development Cooperation’s four year project in Muminabad, Tajikistan adopted an integrated approach to risk through reforestation and integrated watershed management (SDC, 2008).

_____END BOX 6-5 HERE _____

Ecosystem-based adaptation strategies, often considered as part of ‘soft’ options are widely applicable approach to climate change adaptation because it can be applied at regional, national and local levels, at both project and programmatic levels, and benefits can be realized over short and long time scales. They can be a more cost-effective adaptation strategy than hard infrastructures and engineering solutions, as also discussed in 6.5.2.1, and produce multiple benefits, and are also considerably more accessible to the rural poor than measures based on hard

infrastructure and engineering solutions (Sudmeier-Rieux and Ash, 2009). Communities are also able to integrate and maintain traditional and local knowledge and cultural values in their risk reduction efforts (SCBD, 2009).

In the choice of ecosystem-based adaptation option, decision makers may though at times require making tradeoffs between particular climatic risk reduction services and other ecosystem services also valued by humans, and would thus also need to be subject to risk assessment, scenario planning and adaptive management approaches that recognise and incorporate these potential trade-offs. For example when deciding to use wetlands for coastal protection that require emphasis on silt accumulation and stabilization possibly at the expense of wildlife values and recreation (SCBD, 2009), particularly when achieving a full complement of biodiversity values is highly complex and long term in nature (UNEP, 2006).

However, countries would need to overcome many challenges if they are to be successful in increasing investment in ecosystem-based solutions, including for example:

- Insufficient recognition of the economic and social benefits of ecosystem services under current risk situations, let alone under potential changes in climate extremes and disaster risks (Vignola et al, 2009).
- Lack of interdisciplinary science and implementation capacity for making informed decisions associated with complex and dynamic systems (OECD, 2009; Leslie and McLeod, 2007).
- Ability to estimate economic values of different ecosystem services supported by nature (TEEB 2010)
- Lack of capacity to undertake careful cost and benefit assessments of alternative strategies to inform choices at the local level. Such assessments could provide total economic value of the full range of disaster-related ecosystem services, compared with alternative uses of the forested land such as in agriculture (see e.g. Balmford, 2002).
- Where they exist, data and monitoring on ecosystem status and risk are often dispersed across agencies at various scales and are not always accessible at the sub-national or municipal level where land use planning decisions are made (ISDR, 2009a).
- The mismatch in geographic scales and mandates between the administration and responsibilities for disaster reduction, and that of ecosystem extent and functioning, such as in water basin (OECD, 2009; Leslie and McLeod, 2007).

6.5.3. *Transferring and Sharing ‘Residual’ Risks*

Not all risk can be reduced, and a residual, often sizeable risk will remain. Mechanisms for sharing and transferring residual risks for households and businesses have been introduced in section 5.5.2.2 in the context of managing local level impacts and risks. Chapter 5 also discusses the incentive and disincentive aspects provided by insurance for risk management and adaptation to climate change at the local level. This section sets out the role of national-level institutions, especially governments, in enabling and regulating practices at national scales. It also discusses the need on the part of some governments to transfer their own risks.

Markets offer risk sharing and transfer solutions, most prominently property and asset insurance for households and business, and crop insurance for farmers. Insurance markets are generally segregated and regulated nationally. Existing national insurance systems commonly offer a wide variety of choice in providing protection for property and assets against natural hazards. National insurance systems differentially include hazards, such as storms, hail, floods, earthquake, and also landslides or subsidence. Risks may be covered separately or bundled with a fire policy or covered under an “all hazards” policy. The contracts differ on the extent of cover offered, as well as indemnity limits, and whether the policies are compulsory, bundled or voluntary. Importantly, they differ institutionally with regard to the involvement of the public authorities and private insurers and how they allocate liability and responsibility for disaster losses across individual households, businesses and taxpayers (Schwarze and Wagner, 2004; Aakre et al., 2010).

Yet, insurance cover is limited and globally only about 20% of the losses from weather-related events have been insured over the period 1980 and 2003 (also see 6.2.2). 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 these risks, as well as problems of moral hazard and adverse selection (Froot, 2001; Aakre, et

al. 2010). In some highly exposed countries, such as the Netherlands for flood risk, insurance is even non-existent and government relief is dispensed in lieu (Botzen et al., 2009). In many developing countries, there is little in terms of insurance for disaster risks, yet novel index-based micro-insurance solutions have been developed and are starting to show results (Hazell and Hess, 2010, see also Chapter 5.6.3. and Chapter 9.2.13 on risk financing). Market mechanisms may work less well in developing countries, particularly because there is often limited risk assessment information, limited scope for risk pooling and little or no supply of insurance instruments. In such circumstances, governments may need to create enabling environments by helping to estimate risk, help to develop training programs for insurer's staff and generally promote awareness among the population at risks (Linnerooth-Bayer et al., 2005; Hoeppe and Gurenko, 2006; Cummins and Mahul, 2009; Hazell and Hess, 2010).

Employing insurance and other risk financing instruments for helping to manage the vagaries of nature may often involve the building of PPPs in developing and in developed countries in order to tackle 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. In the development context, Hazell and Hess (2010) distinguish between protection and promotion models, while acknowledging that in many instances hybrid combinations may contain elements of both. Protection relates to governments helping to protect themselves, individuals and business from destitution and poverty by providing ex-post financial assistance, which however is taken out as an ex ante instrument as insurance before disasters. The promotion model relates to the public sector promoting more stable livelihoods and higher income opportunities by better helping businesses and households access risk financing, including micro-financing.

Private insurers are often not willing to fully underwrite the risks and many countries, including Japan, France, the US, Norway and New Zealand, have therefore instituted public-private national insurance systems, where participation of the insured is mandatory or voluntary and single hazards may be insured or comprehensive insurance offered (Linnerooth-Bayer and Mechler, 2007). Further, specific strategies may be employed to increase market penetration of risks, which are not easily covered by regular avenues. As one example, in India pro-poor regulation stipulate that insurers within their regular business segment reserve a certain quota of insurance policies for the poor and thus cross-subsidize fledgling low income micro-insurance policies (Mechler et al., 2006a).

As well, governments may insure their liabilities, through sovereign insurance. Liabilities arise as governments own a large portfolio of public infrastructure and other assets that are exposed to disaster risks. Moreover, most governments accept their role as provider of post-disaster emergency relief and assistance to vulnerable and affected households and businesses. In wealthy countries, government (sovereign) insurance hardly exists at the national level and in Sweden, insurance for public assets is illegal (Linnerooth-Bayer and Amendola, 2000). On the other hand, states in the US, Canada and Australia, although regulated not to incur budget deficits, often carry cover for their public assets (Burby, 1991). As discussed earlier (see 6.4.3), this is consistent with Arrow and Lind Theorem, which suggests that governments can efficiently spread and share risk over its citizens, without buying sovereign insurance policies.

Yet, realizing the shortcomings of after-the-event approaches for coping with disaster losses for small, low-income or highly exposed countries with over-stretched tax bases and highly correlated infrastructure risks (OAS, 1991; Pollner, 2000; Mechler, 2004; Cardona, 2006; Linnerooth and Bayer, 2007; Mahul and Ghesquiere, 2007), sovereign insurance for public sector assets and relief expenditure has become a recent cornerstone for tackling the substantial and increasing effects of disasters (Mahul and Ghesquiere, 2007). As a general statement, the strategy involves transferring a layer of risks ranging from infrequent risk (such as events with a return period of more than 10 years) up to risks associated with 150 year return periods, beyond which it will become very costly to insure (Cummins and Mahul, 2009). One key element is to define the financial vulnerability indicating the inability to bear losses with a certain return period (Mechler et al., 2010).

Key applications have been implemented in Mexico in 2006, which insured its government emergency relief expenditure, and in the Caribbean with the Caribbean Catastrophe Risk Insurance Facility (CCRIF) in 2007 (Cardenas et al., 2007; Ghesquiere, et al., 2006). Like national governments, donor organisations, exposed indirectly through their relief and assistance programs, too, have been considering similar transaction and the World Food Programme in 2006, for example, purchased 'humanitarian insurance' for its drought exposure in Ethiopia through

index-based reinsurance (see 9.2.13). These transactions set innovative and promising precedents in terms of protecting highly exposed developing and transition government portfolios against the risks imposed by disasters.

