Chapter 9. Case Studies

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9.1. Introduction

9.1.1. Description of Case Studies Approach in General

This section seeks to convey the value of case studies in identifying lessons and good practices from past responses—in this case to extreme climate-related events. Case studies are widely used in many disciplines including health care (Keen and Packwood, 1995; McWhinney, 2001) and social science (Flyjberg, 2004), especially in political science, anthropology, comparative sociology and education (Verschuren, 2003). It is reported that case studies are the most popular research method used by industrial marketing researchers (Easton, 2010). In addition case studies have been found to be useful in previous Intergovernmental Panel on Climate Change (IPCC) Assessment Reports including the 2007 report (Parry et *al.,* 2007).

Case studies are often perceived to be among the most interesting articles to read (Eisenhardt and Graebner, 2007) possibly because they challenge readers' assumptions and have practical implications; interesting reading in turn produces a higher degree of learning (Bartunek et *al*., 2006). Case studies have been defined as 'research situations where the number of variables of interest far outstrips the number of data points' (Yin, 1994). Keen and Packwood consider that case study evaluations are valuable where broad, complex questions have to be addressed in complex circumstances often using multiple methods. They go on to state that the case study is a way of thinking about complex situations which takes the conditions into account but is nevertheless rigorous and facilitates informed judgments about success or failure (Keen and Packwood, 1995).

Indeed case studies seek to study phenomena in their real life context, not independent of context, and offer an opportunity to report an event from the 'ground' or from the 'front line'. Thus case studies are suitable for studying highly complex phenomena (Nyame-Asiamah and Patel, 2009) and analyzing extreme events allowing lessons to be identified and good and bad practices to be determined. For example many everyday decisions by health care professionals are qualitative rather than quantitative (Keen and Packwood, 1995) but directing them to the best evidence such as the Cochrane Collaboration for these decisions may reduce poor decision making (Jadad and Hanes, 1998).

Case studies can be records of innovative or good practice. Specific problems or issues experienced can be documented as well as the actions taken to overcome problems. Case studies validate our understanding or can encourage their re-evaluation. Often they are used where there have been limited solutions found to a particular problem and can identify success/failure factors in DRR[1] and adaptation. Case studies generally report factual information as well as opinions (good and bad). Their strengths include:

- Provide real examples
- Encourage replication
- Are generally practical in nature
- Provide innovative ideas (Twigg, 2001).

Therefore case studies should use concrete examples of disasters types; share prevention and preparedness methodologies and subsequent response and recovery actions because they provide useful insights into the practical application of prevention and risk reduction measures.

[INSERT FOOTNOTE 1 HERE: New South Wales Australia Department of Environment, Climate Change, and Water. Characteristics, strengths, and weaknesses - Case studies web site <http://www.environment.nsw.gov.au/community/edproject/section404.htm>.]

9.1.2. Case Study Analyses: Lessons Identified and Learned – Good and Bad Practices

Good storytelling or case studies are useful as a first step to explain issues but good theory is fundamentally the result of rigorous methodology and comparative multi-case logic (Eisenhardt, 1989). By describing the interpretation of cases studies, Leiberson demonstrated that they need rigorous justification of assumptions to guard against possible distortions (Lieberson, 1991). Most case study research points to the preparations for such research not to the benefit obtained from using case studies to illustrate issues identified by studies.

Case studies must be methodologically rigorous and include external validation. Fundamental quality measures will improve their reliability (Gibbert et *al.,* 2008). Verschuren reported that case study design should include observation of patterns in a diachronic (over time) manner, represent a strategic sample, and is labour intensive, open ended and iterative. Bozeman and Klein reported that policy evaluators and other social scientists often approach case studies with considerable wariness (Bozeman and Klein, 1999). They stated that case studies if properly deployed for heuristic purposes should be based on the explicit examination of the event with critical assessment to determine if the data is unique or illustrative of the wider dataset. Yin has documented the desired characteristics of case studies and recommended that sources of evidence be focused in an operational framework (Yin, 1999).

Woodside, using industrial marketing techniques, points to the principal criticisms of case study research studies. These include needing to fulfill generality of findings, achieving accuracy of process actions and outcomes, and capturing complexity of nuances and conditions in order to achieve clarity in processes involving decisions and organizational outcomes (Woodside, 2010).

A comparative study of real-life cases is then a way to check fact whether our understanding of a problem or solution (based on theory) is correct in reality and in various settings.

9.2. Methodological Approach

9.2.1. Case Studies

This chapter seeks to gain a better understanding of the threat posed by extreme climate-related events, while identifying lessons and best practices from past responses to such occurrences. To achieve these goals, several events, vulnerable regions and management approaches were identified and examined to gain a better understanding of the threats that extreme events pose and the most successful prevention and response measures. Specifically, case studies examining specific extreme events were: cyclones; urban heat waves; sandstorms; floods; drought, drought-heat-fires complex events; cold spells; and epidemics. Case studies focusing on vulnerable regions included: coastal and mega-cities; small island developing states (SIDS); Arctic regions; and least developed countries and fragile states. The third grouping looked at management approaches: risk transfer; public education and awareness; institutional approaches-multi-level governance; legislative approaches; hard and soft engineering in coastal zones; linking disaster risk reduction (DRR) and climate change adaptation (CCA) practices; and early warning systems. This selection created a good basis of information and served as an indicator of the resources needed for future disaster risk reduction. Additionally, it allows good and bad practices to be determined and lessons to be extracted.

As Margareta Wahlström asserts, “the real tragedy (of disasters) is that many of these deaths can be avoided” (Wahlström, 2009). To that end, the analysis of case studies is essential to the Special Report on Extreme Events and Disasters: Managing the Risks, due to the lessons they provide about best and worst practices, which will contribute to future disaster risk reductions. Further, the case studies provide the opportunity for connecting common elements across the other chapters. As the ICSU Report, *A Science Plan for Integrated Research on Disaster Risk* (2008) explains, despite a growth in knowledge surrounding environmental hazards, losses from these events have also increased. In other words, despite an increase in scientific knowledge, disasters still occur. This emphasizes the need for an integrated approach that examines scientific, social, economic and political aspects of disasters and broadens the scientific realm to include different spatial and temporal scales. Analyzing case studies of extreme events allows lessons to be identified and good and bad practices to be determined. Specifically, successful cases are compared in an effort to isolate the components necessary for success. Similarly, failed attempts are analyzed to determine the causes of failure. It is important to use concrete examples of disasters types; prevention and preparedness methodologies and subsequent response and recovery actions because they provide useful insights into the practical application of prevention and risk reduction measures. This is particularly important because there are sometimes gaps between the theoretical assumptions of what should succeed, and the practicality of what has succeeded or failed in the past. The study of these case studies lends greater context and understanding to the analysis completed in other chapters, thus contributing to value-added conclusions that will produce stronger, more effective disaster responses. Given that climate change can exacerbate extreme events and hazards, identifying good and bad practices will prove to be an important step for future risk reduction efforts.

9.2.2. Literature: Papers, Reports, Grey Literature

To properly assess the selected case studies, a variety of literature was studied including approaches that rely on resources from many disciplines and different types of literature. As noted above, an integrated approach that examines scientific, social, economic and political aspects of disasters and includes different spatial and temporal scales is needed and many of these aspects are covered in grey literature, materials that are not formally published or peer-reviewed. The specialized insight they provided was invaluable in evaluating the current disaster response practices. It is necessary to delve into such areas in order to create a more complete study of climate-related events.

Important primary resources were found in country-based reports focused on disaster accounting. These records included statistics on human life loss, financial damage, rebuilding costs and infrastructural weaknesses, as well as detailed accounts of rescue efforts. Further, they were able to provide information on level of preparedness, status of warning systems and any adaptation efforts. Additionally, resources from organizations such as the United Nations Development Programme, UNISDR, Amnesty International, or CARE proved especially useful as they provided an impartial account of the disaster as well as problems that emerged within relief efforts. Other sources such as articles from international journalists were helpful in providing the social or human costs that resulted from the extreme event.

The unpublished and un-peer-reviewed resources utilized in this study will be used in accordance with the IPCC regulations regarding grey literature. Specifically, each source was critically assessed by the authors to ensure an overall consistency with peer-reviewed sources. In the event of inconsistencies, additional methods of validation were employed. Used in this way, these resources provided accurate information that ensures the case studies will be useful learning tools.

9.2.3. Relationship between Extreme Climate-Related Events and Climate Change

The Intergovernmental Panel on Climate Change's 2007 Fourth Assessment Report (IPCC) has concluded that the "warming of the climate system is unequivocal"(IPCC 2007a, pg 5). As the temperature has warmed there have been increases in: frequency of warm spells/heat waves over most land areas; frequency of heavy precipitation events; area affected by drought; intense tropical cyclone activity; and increased incidence of high sea levels have arisen. The IPCC assessment was that it is likely, meaning greater than 66% probability, that these changes are a reality (IPCC 2007a, pg 3). The impacts of these events are highlighted by Wahlström (2009) who stated "*Over the last two decades (1988-2007), 76% of all disaster events were hydrological, meteorological or climatological in nature; these accounted for 45% of the deaths and 79% of the economic losses caused by natural hazards*." As the climate changes in the future there will be continued increases in the frequency and intensity of extreme events, as weather patterns change (UNISDR, 2008). The risks from climate hazards present a growing threat, especially to developing countries that lack the financial capacity or material resources to prevent disasters or mitigate their risks. (Laszlo, 2008). It is necessary to take these realities and relationships into account when planning prevention measures or instituting lessons learned. The interaction between extreme weather events and climate change is consistently referenced throughout the chapter as a reminder that older strategies may not work in the future and that infrastructure and disaster risk management plans need to be flexible to be effective. The overall objective of this report and ongoing research needs to be a legacy of an enhanced capacity and knowledge around the world to address climate-related hazards and make informed decisions on actions to reduce their impacts, such that in ten years, when comparable events occur, there would be a reduction in loss of life, fewer people adversely impacted, and wiser investments and choices made by governments, the private sector and civil society.

Additionally, the goals of disaster risk reduction and climate change adaptation are essentially the same- "reducing vulnerability to hazards" (IPCC Scoping Meeting for a Possible IPCC Special Report on Managing the Risks of Extreme Events to Advance Climate Change Adaptation, 2008, 4). Climate change adaptation is defined as "adjustment in natural or human systems in response to actual or expected climactic stimuli or their effects that moderates harm and exploits beneficial opportunities"[2]. Similarly, disaster risk reduction attempts to "minimize vulnerabilities and disaster risks throughout a society, to avoid (prevention) or to limit (mitigation and preparedness) the adverse impacts of hazards…"[3] Each discusses the need for preparation and prevention in order to escape the worst impacts of disaster. By administering the lessons learned in disaster risk reduction exercises, perhaps climate change adaptation will be more effective.

[INSERT FOOTNOTE 2 HERE: UN Framework Convention on Climate Change. Glossary. <http://unfccc.int/essential_background/glossary/items/3666.php>.]

[INSERT FOOTNOTE 3 HERE: UN International Strategy for Disaster Reduction. Terminology. <http://www.unisdr.org/eng/library/lib-terminology-eng%20home.htm>.]

9.2.4. Scale

This chapter addresses events whose impacts were felt on many dimensions. A single event can produce effects that are felt on local, regional, national and international levels. These could have resulted directly from the event itself, from the response to the event or indirectly through, for example, the reduction of food production in the region or a decrease in available oil. In addition to the spatial scales, this chapter also addresses temporal scales in both event-related impacts and responses. For example, some climate-related events such as a storm or hurricane last for a few days whereas others such as drought or sea-level rise occur and make their effects felt over a number of years. These factors are generally dependent on the magnitude and intensity of the event. However, the way effects are felt is additionally influenced by social and economic factors. The resilience of a society and its economic capacity to prevent a disaster and cope with the after-effects has significant ramifications for the intensity of the event (UNISDR, 2008). Developed nations are better equipped with technical, financial and institutional support to enable better adaptive planning including preventative measures and/or quick, effective responses (Gagnon-Lebrun and Agrawala, 2006). In developing nations in contrast, a less intense hazardous event can result in a disaster because their capacity to cope is so much lower (IPCC, 2001). The implications of factors such as location, development status, scale of disaster and response efforts in specialized communities, will make it easier for strategies to be applied in similar situations. Most importantly, this chapter recognized the complexity of disasters in order to encourage more solutions that address this complexity rather than just one issue or another.

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9.3. Case Studies

9.3.1. Extreme Events

Case Study 9.1. Tropical Cyclones

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1. Introduction

Tropical cyclones, also called typhoons and hurricanes, are powerful storms generated over tropical and sub-tropical waters. They are characterized by extremely strong winds, capable of damaging buildings and infrastructure; torrential rains causing floods and landslides; and high waves and storm surges that can lead to extensive coastal flooding. Due to their combined wind, rain and in some cases, cyclonic power, even relatively weak events can be destructive, as can be observed in the case of Typhoon Morakot in Taiwan. On 7 August 2009, Typhoon Morakot, classified as a category 1 cyclone, moved slowly toward Taiwan. Landing on the East coast of Taiwan at about midnight, the cyclone continued to travel, slowly dwindling in strength until it was classed as a tropical storm by mid-day on 8 August. Though Morakot did not exhibit extraordinary strength or power, moving approximately 30% slower than average and producing a relatively large gall wind radius of about 400km, it resulted in a record setting rainfall in Taiwan. Specifically, Morakot had the highest one-day precipitation (1624 mm), continuous two-day precipitation (2361 mm) and total accumulation over the duration of a typhoon (3060 mm, from 6 to 10 August 2009) ever recorded in Taiwan (Lin et al., 2010). In fact, its maximum single-day precipitation and continuous two-day precipitation were only about 10% less than the world records. The record amount of precipitation caused the worst flooding in Taiwan since 1959. As a result, close to 700 people lost their lives and more than ten thousand people were left homeless. Additionally, this downpour triggered an astonishing number of landslides. Approximately 51,300 landslides were recorded, more than twice the number observed in any previous individual event. In one case, a single landslide buried a village with about 400 inhabitants. Landslides seriously damaged nearly all roads in the central and southern mountains of Taiwan. Total damages to properties and infrastructures, and agricultural losses were estimated to be around US$ 3 billions.

The tropical cyclones considered in this case study demonstrate various issues related to the risk management practices and changing vulnerability of the exposed population over time and locations. In particular, the comparative studies clearly demonstrate that efforts towards disaster risk reduction can be effective in the context of adaptation to extreme events.

2. Sidr and Nargis: Comparison of Two Cyclones in Indian Ocean

Although only about 7% of the world's tropical cyclones occur in the North Indian Ocean (Muni Krishna, 2009), they account for 86% of global mortality risk from tropical cyclones (ISDR, 2009). This is largely due to high population density in exposed areas and poor governance in this region. Given that the historical tropical cyclone records exhibit existing trends in frequency and intensity in this region, the existing vulnerability is of particular concern (Muni Krishna, 2009, Singh et al., 2001). These trends must be considered cautiously, however, as there is still a lack of consensus regarding the heterogeneity of the data (Ch. 3, section 3.2.1; Landsea et al., 2006; Kossin et al., 2007). Despite this lack of consensus, the observed trends do carry some potential for representing future trends and the heightened exposure and potential for loss of life in this region makes it imperative that efforts are made to improve forecasting and mitigation. This point is especially important when considering that 80% of victims from Nargis were killed by storm surges for which there is currently no early warning system (Webster, 2008).

In 2007 and 2008, several cyclones with disastrous impact occurred in the North Indian Ocean. Two of these, namely Cyclone Sidr in 2007 (Paul, 2009), which mainly affected Bangladesh, and Cyclone Nargis in 2008 (Webster, 2008), which mainly affected Myanmar, were comparable events that had vastly different impacts. It is important to compare the two events in order to determine the reason why one was significantly more deadly than the other.

Sidr made landfall in Bangladesh on 15 November 2007. Its maximum wind speed reached 245 km/h and the storm surge reached between 5-6 m (Paul, 2009). Between 8 and 10 million people were exposed/affected and the number of reported fatalities was about 4,200 (PREVIEW, 2009; CRED, 2009). Conversely, Nargis hit Myanmar on 2 May 2008. Its maximum wind speed reached 235 km/h and the storm surge reached about 4 m (Webster, 2008). Between 2 and 8 million people were exposed/affected. The fatalities exceeded 138,000 (PREVIEW, 2009; CRED, 2009), making Nargis the eighth deadliest cyclone ever recorded (Fritz et al., 2009).

The difference between the two is evident in their level of preparedness and ability to respond in the aftermath of the events. Bangladesh has a significant historical record of large scale disasters and serious efforts to decrease risk from tropical cyclones have been made (Paul, 2009; Ch. 9, Case Study 18). The country experienced 15 disasters of more than 1000 casualties since 1960, including the infamous Cyclone Gorky (April 1991, causing about 140,000 fatalities) and the November 1970 Cyclone Bhola, which caused 300,000 (CRED, 2009) to 500,000 (Shamsuddoha and Chowdhury, 2007) deaths. After the devastating cyclone of 1970, the Bangladesh government initiated several structural and non-structural measures to reduce the cyclone risk (Paul, 2009). These measures, described more fully in Case Study 18, consisted of three major actions:

a) Implementation of an early warning system, including an extensive, equipped and trained group of volunteers
b) Construction of close to 4,000 public cyclone shelters
c) Construction of shelters to provide protection for cattle during storm surges.

Environmental features also played an important role in limiting the impact of Cyclone Sidr. The 590,000ha of the Sunderban mangroves and coastal forests proved to be effective barriers during the event (GoB, 2008). In Bangladesh, a coastal reforestation program was initiated in 1960, covering about 159,000ha of coastal land, the riverine coastal belt, and abandoned embankments. These plantations reduced the impact of previous cyclones and floods in addition to creating employment opportunities (GoB, 2008). Cyclone Sidr demonstrated that coastal reforestation protects embankments against cyclonic surge and monsoon waves – with the tremendous additional benefit of greatly reducing the impact of the storm surge (GoB, 2008).

In contrast to Bangladesh, Myanmar has very little experience with previous natural disasters. Prior to Nargis, Myanmar had only experienced one tropical cyclone disaster with more than 1000 fatalities since 1960 (CRED, 2009). The landfall of Nargis was the first time that Myanmar had experienced a cyclone of such a magnitude and severity (Lateef, 2009) and the path the storm took added to the degree of destruction (Webster, 2008). Several unfavourable conditions joined hands to transform this hazardous event into a large-scale disaster. First, there was virtually no early warning for this event. The Indian meteorological department has the responsibility to issue cyclone warnings for the region, but has no mandate to provided storm surge forecasts (80% of the victims from Nargis were killed by the storm surge). Myanmar's official forecasts appeared on page 15 in the newspaper The New Light of Myanmar from 29 April to 2 May, suggesting that the media underestimated the potential impacts of the threat, which resulted in insufficient warning to the population (Webster, 2008).

Despite being slightly less powerful than Sidr and affecting fewer exposed people, Cyclone Nargis resulted in human losses that were 32 times higher than Sidr. Bangladesh and Myanmar are both very poor countries. In 2008, the estimated GDP/population for Bangladesh was $1,500, while it was $1,200 for Myanmar (CIA, 2009). The relatively small difference in poverty (20%) cannot explain the discrepancy in the outcome. The World Bank has developed a series of indicators on governance (World Bank, 2009). These indicators suggest significant differences in the quality of governance between Bangladesh and Myanmar notably: Voice and accountability, Rule of Law, Regulatory quality, and Government effectiveness. The low quality of governance, and low level of accountability were highlighted as major components of human mortality risk with respect to tropical cyclones (Peduzzi et al., 2009).

3. Stan and Wilma: Comparison of Two Hurricanes in Mesoamerica

Hurricane Stan hit the Atlantic coast of Central America and the Yucatan Peninsula in Mexico (Mesoamerica) between the 1st and 13th of October 2005. It was associated with a larger non-tropical system of rainstorms that dropped torrential rains and caused debris flows, rockslides and widespread flooding. Guatemala reported more than 1,500 fatalities, El Salvador 72 and Mexico 98. Hurricane Wilma hit one week later (October 19-24th), with a diameter of 700km and winds reaching a speed of 280 km/h. It caused twelve fatalities in Haiti, eight in Mexico and thirty-five in the USA, most in Florida (National Hurricane Center, April 6, 2006). 560,000 residents in western part of Cuba and 90,000 tourists and local inhabitants in the Yucatan Peninsula in Mexico were evacuated during this event (EM-DAT, 2010).

A joint study by the World Bank with CEPAL and CENAPRED (the National Center for Disasters; García et al., 2006) evaluated socioeconomic damages in Mexico. The report shows that Stan caused about $2.2 billion damage in Mexico, 65% of which were direct losses and 35% impact on future productive activities (coffee, forestry and livestock). About 70% of these damages were reported in the state of Chiapas, where 40% of the natural vegetation of the Tuxtla Sierra was destroyed (Oswald Spring, 2010).

While Stan mainly hit the poor indigenous regions of Guatemala, El Salvador and Chiapas in Mexico, Wilma affected the international beach resort of Cancun. The damages caused by Wilma were estimated to be $1.74 billion, 25% of which were direct damage and 75% indirect costs due to lost economic opportunities. The damages caused by Wilma were mostly to the tourist sector. However, most of the affected and destroyed hotels were insured.

Comparing the management of the two hurricanes by the Mexican authorities, in the same month and year, highlights important issues in disaster risk management. The early alert for Wilma was quite effective: 98,000 people were evacuated, 27,000 tourists were brought to safer places, and 15,000 local inhabitants and tourists were taken to shelters. Before the hurricane hit the coast, heavy machines and emergency groups were situated in the region to re-establish water, electricity, communications and health services immediately. After the disaster, all ministries became involved in order to re-establish the airport and tourist facilities as soon as possible. By December, most hotels and the sand lost in the beaches were re-established. By comparison, the evacuation of Stan in Chiapas, Mexico started during the emergency phase, when floods in 98 rivers had affected 800 communities (Pasch and Roberts, 2006). About 100,000 people fled from the mountain regions; 84,000 lived in improvised shelters -mostly schools- and 1,200 affected families lived with "guest families". In total, about 2 million people in Mexico were affected by this event. Over 80% of the damages were concentrated in four municipalities (Motozintla, Tapachula, Huixtla and Suchiate). They were rural, isolated in mountainous areas, marginal, indigenous, and most inhabitants were extremely poor and had little or no education. The cost of damages caused by Stan represented 5% of the GDP of the State of Chiapas and most of the productive infrastructure (75,000 hectares of coffee plantation) in the affected areas was destroyed (Calvillo et al., 2006). Emergency help was brought by ship, plane and cars, but the head of SEDESOL (Ministry of Social Development) in Chiapas, Luis Alberto Molina Rios, had to admit a year later that less than 10% of the 10,200 houses affected by Stan were rebuilt. The most common adaptation strategy was migration to urban areas or to the USA in search of a dignified livelihood

Comparing the two hurricane responses, it is obvious that the amount of federal attention given to the affected region contributed greatly to the ability of that region to respond. Regrettably, Cancun received much more attention and funding than Chiapas though the latter's damages were more serious and the residents of that area were without insurance due to their high social vulnerability. Despite the similarity in strength of hurricane, each region felt the event differently due to the disparity in terms of early warning, evacuation and reconstruction efforts.

4. Typhoon Maemi's Role in Korea's Disaster Recovery Policies

The Northwest Pacific Ocean (NWPO) is the world's most prolific generator of tropical cyclones, producing about 6 to10 category 4 and 5 (in Saffir-Simpson scale) typhoons each year (WMO, 2004). These severe typhoons are direct threats to the half-billion people living in the coastal regions of East Asia (Lin et al., 2005).

Typhoon Maemi ('Cicada') formed as a tropical depression near Guam, east of the Philippines on 5 September 2003 and developed into a category 5 super-typhoon as it approached the southern Japanese islands of Okinawa (Guy Carpenter, 2003; Ye, 2004; Kim et al., 2007). It struck the south coast of the Republic of Korea during the night of September 12 as a category 3 typhoon, with wind gusts reaching 216 km/h (Kikitsu, 2004) and rainfall of up to 450 mm. Maemi was one of the most powerful typhoon to strike Korea since records began in 1904. The strong winds, storm surge and heavy rainfalls caused widespread damage throughout the country, severe flooding along the Nakdong River, and a number of debris flows and landslides with severe impacts (Met Eireann, 2003; Guy Carpenter, 2003; Ye, 2004; Kim et al., 2007; Chae et al., 2006). According to the Korean anti-disaster office, the total economic losses caused by Typhoon Maemi were about $4.8 billion.

After Typhoon Maemi, 116 petitions were gathered from people complaining that the post-disaster support process was not simple and fast enough. In response to these petitions, Korea has developed the One-Stop Support Service to increase the effectiveness of the disaster recovery support process. The One-Stop Support Service is a customer-oriented, rapid and precise system for providing support to the affected population after a natural disaster. In the case of typhoon Ewiniar in July 2006, the One-Stop Support Service was applied to the damaged areas and the recovery fund was directly transferred to affected individuals in 20 days, a process which normally took about 90 days. This kind of rapid money transfer helped the people focus on the recovery works (ADRC, 2007).

The Korea Meteorological Agency (KMA) has plans for strengthening its observational networks within three years. The aims of these plans are to improve the resolutions of Automatic Weather Stations (AWSs) from 15 km to 13 km; to establish 2 radar sites; to deploy 10 buoys; to build a Composite Site for Marine Meteorological Observation on an uninhabited island located at the westernmost tip of Korea; and to install 10 wind profilers across the county (Park, 2003). The improvements in the observational network will improve the efficiency and accuracy of typhoon warnings from the KMA in the future.

5. Lessons and Key Messages

Disaster management of the tropical cyclones discussed in this case study demonstrate that the *choices and outcomes for response to climatic extremes events are complicated by* ***multiple interacting processes****, competing prioritized* ***values*** *and* ***objectives***. The government response to similar extreme events may be quite different in neighbouring countries, or even within the same country.

Awareness (past occurrence of large scale disasters) and improved governance (implementation of improved early warning systems, evacuation plans, infrastructures, the protection of healthy ecosystems, post-disaster support service to disperse the recovery funds to the victims quickly and efficiently) are essential in coping with extreme tropical cyclone events.

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Case Study 9.2. Urban Heat Waves, Vulnerability and Resilience

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1. Introduction

In August of 2003, temperatures in much of Europe greatly exceeded historical norms. During the first 2 weeks of August 2003 much of Western Europe experienced daytime temperatures of 35°-40°C and night time temperature which did not drop below 20°C (Institut de Veille Sanitaire, 2003). This corresponded to an increase in monthly mean temperature of about +7°C (Fink et al., 2004). The European heat wave had significant health impacts (Lagadec, 2004): initial estimates put the death toll in the range of 70,000 (Robine et al, 2003) with approximately 14,800 excess deaths in France alone (Pirard et al., 2005). The severity, duration, geographic scope, and impact of the event were unprecedented in recorded European history (Fouillet et al., 2006; Grynszpan, 2003; Kosatsky, 2005) and put the event in the exceptional company of the deadly Beijing heat wave of 1743, which killed at least 11,000, and likely many more (Levick, 1859; Bouchama, 2004). Efforts to minimize the public health impact were hampered by denial of the events seriousness and the inability of many institutions to instigate emergency-level responses (Lagadec, 2004). Afterwards, several European countries quickly initiated plans to prepare for future events (WHO, 2006). France, the country hardest hit, initiated a national heat wave plan, surveillance activities, clinical treatment guidelines for heat related illness, identification of vulnerable populations, infrastructure improvements including air conditioning in nursing homes and hospitals, and home visiting plans for future heat waves (Laaidi *et al*., 2004).

Three years later, during the last two weeks of July 2006, Europe experienced another major heat wave. Several temperature records were broken. In France, it ranked as the second most severe heatwave since 1950, with the first being the event in 2003. Based on historical models, the temperatures were expected to cause 6,452 excess deaths in France alone, yet, only 2,065 excess deaths were recorded (Fouillet et al., 2008). Some decrease in mortality may be attributed to increased awareness of the ill-effects of extreme heat, the preventive measures instituted after the 2003 heat wave, and the heat health watch system set up in 2004 (Fouillet et al., 2008). While the mortality reduction likely demonstrates the effectiveness of public health measures, the persistent, excess mortality highlights the need for optimizing existing public health measures such as warning and watch systems (Hajat et al., 2010), health communication with vulnerable populations (McCormick 2010), vulnerability mapping (Reid et al., 2009), and heat wave response plans (Bernard and McGeehin, 2004). It also highlights the need for other, novel measures such as modification of the urban form to reduce exposure (O'Neill *et al*., 2009; Hajat et al., 2010; Reid et al., 2009; Bernard and McGeehin, 2004; Silva, Phelan and Golden, 2010).

2. Description of Thematic Events

As with other types of hazards, extreme heat can have disastrous consequences for populations with extreme vulnerability. Vulnerability is a function of hazard exposure and susceptibility to illness or injury. The magnitude of the hazard is important, as it drives exposure, but does not necessarily translate into extreme impacts if vulnerability is low. Extreme heat is already a prevalent public health concern throughout temperate regions of the world (Kovats and Hajat, 2008). Extreme heat hazards have been encountered recently in North America (Hawkins-Bell and Rankin, 1994; Klinenberg, 2002), Asia (Kalsi and Pareek, 2001; Srivastava et al., 2007; Kumar, 1998), Africa (McGregor et al.), and Australia (Victorian HHS 2009), and there is consensus that climate change is highly likely to increase the frequency of extreme heat events (AR4). It is important, therefore, to consider factors that contribute to hazard exposure and population susceptibility. Recent literature has identified a host of factors that can amplify or dampen hazard exposure. Experience with past heat waves and public health interventions suggests that it is possible to manipulate many of these variables to reduce both exposure and susceptibility and thereby limit the impacts that extreme heat hazards present.

3. Heat Wave Vulnerabilities

3.1. Understanding local vulnerability and working with communities to improve resilience

Several factors influence susceptibility to heat related illness and death. Physiologic factors, such as age, gender, body mass index, and pre-existing health conditions play a role in the body's ability to respond to heat stress. Older persons have a number of physiological and social risk factors that place them at elevated risk, such as decreased ability to thermoregulate (the ability to maintain temperature within the narrow optimal physiologic range) (Havenith, 2001). Pre-existing chronic disease, more common in the elderly, also impairs compensatory responses to sustained high temperatures, and certain medications may interfere with thermoregulatory mechanisms as well (Havenith, 2001; Shimoda, 2003). Many older adults tend to have suppressed thirst impulse. In addition, multiple diseases and/or drug treatments also increase the risk of dehydration (Hodgkinson, Evans and Wood, 2003; Ebi and Meehl, 2007). Older persons may also be more likely to be isolated and living alone than younger persons (Semenza, 2005; Naughton, et al., 2002). Babies and young children are at risk for adverse heat affects (Weiland 2004).

A wide range of socio-economic factors are also associated with increased susceptibility. Areas with high crime rates, low social capital, and socially isolated individuals increased vulnerability during the Chicago heat wave in 1995 (Klinenberg, 2002). People in low socioeconomic areas are generally at higher risk of heat-related morbidity and mortality due to higher prevalence of chronic diseases that increase risk, from cardiovascular diseases such as hypertension to pulmonary disease such as chronic obstructive pulmonary disease and asthma (Smoyer, Rainham, Hewko, 2000; Sheridan, 2003). Minorities and communities of low socio-economic status are more frequently situated in higher heat stress neighborhoods (Harlan et al 2006). Protective measures are often less available for those of lower socioeconomic status, or even if air conditioning is available, some of the most vulnerable populations will choose not to use it out of concern over the cost (O'Neill et al. 2004). Other groups, like the homeless and outdoor workers, are particularly vulnerable because of their living and working conditions. During the 2005 heat wave in Phoenix, Arizona, outdoor workers and the homeless had the highest burden of heat stroke mortality (Yip et al., 2008).

3.2. Adapting the urban infrastructure to improve resilience to extreme heat

It is particularly important to address these vulnerabilities in urban areas. About half the world's population live in urban areas at present, and by 2050, this figure is expected to rise to about 70 percent. Cities across the world are expected to absorb most of the population growth over the next four decades, as well as continuing to attract migration from rural areas (UN, 2008). It is projected there may be 27 mega-cities with populations of over 10 million by 2050, up from 19 today (WB, 2003). In the context of an extreme heat event, certain infrastructural factors can either amplify or reduce the vulnerability of exposed populations. The built environment is important since the urban thermal budget is affected by local heat production (from internal combustion engines, air conditioners, and other activities), surface reflectivity or albedo, the percent of vegetative cover, and thermal conductivity of building materials. The urban heat island effect, caused by increased absorption of infrared radiation by buildings and pavement lack of shading by vegetation and increased local heat production, can significantly increase temperatures in the urban core by several degrees Celsius, raising the likelihood of hazardous heat exposure for urban residents (Clarke, 1972; Shimoda, 2003). Research has also identified that, at least in the North American and European cities where the phenomenon has been studied, these factors can have significant impact on the magnitude of heat hazards on a neighborhood level (Harlan et al., 2006). One study in France has shown that higher mortality rates occurred in neighborhoods in Paris that were characterized by higher outdoor temperatures (Cadot, Rodwin, Spira, 2007). High temperatures can also affect transport networks when roads and railtracks are damaged by the heat. Within cities, outdoor temperatures can vary significantly, some work has found by as much as 5 degrees C (Konopacki and Akbari, 2001; Rosenzweig, Solecki 2005). Amplification of heat exposure varies between cities, as well, as sprawling cities – those with less dense development, a lower proportion of vegetative land cover, and more impervious surfaces – are warming at a faster rate than more dense urban areas (Stone et al., 2010).

Systems of power generation and transmission are also important in explaining vulnerability. Electricity supply underpins a significant adaptation strategy particularly in developed countries, but it is also at increased risk of failure during a heat wave. Demand increases as the need for refrigeration and air conditioning is felt more. Increases in emergency medical dispatch calls during periods of increased heat have been shown to place increased burden on multiple financial and human resources (Golden, et al., 2008). High emergency medical dispatch volumes related to heat stress are greatest at the same time as maximum demand for electricity, which also increases strain on power grids, increasing the potential for failure of a significant adaptation strategy (Gordon et al 2008; California Energy Commission, 2007). Power grids have failed due to strain from high electricity demand, most notably in the state of California and the cities of Chicago and New York. Areas with lower margins face increased risk of disruptions to generating resources and transmission under excessive heat events (North American Electric Reliability Council, 2006).

In addition to increased demand, there can be a risk of reduced output from power generating plants (UNEP, 2004). Inland nuclear power plants in particular face environmental restrictions on the temperature of the water they are allowed pour back into rivers, which affects their ability to cool the generators down. During periods of extreme heat, they may have to reduce their output or risk environmental damage. In Europe, nuclear reactors have already had to slow down or issue special temporary dispensations granted during periods of extreme heat, such as during the summer 2003 (Jowit and Espinoza, 2006; Pagnamenta, 2009). Additionally, there is the issue of long-term adaptation, like in the case of hydropower where fluctuating levels of water availability will determine energy outcomes. With projected changes to the hydrological cycle in the Phoenix, Arizona area amounts of water available for hydropower may decrease dangerously in the rapidly developing, energy-intensive metropolitan area (Environmental Protection Agency, 1998).

Several types of infrastructural measures can be taken to prevent negative outcomes of extreme heat events. Reducing energy consumption in buildings can improve resilience, since then localized systems are less dependent on vulnerable energy infrastructure. In addition, by better insolating residential dwellings, people would suffer less effect from extreme heat. Tax incentives have been trialled in some European countries as a means to increase energy efficiency by supporting people who are insulating their homes. Urban greening can also reduce temperatures, protecting local populations and reducing energy demands (Akbari 2001). Preparedness for extreme heat therefore requires environmentally-friendly land use planning (Myeong 2009). Models suggest that significant reductions in heat related illness would result from land use modifications that increase albedo, proportion of vegetative cover, thermal conductivity, and emmissivity in urban areas (Silva et al. 2010).

4. Role of Disaster Risk Reduction or Climate Change Adaptation

4.1. Reducing exposure

From a Disaster Risk Management (DRM) perspective, the risks associated with extreme heat hazards can be reduced by lowering the likelihood of exposure and reducing susceptibility. A common public health approach to reducing exposure likelihood is the Heat Warning System (HWS) or Heat Action Response System (HARS). The four components of the latter include an alert protocol, community response plan, communication plan and evaluation plan (Health Canada 2010). The HWS is represented by the multiple dimensions of the EuroHeat plan, such as a lead agency to coordinate the alert, an alert system, an information outreach plan, long-term infrastructural planning, and preparedness actions for the healthcare system (WHO 2009). There are a range of approaches used to trigger alerts and a range of response measures implemented once an alert has been triggered. Some jurisdictions rely on existing emergency plans when the most severe type of event is triggered. For many cities, there are separate plans that integrate actions as needed and address more modest heat wave events. In some cases, departments of emergency management lead the endeavor, while in others public health-related agencies are most responsible (McCormick *in press*). Heat warning systems are sometime only present in urban areas (e.g. in Canada) (Paszkowski, 2007). However, many cover both urban and rural areas (e.g. France, England and Wales).

There is very limited evidence on the effectiveness of the heat warning systems. A few studies have identified a reduced impact. For example, the use of emergency medical services dropped by 49% during a heatwave in

Milwaukee, Wisconsin, U.S.A. between 1995 and 1999, and were not entirely attributable to differences between two heat waves in those years (Weisskopf et al., 2002). Evidence has also indicated that interventions in Philadelphia could have reduced mortality rates by 2.6 lives per day during heat events (Ebi et al., 2004). An Italian intervention program found that caretaking in the home resulted in decreased hospitalizations due to heat (Marinacci et al., 2009). Following the 2003 heatwave, France developed the *"Plan Canicule,"* focused on prevention, responsibility, and solidarity. When a subsequent heat wave occurred in 2006, mortality rates were two to eight percent lower than expected mortality (Fouillet et al., 2008). However, for all these studies, it is not clear whether the observed reductions were due to the interventions. Questions remain about the levels of effectiveness in many circumstances (Cadot, Rodwin and Spira, 2007).

Philadelphia was one of the first US cities to begin a heat preparedness plan, and today has a ten-part program that has been economically beneficial and suggested as effective (Ebi et al., 2004). The primary components in Philadelphia is the integration of a pre-existing social program including home visiting for vulnerable communities (Sheridan, 2006). The program incorporates existing social capital by utilizing a "block captain" system where local leaders are asked to notify community members of dangerous heat (McCormick, 2010). Such programs that utilize social networks have the capacity to shape behavior since networks can facilitate the sharing of expertise and resources across stakeholders (Crabbé and Robin, 2006). Social networks that are a critical aspect of social capital do not always facilitate adaptive behavior, however, and can lead to contribute to vulnerability (Adger et al. 2010). Other heat warning systems, such as that in Melbourne, Australia, are based solely on alerting the public to weather conditions that threaten older populations (Nicholls et al., 2008). In Canada, a HARS was developed through participatory processes, including 1) community HARS Advisory Communities 2) conducting heat health vulnerability assessments, 3) conducting extreme heat simulation exercises 4) developing HARS communications strategies and 5) evaluating the systems.

Addressing social factors in preparedness promises to be critical for the protection of vulnerable populations. This includes incorporating communities themselves in understanding of and responses to extreme events. Top-down measures imposed by health practitioners that do not account for community-level needs and experiences are likely to fail. Greater attention to and support of community-based measures in preventing heat mortality can be more specific to local context, such that participation is broader (Semenza, 2006). Such programs can best address the social determinants of health outcomes.

4.2. Communication and education

One particularly difficult aspect of heat warning is health communication. This is particularly relevant for older adults who may depend on numerous tools and strategies to address their special needs (Aldrich and William, 2008). In many locations populations are unaware of their risk and heat wave warning systems go largely unheeded (Golding, 2009) (Luber and McGeehin, 2008). Developing appropriate educational messages about heat waves is a difficult task. Some evidence has even shown that top-down educational messages result in a very limited amount of resultant action (Semenza et al., 2008). The receipt of information is not sufficient to generate new behaviors or the development of new social norms. Even when information is distributed through pamphlets and media outlets, behavior of at risk populations often does not change, and those targeted by such interventions have suggested that community-based organizations be involved in order to build on existing capacity and provide assistance (Abrahamson, 2008). Older people, in particular, engage better with prevention campaigns that allow them to maintain independence and do not focus on their age, as many heat warning programs do (Hughes, Van Beurden, and Eakin, 2008). More generally, research shows that these programs should be centered around engaging with communities in order to increase awareness (Smoyer-Tomic and Rainham, 2001).

4.3. Assessing heat mortality

Assessing heat mortality presents particular challenges in itself. There are a number of estimates of mortality for the European heat wave that vary depending on geographic and temporal ranges, methodological approaches, and risks considered (Assemblee Nationale, 2004). Accurately assessing heat-related mortality faces challenges of differences in contextual variations (Poumadere et al., 2005; Hémon and Jougla, 2004) and coroner's categorization of deaths (Nixdorf-Miller, Hunsaker and Hunsaker, 2006).

The different types of analyses used to assess heat mortality, such as certified heat deaths and heat-related mortality measured as an excess of total mortality over a given time period, are important distinctions in assessing who is affected by the heat (Kovats and Hajat 2008). Learning from past and other countries' experience, a common understanding of definitions of heatwaves and excess mortality, and the ability to streamline death certification in the context of an extreme event could improve the ease and quality of mortality reporting.