6.5.4. *Managing the Impacts*

Even in the rare circumstances where efforts outlined previously are all in place, there still needs to be investment in capacities to manage potential disaster impacts as risk cannot be reduced to zero (Coppolla, 2007; Pelling, 2003; Wisner et al. 2004). The scale of the disaster impact should ideally dictate the level and extent of response. Individual household capacities to respond to disasters may be quickly overwhelmed, requiring local resources to be mobilised (Del Ninno, 2001). When community-level responses are overwhelmed, regional or central government are called upon (Coppolla, 2007). Some events may overwhelm national government capacities too, and may require mobilisation of the international community of humanitarian responders (Fagen, 2008; Harvey, 2009). International responses pose the most complex management challenges for national governments, because of the diversity of actors that are involved and the multiple resources flows that are established (ALNAP, 2010a; Bennet, J, et al, 2006; Borton, 1993; Ramalingam, 2008 et al.). However, although humanitarian principles call for a proportionate and equitable response, in practice there are a few high-profile disasters that are over-resourced, with many more that are ‘forgotten or neglected emergencies’ (Slim, 2006). Despite the definition of international or national disasters as those where immediate capacities are overwhelmed, evaluations routinely find that most of the vital life-saving activities happen at the local level, led by households, communities and civil society (See 5.1; 5.2; ALNAP, 2005; Hilhorst, 2003; Smillie, 2001; Telford and Cosgrave, 2006).

In terms of how responses are managed nationally, there are different models to consider (ALNAP, 2010b). Many countries now have some standing capacity to manage disaster events (Interworks, 1998) and this should be considered distinct from national systems for managing disaster risk, commonly associated with ‘national platforms’ detailed in section 6.4.2. Examples of standing disaster management capacity include the Federal Emergency Management Agency in the US, Public Safety in Canada, National Commission for Disaster Reduction in China, the National Disaster Management Authorities in India and Indonesia, National Disaster Management Offices (NDMO) in many Pacific island countries and the Civil Contingencies Secretariat in the UK. Comparative analysis of these structures shows that there are a number of common elements (Coppolla, 2007, Interworks, 1998). Countries with formal disaster management structures typically operate a system comprised of a National Disaster Committee, which works to provide high-level authority and ministerial coordination, alongside a National Disaster Management Office (NDMO) to lead the practical implementation of disaster preparedness and response (Interworks, 1998). National Committees are typically composed of representatives from different ministries and departments as well as the Red Cross/Red Crescent. They might also include donor agencies, NGOs and the private sector. The committee works to coordinate the inputs of different institutions to provide a comprehensive approach to disaster management. NDMOs usually act as the executive arm of the national committee. Focal points for disaster management, NDMOs are usually staffed by professional disaster managers NDMOs may be operational, or in large countries they may provide policy and strategic oversight to decentralised operational entities at federal or local levels. Where formal structures do not exist, national ministerial oversight is provided to the efforts of the NDMO in times of national disasters.

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

There may be states where there is an existing or emerging social contract with its citizens, by which the state undertakes to assist and protect them in the face of disasters, and there is a limited role for international agencies, focusing on advocacy and fundraising. By comparison, there are states that have a growing capacity to respond and request international agencies to supplement their effort in specific locally owned ways, through filling gaps in

national capacities or resources. Next, there are states that have limited capacity and resources to meet their responsibilities to assist and protect their citizens in the face of disasters, and which request international assistance to cope with the magnitude of a disaster, resulting in a fully-fledged international response. Finally, there are states that lack the will to negotiate a resilient social contract, including assisting and protecting their citizens in times of disaster. These pose significant challenges and involve a combination of direct delivery and advocacy. Across all four categories of response, there are challenges around resources availability, proportionality of distribution, coordination and leadership (ALNAP, 2010a).

Details of the disaster management systems of two countries are outlined in Box 6-6 – these have been chosen to illustrate the different stages of disaster management development that are evident across states.

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

China

The Government's disaster management process, developed as National Integrated Disaster Reduction, is a comprehensive system bringing together a number of central and local government sectors and covering the different phases of disasters preparedness, response and recover / rehabilitation. China has put in place over 30 laws and regulations on to disaster management. The Emergency Response Law was adopted on 30 August 2007 as the central legal document governing all disaster related efforts in China.

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

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

Kenya

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

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

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

_____ END BOX 6-6 HERE _____

Although the level of response and actors involved can vary considerably between disasters and countries (ALNAP, 2010a), the basic actions taken to manage disaster impacts remain broadly the same across countries, and correspond closely to the different stages of the disaster timeline (see Table 6-4, Coppola, 2007). In general, disaster management employs immediate humanitarian activities, needs assessments and the delivery of goods and services to meet requirements. The demand for water, food, shelter, sanitation, healthcare, security and – later on – education, employment, reconstruction and so on is balanced against available resources (Wisner and Adams, 2003).

[INSERT TABLE 6-4 HERE

Table 6-4: Activities associated with managing the impacts of disasters.]

Despite the existence of evidence that the climate change is not responsible for the vast majority of the increasing trend in disaster losses (See summary in SPM and 4.5.3.3), climate change-related disasters are still widely, if incorrectly, seen by particularly the humanitarian community as playing a major role in the increasing the overall human impact of disasters. Numerous trends in disaster events are commonly attributed to climate change, (IASC, 2009a, IFRC 2009) and as such, climate change is often cited as a reason for enhancing both national and international disaster management capacities (Oxfam, 2007, IASC, 2009a, IASC, 2009b, HFP, 2007). Consequently, climate change-related considerations are increasingly featuring in literature on disaster management (Barret et al., 2007; IASC, 2009a, McGray, 2007, Mitchell and Van Aalst, 2008; Venton and La Trobe, 2008). As presented in this report, evidence is available for the influence of climate change on some extreme weather events but not for others (Chapter 3), and perhaps because of this, challenges remain in how climate change-related information can be used as a direct guide to decision-making in the humanitarian sector (IASC, 2009a).

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

6.6. Aligning National Disaster Risk Management Systems to the Challenges of Climate Change

As has been mentioned above, climate change presents multidimensional 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 and projected impacts on hazards, exposure and vulnerability. As climate change is altering the frequency and magnitude of some extreme events (see Chapter 3) and contributing to trends in exposure and vulnerability (see Chapter 4), the efficacy of national systems of disaster risk management requires review and realignment with the new challenges (Mitchell *et al*, 2010a; Polack 2010; ISDR, 2009c; see FAQ 6.1). Literature suggests that the effectiveness of national systems for managing disaster risk in a changing climate will be improved if they integrate assessments of changing climate extremes and disasters into current investments, strategies and activities; seek to strengthen the adaptive capacity of all actors and address the causes of vulnerability and poverty recognising climate change as one such cause (ISDR 2009c; Schipper, 2009; Mitchell *et al*, 2010a). In practice, this might require: (i) new alliances and hybrid organisations across government and potentially across countries, (ii) different actors to join the national system, (iii) new cross-sector relationships, (iv) reallocation of functions, responsibilities and resources across scales, and (v) new practices (Mitchell *et al* 2010a; Polack 2010, Hedger *et al*. 2010). As a compliment to the available data, information and knowledge about the impact of climate change and disaster risk presented in chapter 2, 3 and 4, this section seeks to elaborate the key areas where realignment of national systems could occur – in assessing the effectiveness of disaster risk management in a changing climate (6.6.1), managing uncertainty and adaptive management (6.6.2), in tackling poverty, vulnerability and their structural causes (6.6.3), and commenting on the practicalities of approaching such changes holistically (6.6.4).

6.6.1. *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 that information remains patchy at best. Adopting an economic assessment framework, different approaches have been used to comment on the effectiveness or efficiency of adaptation option. Many climate adaptation studies have focused on the national level costs of adaptation rather than comparing costs and benefits (i.e. examining the benefits of adaptation or reduced disaster impacts and damage costs) (see UNFCCC, 2007a; World Bank, 2008; EEA, 2007; ECA, 2009; Nordhaus, 2006; Parry *et al*, 2009; Agrawala and Fankhauser, 2008). National level adaptation assessments have been conducted among others, in the EU, UK, Finland, Netherlands and Canada, as well as in a number of developing countries using the NAPA approach (UNDP, 2005; Lemmen *et al*, 2008; MMM, 2005; De Bruin *et al*, 2009a; DEFRA, 2006; UNFCCC, 2007b).