5. Relationship to Key Messages

With climate change, heatwaves are likely to increase in frequency and severity in many parts of the world. Urban settings are especially susceptible to heatwaves, even, and possibly more so, in highly developed countries. Climate change adaptation will require smarter urban planning, improvements in existing housing stock and critical infrastructures, and effective public health measures. Disaster risk originates from a combination of social processes and their interaction with the environment. Social, biological, built environmental and infrastructural characteristics shape vulnerability to extreme heat events.

Effectively preparing for, responding to, and recovering from extreme events and disasters require understanding current and projected risks. The specificity of heat risks to particular sub-populations can facilitate appropriate interventions and preparedness.

Risk is a product of both exposure and vulnerability. The differences in mortality between the European heat waves in 2003 and 2006 reflect how interventions may reduce vulnerability over time, as well as the difficulty in measuring the efficacy of interventions aimed at reducing risk.

Risk is context specific and the result of local conditions of endangerment, global and historical root causes, and intervening dynamic pressures. Heat impacts are felt distinctly based on local context, and handled based on historical practices, adaptation to trends in temperature, institutional preparedness, and community engagement.

Long-term adaptation to climate extremes will require climate smart disaster risk management. By using the long-term impacts of climate change as a guide for planning in places where temperatures are projected to increase, adaptation can be developed appropriately and effectively.

6. Research Gaps and Needs

There is little understanding regarding the interrelationship between individual-level vulnerabilities and neighborhood-level characteristics such as built environment and social factors. Further research is needed in these areas.

Further research is needed on the effectiveness of existing plans, how to develop improved preparedness that specifically focuses on vulnerable groups, and how to best communicate heat risks across diverse groups. There are methodological difficulties in describing individual vulnerability that need further exploration.

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Case Study 9.3. Drought and Famine in Ethiopia in the Years 1999-2000

Authors: M Nunez, WF Erian, Oyun Rasval, S Myeong, A Taye, DH Mariam, V Murray and IA Kreis

1. Introduction

Historical accounts of droughts resulting in famines in Ethiopia go as far back as the 9th century however some evidence on health impact started to emerge from the 15th century onwards. Unfortunately, famine has been endemic in Ethiopia in the last few decades. The famine in 1973 claimed over 300,000 lives. In 1985, approximately ten million people were reported to be starving, with approximately 300,000 already dead and about 1000 dying daily. In the following years, droughts leading to food shortages have had local and national adverse health effects, in particular in 1999/2000 (Taye et al 2010).

Adverse climatic conditions such as droughts have caused major fluctuations in agricultural and economic growth, rendering the country one of the poorest in the world. The largest group of poor people in Ethiopia is small scale farmers. (World Health Statistics 2008) The impact of adverse climatic conditions has been exacerbated by, the improving yet still existing, underdeveloped farming technologies, transport and communication networks and environmental degradation (Ethiopia has one of the highest rates of soil nutrient depletion in sub- Saharan Africa). (International Fund for Agricultural Development 2008) The country is reported to be currently only irrigating about 6% (5.8%) of its irrigable potential with plans to improve this capacity by 2010. (World Health Statistics 2008) In 2007/2008, 60% (59.9%) of the population had access to safe water and coverage with latrines was 37%. (Federal Ministry of Health of Ethiopia 2008)

2. Meteorological Background

Drought is the consequence of a natural reduction in the amount of precipitation over extended period of time, usually a season or more in length, often associated with other climatic factors (such as high temperatures, high winds and low relative humidity) that can aggravate the severity of the event. (Sivakumar 2005) It is a normal event that takes place in almost every climate on Earth, even the rainy ones. Drought manifestation varies from region to region and therefore a global definition is a difficult task e.g. one might define drought in Libya as occurring when annual rainfall is less than 180 mm, if less than 2.5 mm of rainfall in 48 hours in USA, about 15 consecutive days with daily precipitation totals of less than 25 mm in GB, actual seasonal rainfall deficient by more than twice the mean deviation in India, but in Indonesia, Bali drought might be considered to occur after a period of only 6 days without rain. (Ragab 2005)

Ethiopia is particularly sensitive to periodic droughts due to changes in the rainfall pattern related to El Niño events in the Pacific and Indian oceans. Investigating the published rainfall patterns between 1979 and 2005 indicated that the main growing-season rainfall has diminished by about 15% in food-insecure countries clustered along the western rim of the Indian Ocean. Some have concluded that there are moisture deficits upstream in a warming Indian Ocean, is likely to result in further rainfall declines. (Funk et al 2008).

Drought is one of the main causes of global disasters and during the past 30 years there has been an increased frequency and intensity of this phenomenon in most regions in the world, according to the IPCC.

3. Geological and Demographic Background

The total population of Ethiopia in 2008 is estimated to be about 81,021,000 with a Gross National Income per capita (PPP international $) of $630 and a total expenditure on health per capita (Intl $, 2006) of $22 or as percentage of GDP (2006) $4.9. (World Health Statistics 2008) In Ethiopia, more than 85% of the country’s population depend on agriculture as their primary source of income. (International Fund for Agricultural Development 2008) Ethiopian agriculture is reported as being dominated by a subsistence rain-fed farming system, which could render the livelihoods of those who depend on it, vulnerable to climatic conditions.

4. Events Summary

A Drought resulting in a famine has, inherently, a smouldering beginning. Periods of reduced rainfall silently turn into drought which turns into failing crops or forced sell-off of animals by pastoralists. The populations live on limited reservoirs of food or economic means and it slowly turns into a famine. International recognition of such a famine than requires a great number of steps again. During 1999/2000, great parts of Ethiopia experienced a period of famine which was recognised internationally. To illustrate the effects a specific study on a typical area is used. The study used data on individuals from a longitudinal population-based investigation from the Butajira region combined with rainfall data from a local site. Additional routinely collected demographic, meteorological and agricultural data were used also. (Emmelin et al 2008)

Quoting from the report by Emmeling et al (2009): "*Rainfall was high in 1998 and well below average in 1999 and 2000. In 1998, heavy rains continued from April into October, in 1999 the small rains failed and the big rains lasted into the harvesting period. For the years 1998/1999, the mortality rate was 24.5 per 1,000 person-years, compared with 10.2 in the remainder of the period 1997/2001. Mortality peaks reflect epidemics of malaria and diarrhoeal disease. During these peaks, mortality was significantly higher among the poorer. A serious humanitarian crisis with the Butajira population occurred during 1998/1999, which met the USA-Centre for Disease Control (CDC) guideline crisis definition of more than one death per 10,000 per day*." (Emmelin et al 2008)

It can be concluded that in extreme droughts such as this one in Ethiopia in 1999/2000, the poorest in the farming communities are vulnerable to major heath effects as well as economic and social effects. Food insecurity and reliance on subsistence agriculture continue to be major issues in Ethiopia and similar communities. Also, under these circumstances, epidemics of traditional infectious diseases can still be devastating in mal-nourished populations with little access to health care. (Emmelin et al 2008)

5. Impacts

Besides substantial economic and social impacts, the health impacts of a severe famine due to drought (or other causes) are hard to measure. However, one survey conducted in 2000 in Gode district (southeastern Ethiopia and epicentre of the famine) of 595 households (4032 people), showed that mortality rate in children under 5 was 6.8/10,000 per day (95% CI 5.4 – 8.2/10,000), about double the crude mortality rate which was 3.2/10,000 per day (95% CI 2.4 – 3.8). The mortality rate was declining by the time intervention was introduced and then increased, however, 225 (76.8%) of all the deaths had occurred before any intervention had arrived. (Salama 2001)

The increase in mortality rate may have been due to influx of non-immune malnourished people to the centralised intervention centres. Almost 80% of all deaths were among children aged 14 years or younger and around 8% occurred among older persons. In addition wasting together with one of four major communicable diseases contributed to 206 (70.3%) deaths (communicable diseases included: measles, diarrhoea, malaria and respiratory tract infection). Cause of death was different before and after the intervention was started, excluding the other category, 29% vs 15% attributed to wasting alone before and after intervention respectively, 55% vs 50% attributed to wasting and one of the four major communicable diseases and 16% vs 35% to one of the four communicable diseases alone respectively ($p < 0.01$ for all). (Salama 2001)

In total, wasting alone contributed to 72.3% of all deaths among children under 5 years. The authors highlight the fact that there is no standard nutritional assessment tool for adults, and that in the study area, lack of data on adults resulted in groups potentially at high risk of mortality due to malnutrition not being targeted for feeding interventions. In addition, understanding adult nutritional status is important as it can contribute to a better understanding of community nutritional status. In addition, finding low prevalence rates of wasting in children in such situations could lead to an erroneous conclusion that nutritional situation is stable or improving because by the time nutritional assessments are done, those who are severely malnourished may have already died. But death is not always registered or recorded, notably; the authors remark that there was no available local baseline mortality data.

They suggest that collecting and analysing retrospective mortality data may be particularly important for the interpretation of results from nutrition surveys in prolonged famines. (Salama 2001)

But, famine is probably not equally spread in one population. It is generally assumed that, to the extent possible, adults will protect younger household members from the worst hunger. In Ethiopia, where girls have lower social status, it is possible that boys are more protected than girls. A study into this in southwestern Ethiopia indicates that boys and girls were equally likely to be living in severely food insecure households. But, girls were more likely than boys 9including their siblings) to report being food insecure themselves and more so in severely affected households. (Hadley et al 2007)

Droughts have occurred in many places other than Ethiopia and not necessarily always led to famines. However, it is relevant to investigate where substantial droughts have occurred and what impacts they had.

6. Comparable Other Events

Droughts can be due to many climactic events on of which can be the change in weather patterns during an ENSO (El Niño/La Niña-Southern Oscillation), a climate pattern that occurs across the tropical Pacific Ocean on average every five years) event alters regions of high and low pressures around the globe. They cause high surface pressures that prevent the areas of precipitation from moving into its region and lead to drought conditions, depriving the area and ecosystem of rainfall. Droughts generally occur in the western Pacific during ENSO Events, an area normally rich in rainfall. However, droughts in many other regions of the world, including south eastern Africa, India, China and north eastern region of the South American continent, have been linked to El Niño. ENSO results in drier conditions in Northeast Brazil during the Northern Hemisphere winter, the climatic impact of El Niño is drier conditions in Central America, Colombia and Venezuela.

During the 1997/1998 it caused severe droughts and forest fires in northeast Brazil. (World Meteorological Organisation 1999) The dry spells observed in the La Plata Basin, was studied using daily data supplied by 98 stations during variable periods between 1900 and1998. (Naumann et al 2008) From this it appears that the 1988 drought is considered to be the one of the longest dry spell in the basin. Water deficits translate to Argentinean economic losses of more than four billion dollars.

In 2005 large sections of south western Amazonia experience one of the most intense droughts of the last hundred years. (Marengo et al 2007) The through severely affected human population along the main channel of the Amazon River and its western and south western tributaries, the Solimões (also known as the Amazon River in the other Amazon countries) and the Madeira River, respectively. The river levels fell to historic low levels and navigation along these rivers had to be suspended. The causes of the drought were not related to El Niño but to: 1) the anomalously warm tropical North Atlantic, 2) the reduced intensity in the northeast trade wind moisture transport into southern Amazonia during the peck summertime season, and 3) the weakened upward motion over this section of Amazonia, resulting in reduced convective development and rainfall. The drought conditions were intensified during the dry season into September 2005 when humidity was lower than normal and air temperature were 3º - 5º warmer than normal. Because of the extended dry season in the region, forest fires affected part of south western Amazonia. Rains returned in October 2005 and generated flooding after February 2006.

The years 2008 and 2009 are considered to be one of the worst droughts in 50 years devastated crops, dry rivers and springs, and killed cattle in Argentina, a phenomenon also impacted on socio-economic and productive communities and regions. La Niña 2008-2009 depleted water reserves not only in Argentina but also in Paraguay, Uruguay and Brazil. According to the Meteorological Weather Service of Argentina (SMN), during 2008 observed rainfall values were below normal in most of the humid and semi-humid region of the country (the Pampas), comparing with the main value of the period 1961-1990. The accumulated rainfall in the center of the region represented only 40-60% of the normal values, and in some locations values of precipitation were the lowest of the last 47 years.[4]

[INSERT FOOTNOTE 4 HERE: Secretaría de Agricultura, Ganadería, Pesca y Alimentos. MECON. Argentina.]

It is unclear how much these severe droughts have affected the actual nutritional state of the populations affected or their long-term economic situation. However, Argentina is an important wheat producer and highly contributes to global exportations. The main planted area is located in the Pampas region, where the crop is developed under rainfed conditions. In the last decade, the area devoted to wheat ranged between 4.9 and 7.3 millions of hectares, mean yield attained 1,900-2,600 kg/ha, and country's production varied between 9.4 and 16 millions of tons (Mt). The internal consumption is near to 6 Mt, and remainder production is exported, transforming the country in the fifth world's exporter with a key role in food security. In Argentina the 2008-2009 draught impacted the richest agricultural area (Pampas region), substantially reduced grain production and caused millions US dollars in losses to livestock in the country.[5]

[INSERT FOOTNOTE 5 HERE: Secretaría de Agricultura, Ganadería, Pesca y Alimentos. MECON. Argentina.]

Drought is considered the major disaster occurring in the Arab region, where, the total people affected between the years 1970-2009, by drought is of about 38.09 million. (Abu Swaireh 2009) The Global Assessment Report included Mauritania, Sudan and Comoros Islands as countries exposed to drought hazard. Some countries of the region are also economically vulnerable to natural hazards and Syria could be considered one of the most economically affected countries by drought. (Global Assessment report 2009) The year 2008 is considered to be one of the worst droughts in devastated crops in Syria, The drought frequency increased during the last 10 years, and the rainfall as total and variability have shown negative impact on yield for most of the years. The rainfall was not enough to satisfy the water requirements of the cereal crops, beside half of the animal population in the steppe areas has been died or get read of due to the continues drought cycles. As a consequence of the agriculture drought the population immigration increased from the northwestern part of Syria and from Syrian steppe to Urban causing high pressure on the services and stability of those communities. (Erian 2010, Nashawatii 2010)

Mongolia is another country that regularly suffers drought and the country has experienced a drought every three years. Depending on drought and precipitation levels, the condition of the vegetation cover in the pasture lands differs from year to year. (MARCC 2010) Studies show that during drought years the vegetation cover diminished by 12-48% in high mountain areas and by 28-60% in the desert and steppe regions. (L.Natsagdorj 2002, L.Natsagdorj, et. al. 2003) Drought has increased significantly at the level of 95 per cent in Mongolia for the last 60 years, particularly in the last decade. The worst droughts Mongolia experienced were in the consecutive summers of 1999, 2000, 2001, and 2002, which affected 50-70 percent of the territory. Such long-lasting and severe droughts have not been observed in Mongolia in the last 60 years. However, besides the episodic drought, Mongolia suffers from systematic reductions in rainfall. During the past four years, about 3,000 water sources including 680 rivers and 760 lakes have dried up. Such environmental degradation in turn has affected the level of primary production of vegetations/plants and water resources, which support livestock as well as human populations. (AIACC, 2006) Because of the systemic nature, the drought in Mongolia was not regarded as a natural disaster, unlike in many African and South Asian countries. However, it has resulted in: a) the decrease of pasture plants; (b) the decrease of palatable species in pasture plant; (c) reduced water availability; and (d) the absence of grass on pasture. This prevents herders from preparing hay and other supplementary feed for animals and dairy products for themselves. Most importantly, animals are unable to build up the necessary strength (i.e., calories/fat) during the drought period in summer to enable them to cope with the harsh winter and spring windstorms and therefore, they die in large numbers resulting in economic and social hardship. (AIACC, 2006)

7. Policy-Management Practices – DRR / DRM / HFA / CCA – Response-Recovery

Considerable achievements in the global reduction of hunger and poverty have been made but, progress in Africa so far has been very limited. It is estimated that a third of the African population faces widespread hunger and chronic malnutrition and is exposed to a constant threat of acute food crisis and famine. Traditional rural households are most affected and are forced to adopt coping strategies to meet their immediate needs. This may have adverse long-term impacts on both the population and the environment. (Haile 2005)

In the absence of safety nets and appropriate financial support mechanisms, humanitarian aid is needed to allow people to cope with emergencies and manage their limited resources more efficiently. Timely and appropriate humanitarian aid will provide households with opportunities to engage in productive and sustainable livelihood strategies. For the longer term management, investments in poverty reduction efforts require timely and predictable response mechanisms in crisis situations. With an improved understanding of climate variability including El Niño, the implications of weather patterns for the food security and vulnerability of rural communities have become more predictable and can be monitored effectively. (Haile 2005)

The traditional approach to drought management has been reactive, relying largely on crisis management. This approach has been ineffective because response is untimely, poorly coordinated, and poorly targeted to drought stricken groups or areas. (Whihite 2005) Two important trends in drought management could be considered: (1) improved drought monitoring tools and early warning systems (EWSs) and (2) an increased emphasis on drought preparedness and mitigation. Effective drought EWSs are an integral part of efforts worldwide to improve drought preparedness. Activities of regional centers in eastern and southern Africa and efforts in WANA are increasing, but not enough. An Expert group meeting on EWSs sponsored by the World Meteorological Organisation and others summarized the shortcoming on the following areas:

- Lack of data networks on all major climate and water supply parameters
- Inadequate data sharing and high cost of data limits the application of data in drought preparedness, mitigation and response
- EWSs products are not user friendly; inadequate indices for detecting the early onset and end of drought
- No historical drought database exists. (Wihite 2000)

In India, Syria, and in the Arab Center for The Studies of Arid Zones and Dry Lands (ACSAD), major research efforts on improving the productivity of rainfed areas with focus on reducing the adverse effects of drought have been underway for at least 2-3 decades. These include improving and introducing appropriate crops, improved varieties and new varieties of cereal that are tolerant to drought and heat; improving conservation of soil and water increasing areas of conservation agriculture, improving water efficiency and improvement in terms of living conditions of the rural areas who suffer most due to scarcity and drought in particular.

In arid, semi-arid and marginal areas with a probability of drought incidence it is recommended to re-planning their land use and developing methods of predicting many weeks/months in advance, the occurrence of rainfall deserves high priority. The agricultural planning and practices need to be worked out with consideration of overall water requirement within the individual agro-climatic zones. Crops that need shorter duration to mature and require less water need to be encouraged in the drought prone areas. Food reserves to meet the emergency of maximum up to two consecutive droughts must be planned.

Africa is thought to be the part of the world that is most vulnerable to climate variability and change, but knowledge of how to use climate information and the regional impacts of climate variability and change in Africa is rudimentary. Besides predictions of rainfall, the entire food chain needs to be reconsidered, from production to distribution, access and utilization. Even complete changes in types of grains and cereals are to be evaluated. (Slingo et al 2005)

8. Drought Monitoring and Early Warning: Preparedness/ Response, National and Local Levels

Drought is typically a slow-onset phenomenon, which means that it is often possible to provide early warning of an emerging drought. Global Circulation Models (GCMs) and associated statistical ensemble methods are being routinely used to provide predictions of upcoming climate anomalies and offer promise for increasingly useful forecast of the onset, severity and duration of drought for large geographic regions on monthly and seasonal timescales.

There have been important developments[6] in recent years in the area of subseasonal and seasonal-to-interannual prediction, leading to dramatic improvements in predictions of weather and climate extremes (Nicholls, 2001). Some of these improvements, such as the use of soil moisture initialization for weather and (sub-)seasonal prediction (Koster et al., 2010), have potential for applications in transitional zones between wet and dry climates, and in particular in mid-latitudes (Koster et al., 2004). Such applications may be potentially relevant for projections of temperature extremes and droughts.

[INSERT FOOTNOTE 6 HERE: See S. Mason (IRI, Chapter 3) and Early Warning case study – 19 in this chapter.]

9. Relationship to Key Messages

- Droughts have historically occurred and led to severe famines and other effects
- Droughts are likely to occur more widely and frequently
- Areas where droughts currently do not result in famines, might do so in the future
- Other effects from drought (economic, social and other health effects) are likely but insufficiently investigated

10. Research Gaps

At this time, periods of drought are poorly assessed in their economic, social and health impact. Also, there is no clarity and worldwide agreement on potable and agricultural water supply needs of populations.

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Case Study 9.4. Sand and Dust Storms

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1. Introduction – Asian Dust Cloud of 2001

A major dust storm started over East Asia on 6th April 2001 and dust from this storm was transported all the way to the United States. This "Asian Dust Cloud, 2001"[7] affected large areas of the world for the next two weeks Although dust from the Sahara Desert is routinely transported across the Atlantic to the east coast of the United States, Asian dust rarely makes the distance across the Pacific to the west coast of North America. These airborne microscopic dust and smoke particles, or aerosols, are measured by the Total Ozone Monitoring Spectrometer (TOMS) instrument on the Earth Probe satellite. For governments struggling to meet national air quality standards, knowing more about the sources and movement of pollution across national borders has become an important issue. Recent advances in satellite imagery allow the tracking and documentation of these huge Asian aerosol clouds. The dust cloud trajectory monitored from SEAWIFS had been observed day by day. In this case a thick shroud of dust appeared on April 6th, 2001 over Mongolia and formed a series of huge sandstorm events. These swept across western China reducing visibilities to near zero and making ground transportation all but impossible. The dust cloud trajectory monitored during the period from 7-11 April 2001 could be observed day by day by satellite and the cloud reached Arizona by 12th April with a dramatic and very distinct frontal boundary. Within hours, a thick veil of dust covered the entire sky. The haze layer was initially confined to layers aloft (April 12th and 13th) but by April 14th and 15th, as subsidence set in with a developing high pressure system, the main band of aerosols moved down to lower levels and the local visibility which is normally unlimited was reduced down to 30 miles or less. The trapped hazed layer persisted in Page, Arizona until the April 16th. The Asian Cloud at higher levels was eventually tracked into the Midwest region of the United States. After 11 days the dust storm from Mongolia that has dispersed dust from the Gobi Desert and industrial pollution from China across a quarter of the mainland United States seemed to be ended.

[INSERT FOOTNOTE 7 HERE: http://science.nasa.gov/science-news/science-at-nasa/2001]

2. Asian and African Sand and Dust Storms: Sources and Frequency

Sand and dust storms are natural events that occur widely around the world, especially in the dry lands which occupy half of the world's land surface. It has been estimated that in arid and semi-arid zones of the world, 24% of the cultivated land and 41% of the pasture land are affected by moderate to severe land degradation from wind erosion (Sivakumar, 2005). Dust storms are recognized as having a very wide range of environmental impacts. Atmospheric mineral-dust loading is one of the largest uncertainties in global climate-change modeling and is known to have an important impact on the radiation budget and atmospheric instability (Washington et al., 2003). The major sources of present-day dust emissions are the subtropical desert regions and the semi-arid and sub-humid regions, where dry exposed soil is subject to severe winds at certain times of the year. Human-induced change is by far the most significant factor in the alarming increase in some regions. Past policies on land use and the promotion of farming systems that were unsustainable are at the root of most of these changes (Sivakumar, 2005). Analysis of TOMS data has enabled a global picture of desert dust sources to be determined and it has demonstrated the primacy of the Sahara and has also highlighted the importance of some other parts of the world's drylands, including the Middle East, Taklamakan, southwest Asia, central Australia, the Etosha and Mkgadikgadi of southern Africa, the Salar de Uyuni in Bolivia, and the Great Basin in the United States (Washington et al., 2003). In the West Africa Sahel, rapid population growth, at annual rates of 3% during recent decades, has increased demand of food. Instead of intensifying farming systems, the previously sustainable fallow system has broken down, yield have declined, and more marginal land, which used to be communal grazing land, is now cropped. Consequently, over-exploitation has resulted in land degradation, or desertification, on a large scale. In his study to identify the sources of Asian dust, Zhang et al (2003) concluded that the deserts in Mongolia and in western and northern China (mainly the Tkimakan and Badain Juran, respectively) contribute 70% of the total dust emissions; non-Chinese sources account for 40% of this. Several areas, especially the Onqin Daga sandy land, Horqin sandy Land, and Mu Us Desert, have increased in dust emissions over the past 20 years, but efforts to reduce desertification in these areas have a little effect on Asian dust emission amount because these are not key sources. They added that meteorology and climate have had a greater influence on Asian dust emissions and associated Asian dust storm occurrences than desertification. The impacts of natural and anthropogenic factors on sand and dust storm distribution of 2001 in East Asia have been investigated by using the most up-to-date desertification map in China and desert reversal scenarios in natural precipitation zones, show that although desertification in China has only increased total area of desert by 2-7% since 1950s, it has generated disproportionably large areas with dust storm production potentials, depending on the degree of desertification newly formed deserts covered 15-19% of the original desert areas and would generate more dust storm ranging from 10-40% under the same meteorological conditions for spring 2001, Among the natural factors, the restoration of vegetation covers in Chinese deserts within the 200mm/y and 400mm/y precipitation zones was found to decrease the surface mass concentrations by 10-50% in most regions It was also found that the contributions of surface concentrations from non-Chinese deserts account for up to 60% in Northeast China and up to 50% in Korea and Japan (Gong et al., 2004).

Chun *et al* (2008) reviewed the documentation of Asian dust events, and concluded that the temporal distribution of dust storms in China during the period from 1915-2005 shows two peaks: during the warm perido of the 1930's and again in the last few years. Guoguang (2002) indicated that the main tracks of dust storms in China have three paths: North-Westerlies, Westerlies and Northerlies. The long-term variation of annual accumulated days of dust weather in China shows high frequency period: 50's-70's in cold and dry seasons with frequent development of extra-tropical cyclones and cold waves, with , decreasing frequency period: 1982-1997 and recent increase since 1998 that characterized with dry climate condition, increasing dry soil and warmer temperature layer thicker than 3 cm. Natsagdorj *et al* (2003), based on their observation for the compiled climatologically data of dust storms in Mongolia collected from 49 meteorological stations from 1960 to 1999 and compared with data between 1937 and 1989. An important outcome of this study is the trend of dusty days between 1960 and 1999. It shows that the number of dusty days has tripled from the 1960s to 1990s and has decreased since 1990.

The Sahara is the largest source of desert dust, indicating the importance of aeolian geomorphology in this major world desert (Middleton and Goudie 2001). Dust storms moving from the Sahara desert to the Eastern Mediterranean sea basin can occur between October and May, but mostly from December to April, (Dayan et al., 1991). A March 2003 event strongly resembled a February 1903 dust fall episode that was well documented in the contemporary literature, 100 years ago. The 1903 February 21-22 dust event impacted northern Europe including southern England, northern France, Holland, Germany and Denmark. For the early researchers, the most conclusive evidence regarding the Sahara origin of the dust was derived from the meteorological sources. Using the measured pressure fields they were able to map the trajectory of several dust bearing storms and traced them back to a point of origin in northern Africa. The source regions of dust particles that found on the south-Eastern corner of Italy during Saharan dust storm events have proven to be from the central and western Sahara, the samples collected along dust events with the origin mainly in Chad, Niger, Algeria and Libya, (Blanco et al., 2003). A recent Sahara dust incursion to northern Europe recorded by the Sea-Viewing Wide field-of-View Sensor (SeaWiFS) satellite on March 15, 2003. A thick yellow dust cloud is seen over England and France. Operational forecast models show that the dust source was over North Africa. This dust transport event, like many other recent dust events, has attracted a great deal of admiration particularly due to the real–time availability of spectacular color satellite images. However, just like most other dust events, it was not analyzed quantitatively for its key physical and chemical features (Husar, 2004).

3. <u>Impacts of Sand and Dust Storms</u>

Sand and dust storms, especially major ones, can be hazardous extreme events with major impacts. These impacts can be negative and positive.

3.1. Negative impacts

When sand and dust storms occur, they act almost like an overwhelming tide and the strong winds carry drifting sands that can: bury farmlands and blow away top soil; denude steppes; hurt animals and damage young crop plants and result in a loss of production; and reduce the temperature and pollute the atmosphere. Sand and dust storms accelerate the process of land desertification and cause serious environment pollution and huge destruction to ecology and living environment. They also effect human settlements through, for example, destroying mining, and communication facilities, and impacting on human health through the inhalation of dust and increasing the spread of disease across the globe. Virus spores in the ground are blown into the atmosphere by the storms with the minute particles which then act like urban smog or acid rain. Other hazardous consequences include severe threats to the safety of transportation (reduced visibility affecting aircraft and road transportation) and electricity supplies and they contribute unforeseen impacts to people's life and property (Wang Sh., et al., 2001).

The large amount of dust that is transported from the desert in China to Korea and Japan often provide long-range transport to various microorganisms, including Aquabacterium sp., Flavobacteriales bacterium sp., Prevollaceae bacterium sp.,and others. The result is that humans in the affected regions are exposed to communities microorganisms that might cause various adverse health effects (Lee et al., 2009). Sand storms may be a potential source of exposure to Polychlorinated biphenyl (PCBs). The total PCB residues analyzed from samples taken from the yellow dust storms indicated that its concentration ranged from 1.6 to 15.6 ng g^{-1} with tri-chlorinated biphenyls as the predominant homologue (>50.4%)(Fu et al , 2008).

In his study on health impacts caused by dust days in the Dair El Zohr area in Syria, Al Ebaid (2000) indicated that dust days cause breathing problems that impact on 60% of the total population mainly in rural areas; 70% of the population suffers eye diseases and 25% suffers digestion problems with emergency cases increasing by 380%. Toxicity of coarse particles is substantially less than that of fine particles. The microbial materials adhered to Asian sand/dust cause allergic lung inflammation. In Taiwan, Bell et al (2007) concluded that risk of hospital admission in Taipei may be increased by air pollution and sandstorms. Li-Wei and Wan-Li (2008) indicated that short-duration Asian dust storm events caused a larger revised air quality index (RAQI) than the long duration, PM_{10} and O_3 concentrations significantly increased on the first two days of the event. Yong-Shing et al (2004) concluded that the dust storms increased the risk for respiratory disease by more than 66% one day after the event, by about 5% for total deaths 2 days following the dust storms and by about 3% for circulatory diseases 2 days following the dust storms.

3.2. Positive impacts

Mineral dust, as has been suggested, has an important role to play in the supply of nutrients and micro-nutrients to the oceans and to terrestrial ecosystems (Shinn et al., 2000; Sivakumar 2005). Mineral dust is a term used to indicate atmospheric aerosols originated from the suspension of minerals constituting the soil, being composed of various oxides and carbonates. Human activities lead to 30% of the dust load in the atmosphere. The Sahara is the major source of mineral dust, which subsequently spreads across the Mediterranean and Caribbean seas into northern South America, Central America, North America, and Europe. Additionally, it plays a significant role in the nutrient inflow to the Amazon rainforest (Koren et al., 2006). The soil of the Amazon tropical rainforest is shallow, poor in nutrients and almost without soluble minerals. Heavy rains have washed away the nutrients in the soil obtained from weathered rocks. The rainforest has a short nutrient cycle, and due to the heavy washout, a stable supply of minerals is required to keep the delicate nutrient balance (Vitousek and Stanford, 1986). About 40 million tons of dust are transported annually from the Sahara to the Amazon basin, Saharan dust has been proposed to be the main mineral source that fertilizes the Amazon basin, generating a dependence of the health and productivity of the rain forest on dust supply from the Sahara, about half of the annual dust supply to the Amazon basin is emitted from a single source: the Bodélé depression located northeast of Lake Chad, approximately 0.5% of the size of the Amazon or 0.2% of the Sahara. Placed in a narrow path between two mountain chains that direct and accelerate the surface winds over the depression, the Bodélé emits dust on 40% of the winter days, averaging more than 0.7 million tons of dust per day (Koren et al., 2006). Central and South American rain forests get most of their mineral nutrients from the Sahara; Traces of African dust have been discovered as far west as New Mexico. According to Swap (1992), the western states are also the recipients of dust that's been stirred up in China's deserts and blown across the Pacific; the area of dust cloud observed was 1.34 million Km^2, the mean particle radius of the dust was 1.44 mm, and the mean optical depth at 11mm was 0.79. The mean burden of dust was approximately 4.8 tons/Km^2 and main portion of the dust storm on April 07, 2001 contained 6.5 million tons of dust, (Yingxin et al, 2003).

4. Measures for Adaptation to Sand and Dust Storms

The use of remote sensing technology, leading to improved and affordable, effective and efficient monitoring systems can enhance detection and modeling of sand and dust storms. They can also be used an important step for combating wind erosion (Husar, 2004; El-Askary et al., 2003; Koren and Kaufman, 2004). Preventing the sand from being picked up in the source area is the main cheaper and more effective action than to fixing the dunes formed in the accumulation area (Sivakumar 2005). Through use of live windbreaks, wind speeds could be reduced by 50% at a leeward distance of 20 times the barrier height (Skidmore, 1986). Planting and maintaining shelterbelts is an important conservation practice in the great plains region and it produce many benefits for farmers such as decreased soil erosion, increased crop yields, reduced livestock stress (Forman and Baudry 1984; Loucks 1984; USDA 1989). Protecting the loose soil particles by using crop residues or plastic sheets or chemical adhesives (Michels et al., 1995) and increasing the cohesion of soil particles by soil mulching are other possible approaches. These need to be further investigated. It needs also to be remembered that dust and sand storms do have positive attributes, as discussed, and these benefits need to be accounted for the analysis of adaptation strategies.

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Case Study 9.5. Floods

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1. Introduction

A flood is a 'rise, generally brief, in the water levels in a stream to a peak from which the water level receded at a slower rate' (United Nations Educational, Scientific and Cultural Organization/World Meteorological Organization, 1992). There is a common basis between floods is related to heavy (or long) rainfall and air temperature, which can lead to *water logging of the soil, river floods (or flash floods) and landslides*. Some floods overflow the normal confines of a stream or other body of water and cause flooding over areas which are not normally submerged (World Meteorological Organization, 2010). Floods cause not only material damage, but lead to loss of life and have adverse effects on the health of people.

Floods have been a major natural hazard in many regions of the world. There have been several recent flood events, in each of which the material losses are reported to have exceeded US$ 10 billion (material damage during the summer 1998 floods in China rose to US$ 30 billion) (Kundzewicz 2006). The death toll has remained high, with single events in less developed countries causing more than 1,000 fatalities (Kundzewicz 2006). Floods occur because of complex interactions between hydro meteorological and hydro-geological processes, usually classified according by rain, sea or snow floods, flash floods, storm surge, mudflow, and ice jams (Collins 2007).

2. Catastrophic Floods in Mozambique in 2000

2.1. Hydrometeorological and geographical background of floods in Mozambique

Mozambique is vulnerable to natural disasters such as tropical cyclones, floods and droughts because of its geographical position. From 1956 to 2008 Mozambique experienced 20 major floods (killing 1,921 people), 10 major droughts (killing 100,000 people) and 13 major tropical cyclones (killing 697 people) (World Bank 2005). Mozambique's high incidence of flooding is explained by two influential factors. Firstly the meteorological factors, especially the tropical cyclones that form in the southwestern Indian Ocean and sweep towards the country's coast. While relatively few of these actually make landfall, an average of three or four get close enough each year to cause high winds and heavy rain, leading to flooding. Further variations in rainfall are strongly related to sea surface temperature variations in the Indian Ocean and the Atlantic which may sometimes alter normal tidal patterns.

The second factor is the geography. Mozambique is a 'downstream' country. Nine out of the eleven rivers in Mozambique are trans-boundary rivers. Mozambique is the last riparian country before the rivers discharge into the Indian Ocean. As a result, the quantity and quality of the water resources available to the country is dependent on activities of the upstream countries, the water which caused the most damaging floods originated upstream from other riparian countries: South Africa, Botswana and Zimbabwe. The management of water flows from two major dams, the Cabora Bassa and the Kariba, also has a major impact on flood risks in Mozambique. Early warning and flood control systems for Mozambique are therefore an international issue that involves close collaboration with other countries of the Southern Africa Development Community (SADC). The importance of adapting disaster risk management (DRM) to new climate change situations becomes very apparent when conflicting weather fronts clash, and flooding crosses international boundaries.

Every continent can suffer from devastating floods when rivers run through several countries. In August 2002 a 100-year flood caused by over a week of continuous heavy rains ravaged Europe, killing dozens, dispossessing thousands, and causing huge damage in the Czech Republic, Austria, Germany, Slovakia, Poland, Hungary, Romania and Croatia.

2.2. Event summary of floods 2000 in Mozambique

In January-February of 2000, the Mozambican coast was hit by a series of tropical storms. According to a report of the United Nations Office for the Coordination of Humanitarian Affairs (UNEP/UNCHS 2010) in late January 2000, torrential rainfall caused the flooding of the Incomati, Umbeluzi, and Limpopo rivers in Maputo and Gaza Provinces of Mozambique. Following this, from 4 to 7 February, Mozambique then received the heaviest rains in 50 years. The accumulated rainfall over a three-day period in Maputo Province alone reached 455mm compared to a total rainfall of 549 mm from September 1998 to 31 January 1999.

The extreme rainfall was concentrated in two periods, from 5th to 10th February and from 22nd to 25th February 2000, and was caused by tropical weather systems that moved from west to east over the subcontinent (Dyson 2000). The combination of the two systems and high levels of soil saturation from an already wet December resulted in excessive flooding (Van Biljon 2000).

The most severe of the tropical weather systems was cyclone Eline, which followed cyclone Connie (Kwabena at al. 2007). Eline made landfall on February 22nd, moving over the headwater basins of the Limpopo River and causing record amounts of rainfall. The historically high rainfall from Eline, coupled with saturated soil conditions due to the passage of Connie, produced a flood wave in the lower regions of the Limpopo basin.

From 21 to 22 February cyclone Eline hit the Inhambane and Sofala Province, and a month later banks burst in Gabo Delgado, North Western Tete Province as flood crests moved down the Zambezi, Save and Buzi Rivers.. Waves of water, reaching up to three meters high, descended down the river and flooded the whole city of Chokué and the commercial area of Xai-Xai City both in Gaza Province. The Save River was also flooded by water from Zimbabwe. Further south the towns of Vilanculo and Inhassoro in central Inhambane province were cut off due to flooded roads.

The torrential rain also washed away roads in the north of the country which had not been affected and flooded four villages. These floods destroyed the main road, which runs from the north to the southern part of the country 110 kilometres from the Tanzanian border (UN General Assembly 2000).

2.3. Impacts of floods 2000 on the population and economy of Mozambique

Heavy floods in February and March 2000 had both devastating direct and indirect impacts on the population and economy of Mozambique. The emergency hit a country which is among the 10 poorest of the world, with a poverty index of 70 per cent. It affected 12.1 per cent of the population, that is, 2.04 million people in five provinces; more than 700,000 of them required assistance. Among these, 500,000 were displaced by the floods and temporarily sheltered in over 100 camps set up by the Government. 699 lives were lost. The impact of the floods on all sectors of the economy was enormous: 10 per cent of the cultivated land was destroyed, while 90 per cent of the irrigation structure in the affected areas was damaged. More than 600 primary schools were either destroyed or severely damaged, as were health posts and hospitals. The World Bank estimates that direct losses amount to US $273 million, while lost production amounts to $247 million (UN General Assembly 2000). The principle water system in the capital Maputo was destroyed cutting off the water supply.

Japan Disaster Relief was sent to provide health care to flood-disaster victims for nine days between 16th and 29th March to the Hokwe area of the State of Gaza, in the mid south of Mozambique, where damage was the greatest (Kondo et al 2002). Besides providing care to 2,611 people they conducted an epidemiological study. Infectious diseases were detected in 85% of all of patients, predominantly malaria, respiratory infectious diseases, and diarrhea. Of note they reported the incidence of malaria (28%) with 43% of cases being identified in children aged 1-4. They speculated that malaria had increased by four to five times over non-disaster periods with both the incidence and the risk of infection augmented following the flood. It was reasoned that this increase in infectious disease incidence was due to the heightening of the associated risk factors:

- Increase in population density
- Temporary living conditions
- Degeneration of quality of drinking water

- Physical strength deterioration due to lack of food.

The findings support the hypothesis that in the aftermath of a flood transmission of waterborne disease increases and there are heightened levels of endemic illness.

2.4. Role of key personnel and agencies

In 1999, a new national Government policy on disaster management was formed that created the National Institute for Disaster Management (INGC) with an emphasis on coordination rather than delivery (World Bank 2005). This reflected a shift in aid given by both national and international agencies from emergency response to development following the end of the civil war in 1992. From September 1999, INGC, the National Meteorological Institute (NMI) and the Southern African Regional Climate Outlook Forum (SARCOF) began to warn of weather forecasts indicating an unusually heavy rainy season. In the September-December period, there were a number of front-page articles in the local press repeating that warning. In November 1999, the Minister for Foreign Affairs and Cooperation, accompanied by the United Nations Resident Coordinator held a meeting for the press and the international community to launch the INGC contingency plan for 1999-2000

The Ministry of Health instructed its provincial directorates to prepare for possible floods, illustrating that the protocol was followed in advance; practicing the now known wisdom that DRM is facilitated by anticipatory strategies within and between sectors. Contingency stocks of medicines and implementation plans for staff response were developed (UN General Assembly 2000) indicating the process off filtering top-down knowledge to local management levels and some of the general considerations laid out in the Hyogo Framework for Action (HFA) such as:

- The involvement of international cooperation
- An integrated multi-hazard approach to Disaster Risk Reduction (DRR) in all policies is advisable
- Communities and local authorities need to be empowered, the relationship between international and regional agencies needs to be one of cooperation
- Proactive measures need to be taken in order to have an effective programme for Climate Change Adaptation (CCA).