Other approaches include assessments of disaster risk management with risk assessment at the core, and focussing on economic efficiency of management responses (see World Bank, 1996; Benson and Twigg, 2004; Mechler, 2004). Using such a rationale, the World Bank, for example, goes as far as suggesting that governments should in many instances prioritize allocating their resources on early warning (such as for floods), critical infrastructure, such as water and electricity lifelines and supporting environmental buffers such as through mangroves, forests and wetlands, of which the latter should be treated with caution (World Bank/UN 2010). Another report suggests taking an adaptation cost curve approach to selecting adaptation options (ECA, 2009); this approach organises adaptation options around their cost-benefit ratios, similar to mitigation cost curves. Interestingly, many of the options considered efficient in this analysis are “soft” options, such as reviving reefs, using mangroves as barriers and nourishing beaches.

It is though difficult to make conclusive assessments about the effectiveness of disaster risk management in a changing climate, as overall the evidence base used to determine economic efficiency, that is benefits net of costs of adaptation, remains limited and fragmented (Adger *et al.*, 2007; Agrawala and Fankhauser, 2008; UNFCCC, 2007a). In addition to the rather small number of studies available, there are important limitations of these assessments as well. These relate to the types of hazards examined as well as treatment of extreme events and risk, affecting the robustness of the results. Another key limitation, relevant for this report, is that only very few national level studies assessing economic efficiency of options have focussed explicitly on disaster risk, and in most instances the hazards examined have been gradual, such as sea level rise and slower onset impacts, such as drought, on agriculture (see UNFCCC 2007a; Agrawala and Fankhauser 2008). Where extreme events and disaster risks have been considered, studies have often adopted deterministic impact metrics, when disaster risk associated with frequency and variability of extreme events can change. Where disaster risks have been accounted for, the robustness of future projections of risk is also uncertain (Bouwer, 2010).

Furthermore, many of the economic costs assessments faced key methodological challenges, including the difficulty in estimating economic values of intangible effects of disasters, such as impact on human life, suffering, and ecological services, different rates of time preferences or discounting the future, as well the difficulties associated with properly accounting for the distribution of costs and benefits across different sectors of society (Parry *et al.*, 2009). Such challenges suggest that the value of tools, such as cost-benefit analysis, for the assessment of economic efficiency, even with risk considerations, may lie in the usefulness of the analytical process rather than the numeric outcomes per se. They suggest that in the context of climate adaptation such tools may be most usefully employed as a heuristic tool in the context of iterative stakeholder decision-making processes (Moench *et al.* 2009).

A limited number of studies have used other tools such as multi-criteria analysis (MCA), and other variants, that do not rely on just quantitative values, to help in the stakeholder based adaptation decision-making (Debels *et al.*, 2009; De Bruin *et al.* 2009a; Cardona *et al* 2010). Debels *et al* (2009) developed a multi-purpose index for a quick evaluation of adaptation practices in terms of proper design, implementation and post-implementation evaluation and apply it to cases in Latin America. Mechler *et al.* (2006b) developed a metric for measuring fiscal vulnerability to natural hazards, capturing the relationship between the economic and fiscal losses that a country could experience

when a catastrophic event occurs and the availability of funds to address the situation. Cardona et al (2010), building on this, constructed the Disaster Deficit Index (DDI) and applied it across a range of Latin American countries to support governmental decision-making in disaster risk management over time. De Bruin et al. (2009b) 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, for example an integrated portfolio of nature and water management with risk based policies has particular high potential and acceptance for stakeholders. Overall, the assessment of adaptation explicitly considering the risk based nature of extreme events remains fragmented and incipient, and more work will be necessary to improve the robustness of results, and confidence in assessment.

6.6.2. *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 (Hallegatte et al., 2007, see Chapter 3). 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 (Aldunce et al 2008; 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 (see 3.2.3 and Box 3-2; 9.2.11). 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 perception of risk, trust in the information-providing institution, previous experience of the hazard, degree of social exclusion, and gender (see for example Drabek, 1986; Drabek, 1999). Enhanced scientific modelling and interdisciplinary approaches to early warning systems can address some of these uncertainties provided good baseline and time series information is available (see 3.2.3 and Box 3-2). Even where such information is available, there remain other unresolved questions 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 these issues into account include adaptive management and resilience, yet these approaches are not without their challenges (also see 8.6.3.1).

Adaptive management, as defined in chapter 8 (8.6.3.1), is 'a structured processes for improving management policies and practices by systemic learning from the outcomes of implemented strategies, and taking into account changes in external factors as a proactive manner' (Pahl-Wostl, 2009; Pahl-Wostl et al, 2007). It has come to also mean bringing together interdisciplinary science, experience and traditional knowledge into decision making through 'learning by doing' by individuals and organisations (Walters, 1997). Decision makers, under adaptive management are expected to be flexible in their approach, and accept new information as they become available, or when new challenges emerge, and not be rigid in their responses. 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).

In most cases adaptive management has been implemented at the local or regional scale and there are few examples of its implementation at the national level. Examples of adaptive management abound in ecosystem management (Johnson, 1999; Ladson and Argent, 2000) and in disaster risk management (Thompson and Gaviria, 2004; Tompkins, 2005 (see Box 6-7). Nearly forty years of research, after the seminal paper was published by Holling in 1973, have produced evidence of the impacts of aspects of resilience policy (notably adaptive management) on forests, coral reefs, disasters, and adaptation to climate change); however most of this has been at the local or ecosystem scale.

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

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

_____ END BOX 6-7 HERE _____

One of the main unresolved issues in adaptive management is though how to ensure that scientists and engineers tasked with investigating adaptation and disaster risk management processes are able to learn from each other and from practitioners and how this learning can be integrated to inform policy and management practices. In the case of the restoration of the Florida Everglades a limiting factor to effective management observed 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). The Cayman Islands hurricane management, on the other hand, demonstrates a success story in a flexible disaster management committee being prepared to change their strategies and measures from experience, and essentially learning by doings (Box 6-7).

Spare capacity within institutions has been argued to increase the ability of socio-ecological systems to address surprises or external shocks (Folke *et al*, 2005). McDaniels *et al* (2008) in their analysis of hospital resilience to earthquake impacts, agreed with this finding, concluding that key features of resilience include the ability to learn from previous experience, careful management of staff during hazard, daily communication and 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).

‘Learning by doing’ in disaster risk management can only be undertaken effectively if the management institutions are scaled appropriately, where necessary at the local level, or at multiple scales with effective interaction (Gunderson and Holling 2002, Eriksen *et al*, 2011). For the management of climate extremes, the appropriate scale is influenced by the magnitude of the hazard and the affected area, including biological diversity. Research suggests that increasing biological diversity of ecosystems allows a greater range of ecosystem responses to hazards, and this increases the resilience of the entire system (Elmqvist *et al*, 2003). Other research has shown that reducing non-climate stresses on ecosystems can enhance their resilience to climate change. This is the case for coral reefs (Hughes *et al.* 2003; Hoegh-Guldberg, *et al.*, 2008), 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; Sorensen 1997).

Climate resilience as a development objective is though difficult to implement, particularly as it is unclear as to what resilience means (Folke, 2006). Unless resilience is clearly defined and broadly understood, with measurable

indicators designed to fit different local contexts and to show the success, the potential losers from this policy may go unnoticed, causing problems with policy implementation and legitimacy (Eakin et al. 2009). Please see the ‘glossary’ for the report’s definition of resilience, also more details regarding uncertainty and resilience related to extreme events in the light of climate change are given in 3.2.3, Box 3-2, and 8.5.1.

6.6.3. Tackling the Underlying Drivers of Vulnerability

This assessment has found that future trends in exposure, vulnerability and climate extremes may further alter disaster risk and associated impacts. Future trends in climate extremes will be affected by anthropogenic climate change in addition to natural climate variability, and exposure and vulnerability influenced by both climatic and non-climatic factors (SPM; 2.2, 2.3, 2.5). Accordingly, reducing vulnerability and its underlying drivers is a considered as a critical aspect of addressing both observed and projected changes in disaster risk (ISDR 2009c, 2011b, Figure 6-3). Section 6.5.2.2 discussed the centrality of human development and vulnerability reduction to the goal of disaster risk reduction. As an extension, literature focused on aligning national disaster risk management systems to the challenges posed by climate change and other dynamic drivers of disaster risk places considerable importance on addressing the underlying drivers of vulnerability as a one of the most effective ‘low or no’ regrets measures (see Figure 6-3 and Table 6-5 in FAQ 6.1; ISDR 2009c, Mitchell *et al.* 2010a, Davies *et al.* 2009, Tanner and Mitchell, 2008, CCCD 2009). Such underlying drivers of vulnerability include inequitable development, poverty, declining ecosystems, lack of access to power, basic services and land and weak governance (ISDR 2009c’ 2011b; Wisner et al. 2004; Schipper 2009). An approach to managing disaster risk in the context of a changing climate highlights that disaster risk management efforts should seek to develop partnerships to tackle vulnerability driver by focussing on approaches that *promote more socially just and economic systems, forge partnerships to ensure the rights and entitlements of people to access basic services, productive assets and common property resources; Empower communities and local authorities to influence the decisions of national governments, NGOs, international and private sector organisations and to promote accountability and transparency; and promote environmentally sensitive development* (Mitchell et al., 2010a, Polack 2010; Hedger et al. 2010).