Most people in the affected areas received warnings issued by the water management about the rising river levels in upstream reaches of the Limpopo River and warned people in low-lying areas to move to higher ground. However, the warnings were qualitative in nature, and they failed to convey the magnitude of the event (Kwabena et al. 2007). This scenario has great implications for communication systems and their role in facilitating CCA, as it is through good communication that international and local cooperation occurs, that knowledge transfer and innovation can enhance early warning and cause actions to occur once the warning has been given. Poor communication flow can impede the awareness of risk determinants diminishing the ability to adapt to climate change.

There were problems with the installation and maintenance of in situ gauging equipment due to financial constraints. This is an illustration of a DRM culture that did not embrace prevention and where there was a lack of resources and anticipation, key factors for CCA. In addition, in situ flow and precipitation gauges are often washed away by the very floods they are designed to monitor, and reconstruction of gauges is a common post-flood activity around the world (Asante et al. 2005). By the time the third and largest flood wave arrived, many key stations were already destroyed, leaving Mozambican water authorities with no source of information on the actual magnitude of floodwater. They consequently relied on their knowledge of previous flood events to issue the flood warnings. The 2000 floods turned out to be far more severe than any previous event in living memory, and many areas previously regarded as safe were inundated (Kwabena et al. 2007). The failure of the scientific Early Warning Systems (EWS) led to a reliance on local knowledge, showing how local knowledge needs to be valued and absorbed into DRM policy, but also how this also needs to interplay with reliable scientific tools, as climate change is causing unpredictable magnitudes of effect.

At the request of the Government and the Resident Coordinator, the Office for the Coordination of Humanitarian Affairs fielded a United Nations Disaster Assessment and Coordination (UNDAC) team immediately in response to the 12th February floods. Good international response was tantamount to the response effort, which is part of the HFA, as would have been expected from Mozambique's historical use of aid. The coordination between civil international staff and military personnel from seven countries became a particularly important task of the UNDAC teams, their services during the acute phase of the emergency were invaluable: overall, some 50,000 people were rescued (UN General Assembly 2000).

In February, the Government of Mozambique and the United Nations entities appealed for some $60 million for 300,000 flood victims. The impact of Cyclone Eline drastically increased those requirements, and $130 million was contributed by donors to the relief phase. On 22nd March, the Government and United Nations entities launched a transitional appeal, seeking $100 million of additional emergency assistance for the benefit of more than 600,000 flood victims until the next agricultural season in September. A massive national and international relief operation avoided greater loss of life with 16,500 people rescued by helicopter and aircraft, and over 29,000 rescued by boats (World Bank 2005).

The International Conference on the Reconstruction of Mozambique, organized by UNDP with the Government of Mozambique in Rome on 3rd and 4th May 2000, succeeded in obtaining pledges of $453 million for the reconstruction (UN General Assembly 2000). This conference was the reaction of the international community to the catastrophic flooding having a place in Mozambique in the beginning of 2000.Clearly there was very good cooperation between national structures and international aid although it is not clearly reported whether the reconstruction was planned in accordance to the HFA priorities and with climate change adaptation in mind. Particularly of concern is the issue of empowering local authorities and communities and taking a proactive stance.

Prior to the floods in 2000 Mozambique received a constantly high level of international aid and has a high dependency on foreign financial and developmental assistance. It must be recognized that a significant aspect of the response and recovery after the floods was the positive relationship with donors, hence the quick call for international help.

2.5. Lessons and problems

The enormous material damage and human losses during the floods in Mozambique in 2000 were associated with the following problems:

a) Institutional problems. In 1999 National Policy on Disaster Management in Mozambique marked a shift from a reactive to a proactive approach to disaster management aimed at developing a culture of prevention (World Bank 2005). Previously the national policy was mainly concentrated on disaster response and preparedness as opposed to prevention and mitigation. This illustrates a shift in thinking to accommodate climate change adaptation, so taking the standpoint that extreme weather events will occur, which are not preventable, therefore the response and process of disaster reduction should be the focus. The INGC's role in post-disaster recovery was linked to the mobilizing of resources and ensuring efficient transition between the relief and recovery phases and keeping the ministerial level Coordinating Council for Disaster Management (CCGC) informed of recovery activities. National Policy on Disaster Management did not have the legal backing of a national disaster management plan, although a draft plan was in the pipeline. Prior to the 2000 floods many agencies had allowed their strategy and planning documents for disaster response to lapse. The floods resulted in an updating of their strategy documents and a renewed commitment to disaster preparedness, response, and mitigation. However, there was little specific coverage in these policies for recovery strategies (World Bank 2005). The National Policy on Disaster Management covered the national level, but had not been sufficiently developed at the regional and local level. Training of the population and local authorities to act in emergency situations was insufficient.

b) Technological problems. Before the floods of 2000 active observational hydrometeorological measurement in Mozambique had been rare. Hydrometric measuring instruments and equipment were insufficient and largely outdated, so there was no provision of contingency systems. There was no protection of instruments and equipment from possible damage, and no plan for the timely replacement of equipment and devices. There were no reliable methods for quantitative forecasting of the hydrograph for the river of Mozambique. To ensure the secure, reliable and timely hydrological information during the start and development of flood requires close cooperation with all countries situated within transboundary river basins.

c) Financial problems. Insufficient budgetary resources singled out for the creation, development and maintenance of the National Policy on Disaster Management.

d) *International involvement Systems*. Recovery response was slow and delayed from many donor organizations. There was enormous international input into the recovery and future development process, which shows the value of international cooperation, the sharing of knowledge, financial assistance and support to the government. However the bureaucracy each donor organization had to manoeuvre within combined with the national government systems meant there was slow progress and little coordination. The World Bank, through building in a disaster policy into their funding, managed to fast track the flow of resources, but more external agencies need to put into place similar systems. In the Republic of Korea there is an economic and damage threshold that triggers the release of government aid after a disaster and after Typhoon Maemi a service was developed that allowed a rapid transfer of money to individuals from a recovery fund within 20 days, instead of the usual 90 days.

There was a sense from the community survey conducted by ANSA (Food Security and Nutrition Association – Mozambique) in October/November 2002 (World Bank 2005) that there was little local and regional involvement in programme design and development. Further standard ministry drawings and specifications were used to reconstruct schools and health care facilities. This raises the question of whether reconstruction was considered in terms of CCA and resilience.

2.6. Actions after the floods 2000

International and local coordination

A further limitation highlighted has been the use of international contractors rather than local ones for the reconstruction programmes. However, the ANSA survey did report that in some areas coordination between local authorities and external agencies was good and effective, however this was completely dependent upon the ethos of the individual foreign aid and not in the power of the local authorities.

Further, the report raised the concern that beneficiaries of the recovery aid were very poorly informed about the work and the plans, leading to disempowerment and a lack of ownership by the communities, which resulted in a greater dependency on external agencies. This will build weak local resilience to prevention, response and recovery for future flooding events. The participation that the community had was generally at the level of providing labour and compliance with externally set rules.

There was also a lack of communication and transparency between NGOs and government organizations about planning and finance (World Bank 2005).

After the floods of 2000 and 2001 the Government of Mozambique wanted to move quickly from activities of relief to those of recovery, seeing an opportunity for development, both in terms of improving infrastructure as well as reducing risk and vulnerability. Anticipatory strategies facilitates disaster risk management, and understanding the driving factors of vulnerability will enhance the effectiveness of these strategies, and lead to a better understanding of CCA.

Mozambique's government learned some tough lessons from the devastating floods that hit the country a decade ago. The disaster management plans developed by the government of Mozambique after the floods 2000 may be used as a model for other African countries.

In 2001, the government of Mozambique adopted an Action Plan for the Reduction of Absolute Poverty (PARPA I), which was revised for the period 2006–2009 (PARPA II). Drawn up with the assistance of the World Bank and international donors, it is intended to outline 'the strategic vision for reducing poverty, the main objectives, and the key actions to be implemented, all of which will guide the preparation of the Government's medium-term and annual budgets, programs, and policies' (Foley 2007, The National Action Plan 2001, republic of Mozambique Action Plan 2006). The first version did not give disaster preparedness prominence, only including a short section at the back which made reference to strengthened capacity and improved EWS, but there were no specific indicators or budget allocations. The second version illustrates a greater understanding of the link between poverty, development and disaster risk management. In October 2006, the government adopted a Master Plan, which provides a comprehensive strategy for dealing with Mozambique's vulnerability to natural disasters, covering issues ranging from the need for re-forestation and the development of a national irrigation system to the development of crops that can survive prolonged droughts.

After the floods 2000 Mozambique implemented intensive programs to move people to safe areas. Thus over the past five years about 120,000 families have been resettled.

One of the positive aspects of the recovery was the start of recognition for women. External agencies facilitated their greater involvement in community meetings and reallocated land and housing were registered to acknowledge women's rights. The HFA explicitly lists in its general considerations that a gender perspective must be part of DRM and this may also mitigate some of the social risk factors associated with climate change and disasters.

The infrastructure recovery work was extensive, rebuilding damaged and destroyed parts, usually to a higher standard, and the funding also allowed for the construction of new ones where there were none before.

The 2000 floods demonstrated that extensive recovery activities are possible after a disaster, and unlike many damaging events, the funding for the recovery was pledged and delivered over two years, allowing for a strong recovery period rather than all the funds being used on the relief period.

The country has put in place early warning systems some of which are operated by community members. An example of this is the Búzi Early Warning System (further description below).

For the development of modern preparedness strategies and early warning systems on the international level the South African Weather Service has developed a proposal to set up a regional flash flood warning system that would cover all affected countries within the region which Mozambique will be part of.

Mozambique has developed a strong collaboration between the meteorological services, hydrological services and disaster management teams. The flooding in 2000 killed 700 people. Since then, the government has increased the budgetary allocation for disaster management, put in place early warning systems, and established community-driven rescue systems. When heavy flooding occurred again in the 2007-2008 rainy season, an enhanced level of preparedness is credited with reducing the number of people affected.

Limitations

The ANSA survey found that post-emergency capacity building and training was minimal. Very few organizations worked with communities to identify existing skills, or create opportunities to reestablish and further income sources. There was no mention of work to prepare for the occurrence of further disasters, or to train local communities in appropriate response, as the HFA suggests. The high level recovery plans did include improvements to disaster response, however by 2005 this still had not filtered down to the district or local level, where there was little planning and preparedness, losing the opportunity to build on the positive experiences and respond to any lessons learned or experience gained during the floods. This reinforced the report from the World Bank that there was a gap in the procedures between rapid relief response and long term development.

The overall donor support to Mozambique after the floods was very good; however it was very unevenly distributed across the sectors. The productive and infrastructure sectors were well endorsed (123 and 213 US$ million respectively) however health, social welfare and education were poorly allocated to (90.3 US $ million combined). Factors associated with emergency response such as preparedness, early warning systems, capacity building and vulnerability reduction were the least well funded supported by only 21.9 US$ million (World Bank 2005). This illustrates the need for financial planning to support and lead on DRM by following the Priorities for Action as laid out in the HFA, and that CCA needs to actively invested in.

3. Floods in Mozambique in 2007

3.1. Event summary of floods 2007 in Mozambique

Between December 2006 and February 2007, strong rains across northern and the central Mozambique together with a serious downpour in neighbouring countries, have led to flooding in the Zambezi River basin in Tete, Manica, Sofala and Zambezia provinces. The World Meteorological Organization reported it to be the worst case of flooding since 2000 (WMO Reports 2007).

The 2007 Mozambican floods began in late December 2006 when the Cahora Bassa Dam overflowed from heavy rains on Southern Africa. The dam was discharging water at a rate of 7,000 m^3/s from 7 February 2007. The National Water Directorate increased the discharge rate to 8,400m^3/s, on 9 February, while the inflow into the dam reservoir has increased to 10,000 m^3/s. Due to the continuing heavy rains in Mozambique and neighbouring countries as well as the increased discharge rate at the Cabora Bassa Dam significant flooding was expected in the Zambezi River basin. The hydrological situation was worsened in February 2007 when the Zambezi River broke its banks, flooding the surrounding areas in Mozambique (DREF Bulletin 2007).

Additional flooding has been linked with the approach of tropical cyclone Favio (category 4) which struck the Búzi area on the evening of 22 February 2007. Tropical Cyclone Favio made landfall in Vilankulo District, Inhambane Province and continued through Sofala and Manica provinces. Strong winds and heavy rain caused major damage.

3.2. Impacts of floods 2007 on the population and economy of Mozambique

On 22 February 2007, when cyclone Favio hit southern coast of Mozambique, nine people were killed, 70 people were injured. The heavy rains, strong winds and floods damaged 17 health centres and an estimated 332 classrooms and 38 public administration buildings. It also destroyed drug stocks and medical equipment and affected safe water and sanitation facilities.(UN JCHA 2007). In total, the floods and cyclone caused approximately $71 million in damage to local infrastructure and destroyed 277,000 hectares of crops primarily in Vilanculos, Inhassoro, Govuro, and Masinga districts in Inhambane Province, according to the INGC (U.S. Agency for International Development Bureau for Democracy 2007).

The total number of people affected during the floods in January-February 2007 in Mozambique is estimated to have been between 300,000 and 500,000. The Department for International Development (UK) stated that 163,000 people had been forced to leave their homes due to the flooding, and that an additional 134,000 had been affected by Cyclone Favio (UK Department for International Development 2007) The World Food Program (WFP) states that the floods affected 285,000 people, and the cyclone 150,000 more (WFP Mozambique, 2007). It also reported that 140,000 flood-affected people had been placed in temporary accommodation centres in the Zambezi region, and that an additional 55,500 had moved to expanded resettlement sites established after previous floods. Tens of thousands of people lost their crops less than a month before the harvest, and essential infrastructure, including schools and hospitals, was badly damaged. USAID estimated that 331,500 people had been affected by the flood and 162,770 by the cyclone (USAID Mozambique 2007).

3.3. Role of key personnel and agencies

Activities of local authorities and agencies before and during the floods period in 2007

In 2005-2006 the German Agency for Technical Cooperation (GTZ) developed a simple but effective early-warning system along the River Buzi (Loster et al. 2007). This warning system was adapted to the specific needs and skills of the people. The village officials receive daily precipitation at strategic points along the Buzi river basin. At the same time, they monitor a water level with using of clearly marked gauges on the river. If precipitation is particularly heavy or the river reaches critical levels, this information is passed on by radio. If reports reaching the control centre indicate widespread heavy rainfall, the alarm is raised. Blue, yellow or red flags are raised depending on the flood-alert level and an army of helpers spreads the warning by megaphone. Critical areas are evacuated. This is a good example of a scientific high technology adaptation for DRM that has been tailored to the local community and capability.

During the course of January 2007, it became clear that there was an imminent threat of severe flooding in the Zambezi River basin valley. On 20 January the INGC, which had been monitoring the situation, began to call daily coordination meetings to plan its response:

- **On 26 January**, OCHA issued a regional flood warning which covered Zambia, Malawi and Mozambique.
- **On 30 January**, the INGC deputy director briefed the UN Country Team on preparations for potential flooding.
- **On 4 February 2007**, the INGC issued a formal 'Red Alert' warning that large-scale flooding was anticipated along the Zambezi River basin. The following day the INGC briefed the government's Council of Ministers.
- **On 6 February**, the INGC wrote to WFP requesting support to respond to additional flooding needs.
- **On 7 February** Mozambique's prime minister visited the Zambezi River valley and reported that incountry protocols, actors and resources were being effectively mobilised. She stated that the government, in cooperation with its in-country partners, including the UN, would be able to respond adequately to the flooding. She ordered the army to forcibly evacuate any people who had continued to defy instructions to leave the affected area.
- **On 8 February**, the UN Country Team decided to approach the other internal humanitarian actors to form an ad hoc Humanitarian Country Team. It was also decided to make a Central Emergency Response Fund (CERF) application for the expected floods, and to adopt the 'Cluster Approach' in its humanitarian response. The team asked for assistance from OCHA in Geneva to establish the necessary systems, and an official was immediately dispatched from its Humanitarian Reform Support.
- Active response steps taken: a) enforced evacuation b) resource management in response to warnings and c) international bodies called upon.
- **On 20 February** the district government received a blue-alert storm warning (cyclone approaching within the next 48 hours) advising that severe Tropical Cyclone Favio is on its way. The assessment and prognosis group of the SIDPABB (Inter District Operational Flood Warning System for the Buzi River Basin) is asked to monitor rainfall and water levels along the rivers.
- **On 21 February** the district government received a yellow-alert storm warning from the provincial government, indicating that Favio will arrive in 12 hours. The CENCOE (Disaster Operation centre) district office is advised and accordingly working groups are formed. Using two way radios and the local community and the services of the local council, the heads of the administrative centres and members of the local disaster-prevention committees are instructed to raise the warning flags and alert people to the approach of Cyclone Favio. The local disaster committees of Muchenesa, Inharague, Munamicua, Grudja, Begaja, Inhanjou, Estaquinha and Mamunje raised the warning flags. Following the instructions that are issued, people begin to leave the danger zones and make their way towards previously identified safer zones by their own means.
- **On 22 February** the Buzi district government received a red-alert storm warning from the provincial government.
- Active response steps taken: a) response to working EWS b) use of top down management approach that utilizes local resources and c) respect for warnings followed by appropriate action, unlike in 2000.

- **On 24 February** rainfall on the upper reaches of the River Buzi basin increased in intensity and the water level suddenly raised, exceeded flood-alert levels. The Buzi district government ordered the mandatory evacuation of the populations of five areas of Buzi. Regional Red Cross helpers worked in the local disaster-prevention committees.
- **On 25 February** lower-lying, flood-prone zones in the Buzi district, including parts of the district capital, were completely awash. All access roads to Buzi itself were cut off. On the assessment of Sergio Sional Moiane, head of the district government responsible for the Buzi: “The losses are dramatic but, without the disaster prevention programme, things could have been much worse”(Loster et al. 2007).

Activities of international organizations and humanitarian agencies

As a result of the flooding and cyclone, humanitarian agencies are concerned about the potential for outbreaks of water- and vector-borne diseases, such as malaria, cholera, and acute diarrhea. The U.N. Children’s Fund (UNICEF) and the International Federation of Red Cross and Red Crescent Societies (IFRC) raised public awareness through health campaigns that included radio messages, community theatre performances, and promotional material on good hygiene practices. To address the increased risk of vector-borne diseases USAID/OFDA provided $626,500 for the procurement and transportation of 50,000 insecticide-treated mosquito nets to flood-affected populations. In all flood- and cyclone-affected provinces, the INGC, international NGOs, and U.N. agencies are responding to water, sanitation, and hygiene concerns through the distribution of Certeza, a locally produced water purification product. To mitigate the spread of disease, the U.N. Population Fund, in coordination with the GRM’s Ministry of Health, has distributed hygiene kits in accommodation centers. These are all good examples of international cooperation for health protection.

To address emergency food needs, UNICEF provided food assistance to 110,000 people in flood-affected areas along the Zambezi River and 32,000 people in cyclone-affected areas in southern Mozambique. In addition, WFP is providing food assistance to 140,000 people in Tete, Manica, Sofala, and Zambezia provinces and 67,000 people in cyclone-affected Inhambane Province.

In response to previous and recurrent flooding in Mozambique, the INGC has established accommodation and resettlement centers to provide temporary shelter to flood-affected families. To meet the basic needs of displaced populations, IFRC are distributing emergency relief supplies, including tarpaulins, tents, sleeping mats, water containers, soap, and ITNs, to more than 23,000 families.

4. Summary and Conclusions

In 2000 when a cyclone hit the coast, the country descended into a humanitarian crisis. In all, 800 people lost their lives and hundreds of thousands were left homeless. In 2007, the death toll was far smaller, at 29 people. Although the floods of 2007 were less severe than those of 2000, another factor explained the difference in the number of fatalities: in 2007, Mozambique was prepared. Well before the floods came in 2007, the INGC was putting measures in place to deal with them. An early warning system alerted the Institute in October to the likelihood of intense rains, and by December actions were being taken on the ground. Supplies of food and medical items were stockpiled, vulnerable people were evacuated to safer areas and a network of local centres was set up to coordinate emergency operations. When the floodwaters began to rise, the effects were devastating, and the international community rallied to provide aid, but a crisis similar to that of 2000 was averted. A rapid flow of information is the essence of disaster prevention. The first communication centre was established by Telecoms Sans Frontieres (TSF) at the NDMI office in Caia District on 15th February. This centre was used by the different organisations working in the area such as Oxfam, World Vision, Red Cross, WFP, UNICEF.

The Red Cross, USAID and other organisations worked hard to distribute basic commodities, foods and medical assistance during the emergency period. The coordination between the Mozambican government represented by the NDMI and the partner organizations improved during the emergency period. Different government agencies and Non Governmental Organizations (NGOs), UN agencies were involved in emergency operations. The NDMI prepared the population with an early warning system, emergency aid centres and coordination channels which can be considered to have been effective during the flood event. The role of NGOs and other government partners was crucial in the success of the disaster management.