To date, strategies for tackling the risks of climate extremes and disasters, in practice, have tended to focus on treating the symptoms of vulnerability, and with it risk, rather than the underlying causes, partly due to disaster risk management still not being a core component of 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 (ISDR, 2011b) and other studies have found a continued 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 (ISDR 2009c; CCCD 2009). The impacts of climate change, both on disaster risk and on vulnerability and poverty are viewed by some as a potential force that will help to forge a stronger connection between disaster risk reduction measures and poverty and vulnerability reduction measures, also partly as a result of increased availability of financial resources and renewed political will (Soussan and Burton 2002; Mitchell et al. 2010a; Schipper 2009). A recent and growing body of literature has focused on the potential for strengthening the links between particular forms of social protection, disaster risk reduction and climate change adaptation measures as a way to simultaneously tackle the drivers of vulnerability, poverty and hence disaster risk (see 8.3.1; Davies et al. 2008; Heltberg et al. 2009). With increasing levels of exposure to disaster risk in middle income countries (see 6.1; ISDR 2009c; 2011a), reducing vulnerability of poor people and their assets in such locations is becoming a focus for those governments and for CSOs and CBOs (Tanner and Mitchell 2008).

6.6.4. Approaching Disaster Risk, Adaptation, and Development Holistically

As this chapter has demonstrated, climate change poses diverse and complex challenges for actors in national disaster risk management systems and for disaster risk management policies and practices more broadly. These challenges include changes to the magnitude and frequency of some hazards in some regions, impacts on vulnerability and exposure, new agreements and resource flows and the potential of climate change to alter value-systems and people’s perceptions. As Table SPM-1 highlights, it is the complexity resulting from the combination of these factors, in addition to the uncertainty generated, that means national disaster risk management systems and

broader national strategies may need to be realigned to maintain and improve their effectiveness. There is *high agreement* but *limited evidence* to suggest that a business-as-usual approach to disaster risk management, which fails to take the impacts of climate change into account, will become increasingly ineffective. Section 6.6 and other parts of the chapter have assessed evidence on the different elements involved in such a realignment. In conclusion a selection of these elements is briefly summarized here.

As discussed in 6.6.2, there is *high agreement* but *limited evidence* to suggest that flexible and adaptive national systems for disaster risk management, based on the principle of learning by doing, are better suited to managing the challenges posed by changes in exposure, vulnerability, weather and climate extremes than static and rigid systems [see 8.6]. This ability to be flexible will be tested by a systems' capacity to act on new knowledge generated by the frequent assessment of dynamic risk needed to capture trends in exposure vulnerability and weather and climate extremes and by information on how the costs and benefits of different response measures change as a result (6.6.1). The accuracy of these assessments will be based on the quality of available data (6.5.2.1). Where such assessments generate uncertainty for decision-makers, tools such as multi-criteria analysis, scenario planning and flexible decision-paths offer ways of supporting informed action (6.6.1)

There is *high agreement* and *robust evidence* to demonstrate that the mainstreaming of disaster risk management processes into development planning and practice leads to more resilient development pathways. By extension, with climate change and other development processes having an impact on disaster risk, then these changes need to be factored into development and economic planning decisions at different scales. This suggests an ideal national system for managing the risks from climate extremes and disasters would be designed to be fully integrated with economic and social development, environmental, poverty reduction and humanitarian dimensions to create a holistic approach. The nature of transformational changes in thinking, analysis, planning, approaches, strategies and actions is the subject of Chapter 8 (particularly 8.2.2.).

While there is *limited evidence* that some countries have begun to factor climate change into the way disaster risks are assessed and managed (see 6.3; 6.6.1), few countries appear to have adopted a comprehensive approach – for example by addressing projected changes in exposure, vulnerability and extremes as well as adopting a learning-by-doing approach to decision-making embedded in the context of national development planning processes. Incremental efforts towards implementing suitable strategies for mainstreaming climate change responses into national development planning and budgetary processes, and climate proofing at the sector and project levels [6.2 and 6.3] in the context of disaster risk management appear to be the most likely approach adopted by many countries. None of these measures will be easy to implement as actors and stakeholders at all levels of society are being asked to embrace a dynamic notion of risk as an inherent part of their decisions, and continuously learn and modify policies, decision and actions taking into account new traditional and scientific knowledge as it emerges.

The knowledge-base for understanding changing climate-related disaster risks and for the way national systems are acting on this understanding through modifying practices, altering the nature of relationships between different actors and the adopting new strategies and policies is fragmented and incomplete. As this chapter has illustrated, incomplete information and knowledge gaps do not need to present blockages to action. As FAQ 6.1 and section 6.3.1 highlight, there is considerable experience of governments and other actors investing in measures to respond to existing climate variability and disaster risk that can be considered as 'no or low regrets' options when taking into the account the uncertainty associated with future climate. However, in conducting this assessment, some knowledge gaps have emerged that if filled would aid the creation of enduring national risk management systems for tackling observed and projected disaster risk. These gaps include the need for more research on:

- The extent to which efforts to build disaster risk management capacities at different scales prepare people and organisations for the challenges posed by climate change.
- Whether the current trend of decentralising disaster risk management functions to sub-national and local governments and communities is effective given the level of information and capacity requirements, changing risks and associated uncertainties presented by climate change.
- How the function, roles and responsibilities of different actors working within national disaster risk management systems are changing given the impacts of climate change at national and sub-national level.
- The characteristics of flexibility, learning-by-doing and adaptive management in the context of national disaster risk management systems in different governance contexts.

- How decisions on disaster risk management interventions are made at different scales if there is limited context specific information.
- The costs and benefits of different risk management interventions if the impacts of climate change and other dynamic drivers of risk are factored in.
- The benefits and trade-offs of creating integrated programmes and policies that seek to manage disaster risk, mitigate greenhouse gases, adapt to climate change and reduce poverty simultaneously?

Frequently Asked Questions

FAQ 6.1: What can a government do to better prepare its people for changing climate-related disaster risks?

In almost all countries, governments create the enabling environment of policies, regulations, institutional arrangements and co-ordination mechanisms to guide and support the efforts of all agencies and stakeholders involved in managing disaster risks at different scales. Such risks are increasing and changing because of population growth, migration, climate change and range of other factors. National systems for managing disaster risk need to act on these changes in order to build resilience in the short and long-term. Accordingly, the following measures can be considered:

- **Generate and communicate robust information about the dynamic nature of disaster risk:** Given the dynamic and changing nature of disaster risks in the context of climate change, regular updates on changes to the level of risk will further strengthen such systems if the information is acted upon. Not possessing information about changing disaster risks or not integrating the information into decisions about longer-term investments can lead to increases in the exposure and vulnerability of people and assets and may increase risk over time. An example could be non-drought tolerant mono-culture agriculture in an area likely to experience increased frequency and/or longer durations of drought conditions, or water harvesting tanks installed in houses or communities that lack the capacity to supply water during longer periods of drought, or roads not raised sufficiently above future projected flood levels. Knowledge about dynamic risks can be generated from scientific observations and models, combined with analysis of patterns of vulnerability and exposure and from the experiences of local communities (see 6.5.1).
- **Even without robust information, consider ‘no or low’ regrets, strategies, including ecosystem based adaptation:** Countries have started to adopt ‘no or low regrets’ strategies that generate short-term benefits as well as help to prepare for projected changes in disaster risks, even when robust information is not available (see 6.3.1). Included in these ‘no or low’ regrets strategies are ecosystem based strategies that not only help reduce current vulnerabilities and exposure to hazards, but also produce other co-benefits such as improved livelihoods and reduce poverty, that help reduce vulnerability to projected change in climate. Table 6-5, a considerably reduced version of Table 6-1, shows a summary of these options. Such no or low regrets practices also tend to include measures to tackle the underlying drivers of disaster risk and are effective irrespective of projected changes in extremes of weather or climate (see 6.5.2). Where better information is available, this can be mainstreamed across line ministries and other agencies to shape practices that help to build resilience to projected changes in disaster risk over the longer term. These are highlighted in the right hand column of Table 6-5.
- **Use risk sharing and transfer mechanisms to protect financial security:** To effectively support communities and protect the financial security of the country, governments are increasingly using a range of financial instruments for transferring costs of disaster losses through risk sharing mechanisms. Key risk transfer instruments include financial insurance, micro-insurance and micro-financing, government disaster reserve funds and intergovernmental risk sharing. The latter two help to provide much needed relief, immediate liquidity after a disaster in regions where individual countries, because of their size and lack of diversity, cannot have viable risk insurance schemes. Such mechanisms can allow for more effective government response, provide some relief of the fiscal burden placed on governments due to disaster impacts and constitute critical steps in promoting more proactive risk management strategies and responses (see section 6.5.3).
- **Not all disaster risk can be eliminated, so act to manage residual risk too:** Even with effective disaster risk reduction policies and practices in place, it is impossible to reduce all disaster risks to zero and some residual risks will remain. With disaster risks increasing in many countries, steps could be taken to

strengthen government's ability to effectively manage residual risks effectively and in doing so will need to strengthen partnerships with other actors and stakeholders to enable quick and effective humanitarian response that includes measures to 'build back better' and build resilience over time (for example using rapid climate risk assessments to position critical infrastructure or relief camps in safer locations during relief and reconstruction phases). Many governments are also already working to enhance their disaster preparedness and early warning systems, focusing on the accuracy and timeliness of warnings, increasing public awareness, working with communities to ensure messages are communicated and transmitted effectively and enhancing preparedness measures, such as first aid training, providing swimming lessons, encouraging households to have a disaster plan and an emergency kit, securing and indicating evacuation routes and shelters and enhancing the skills of relief workers in child protection for example (see section 6.5.4).

- **Review resilience building efforts:** Given competing priorities and development goals, governments are forced to balance resource allocation across development goals. The decision to bear residual losses is always a risk management option due to financial and other constraints. Many governments decide to accept the full risk of very low probability and surprise events, but new information on the impacts of climate change on such events may lead to such decisions being reviewed. Even in such cases where risk reduction and risk transfer is not a viable management option, investments in reducing vulnerability, enhancing early warning and preparedness and standing capacity for emergency response can lead to positive returns. Furthermore, given uncertainties associated with disasters, efforts to promote flexible institutions, cross-scale learning, improved knowledge and awareness and redundancies in response systems (in case one part of the system is badly impacted) can all help to promote resilience to very low probability and surprise events. Many governments are also encouraging maintenance and strengthening of social cohesiveness and social networks as a form of insurance enabling families and friends to support each other in times of disasters (see 6.6.2 and 6.6.3).

[INSERT TABLE 6-5 HERE]

Table 6-5: Range of practices to demonstrate comparison between 'no or low regrets' measures and those integrating projected changes in disaster risk.]

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

Sector/ Response	“No regrets” and “low regrets” actions for current and future risks	('No/low regrets' options plus...) Preparing for climate change risks by reducing uncertainties (building capacity)	("Preparing for climate change" risks plus...) Reduce risks to future climate change	Risk transfer	Accept and deal with increased and unavoidable (residual) risks	‘Win-win’ synergies for GHG reduction, adaptation, risk reduction and development benefits
Natural Ecosystems and Forestry	<ul style="list-style-type: none"> ▪ Use of Ecosystem-based Adaptation (EbA) or “soft engineering”; Financial recognition of EbA; Integrate disaster risk reduction 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 ▪ Reduce forest degradation, unsustainable harvests and provide incentives for alternate livelihoods, eco-tourism ⁶ 	<ul style="list-style-type: none"> ▪ Synergies between UNFCCC and Rio Conventions ; avoid actions that interfere with goals of other UN 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 National Adaptation Programmes of Action and disaster risk reduction plans ³ 	<ul style="list-style-type: none"> ▪ Adaptation to climate change 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; adaptive agroforestry ⁴ ▪ Changed timber harvest management, new technologies for adaptation to climate change, new uses to conserve forest ecosystem services ⁴ 	<ul style="list-style-type: none"> ▪ Micro-finance 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 	<ul style="list-style-type: none"> ▪ Replace lost ecosystem services through additional hard engineering, health measures ⁶ ▪ Restore loss of damaged ecosystems ⁶ 	<ul style="list-style-type: none"> ▪ Sustainable afforestation (for robust forests), reforestation, conservation of forests, wetlands and peatlands, sustainable and increased biomass; LULUCF; REDD ⁷ ▪ Incentives, sustainable sequestration of carbon; sustainable bio-energy; energy self –sufficiency ⁷
Agriculture and Food Security	<ul style="list-style-type: none"> ▪ Food security via sustainable land and water management, training; Efficient water use, storage; Agro-forestry; Protection 	<ul style="list-style-type: none"> ▪ Increased agriculture-climate research and development ¹⁰ ▪ Research on climate tolerant crops, livestock; 	<ul style="list-style-type: none"> ▪ Adaptive agricultural and agroforestry practices for new climates, extremes ¹² ▪ New and enhanced agricultural weather, 	<ul style="list-style-type: none"> ▪ Improved access to crop, livestock and income loss insurance, (e.g. weather derivatives) ¹³ 	<ul style="list-style-type: none"> ▪ Changed livelihoods and relocations in regions with climate sensitive practices ¹² 	<ul style="list-style-type: none"> ▪ Energy efficient and sustainable carbon sequestering practices; Training; Reduced use of chemical fertilizers ¹⁴

	<p>shelters, crop and livestock diversification; Improved supply of climate stress tolerant seeds; Integrated pest, disease management ⁸</p> <ul style="list-style-type: none"> ▪ Climate monitoring; Improved weather predictions; Disaster management, crop yield and distribution models and predictions ⁹ 	<p>Agrobiodiversity for genetics ¹⁰</p> <ul style="list-style-type: none"> ▪ Integration of climate change scenarios into national agronomic assessments ¹¹ ▪ Diversification of rural economies for sensitive agricultural practices ¹⁰ 	<p>climate prediction services ¹¹</p> <ul style="list-style-type: none"> ▪ Food emergency planning; Distribution and infrastructure networks ¹² ▪ Diversify rural economies ¹² 	<ul style="list-style-type: none"> ▪ Micro-financing and micro-insurance ¹³ ▪ Subsidies, tax credits ¹³ 	<ul style="list-style-type: none"> ▪ Secure emergency stock and improve distribution of food and water for emergencies ¹² 	<ul style="list-style-type: none"> ▪ Use of bio-gas from agri-waste and animal excreta¹⁴ ▪ Agroforestry ¹⁴
Coastal Zone and Fisheries	<ul style="list-style-type: none"> ▪ EbA; Integrated Coastal Zone Management ICZM; Combat salinity; Alternate drinking water availability; Soft and hard engineering ¹⁵ ▪ Strengthen institutional, regulatory and legal instruments; Setbacks ; Tourism development planning¹⁶ ▪ 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 	<ul style="list-style-type: none"> ▪ Climate change 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 	<ul style="list-style-type: none"> ▪ Incorporate adaptation to climate change, sea-level rise into Integrated Coastal Zone Management, coastal defences; ¹⁸ ▪ Hard and “soft” engineering for adaptation to climate change; Sustainable tourism development planning; Resilient vessels and coastal facilities ¹⁶ ▪ Manage for changed fisheries, invasives ²⁰ ▪ Inland lakes: Alter transportation and industrial practices, Soft and hard engineering ²⁰ 	<ul style="list-style-type: none"> ▪ Enhance insurance for coastal regions and resources; Fisheries insurance ²¹ ▪ Government reserve funds ²¹ 	<ul style="list-style-type: none"> ▪ Enhance emergency preparedness measures for more frequent and intense extremes, including more evacuations ¹⁶ ▪ Relocations of communities, infrastructure ¹⁶ ▪ Exit fishing; provide alternate livelihoods ¹⁹ 	<ul style="list-style-type: none"> ▪ Use of sustainable 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	<ul style="list-style-type: none"> ▪ Implement Integrated Water Resource Management (IWRM), national water 	<ul style="list-style-type: none"> ▪ Develop prediction, climate projection and early warning systems for flood 	<ul style="list-style-type: none"> ▪ National water policy frameworks, robust Integrated and Adaptive WRM 	<ul style="list-style-type: none"> ▪ Public-private partnerships; Economics for water allocations 	<ul style="list-style-type: none"> ▪ Enhance National preparedness and evacuation plans for greater risks²⁴ 	<ul style="list-style-type: none"> ▪ Integrated and sustainable water efficiency and renewable hydro