After the 2000 floods national and international organizations updated their strategies to include disaster preparedness, risk management, contingency and response capacities. However the World Bank reports that there was little engagement with the communities to carry out vulnerability assessments on which to build the mitigation plans.

Institutional memory can be short when commitment to disaster reduction is not prioritized or maintained, as the disastrous effects of the collapse of the Kolka Glacier in 2002 showed, it was not expected for 30 years, so it was neither prepared for nor responded to adequately. In the case of Mozambique this commitment was not only determined by national authorities but was greatly dependent on and determined by, external agency commitment, which may wane as other priorities emerge post-disaster.

Other impacts exist from a disaster such the diversion of funds to the relief effort away from longer term development programmes; and monitoring and evaluation of the impact of the disaster on existing programmes and on the relief and recovery efforts are under prioritized.

The dependency on international agencies in 2007 in Mozambique was as heavy as it was in 2000 however the balance of control seemed to have changed, the national and regional centres having taken more responsibility, creating a much more controlled and effective response.

CCA is constrained by limited coordination and collaboration with DRM. As the example of Mozambique shows the better the DRM the more able we are to cope with the effects of climate change. Effective learning and DRM improvements made post-disaster can lead to better CCA and an improved response and reduction in risk to the next disaster.

CCA needs to be achieved through the understanding of vulnerability in all sectors (social, infrastructure, production and environmental) and this knowledge needs to be used for the formulation of preparedness and response mechanisms.

The government in Mozambique introduced new DRM structures between 2000 and 2007 illustrating the flexibility needed to accommodate the scientific and communication systems that need to be in place to adapt to a CC driven disaster; and that this can be done in liaison with and with guidance from external agencies. However, this process needs to be iterative, and as importantly, needs to consider, learn from, and employ local knowledge and expertise for effective implementation and success.

To access this local resource it may be that endemic vulnerabilities and cultural practices need to be addressed, such as the education of women, as vulnerability is exacerbated by poor human development, which can in turn be worsened by the impact of a flood.

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Case Study 9.6. Drought, Heat Wave, and Black Saturday Bushfires in Victoria

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1. Introduction

Fires are extreme phenomena, which means that infrequent dangerous weather and climate situations can lead to major fire related disasters in spite of the huge efforts to increase fire fighting capacity and disaster risk management. Increased heat waves and droughts, and higher temperatures, particularly maximum temperatures, will very likely increase the frequency of extreme fire danger conditions and with it the probability of fire, particularly of large fires (Vázquez and Moreno 1993; Piñol et al. 1998; Viegas 1998; Pausas 2004; Trigo et al. 2006; Australian Government 2009[8]). Episodes such as in the Spanish Levant in 1994, the Republic of Korea in 2000, Portugal in 2003 and 2005, Greece in 2007 and the Australian state of Victoria and its capital Melbourne in 2009 mark unprecedented records. In addition, the increase of the ignitions in the proximity of human settlements and encroachment by vegetation of rural areas can have disastrous consequences, as attested by some of the most devastating multiple fire episodes. During the second half of the 20th century, as unproductive land was abandoned and people moved to the cities, fires became more frequent and widespread.

[INSERT FOOTNOTE 8 HERE: The final report from the Australian Government is expected in July 2010 and this report will be updated dependent on that report.]

In this case study, risk and impacts in Victoria and response actions to reduce risk and damages regarding on drought, heat wave and fires are presented for cases in Melbourne and the state of Victoria. The cases of fire in Europe and Republic of Korea are also described to find similarity of risk and impact of fire in other regions and good response action or early warning system and management system. The relationship between extreme events such as drought, heat wave and fires and climate change; and information and warning system, decision-making abilities and GIS based risk management on disaster risk reduction are also summarized. For reducing potential impact of wildfires and landslides on burned areas and adapt climate change, land-use and land cover changes, post-fire vegetation recovery and recovering ecosystem resilience are also discussed.

2. Victoria and Melbourne Case

2.1. Meteorological backgrounds

Victoria has a varied climate despite its small size which it ranges from semi-arid and hot in the north-west, to temperate and cool along the coast. Air from the Southern Ocean helps reduce the heat of summer and the cold of winter. Melbourne and other large cities are located in this temperate region. The Mallee and upper Wimmera are the warmest regions with hot winds blowing from nearby deserts. Average temperatures top 30 °C during summer and 15 °C in winter and the highest maximum temperature of 48.8 °C was recorded in Hopetoun on 7 February (Bureau of Meteorology 2009). The Victorian Alps in the northeast are the coldest part of Victoria. Average temperatures are less than 9 °C in winter and below 0 °C in the highest parts of the ranges with the lowest minimum temperature of –11.7 °C at Omeo on 13 June 1965 and again at Falls Creek on 3 July 1970 (Bureau of Meteorology 2009). Victoria is the wettest Australian state, after Tasmania, where rainfall increases from north to south, with higher averages in areas of high altitude. Median annual rainfall exceeds 1,800 mm in some parts of the northeast but is less than 250 mm in the Mallee. Rain is heaviest in the Otway Ranges and Gippsland in southern Victoria and in the mountainous northeast. Snow generally falls only in the mountains and hills in the centre of the state. Rain falls most frequently in winter, but summer precipitation is heavier. Highest recorded daily rainfall in Victoria was 375 mm at Tanybryn in the Otway Ranges on 22 March 1983 (Bureau of Meteorology, 2009).

2.2. Geological backgrounds

Victoria is the second most populous state in Australia and has a highly centralised population with over 70% of Victorians living in Melbourne. Victoria's northern border is the southern bank of the Murray River which also rests at the southern end of the Great Dividing Range, stretches along the east coast and terminates west of Ballarat. It is bordered by South Australia to the west and shares the shortest land border with Tasmania. Victoria contains many topographically, geologically and climatically diverse areas, ranging from the wet, temperate climate of Gippsland in the southeast to the snow-covered Victorian alpine areas which rise to almost 2,000 m with Mount Bogong the highest peak at 1,986 m. The Alps are part of the Great Dividing Range mountain system extending east west through the centre of Victoria. There are extensive semi arid plains to the west and northwest. There is an extensive series of river systems in Victoria such as Murray River, Ovens River, Goulburn River, King River, Campaspe River, Loddon River, Wimmera River, Elgin River, Barwon River, Thomson River, Snowy River, Latrobe River, Yarra River, Maribyrnong River, Mitta River, Hopkins River, Merri River and Kiewa River system.

In 2006, there were 8.3 million hectares of forest in Victoria covering 36% of the State. This included 7.8 million hectares of native forest, which accounted for 95% of the total forest area, and 441,000 hectares of plantations. Eucalypt forest types accounted for 93% of Victoria's total native forest area. The most common eucalypt forest types were eucalypt medium open, mallee woodland, eucalypt tall open, and eucalypt medium woodland. The most common non-eucalypt forest type was casuarina which accounted for 2% of the total native forest. There was 619,000 hectares of old-growth forest in 2006, or 11% of the total eucalypt forest assessed. Fire is the main threat to old-growth forest in Victoria, with bushfires destroying over 100,000 hectares of old-growth between 2003 and 2006. A total of 145 forest dependent fauna species have been identified as threatened or extinct in Victoria. This includes 9 extinct, 10 regionally extinct, 19 critically endangered, 31 endangered, 37 vulnerable and 39 near threatened species. Fire is an important part of many forest ecosystems in Victoria. Much of Australia's flora and fauna has evolved with fire and rely on particular fire regimes for continued survival. Since European settlement, the timing, frequency and intensity of fires have changed. These changes can significantly impact on the health of Victoria's native forests.

2.3. Event summary

During this period, there had been areas with very little above average rainfall but most of Victoria received either below or well below average rainfall. Victoria has experienced a decline in average rainfall of 14 % (DSE 2008). A large portion of southern Victoria, notably the area that surrounds Melbourne, received the lowest rainfall on record.

A heat wave commenced in late January of 2009 and led to record-breaking prolonged high temperatures in the southeastern Australia region. The highest temperature recorded during the heat wave was 48.8 °C in Hopetoun, Victoria, a record for the state (National Climate Centre 2009). While Adelaide and Melbourne cities broke records for the most consecutive days over 40 °C, Mildura, Victoria recorded an all time record 12 consecutive days over 40 °C. The exceptional heat wave was caused by a slow moving high-pressure system that settled over the Tasman Sea, with a combination of an intense tropical low located off the North West Australian coast and a monsoon trough over Northern Australia, which produced ideal conditions for hot tropical air to be directed down over Southeastern Australia (National Climate Centre 2009). The heat began in South Australia on 25 January but became more widespread over southeast Australia by 27 January. A weak cool change moved over the southern coastal areas bringing some relief on January 30 (National Climate Centre 2009) including Melbourne, where the change arrived that evening, dropping temperatures to an average of 30.8 °C. Over the five days, 27–31 January 2009, maximum temperatures were 12–15°C above normal over much of Victoria (see Figure 9-1).

[INSERT FIGURE 9-1 HERE:
Figure 9-1: Maximum temperature anomalies for the period 27–31 January 2009.]

The temperature was above 43°C for three consecutive days from 28–30 January reaching a peak of 45.1°C on 30 January 2009. At the time, Melbourne's maximum temperature of 45.1°C on 30 January 2009 was the second-highest on record behind 45.6°C on 13 January 1939 (subsequently surpassed on Saturday 7 February 2009, which reached 46.4°C). Overnight temperatures were also extremely high with Melbourne Airport's minimum of 30.5°C on the 29th January only 0.4°C short of the Victorian record. The extremely high day and night temperatures combined to make a record high daily mean temperature of 35.4°C on 30 January with average of maximum day and minimum night temperature in Melbourne which daily mean temperature has exceeded 35°C was the first time (State Government of Victoria 2009). The heat wave generated extreme fire conditions during the peak of the 2008-09 Australian bushfire season, causing many bushfires in the affected region, contributing to the extreme bushfire conditions on February 7, also known as the Black Saturday bushfires. A study by the Australian Bureau of Meteorology and the CSIRO which found that fire-weather risk is likely to increase at most sites considered from 2020 to 2050 was cited in support (Hennessy et al. 2009).

The Black Saturday bushfires were a series of bushfires that ignited or were burning across the Australian state of Victoria on and around Saturday 7 February 2009 during extreme bushfire-weather conditions, resulting in Australia's highest ever loss of life from a bushfire. As the day progressed, all time record temperatures were being reached, 46.4 °C in Melbourne and humidity levels dropped to as low as 6%. The McArthur Forest Fire Danger Index reached unprecedented levels, ranging from 120 to over 200. This was higher than the fire weather conditions experienced on Black Friday in 1939 and Ash Wednesday in 1983 (Bureau of Meteorology 2009). By midday, wind speeds were reaching their peak of 120 km/h and power lines were felled in Kilmore East by the high winds, sparking a bushfire that would later generate extensive pyrocumulus cloud and become the largest, deadliest and most intense firestorm ever experienced in Australia's post-European history. The overwhelming majority of fire activity occurred between midday and 7 pm, when wind speed and temperature were at their highest and humidity at its lowest.

2.4. Impacts

Drought

The most significant and inherent risk in drought is insufficient water supply for Melbourne. It is positive that Melbourne residents are aware of the scarcity of potable water and have made significant reductions in consumption in recent times. The water restriction regime of Melbourne has helped manage the significant drought issues of recent years. Central Australia has warmed 1.5 – 2.0 °C over the last century (State Government of Victoria 2009). Over the last 12 years from 1998 to 2009, Victoria has experienced warmer than average temperatures, and the last decade has been the warmest on record, breaking records going back 154 years (State Government of Victoria 2009; Parliament of Victoria 2009). During the same period, there has been very little above average rainfall and most of Victoria received either below or well below average rainfall which Victoria has experienced a decline in average rainfall of 14 % (DSE 2008). A large portion of southern Victoria, notably the area that surrounds Melbourne, received the lowest rainfall on record. The same has been experienced in western Victoria (State Government of Victoria 2009). The whole of south-east Australia suffered a severe and protracted drought which is without historical precedent (. In central Victoria the 12-year rainfall totals have been around 10 to 20 % below the 1961–90 average and 10 to 13 % below the lowest on record for any 12-year period prior to 1997 (State Government of Victoria 2009). Across Victoria the average annual rainfall during this drought has been 555 mm, compared with a long-term average (1961–1990) of 653 mm (Australian Government 2009). Rainfall deciles for January and February 2009 indicate that both months are very much below average (Australian Government 2009). Decreased water supply along with warmer temperatures is likely to increase drought risk and severity (CSIRO, 2007). As droughts become more severe fire risk is expected to also become greater. The key adaptation measures are considered to provide benefits across drought risks, this is storm water harvesting. This can assist in both flash flooding events and with insufficient water supply. As storm water volume in Melbourne is almost equal to potable water consumption, this is a valuable resource. Additional capacity in storm water harvesting can also put less pressure on drainage systems during intense rainfall events.

Heat Wave

Mortality during heat waves can be difficult to measure, as deaths tend to occur from exacerbations of chronic medical conditions as well as direct heat related illness, particularly in the frail and elderly. Excess mortality provides a measure of impact, but does not provide information specifically on underlying cause of death. The heat wave has clearly had a substantial impact on the health of Victorians, particularly the Elderly (National Climate Centre 2009; Parliament of Victoria 2009). For the week of the heat wave, 26 January to 1 February 2009, 25% increase in total emergency cases and a 46% increase over the three hottest days; 34 fold increase in cases with direct heat-related conditions; 2.8 fold increase in cardiac arrest cases; almost 4 fold increase in attendances for direct heat related conditions and almost 2 fold increase in calls to attend a deceased person. Emergency Department report that 12% overall increase in presentations, with a greater proportion of acutely ill patients and a 37% increase in those 75 years or older; 8 fold increase in direct heat-related presentations and almost 3 fold increase in patients dead on arrival (State Government of Victoria 2009; Parliament of Victoria 2009). For the total all-cause mortality, there were 374 excess deaths which a 62% increase in total all-cause mortality. The total number of deaths was 980, compared to a mean of 606 for the previous 5 years. Included in these total deaths were 179 deaths reported to the State Coroner's Office; a 77% increase from the 101 deaths reported for the same period in 2008. Reportable deaths in those 65 years and older were more than doubled (State Government of Victoria 2009; Parliament of Victoria 2009). Khalaj, et al. (2009) identified several main diagnoses and underlying conditions for emergency hospital admission that are particularly susceptible to extreme heat events which can contribute directly to establishing health programmes that would effectively target those with higher relative risk of emergency hospital admission due to extreme heat.

Black Saturday Bushfires

A total of 173 people were confirmed to have died and total of 414 people were injured as a result of the Black Saturday bushfires (Australian Government 2009). Of the people who presented to medical treatment centres and hospitals, there were 22 with serious burns and 390 with minor burns and other bushfire-related injuries. The fires destroyed over 2,030 houses, more than 3,500 structures in total and damaged thousands more. The fires destroyed almost 430,000 hectares of forests, crops and pasture, more than 2,000 properties and over 55 businesses (Australian Government 2009). Three primary schools and three children's services were destroyed with 47 primary schools partially damaged or requiring cleaning. The fires also destroyed over 10,000 km of fencing such as private, road and Crown land boundaries, and internal fencing were destroyed. Over 11,000 farm animals were killed or injured and over 3,550 agricultural facilities including dairies, around 211,000 tonnes of hay, wool and machinery sheds were affected by the fires. The fires affected 70 national parks and reserves, 950 local parks, 467 cultural sites, more than 200 historic places and disrupted electricity supply to 60,000 households (Australian Government 2009). Many towns north-east of the state capital Melbourne were badly damaged or almost completely destroyed, including Kinglake, Marysville, Narbethong, Strathewen and Flowerdale. Many houses in the towns of Steels Creek, Humevale, Wandong, St Andrews, Callignee, Taggerty and Koornalla were also destroyed or severely damaged, with several fatalities recorded at each location. The fires affected 78 individual townships in total and displaced an estimated 7,562 people, many of whom sought temporary accommodation, much of it donated in the form of spare rooms, caravans, tents and beds in community relief centres. Millions of animals are estimated to have been killed by the bushfires. Additionally, of the surviving wildlife, many more have suffered from severe burns. The affected area, particularly around Marysville, contains the only known habitat of Leadbeater's Possum, Victoria's faunal emblem. Forested catchment areas supplying five of Melbourne's nine major dams were affected by the fires, with the worst affected being Maroondah Reservoir and O'Shannassy Reservoir[9]. As of 17 February, over ten billion litres of water had been shifted out of affected dams into others. In early March 2009, smoke from the fires was discovered in the atmosphere over Antarctica at record altitudes[10]. The provision of health care to the injured, and then to the displaced communities, was provided by a range of health professionals, including paramedics, nurses, and doctors (Moloney 2009).

[INSERT FOOTNOTE 9 HERE: http://en.wikipedia.org/wiki/Black_Saturday_bushfires - cite_note-age_dash_save_water-166]

[INSERT FOOTNOTE 10 HERE: http://en.wikipedia.org/wiki/Black_Saturday_bushfires - cite_note-168]

2.5. Government aid

About 3582 firefighting personnel were deployed across the state on the morning of 7 February in anticipation of the extreme conditions (Department of Innovation 2009). The Victorian Bushfire Reconstruction and Recovery Authority was established three days after Black Saturday to oversee and coordinate the largest recovery and rebuilding program Victoria has ever faced. Responses to the Black Saturday bushfires included immediate community response, donations and later, international aid efforts, Government inquiries including a Royal Commission and recommendations and discussions from a wide variety of bodies, organisations, authorities and communities. Local government is a significant player in regulating and supporting townships and communities under their jurisdiction. Municipal councils to have a preventative role in leading and contributing to some initiatives aimed at helping to make their communities safer and to protect people during bushfires was recommenced after bushfires. The Commonwealth plays an important role in supporting the states and territories, particularly in the recovery phase. It continued this role after the 7 February bushfires, with considerable assistance, particularly from the Australian Defence Force.

Several of these responses are currently ongoing as of September 2009. Australia's most prominent fire ecologist, Kevin Tolhurst, is developing a new course for the University of Melbourne on fire behaviour. Later that month the City of Manningham announced it was developing the state's first integrated fire management plan in conjunction with the interim findings of the Royal Commission. Eventually all Victorian councils responsible for both urban and rural land will need to develop such plans, which define fire risks in open space areas, along major roads, and in parkland. In September/October 2009, it was announced that a new fire hazard system would replace the previous one. The new system involves a 6-tier scale to advise those in affected areas of the level of risk, activity of the fire, etc. On the highest risk days, residents will be advised to leave the potentially affected areas (Department of Innovation 2009).

3. Fires in Europe

Annual temperatures are projected to increase in southern Europe and the Mediterranean (SEM) more than the global average (IPCC 2007; Moreno et al. 2010). Maximum temperatures are also likely to increase more than average or minimum temperatures (IPCC 2007; Moreno et al. 2010). Annual precipitation is very likely to decrease in most of SEM, and the number of wet days is very likely to decrease. The number of dry spells and the risk of drought are likely to increase in SEM, notably in southern Europe (Lehner et al. 2006). By 2030 Melbourne is expected to likely be significantly affected by warmer temperatures and heat waves, lower rainfall, intense storm events and flash flooding (CSIRO 2007). Every year, approximately 50.000 fires are recorded in Europe, mainly in SEM, where they burn 0.5 MHa (San Miguel and Camia 2009). Despite similar or even more dangerous climatic conditions in the countries of the southern rim of the Mediterranean Sea, or in part of the Anatolian Peninsula, fires in these areas are fewer (Dimitrakopoulos and Mitsopoulos 2006), although Turkey suffered the largest fire in their historical records in 2008, amounting some 20,000 ha. By the late 1960’s wildfires started to occur at an increasing rate in all countries of the European Community (Alexandrian and Esnaut 1998). Area burned increased during the 1970’s and into the 1980’s, by which time Spain and Italy had reached maximum values (Moreno et al., 2010). Greece and Portugal followed suit with some delay. During this decade of transition none of the northern African countries or Turkey experienced a similar increase. Fires became more frequent during the second half of the 20th century, but also more widespread. In general, the number of large fires seems stable (San Miguel and Camia 2009), in some areas is increasing (González and Pukkala 2007). In Bulgaria, the warm and dry conditions led to 1,400 wildfires that consumed more than 58,000 hectares, destroying 73 homes. Greece also suffered from hundreds of fires during the height of the heat wave, particularly on Samos, where fire consumed one-fifth of the island.

4. Fires in Republic of Korea

The landscape of Republic of Korea is divided into five ecoprovinces, 16 ecoregions and 120 ecodistricts (Shin and Lee 2004). The Gangwon ecoregion is located in the centre of the east coast of the Republic of Korea. It is characterized as dry and very windy in spring, and is very susceptible to forest fires. In 1996, this ecoregion experienced the largest forest fire ever recorded to that time; 3762 ha of forestland were burned. The forest fire, six times bigger than fire of 1996, was occurred in Gangwon ecoregion in 2000. After the forest fire in 2000 resulted from drought, 23,448 ha of forest area rapidly burned over 9 days due to propagation under heavy winds, with a maximum instantaneous wind speed of 25 m/s (Kim et al. 2008) in Gangwon Province of Republic of Korea. The Gangwon Province are mainly composed of flammable pine trees, comprise 81% of the entire forested area (Lee et al. 2004). Therefore, this area is subject to increased risk of forest fires. The dry and windy climate caused by foehn winds during spring, and high-density planting on steep slopes of Gangwon Province, can accelerate flame propagation over a wide area. This fire increased landslides related damages increased annual precipitation, most notably from Typhoon RUSA in 2002. According to Lee et al. (2004), soil erosion and sediment outflow is significant within 1–2 years after a forest fire, and it takes about 2 years to stabilize conditions with vegetation settlement in the burned area. Chun et al. (2003b; 2003c) reported that sediment disasters in mountainous areas of Korea can be caused by factors such as forest fires, road construction, abandoned mining, devastated cemeteries, logging, and debris flow.

5. Lessons from Drought, Heat Wave, and Fires

The Victorian Government identified the need to respond to predicted heat events in the Sustainability Action Statement released in 2006 which committed to a Victorian Heat wave Plan involving communities and local government. As a part of this strategy the department has established a heat alert system for metropolitan Melbourne and is undertaking similar work for regional Victoria. A series of pilot projects have been undertaken engaging local government to develop heat wave plans that could be integrated with existing local government public health and/or emergency management plans. One of the outcomes of these pilot projects will be the production of a toolkit to assist local councils in the preparation of heat wave response plans over the period 2009 - 2010. State Government of Victoria (2009) reported that prepare for such heat wave events has resulted in the documentation of heat wave plans such as the heat wave plan for England, “Protecting Health and Reducing Harm from Extreme Heat and Heat waves (Heat wave Plan for England 2008)” and the Californian “Contingency Plan for Excessive Heat Emergencies (Contingency Plan for Excessive Heat Emergencies, 2008).”

The Victorian government intends to debate new fire related planning and building code standards. In response to the Victorian bushfires new building regulations for bushfire-prone areas have been fast tracked by Standards Australia (Bustos 2009). Victoria has no separate building code for bushfire-prone areas. In New South Wales building laws for bushfire-prone areas are incorporated in planning legislation using a 817 °C level as the assumed temperature to which houses are subject when hit by bushfire. A draft national building code for bushfire-prone areas is proposing to use 27 °C as the standard. The system integrates GIS technologies under the same data environment and utilises a common user interface to produce an integrated computer system based on semi-automatic satellite image processing (fuel maps), socio-economic risk modelling and probabilistic models that would serve as a useful tool for forest fire prevention, planning and management (Bonazountas, et al. 2007).

In Victoria, community response to bushfire is guided by a policy that directs residents to Prepare, Stay and Defend or Leave Early, known more commonly as the ‘stay or go’ policy. This policy has been developed over many years and reflects an understanding from research into past fires that with proper planning and prior preparation, most buildings can be successfully defended from a bushfire. Prior to 7 February the State Government devoted unprecedented efforts and resources to informing the community about the fire risks Victoria faced. That campaign clearly had benefits, but it could not, on its own, translate levels of awareness and preparedness into universal action that minimised risk on the day of the fires. This is a shared responsibility between government and the people. However, there were a number of weaknesses and failures with Victoria’s information and warning systems on 7 February. Relying on local knowledge, in combination with fire managers' decision-making abilities, could improve fire management options and reduce wildfire suppression costs and ecological disasters (Kalabokidis et al. 2008).

Fire occurrence may be linked to not only particular abiotic or human factors but also land-use and land-cover experienced. Fires do not burn at random the vegetation (Nunes et al. 2005) and also have preference for certain topographic locations, or distances to towns or roads (Mouillot et al. 2003; Badia-Perpinyà and Pallares-Barbera 2006; Syphard et al. 2009). In the case of the Greece fires in 2007, the risk of causalities and of direct damage to homes and infrastructures is very high in these areas of that natural vegetation is invading the old fields and getting close to the houses. In Spain, the types of vegetation burned have been changing, from more wooded dominated areas to shrub-land dominated areas (Pausas and Verdú 2005; Pausas et al. 2006). This fact, in combination with other long-term anthropogenic disturbances, may cause further fire-induced degradation beyond the resilience domain of Mediterranean ecosystems. As a consequence of this long-term human impact, most of the Mediterranean basin is now regarded as ‘degraded’ (TNC 2004). Post-fire vegetation recovery is important in itself but also because it is a major factor controlling post-fire erosion and flash flood risk (Vallejo and Alloza, 1998). High soil erosion rates are irreversible at the ecological time scale; therefore, it is a major potential impact of wildfires. Recovering ecosystem resilience in those abandoned lands would thus require breaking degradation loops and promoting secondary succession towards more mature, more resilient plant communities (Vallejo and Alloza 1998). Restoration has no easy models to use them as a reference, and many ideas need to be revisited at the light of new paleo-ecological evidence. Given the threats of changes in fire and other climate and global changes over the values at hand, not the least its distinct and rich biodiversity, the challenge of conserving these territories under the ongoing climate and land-use/land cover changes and other global changes is paramount (Fischlin et al. 2007).

By 2030, average annual temperatures are expected to rise by 0.6 to 1.1°C with slightly more warming in summer and less warming in winter and the average stream flow is likely to drop 3 - 11% by 2020 and 7 - 35% by 2050 in Melbourne (CSIRO 2007). Melbourne is expected to accommodate unprecedented population growth to become Australia’s largest capital city by 2030 and include a doubling of the population within the City of Melbourne (Australian Government 2009). The two most significant extreme events for Melbourne likely to be exacerbated by climate change are heat waves and intense rainfall events. While drought and sea level rise also have critical risks, these two priority events can have significant and devastating effects for Melbourne. There are also increasing public health issue driven by increasing numbers of vulnerable elderly and the increasing heat island effect resulting from progressive urbanization in Melbourne (State Government of Victoria 2009). Already a health issue for Melbourne, the most significant risk is the likely increased levels of heat stress and death caused by extreme temperatures and fires. Kolbe and Gilchrist (2009) reported that the health effects of particulate exposure from bushfires and these exposures are likely to increase. High rates of health effects may be experienced by populations exposed to bushfire smoke pollution. Less concerning, but still significant, risks are the potential for food borne disease in the warmer conditions, and the increased maintenance costs to support assets and infrastructure under the more extreme heat conditions.

6. Conclusions

Over the last 12 years from 1998 to 2009, Victoria has experienced warmer than average temperatures and the last decade has been the warmest on record and rainfall totals of around 10 to 20 % below the 1961–90 average. Rainfall deciles for January and February 2009 indicate that both months are very much below average. Decreased water supply along with warmer temperatures is likely to increase drought risk and severity. The January 2009 heat wave has clearly had a substantial impact on the health of Victorians, particularly the elderly. There were two major episodes of exceptional high temperatures, from 28-31 January and 6-8 February, with slightly lower but still very high temperatures persisting in many inland areas through the period in between. There were 374 excess deaths over the January 2009 Victorian heat wave. After heat wave in 2009, a series of pilot projects have been undertaken engaging local government to develop heat wave plans that could be integrated with existing local government public health and/or emergency management plans. The Victorian government intends to debate new fire related planning and building code standards.

Fire occurrence may be linked to not only particular abiotic or human factors but also land-use and land-cover experienced. The heat wave generated extreme fire conditions during the peak of the 2008-09 Australian bushfire season, causing many bushfires in the affected region, contributing to the extreme bushfire conditions on February 7, also known as the Black Saturday bushfires. Soil erosion and sediment outflow is significant within 1–2 years after a forest fire, and it takes about 2 years to stabilize conditions with vegetation settlement in the burned area. Post-fire vegetation recovery for more resilient plant communities and land-use/land cover changes are important in itself but also because it is a major factor controlling post-fire erosion and flash flood risk. Local government is a significant player in regulating and supporting townships and communities under their jurisdiction. Translate levels of awareness and preparedness into universal action is important to minimize risk on the fires. Improving of relying on local knowledge in combination with fire managers' decision-making abilities are required to reduce wildfire suppression costs and ecological disasters. The system integrates GIS technologies under the same data environment and utilises a common user interface to produce an integrated computer system based on semi-automatic satellite image processing, socio-economic risk modelling and probabilistic models that would serve as a useful tool for forest fire prevention, planning and management.

This complex incident points to the many issues driving extreme events and the need for deep understanding of disaster risk reduction focusing on management in order to prepare for and minimize the impact of climate change in the future.

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Case Study 9.7. Dzud of 2009-2010 in Mongolia

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1. Introduction

The most complex and long lasting phenomenon of the cold that causes real disaster for nomadic pastoralism is a Dzud. The widespread deaths of both domestic and wild animals occur in Dzud because of hunger, freezing and exhaustion. Dzud also represents a high risk to health and livelihoods of the herders, economy of the country. The larger the scale and the longer the duration of Dzud, the higher the mortality of the livestock and greater negative impacts on socio-economy [AIACC AS06, 2006]. Dzud mainly is started with summer drought, followed by ice cover in autumn and sudden spurts of heavy snowfall, long-lasting or frequent snowfall, extremely low temperatures in winter, and drifting windstorms in spring that reduce or prevent animals from grazing on pasture [Dzud 2000]. The Mongolian term Dzud denotes unusually difficult winter conditions which result in the death of a significant number of livestock over large areas of the country, a disaster Irrespective of the type of Dzud identified, Mongolian herders included in the term both the exposure to difficult weather, and the impacts thereof [Marin 2008, 2010].

2. Storm, Cold, and Snowfall

In winter of 2009-2010, the total of 81 percent of country territory was with heavy snowfall, extreme cold and snow storms, and total 97.5 thousand or (57 percent of country all) herders' households with their livestock were hit by Dzud [Mongolia Prime Minister S.Batbold speech at the Parliament, 2010b]. In February the northern part of Mongolia was colder by 3.0-6.3oC compare with climatic norms. By the end of February 90 percent of country was under snow. Snowfall was more than climatic norms, and 30-49 cm of snow was covered 40 percent of country territory [Jigmiddroj, 2010].

Drought is a pre-condition of Dzud. The summer 2009 60 percent of country was under drought and pasture was overgrazed and hay making for winter forage reserve was limited. Preparedness to winter of both herds and the herders was not appropriate - animals could not get sufficient fat and the herders could not prepare sufficient forage. In addition, winter pasturing was difficult because of snowdrift was dense and hardened, in some places with covered with ice crust [Jigmiddorj, 2010].

3. Impacts

By official information, total 8.1 million heads of livestock was lost during winter of 2009-2010. Impact of Dzud 2010 by end of April was that total 8711 households lost all their animals, 32756 households lost more than half of their animals, and more than 1400 households migrated from rural area to towns for surviving and seeking for job opportunities. [Batbold, 2010a]. Because of need for additional forage and other necessities to overcome severe winter the herders took loan from commercial banks. Nearly 41 percent of total 170 thousand herders' households are at debt equivalent to 45 millions of US dollar, 3 percent of which is debt of households those lost all their animals [S.Batbold 2010b].

4. Preparedness and Relief

Total 26.2 billion tugrug (equivalent to USD18.7 million) were spent for aid and relief activities. Resources were distributed as 36.2 percent for animal fodder, 20.6 percent for transportation, 17.3 percent for herders' medical and social services, and 16.7 percent for disposing of animal carrions to prevent outbreaks of disease, and 9.2 percent for rehabilitation of roads and mountain passes blocked by snow [S.Batbold 2010b] In April, the Government approved "General plan to overcome and recovery of losses of Dzud disaster" and "Guide for restocking of herders affected by Dzud" [http://open-government.mn].

5. Dzud

The Dzud of 1999-2000 was a combined disaster, covering 70% of the country's territory, caused serious damages to animal husbandry. Main reasons of the mass animal losses were as follows [Dzud 2000]:

- Livestock, suffered from 1998-1999 winter **black and white dzud**, was faced with the **harsh windy spring** of 1999 and **summer drought** and had no chance of getting fattened, the pasture productivity was also very low.
- After heavy snowfall in October of 1999 there was a warm spell in November and December which resulted the melting of snow and pasture was covered by icy crust (**iron dzud**).
- From the end of December the depth of snow increased blocking grazing the livestock at pasture (**white dzud**).
- Due to the extreme cold weather in January and February of 2000, a substantial number of livestock perished from starvation and exhaustion as well as from cold.
- Due to improper management for otor (move of animals to better pasture), the herders had migrated following each other that resulted **hoof dzud** (trampling of pasture) occurrence.

5.1. Dzud impacts

After 3 consequent years of dzud 2000-2002 total 12,000 of herders' families lost all of their livestock, and while thousands of families had to subsist below the poverty line. Mongolia's gross agricultural output in 2003 decreased by 40 per cent compared to that in 1999 and its contribution to the national gross domestic product (GDP) decreased from 38 per cent to 20 per cent [Dzud Impact 2004, AIACC, 2006]. Country lost nearly one third of its livestock, among which half of the total cattle and 37 percent of total horses. The GDP share of livestock falled down by 1.7 times and production of meat and milk decreased by 29 and 42 per cent respectively. Living Standard Measurement surevy of 2002-2003 showed poverty incident of 36.3 percent for the urban popualtion and 43.4 percent for the rural population [Dzud Impact 2004]. The average annual livestock mortality for the combined drought and dzuds years (18%) was 4.8% greater than the years with dzuds alone, and 7% greater than in years with only drought. Thus livestock mortality appears to be more sensitive to dzuds than to droughts, and that dzuds contributes more to livestock mortality even years where combined drought and winter storms occur [Begzsuren et., al., 2004].

5.2. Dzud risks

Multiple risks related to Dzud disaster are: (i) increasing risk to people's lives, livelihoods and health; (ii) increasing risk to infrastructure, ger and other assets; (iii) increasing death of livestock, reduction of meat and milk production and export products of animal origin; (iv) increasing risk to poverty and unemployment; and (v) increased migration of population [Dzud 2000; AIACC AS06, 2006; NCRMSAP 2009, MARCC 2009].

5.3. Dzud future projection

Climate change model projected an increase of air temperature by 4.7°C and winter precipitation by from 4 to 10 percent. The harsh condition of winter will not be critical, winter index will not be lower, but summer droughts will reach an extreme increasing Dzud risk [Table 1]. Threats to large cattle (horse, camel and cattle) are going to be catastrophic Dzud index will be higher than that was in the last 60 years. In such condition, economy of pastoral animal husbandry will be problematic, and this might affect Mongolian traditional way of living and very origin of nomadic civilization [MARCC 2009].

6. Efforts to Mitigate and Reduce Dzud Losses

The lessons learned from and recommendations to reduce risk of Dzud [2000] guided Mongolia central and local governments, professional organizations, herders and donor and aid organizations to take the practical measures towards: i) Improvement of policy and legislation for animal husbandry and disaster management; ii) Capacity building of government officers of meteorological, emergency and agriculture organizations; iii) Development of rural backbone infrastructure including auto road, power supply and mobile communication; iv) Research and development of risk reduction solutions and adaptation options at local and household levels including indexed livestock insurance, early warning system, liquid gas, camel firm, improvement of the breed of livestock, etc.; and v) Sustainable livelihood of rural households and the herders labour and social care including small business, microfinance, etc.

6.1. At national level

The recent national climate change assessment report set government strategy for implementation of the adaptation measures in agriculture and water resource sectors as the following: (i) Education and awareness campaigns between the decision makers, agriculture people and public; (ii) Technology and information transfer to farmers and herdsmen; (iii) Research and technology to ensure the agricultural development that could successfully deal with various environmental problems; (iv) Management measures by coordinating information of research, inventory and monitoring. There are still many uncertainties in direct and indirect effects of climate change on natural resource base and agriculture components, in evaluation and development adaptation options and in adaptation technologies that usually require large initial investments. At the same time, the final results and benefits of any adaptation measures cannot be getting immediately. It will require a long time and great efforts [MARCC 2009].

6.2. At local level

The NCRMSAP [2009] considers importance of practical actions at the local level that addresses the real needs of those most affected by climate change, in particular women, the elderly and children, and set a goal to build climate resilience through reducing risk and facilitating adaptation in priority sectors in the short, medium and long term. Actions for facilitation of adaptation within the animal husbandry sector include the followings:

- Improve access to water and water management through region specific activities such as rainwater harvesting, and creation of water pools from precipitation and flood waters, for use with animals, pastureland and crop irrigation purposes
- Improve the quality of livestock by introducing local selective breeds that produce more and are more resilient to climate impacts
- Improve quality of livestock by strengthening veterinarian services to reduce animal diseases/parasites and cross-border epidemic infections
- Using traditional herding knowledge and techniques, adjust animal types and herd structure to be appropriate for the carrying capacity of the pastureland and pastoral migration patterns.

The multisectoral and multidisciplinary collaboration, public and private partnership, participatory approaches, the formation of community herder groups and the establishment of pasture co-management teams involving herders, local government, and members of civil society [Ykhanbai et., al., 2004], and use of advances of modern information communication technology for reaching rural herders [Oyun, 2005] are the new opportunities for implementation of adaptation at local level.

6.3. At international level

The World Bank is now trying to identify and mobilize resources to help the Government of Mongolia address the emerging disaster. The Bank representatives have met partners, including the United Nations and are taking immediate action [Arshad Sayed, 2010]:

- Exploring opportunities to tap into the World Bank's global disaster response fund
- Working within the Bank-financed Sustainable Livelihoods Program to provide support under the pasture risk management and community initiatives funds, components of the project
- Using the Index Based Livestock Insurance project which covers some 5,600 herders in the country, including in affected areas, to provide some relief to those insured.

The aim is to support an appropriate response to short-term needs and continue to deepen medium-term initiatives that reduce herder vulnerability. This can be achieved by improving pasture management and winter preparedness, the transfer and mitigation of risks from a dzud and strengthening the post-disaster response system [Arshad Sayed, 2010].

7. Relationship to Key Messages

Chapter 5: Key findings: Shared responsibilities for coping and adaptation are needed to harness local knowledge, experience, and action and integrate this into the more top-down strategies emanating from national and international disaster risk reduction/management strategies.
"Top-down" is relevant to process rather than strategy itself. Cold spell and Dzud cases show need for strengthening of peoples' health, knowledge and skills to cope with cold, improvement of households economic capacity, shelters, and grounded and demand driven "bottom-up and participatory approach".

Chapter 7: Perhaps DRM and CAA can achieve more when integrated than both separately.
Integration is needed not only for DRM and CAA, but also for social service, employment, household income and local and national economy growth, natural resource protection etc. all towards well being and sustainable livelihoods of households – basic unit of society.

8. Research Gaps and Needs

The most recent cases of cold weather extremes that introduced here were based on government official and public mass media information available on the Internet. Comprehensive scientific study of winter of 2009-2010 in Europe and Dzud in Mongolia in relation to climate change, preparedness and adaptation is needed with effort of the affected countries. Not only scientific research, but also research for solutions, including findings and engineering for implementation, is needed.

Results of the implementation of recommendations, policy frameworks, and development programmes, action plans and projects have not been monitored and evaluated. There is a need to study Dzud of 2009-2010 and update lessons and recommendations of case study of Dzud 2000 in order to establish operational mechanism to reduce vulnerability of livestock sector to drought and Dzud disasters in relevance to recent findings of climate change and socio-economic development trends.

But looking to the future, other questions come to mind [Arshad Sayed, 2010]:

- Can fragile ecosystems like those in Mongolia continue to bear the burden of an ever increasing livestock herd that continues to deplete pastures and threaten long run sustainability?
- What is the balance between allowing a traditional culture to flourish yet ensuring that modern requirements –such as good quality, access to markets, and access to health and services– are provided in good measure to all, including the far flung herder?"