	<p>efficiency, storage plans ²³</p> <ul style="list-style-type: none"> ▪ Effective surveillance, prediction, warning and emergency response systems; Better disease and vector control, detection and prediction systems; better sanitation; Awareness and training on public health ²⁴ ▪ Adequate funding, capacity for resilient water infrastructure and water resource management; Improved institutional arrangements, negotiations for water allocations, joint river basin management ²³ 	<p>events and low water flow conditions; Research and downscaling for hydrological basins ²⁴</p> <ul style="list-style-type: none"> ▪ Multi-sectoral planning for water; Selective decentralization of water resource management (e.g. catchments and river basins); joint river basin management (e.g. bi-national) ²³ 	<p>for adaptation to climate change ²⁵</p> <ul style="list-style-type: none"> ▪ Investments in hard and soft infrastructure considering changed climate; river restoration²⁵ ▪ Improved weather, climate, hydrology-hydraulics, water quality forecasts for new conditions ²⁴ 	<p>beyond basic needs ²⁶</p> <ul style="list-style-type: none"> ▪ Mobilize financial resources and capacity for technology and EbA²⁶ ▪ Insurance for infrastructure²⁶ 	<ul style="list-style-type: none"> ▪ Enhance health infrastructure for more failures ²⁴ ▪ Alter transport, engineering; increases to temporary consumable water taking permits ²⁴ ▪ Enhance food , water distribution for emergencies, plan for alternate livelihoods²⁴ 	<p>power for adaptation to climate change ²³</p>
<p>Infra-structure, Housing, Cities, Transportation, energy</p>	<ul style="list-style-type: none"> ▪ Building codes, standards with updated climatic values; Climate resilient infrastructure (and energy) designs; Training, capacity, inspection, enforcement; Monitoring for priority retrofits (e.g. permafrost); maintenance ²⁷ ▪ Legal alternatives to shanty settlements, sanitation ²⁷ ▪ Strengthen early warning systems, hazard awareness; Improved weather warning systems; 	<ul style="list-style-type: none"> ▪ Improved downscaling of climate change information; Maintain climate data networks, update climatic design information; Increased safety/uncertainty factors in codes and standards; Develop adaptation to climate change tools ²⁸ ▪ Research on climate, energy, coastal and built environment interface, including flexible designs, redundancy; Forensic studies of failures (adaptation learning), Improved maintenance 	<ul style="list-style-type: none"> ▪ Codes, standards for changed extremes; ³⁰ ▪ Publicly funded infrastructure, coastal development and post-disaster reconstruction to include adaptation to climate change ³⁰ ▪ New materials, engineering approaches; Flexible design and use structures; Asset management for adaptation to climate change ³⁰ ▪ Hazard mapping; Zoning and avoidance; Prioritized 	<ul style="list-style-type: none"> ▪ Infrastructure insurance and financial risk management ²⁹ ▪ Insurance for energy facilities, interruption ²⁹ ▪ Innovative risk sharing instruments ²⁹ ▪ Government reserve funds ²⁹ 	<ul style="list-style-type: none"> ▪ More relocations ²⁸ ▪ Enhance evacuation, transportation and energy contingency planning for increases in extreme events ²⁸ ▪ Increase climate resilient shelter construction ²⁸ 	<ul style="list-style-type: none"> ▪ Implement energy and water efficient GHG reductions, disaster risk reduction and adaptation to climate change synergies ²⁹ ▪ Scale up, market penetration for sustainable renewable energy production; Increased hydroelectric potential; Sustainable biomass; “Greener” distributed community energy systems ²⁹

	<p>Disaster resilient building components (rooms) in high risk areas; Tourism development planning; heat-health responses ²⁸</p> <ul style="list-style-type: none"> ▪ Integrate urban planning, engineering, maintenance ²⁷ ▪ Redundant, diversified energy systems; Maintenance; Self-sufficiency, clean energy technologies for national energy plans, international agreement goals (bio-gas, solar cooker); Use of renewable energy in remote and vulnerable regions; Use of appropriate energy mixes nationally ²⁹ ▪ Use of energy security; Distributed energy generation and distribution ²⁹ 	<p>²⁷</p> <ul style="list-style-type: none"> ▪ Investments for sustainable energy development; Cooperation on trans-boundary energy supplies (e.g. wind energy at times of peak wind velocity) ²⁹ 	<p>retrofits, abandon the most vulnerable; Soft engineering services ³⁰</p> <ul style="list-style-type: none"> ▪ Design energy generation, distribution systems for adaptation; Switch to less risky energy systems, mixes; Embed sustainable energy in disaster risk reduction and adaptation to climate change planning ²⁹ 			
Health	<ul style="list-style-type: none"> ▪ Community/urban and coastal zone planning, building standards and guidelines; cooling shelters; safe health facilities; Retrofits for vulnerable structures; Health facilities designed using updated climate information ³¹ ▪ Strengthen surveillance, health preparedness; Early warning weather-climate-health systems, heat alerts and responses; Capacity for response to early 	<ul style="list-style-type: none"> ▪ Research on climate-health linkages and adaptation to climate change options; Develop new health prediction systems for emerging risks; Research on landscape changes, new diseases and climate; Urban weather-health modelling ³¹ ▪ Education, Disaster prevention and preparedness³¹ 	<ul style="list-style-type: none"> ▪ New food and water security, distribution systems; air quality 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 	<ul style="list-style-type: none"> ▪ Extend and expand health insurance coverage to include new and changed weather and climate risks ³³ ▪ Government reserve funds ³³ 	<ul style="list-style-type: none"> ▪ National plan for heat and extremes emergencies³²; ▪ New disease detection and management systems³²; ▪ Enhanced prediction and warning systems for new risks ³² 	<ul style="list-style-type: none"> ▪ Use of use of clean and sustainable renewable energy and water sources; increase energy efficiency; Air quality regulations; Clean energy technologies to reduce harmful air emissions (e.g. cooking stoves) ³⁴ ▪ Design sustainable infrastructure for climate change and health³⁰

	<p>warnings; Prioritize disaster risks; Disaster prevention and preparedness; Public education campaigns; Food security ³¹</p> <ul style="list-style-type: none"> ▪ 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 ▪ Better land and water use management to reduce health risks³¹ 		<p>services³²,</p> <ul style="list-style-type: none"> ▪ Address needs for additional health facilities and services³² 			
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- ¹ Adger et al, 2005; Barbier, 2009; Colls et al, 2009; FAO, 2008a; ISDR, 2009d; MEA, 2005; SCBD, 2009; Shepherd, 2008; Shepherd, 2004; UNEP, 2009b; 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; UNEP, 2009b; UNFCCC, 2006a
- 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, 2006a
- ⁶ Chhatre and Agrawal, 2009; FAO, 2008b; Mansourian et al., 2009; 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*, 2009; Howden et al, 2007; Easterling *et al*, 2007; ISDR, 2009d; McGray et al, 2007; Neufeldt et al., 2009; SCBD, 2009; World Bank, 2009
- ⁹ FAO, 2007; Hammer et al, 2003; Easterling *et al*, 2007; McCarl, 2007; UNFCCC, 2006a; World Bank, 2009; FAO, 2010
- ¹⁰ FAO, 2007; Campbell et al, 2008; CCCD, 2009; Easterling *et al*, 2007; World Bank, 2009; FAO, 2010
- ¹¹ FAO, 2007; Easterling *et al*, 2007; World Bank, 2009; FAO, 2010
- ¹² Butler and Oluoch-Kosura, 2006; Butt et al, 2005; CCCD, 2009; Davis, 2004; FAO, 2006; FAO, 2008a; Howden et al, 2007; McCarl, 2007; World Bank, 2009
- ¹³ CCCD, 2009; FAO, 2007; ISDR, 2009d; World Bank, 2009
- ¹⁴ FAO, 2007; FAO 2008a; Rosenzweig and Tubiello, 2007
- ¹⁵ Adger et al, 2005; Kay and Adler, 2005; Kesavan and Swaminathan, 2006; FAO, 2008c
- ¹⁶ Adger et al, 2005; FAO, 2008c; Kesavan and Swaminathan, 2006; Klein et al, 2001; Nicholls, 2007; Nicholls *et al*, 2008; Romieu *et al*, 2010; UNFCCC, 2006a
- ¹⁷ FAO, 2007; FAO 2008c; Rahel and Olden, 2008; UNFCCC, 2006a
- ¹⁸ Adger et al, 2005; Dolan and Walker, 2003; FAO, 2008b; Nicholls, 2007; Thorne et al, 2006; UNFCCC, 2006b; World Bank, 2010
- ¹⁹ FAO, 2008c; Kesavan and Swaminathan, 2006; Rahel and Olden, 2008
- ²⁰ FAO, 2007; FAO, 2008c; IIED, 2009; Romieu *et al*, 2010
- ²¹ FAO, 2007; FAO, 2008c; Nicholls, 2007
- ²² FAO, 2008c; UNFCCC, 2006a
- ²³ Branco et al, 2005; CCCD, 2009; Hedger and Cacouris, 2008; ICHARM, 2009; Klijn et al., 2004; Krysanova *et al*, 2010; 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; Krysanova *et al*, 2010; Mills, 2007; Muller, 2007; Thomalla et al., 2006; UNFCCC, 2006b; UNFCCC, 2009a; WHO, 2003; World Water Council, 2009; WWAP, 2009
- ²⁵ CCCD, 2009; Crabbé and Robin, 2006; Hedger and Cacourns, 2008; Krysanova *et al*, 2010; 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, 2008b ; Hodgson and Carter, 1999; Lowe, 2003; Mills, 2007; Nicholls *et al*, 2008; NRTEE, 2009; ProVention, 2009; Satterthwaite, 2007a; Rossetto, 2007; Wamsler, 2004; World Bank, 2000; World Bank, 2008; World Water Council, 2009; Wilby and Dessai, 2010; Haasnoot et al, 2009
- ²⁸ Auld, 2008a ; Auld, 2008b; Lewis and Chisholm, 1996; Mills, 2007; Nicholls *et al*, 2008; Neumann, 2009; ProVention, 2009; Rosetto, 2007; UNFCCC, 2006a; Haasnoot et al, 2009; Hallegate, 2009
- ²⁹ Auld, 2008b ; Islam and Ferdousi, 2007; Kagiannas et al, 2003; Maréchal, 2007; Mills, 2007; Neumann, 2009; Robledo et al, 2005; Van Buskirk, 2006; Warner et al, 2009; Younger et al, 2008
- ³⁰ Auld, 2008b; 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, 2006a Haines et al, 2006; Patz et al, 2000; Patz et al, 2005; UNFCCC, 2006a; WHO, 2003; WHO, 2005; World Bank, 2003
- ³² CCCD, 2009; Ebi et al, 2006a; 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 (modified after Polackova Brix and Mody, 2002).

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.

Table 6-3: Information requirements for selected disaster risk management and adaptation to climate change activities (adapted from Wilby, 2009).

Activities	Information needs
<i>Cross-cutting</i>	
Climate change modelling	Time series information on climate variables - air and sea surface temperatures, rainfall and precipitation measures, wind, and air circulation patterns, and green house gas levels.
Hazard zoning and “hot spot” mapping	Inventories of landslide, flood, drought, cyclone occurrence and impacts at local, sub-national and national levels;
Human Development indicators	Geospatial distribution of poverty, livelihood sources, access to water and sanitation
Disbursement of relief payments	Household surveys of resource access
Seasonal outlooks for preparedness planning	Seasonal climate forecast model; sea surface temperatures; remotely sensed and <i>in situ</i> measurements of snow cover/depth, soil moisture, vegetation growth; monthly rainfall-runoff; crop yields; epidemiology
A system of risk indicators: reflecting macro and financial health of nation, social and environmental risks, human vulnerability conditions; and strength of governance (Cardona et al. 2010)	Macroeconomic and financial impacts (DDI) Measures of social and environmental risks (LDI) Measures of vulnerability conditions reflected in exposure in disaster-prone areas, socioeconomic fragility and a lack of social resilience in general. Measures of organisational, development and institutional strengths (RMI)
<i>Flood risk management</i>	
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 and time series, probabilistic information on extreme wind velocities and storm surges
Flooding hot spots, and structural and non-structural flood controls	Rainfall –runoff data, stream gauges, and flood models, and flood inundation maps. 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
<i>Drought management</i>	
Traditional rain and groundwater harvesting, and storage systems	Inventories of system properties including condition, reliable yield, economics, ownership; soil and geological maps of areas suitable for enhanced groundwater recharge; water quality monitoring; evidence of deep-well impacts
Long-range reservoir inflow forecasts	Seasonal climate forecast model; sea surface temperatures; remotely sensed snow cover; in situ snow depths; multi-decadal rainfall-runoff series
Water demand management and efficiency measures	Integrated climate and river basin water monitoring; data on existing systems’ water use efficiency; data on current and future demand metering and survey effectiveness of demand management

Table 6-4: Activities associated with managing the impacts of disasters (adapted from Coppola, 2007, and ALNAP, 2010a).

	Pre-disaster	Immediate post-disaster	Recovery
Disaster Management Actions	<ul style="list-style-type: none"> • Public education • Awareness raising • Warning and evacuation • Pre-positioning of resources and supplies • Last minute alleviation and preparedness measures 	<ul style="list-style-type: none"> • Search and rescue • Emergency medical treatment • Damage and Needs Assessment • Provision of services – water, food, health, shelter, sanitation, social services, security • Resumption of critical infrastructure • Coordination of response • Manage development partner support 	<ul style="list-style-type: none"> • Transitional shelter in form of temporary housing or long-term shelter • Demolition of critically damaged structures • Repair of less seriously damaged structures • Clearance, removal and disposal of debris • Rehabilitation of infrastructure • New construction • Social rehabilitation • ‘Building back better’ to reduce future risk • Employment schemes • Reimbursement for losses • Reassessment of risks

Table 6-5: Range of practices to demonstrate comparison between ‘no or low regrets’ measures and those integrating projected changes in disaster risk.

‘No or low regrets’ practices with demonstrated evidence of having integrated observed trends in disaster risks to reduce the effects of disasters	Practices that enhance resilience to projected changes in disaster risk
<ul style="list-style-type: none"> • Effective Early Warning Systems and emergency preparedness (<i>very high confidence</i>) • Integrated water resource management (<i>high confidence</i>) • Rehabilitation of degraded coastal and terrestrial ecosystems (<i>high confidence</i>) • Robust building codes and standards reflecting knowledge of current disaster risks (<i>high confidence</i>) • Ecosystem based/ nature-based investments, including ecosystem conservation measures (<i>high confidence</i>) • Micro-insurance, including weather-indexed insurance (<i>medium confidence</i>) • Vulnerability reducing measures such as pro-poor economic and human development, through for example improved social services and protection, employment, wealth creation (<i>very high confidence</i>) 	<ul style="list-style-type: none"> • Crop improvement for drought tolerance, adaptive agricultural practices, including responses to enhanced weather and climate prediction services (<i>high confidence</i>) • Integrated coastal zone management integrating projections of sea level risk and weather/climate extremes (<i>medium confidence</i>) • National water policy frameworks, and water supply infrastructures, incorporated future climate extremes and demand projects (<i>medium-high confidence</i>) • Strengthened and enforced building codes, standards for changed climate extremes (<i>medium confidence</i>) • Advances in human development and poverty reduction measures, through for example social protection, employment, wealth creation measures, taking future exposure to weather and climate extremes into account (<i>very high confidence</i>)

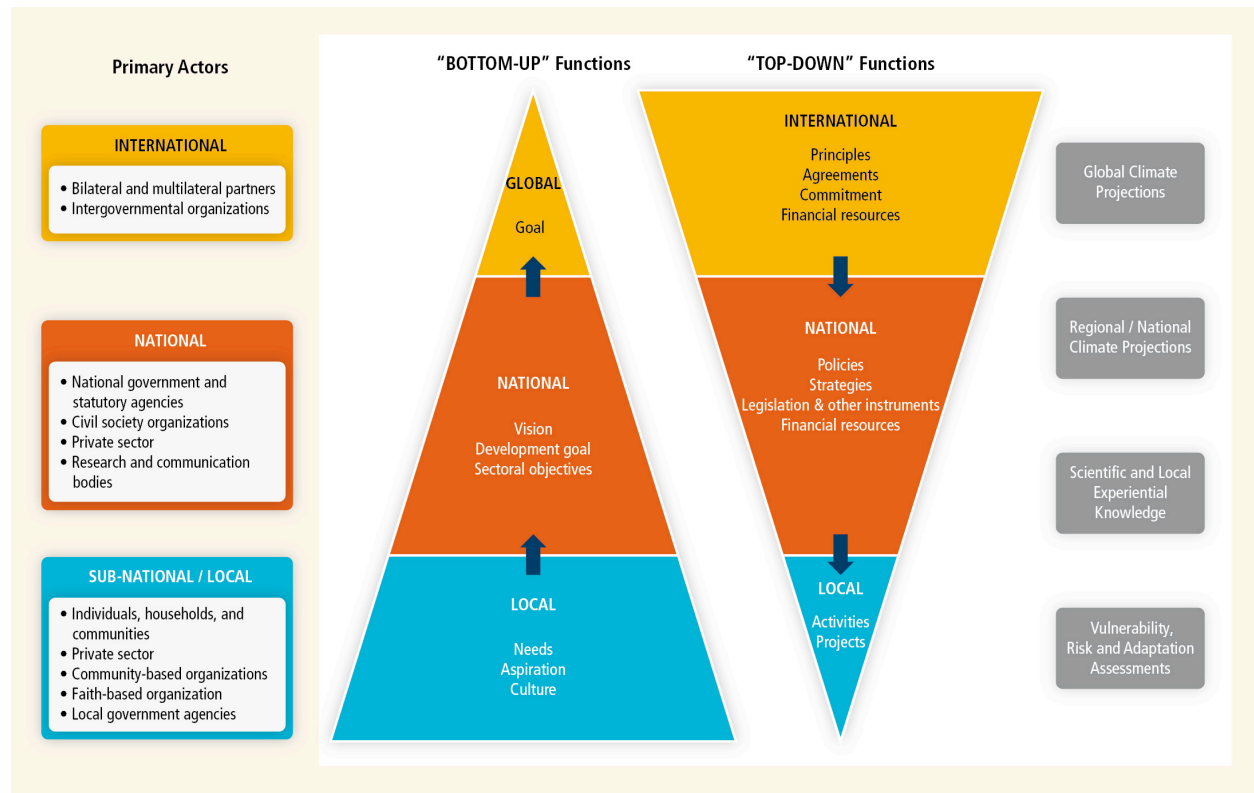


Figure 6-1: National system of actors and functions for managing disaster risk and adapting to climate change.

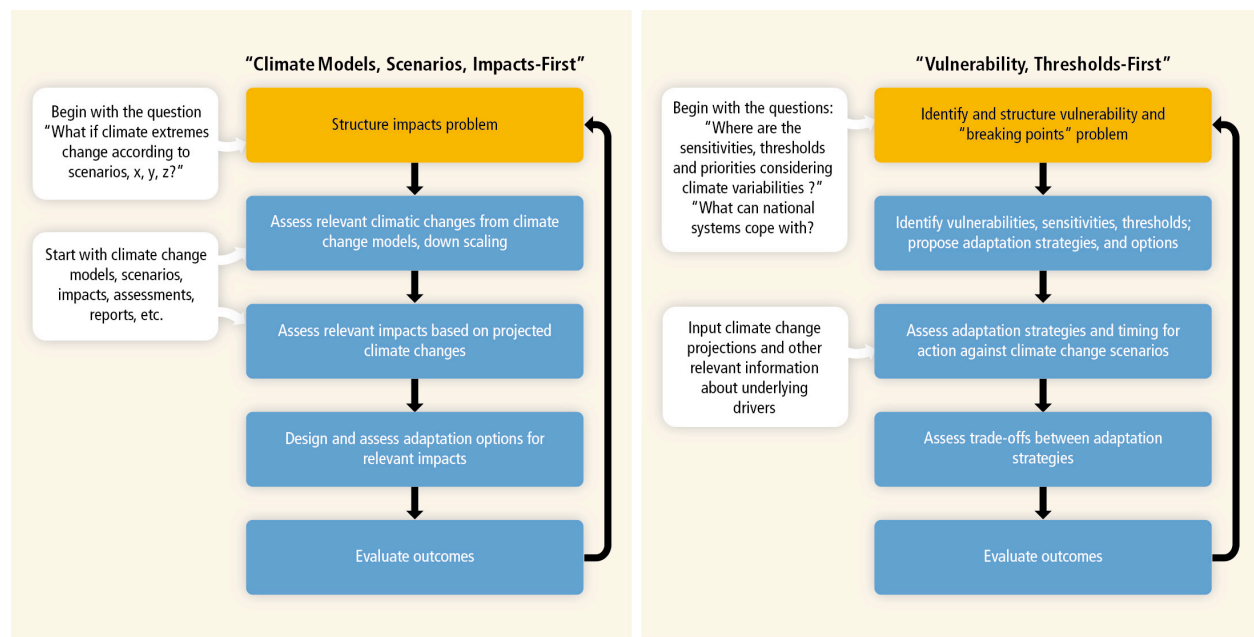


Figure 6-2: Top-down scenario, impacts-first approach (left panel) and bottom-up vulnerability, thresholds-first approach (right panel) – comparison of stages involved in identifying and evaluating adaptation options under changing climate conditions. Source: Adapted from Kwadijk et al., 2010, and Ranger et al, 2010.

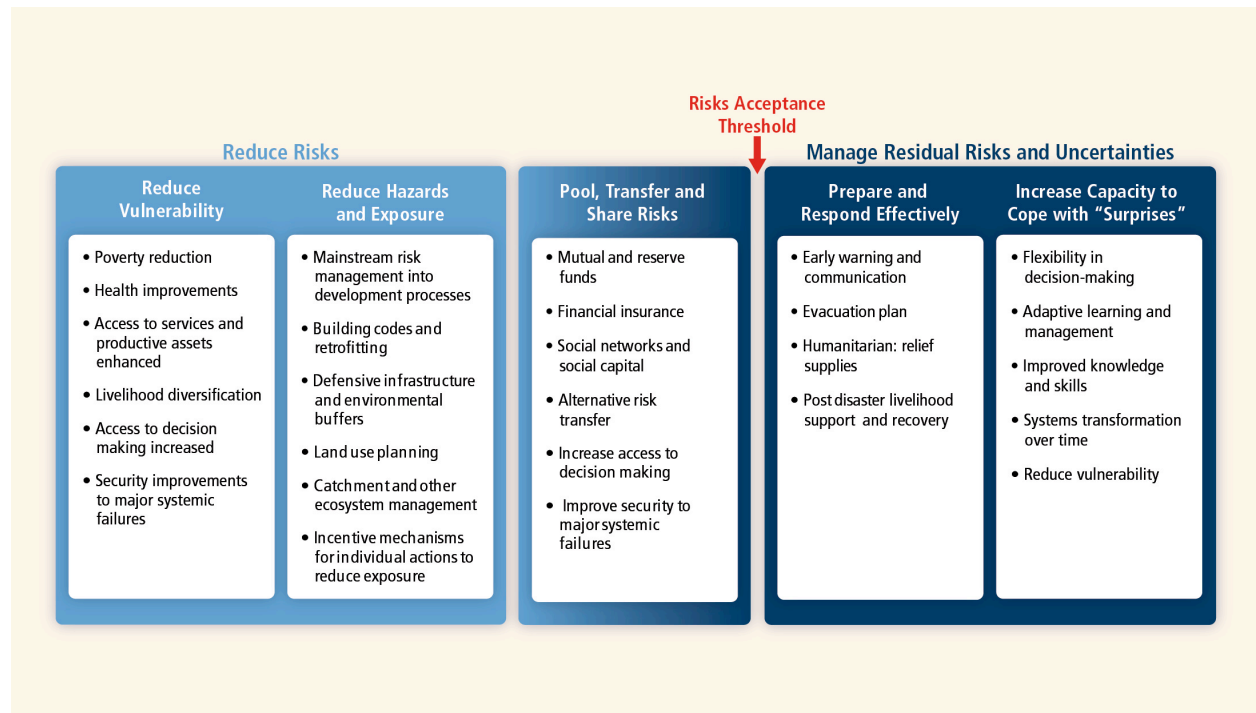


Figure 6-3: Complementary response measures to observed and projected disaster risks supported by respective institutional and individual capacity for making informed decisions.