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Case Study 9.8. Disastrous Epidemic Disease: The Case of Cholera

Authors: Jeremy Hess, Diarmid Campbell-Lendrum

1. The 2008 Zimbabwe Cholera Outbreak

While Zimbabwe has had cholera outbreaks every year since 1998, the 2008 epidemic was the worst the world had seen in two decades, affecting approximately 100,000 people and killing well over 4,500 (Mason 2009). The outbreak began on 20 August 2008, slightly lagging the usual onset of seasonal rains, in Chitungwiza city just south of the capital Harare (World Health Organization 2008). In the initial stages several districts near Harare were affected, but in October the epidemic exploded in Harare's Budiriro suburb and the epidemic soon spread to include much of the country, persisting well into June 2009, and ultimately seeding outbreaks in several other countries (see Figure 9-2). Weather appears to have been crucial in the outbreak, as recurrent point-source contamination of drinking water sources (World Health Organization 2008) was almost certainly amplified by the onset of the rainy season, similar to other recent African outbreaks (Luque Fernandez, Bauernfeind et al. 2009). In addition to its size, this epidemic was distinguished by its urban focus and relatively high case fatality rate (CFR; the proportion of infected people who die), which ranging from 4-5% (Mason 2009) (see Figure 9-3). While other recent African outbreaks have had CFRs up to 10% (Alajo, Nakavuma et al. 2006), most outbreaks have CFRs below 1%. Underlying structural vulnerability was also central to the disastrous impacts: the government, paralyzed after a failed presidential election, had not been providing basic water and sanitation services for months, inflation was rampant, and political infighting undermined response efforts. Medical and public health staff, whose salaries no longer constituted a living wage, were extremely scarce. Harare's Central Hospital closed in November in 2008, at the epidemic's height, and clinics had no potable water and asked patients to bring their own (Peta 2008).

[INSERT FIGURE 9-2 HERE:
Figure 9-2: Regional spread of the 2008 Zimbabwe epidemic.]

[INSERT FIGURE 9-3 HERE:
Figure 9-3: Case fatality rates for Zimbabwe by district.]

2. New Understanding of Cholera's Human Ecology

Cholera has a very long history as a human scourge. The world is currently in the midst of the seventh global pandemic, which began in Indonesia in 1961 and is distinguished by continued prevalence of the El Tor strain of the *Vibrio cholerae* bacterium; the current global burden of disease is estimated at 3–5 million cases and 100,000–130,000 deaths per year (Zuckerman, Rombo et al. 2007; World Health Organization 2010). Figure 9-4 illustrates the recent global burden of disease. Primarily driven by poor sanitation, cholera cases are now concentrated in areas burdened by poverty, inadequate sanitation, and poor governance. In such regions, these and other factors can markedly amplify the impact of cholera outbreaks. A recent survey of epidemics from 1995-2005 revealed that the heaviest burden is in Africa, and that poverty, water source contamination, heavy rainfall and floods, and population displacement were the primary risk factors (Griffith, Kelly-Hope et al. 2006), as exemplified by the Zimbabwe epidemic.

[INSERT FIGURE 9-4 HERE:
Figure 9-4: Cholera outbreaks, 2007-2009.]

Our understanding of cholera ecology is evolving. Weather, particularly seasonal rains, has long been recognized as a risk factor for cholera epidemics, as the Zimbabwe case illustrates. In recent years, scientists have also assembled much new evidence of cholera's climate sensitivity, discovering common ecological drivers of cholera's presence and pathogenicity. These include, for example, the effect of the El Niño Southern Oscillation (ENSO), bringing higher temperatures, more intense precipitation, and consequently enhanced cholera transmission, in a wide range of settings. Several recent epidemics have also highlighted a link with extreme weather events. Cholera has become a prototypical climate-sensitive disease (Lipp, Huq et al. 2002; Colwell and Colwell 2004; Constantin de Magny and

Colwell 2009) and is one of a handful of diseases whose incidence has been directly associated both with climate variability, and long-term climate change (Rodó, Pascual et al. 2002). As climate change is expected to increase climate variability, bring more extreme weather events, and heighten vulnerability through increased malnutrition and population displacement in many regions, there is concern that climate change will increase cholera risk, working synergistically with the established risk factors of poverty and poor sanitation that are part of the human ecology of the disease.

3. <u>The Risk of Disastrous Cholera Epidemics</u>

The risk for epidemic cholera, as for any disaster, is a complex product of environmental and social factors. Moreover, *V. cholerae* is flexible and ecologically opportunistic, enabling it to cause epidemic disease in a wide range of settings and in response to climate forcings (Koelle, Pascual et al. 2005). Given this complexity and cholera's dynamic range, it is most appropriate to use several distinct epidemics to illustrate both the important climatologic drivers associated with increased *V. cholerae* exposure as well as the vulnerability factors that exacerbate risk of large, severe, prolonged epidemics. This risk can be characterized using a standard risk framework common to both public health and disaster risk management that focuses on the interactions between environmental hazards and population vulnerability, with particular emphasis on drivers of pathogen exposure, host susceptibility, and adaptive capacity.

3.1. Exposure

Cholera epidemics occur when susceptible human hosts are brought into contact with toxigenic strains of *V. cholerae* serogroup O1 or serogroup O139. A host of ecological factors affect *Vibrio cholerae*'s environmental prevalence and pathogenicity (Colwell 2002) and the likelihood of human exposure (Koelle 2009). Recent research, focused in particular on the Bay of Bengal, has highlighted several different factors that influence this exposure probability. A retrospective analysis of ENSO effects on cholera incidence in Bangladesh was the first evidence of climate change impacts on human disease (Rodo, Pascual et al. 2002). Long-term climate variability, particularly ENSO, has emerged as a particularly important driver in other ecosystems as well, and has been associated with cholera outbreaks in coastal and inland regions of Africa (Constantin de Magny, Guegan et al. 2007), South Asia (Constantin de Magny, Guegan et al. 2007), and South America (Gil, Louis et al. 2004).

The biological plausibility of the association in coastal regions was first described by Colwell, who discovered a commensal relationship between *Vibrio cholerae*, plankton, and algae (Colwell 1996). Cholera bacteria are attracted to the chitin of zooplankton's exoskeletons, which provides them with stability and protects them from predators. The zooplankton feed on algae, which bloom in response to increasing sunlight and warmer temperatures. When there are algal blooms in the Bay of Bengal, the zooplankton prosper and cholera populations grow as well, increasing the likelihood of human exposure. Precipitation levels, sea surface temperature, salinity, and factors affecting members of the marine and estuarine ecosystem such as algae and copepods also impact exposure probability (Huq, Sack et al. 2005). Many of these factors, such as the association of *V. cholerae* with chitin (Pruzzo, Vezzulli et al. 2008) and the importance of precipitation and sea level (Emch, Feldacker et al. 2008), appear to be similar across various environments, though their relative importance varies by region. In some cases, examination of these dynamics have led to surprising findings: recent research showed that the pathogenic *V. cholerae* strains responsible for cholera epidemics in Mexico in recent El Niño years have originated from marine and estuarine sources rather than from water contamination with sewage as typically assumed (Lizarraga-Partida, Mendez-Gomez et al. 2009).

A wide range of other variables are also associated with increased exposure likelihood, including weather (Hashizume, Armstrong et al. 2008), conflict (Bompangue, Giraudoux et al. 2009), population displacement, crowding (Shultz, Omollo et al. 2009), and political instability (Shikanga, Mutonga et al. 2009). Trends similar to those of coastal regions have been seen in several lake ecosystems in Africa (Olago, Marshall et al. 2007). Many of these factors are actually mediated by the more conventional cholera risk factors of poor sanitation and lack of access to improved water sources and sewage treatment.

3.2. Population susceptibility

Population susceptibility includes both physiological factors that increase the likelihood of infection after cholera exposure as well as social and other structural factors that drive the likelihood of a severe, persistent epidemic once exposure has occurred. There are several physiologic factors that affect cholera risk or severity: malnutrition and coinfection with intestinal parasites (Harris, Podolsky et al. 2009) as well as the bacterium *Helicobacter Pylori* increases the likelihood of infection; infections are more severe for people with blood group O, for children, and for those with low physiologic reserve. Waxing and waning immunity as a result of prior exposure has also been shown to have a significant impact on population vulnerability to cholera over long periods (Koelle, Rodo et al. 2005).

While physiologic susceptibility is important, however, social and economic drivers of population susceptibility persistently seem to drive epidemic risk. Poverty, for instance, is a strong predictor of risk on a population basis (Ackers, Quick et al. 1998; Talavera and Perez 2009), and political factors are often very important drivers of epidemic severity and duration. As noted above, these factors drive exposure likelihood; as the Zimbabwe epidemic illustrates, however, the presence of structural vulnerability factors often drive the epidemic severity and persistence once exposure occurs, driving disastrous impacts. Many recent severe epidemics exhibit population susceptibility dynamics similar to the Zimbabwe case described above. Similar dynamics have been observed in other poor communities (Hashizume, Wagatsuma et al. 2008), and in the aftermath of political unrest (Shikanga, Mutonga et al. 2009) and population displacement (Bompangue, Giraudoux et al. 2009), and are particularly in evidence in sub-Saharan Africa in recent years (Gaffga, Tauxe et al. 2007).

3.3. Adaptive capacity

While adaptive capacity is closely linked with susceptibility, it is important to highlight the role of adaptive capacity and conventional public health measures in mitigating severe disease and reducing the risk that an outbreak will have disastrous impacts with high CFRs and significant loss of life; it is also important to note the role of the response to a cholera outbreak in determining the potentially devastating economic impacts of a large scale epidemic. The conventional public health strategies for reducing cholera risk fall into three general categories: primary prevention, or prevention of contact between a hazardous exposure and susceptible host (promoting access to clean water and reducing the likelihood of population displacement, for instance); secondary prevention, or prevention of symptom development in an exposed host (such as vaccination); and tertiary prevention, or containment of symptoms and prevention of complications once disease is manifest (including dehydration treatment with oral rehydration therapy).

Cholera outbreaks are familiar sequelae of complex emergencies and the disaster risk management (DRM) community has much experience with prevention efforts aimed at reducing the likelihood of cholera epidemics, containing them once they occur, and reducing the associated morbidity and mortality among the infected. Best practices as outlined in the Sphere guidelines (The Sphere Project 2004) include guidelines for water treatment and sanitation and for population-based surveillance. Nevertheless, in the context of political disruption and large population movements, particularly in regions where cholera is endemic, the risk of epidemic disease is increased as a result of increased exposure likelihood and the high susceptibility of the displaced populations.

This was in evidence in the 2002-2003 Ugandan epidemic, which affected approximately 1,000 people and had a case fatality rate of 10.3%, and was found to be associated with rains and floods brought by El Niño (Alajo, Nakavuma et al. 2006). Recent major African epidemics in Kenya, the Democratic Republic of Congo (DRC), and Zimbabwe demonstrate other, structural drivers. Recurrent epidemics in the Lake Kivu region of the DRC, some of which were associated with floods and extreme precipitation, affected over 73,000 people and exhibited a case fatality rate of 2.2%. This series of highlight the role of complex humanitarian emergencies in driving outbreaks in areas with natural reservoirs (Bompangue, Giraudoux et al. 2009). The public health response to the 2008 epidemics in Kenya, which demonstrated a very high 11.4% case fatality rate, were hamstrung by the recent political violence that complicated an organized health sector response (Shikanga, Mutonga et al. 2009).

A cholera outbreak in Peru in 1991 highlights the potentially disastrous economic impact of a large epidemic and how the impact can be compounded by an ill-informed outbreak response strategy. It appears that the epidemic began with coastal residents exposed to autochthonous cholera in the marine environment as a result of El Niño conditions (Seas, Miranda et al. 2000), though the cholera strain that caused the epidemic appears to have originated in Africa and persisted in the marine environment until conditions were more favourable for an epidemic (Lam, Octavia et al. 2010). The epidemic then grew through contaminated water supplies in the typical fashion to include over 530,000 cases and 4,700 deaths in nineteen countries by 1992 (Swerdlow, Mintz et al. 1992). The epidemic caused devastating losses to Peru in terms of loss of productivity and wages of approximately $100 million US (in 1991 dollars). The international response to the epidemic included an effective quarantine in the form of import bans on Peruvian products of marine and plant origin as well as a dramatic drop in tourism to the country, which caused another $175 million in losses (Petrera and Montoya 1992). This case illustrates the potentially dramatic impacts an outbreak can have on a developing economy and the potential to exacerbate those impacts through a maladaptive response.

4. Disease Risk Management

The global burden of disease from cholera and other climate sensitive diseases is substantial. While cholera is a prototypical climate-sensitive diarrheal disease, other aetiologies of diarrheal disease are more common and cause a significantly larger burden of disease. Many other common diarrheal pathogens also exhibit climate sensitivity. Altogether, diarrheal disease causes a substantial global burden of disease, killing approximately 2.2 million people a year (World Health Organization 2008). *Ceteris paribus*, the global burden of diarrheal disease is expected to increase considerably with climate change (McMichael, Campbell-Lendrum et al. 2004). All things need not be equal, however. Recent innovations such as the rotavirus vaccine and continued improvements in sanitation will undoubtedly have an impact. Moreover, as we gain insight into the associations between climate variability, extreme precipitation events, and outbreaks of climate sensitive disease such as cholera, as well as the factors that drive extreme susceptibility among human hosts, we identify potential points of leverage where other risk management strategies can reduce risk.

The case of cholera provides several examples from which we can extrapolate to other disease control efforts: Enhanced understanding of cholera ecology has enabled development of predictive models that perform relatively well (Matsuda, Ishimura et al. 2008) and fostered hope that early warning systems based on remotely sensed trends in sea surface temperature, algal growth, and other ecological drivers of cholera risk can help reduce risks of epidemic disease, particularly in coastal regions (Mendelsohn and Dawson 2008). Strategies to reduce physiologic susceptibility through vaccination have shown promise (Calain, Chaine et al. 2004; Chaignat, Monti et al. 2008; Lopez, Clemens et al. 2008; Sur, Lopez et al. 2009) and mass vaccination campaigns have potential to interrupt epidemics (World Health Organization 2006), and may be cost effective in resource-poor regions or for displaced populations where provision of sanitation and other services has proven difficult (Jeuland and Whittington 2009). Current WHO policy on cholera vaccination holds that vaccination should be used in conjunction with other control strategies in endemic areas and be considered for populations at risk for epidemic disease, and that cholera immunization is a temporizing measure while more permanent sanitation improvements can be pursued (World Health Organization 2010). Ultimately, given the strong association with poverty, continued focus on development may ultimately have the largest impact on reducing cholera risk.

5. The Role of Learning

From the perspective of climate change adaptation, these innovations are important, but equally or perhaps more important are processes by which we have learned about cholera's ecology in the last two decades. Managing disease risk, like other risk management processes, will necessarily become more iterative and adaptive as climate change introduces greater variability into familiar systems. Single and double loop learning are important components of this iterative process.

Single loop learning, in which adjustments are made in response to the difference between what is expected and what is observed, can be crucial, particularly in crisis situations. The established guidelines for identifying and containing a cholera outbreak in a displaced population are an example of an effective single loop learning process. Single loop learning often glosses over root causes, however, in the effort to return to the status quo. As the World Health Organization states, “Current responses to cholera outbreaks are reactive, taking the form of a more or less well-organized emergency response”, and prevention is lacking (World Health Organization 2006).

Double loop learning, however, in which the deeper assumptions, structures, and policy decisions that shape risk are examined, opens the possibility of more fundamental shifts. In the case of cholera, double loop learning is exemplified by our recent leaps in understanding of cholera ecology, which have opened the possibility of devising warning systems and other novel risk management strategies. Another equally important conclusion – one that experts on climate’s role in driving cholera risk have emphasized (Pascual, Bouma et al. 2002) – is that poverty and political instability are the fundamental drivers of cholera risk, and emphasis on development and justice are risk management interventions, as well.

6. Key Messages

- Variability in precipitation and temperature can affect important epidemic diseases such as cholera both through direct effects on the transmission cycle, but also potentially through indirect effects, for example through population displacement.
- If other determinants remained constant, climate change would be expected to increase risk by increasing exposure likelihood – through increased variability in precipitation and gradually rising temperatures and by increasing population vulnerability – through increased population displacement.
- The health impacts of cholera epidemics are very strongly mediated through individual characteristics such as age and immunity, and population level social determinants, such as poverty, governance, and infrastructure.
- Experience from multiple cholera epidemics demonstrates that non-climatic factors can either exacerbate or over-ride the effects of weather or other infection hazards.
- The processes of Disaster Risk Management and preventive public health are closely linked, and largely synonymous. Strengthening and integrating these measures, alongside economic development, should increase resilience against the health effects of extreme weather, and gradual climate change.

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9.3.2. Vulnerable Regions and Populations

Case Study 9.9. Vulnerable Coastal and Mega Cities

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1. Introduction

Cities are one of the major key drivers of climate change due to their high energy consumption, land use, waste generation and other activities that result in the release of the vast majority of greenhouse gases. Cities cover less than 1% of the earth surface, but settled by around 50% of the world population (WWF, 2009). At the same time, it is cities, and in particular the urban poor, in the developing world, that are most vulnerable to and have the least resilience against, for example, heat wave, air pollution, and natural disasters such as storms, floods, and droughts [UEPB 2009].

Many low-lying coastal, river-delta mega-cities (e.g., Adelekan, 2006), already stressed by rapid population growth and economic, social, health and cultural difficulties, are now increasingly vulnerable due to climate change leading to increased risk of disasters that will affect not only the cities but the regions. An OECD report has ranked cities (Nichols et al., 2008) in terms of population and other exposures. The IPCC (Nichols et al., 2007) concludes: "*The impact of climate change on coasts is exacerbated by increasing human-induced pressures (very high confidence)";* and *"Adaptation for the coasts of developing countries will be more challenging than for coasts of developed countries, due to constraints on adaptive capacity (high confidence)."*

The research results will be enhanced capacity of coastal cities to better cope with risks posed by the combined effects of climate change, including sea level rise, and urban growth and development. The research approach will be to integrate climate change adaptation and disaster risk reduction approaches (McBean and Ajibade, 2009) towards building disaster resilient cities where resilience is defined as "*the capacity of a system, community or society to resist or to change in order that it may obtain an acceptable level in functioning and structure"* (UN International Strategy for Disaster Reduction definition). The UN International Strategy for Disaster Reduction (ISDR) Global Assessment Report (2009) recommended a risk reduction approach and concluded that "*investing today to strengthen capacities is essential if future generations are to enjoy a safer tomorrow*." The international START and its Cities at Risk project (Fuchs, 2009; Snidvongs et al., 2003), Integrated Research on Disaster Risk international program (IRDR, 2008) UNESCO International Centre for Water Hazards and Risk Management (ICHARM)(Japan) and other agencies have all identified coastal cities as a research foci.

2. Background

Global average sea-level is now rising faster than earlier predictions (Copenhagen Diagnosis, 2009) such that by 2100, global sea-level rise in a world of unmitigated greenhouse emissions may well exceed 1 meter with the upper limit ~ 2 meters. Sea level will continue to rise for centuries after global temperatures have been stabilized, and several meters of sea level rise must be expected over the next few centuries. Even minor sea level rise has significant societal and economic impacts through coastal erosion, increased susceptibility to storm surges and resulting flooding, ground-water contamination by salt intrusion, loss of coastal wetlands, and other problems. There has been a substantial upward trend in the severity of tropical cyclones (hurricanes and typhoons) since the mid-1970s, with a trend towards longer storm duration and greater storm intensity, strongly correlated with the rise in tropical sea surface temperatures. A further increase in storm intensity is likely to result in more heavy rain and wind events, leading to higher storm surges and risks of river flooding. In mid-latitudes, rainfall has increased overall, while it has declined in the Northern Hemisphere subtropics. Rains are also becoming more intense in already-rainy areas and recent changes are happening even faster than predicted, raising the possibility that future changes could be more severe than predicted. A common theme in the Copenhagen Diagnosis (2009) is that changes are happening more rapidly than earlier predictions so that a risk management approach will be necessary in planning adaptation strategies for coastal cities. Adaptation strategies for vulnerable areas need to be a priority (Schipper and Burton, 2009). There is need to build capacity to deal with climate-related hazards (McBean and Rodgers, 2010) combined with disaster risk reduction approaches.

People living in slums, without adequate urban infrastructure, are particularly vulnerable and will be amongst those that suffer the most from the adverse effects of climate change. Rising temperatures coincide with increased energy use for cooling. Loss of green cover in cities, in the form of parks, trees and agricultural land, raises urban temperatures, as well as contributing to climate change [UEPB 2009]. However steps are being made seen especially in China where as of 2009, 40 eco-cities were in development (4 smart-grid pilot cities, 21 LED-street-light cities, 13 electric-vehicle cities). "Last year the central government banned the distribution of free plastic bags in grocery stores eliminating 3 billion bags every day, and the consumption of 5 million tons of refined crude oil every year for plastic bags alone[11].

[INSERT FOOTNOTE 11 HERE: http://blogs.nationalgeographic.com/blogs/news/chiefeditor/2010/06/china-eco-cities.html]

Cities vary in size, economic situation, geographic location, and access to resources within the country, as well as internationally. Therefore, each city's specific local conditions must be taken into account when determining the most appropriate policies for that particular city [UEPB 2009].

3. Vulnerability of Cities to Climate Change

Assessment of city vulnerability to climate change with systematic and structured way and broad participatory approach were piloted and now have been expanded for cities of developing and least developed countries by joint effort of UN HABITAT and UNEP within Cities in Climate Change Initiative (CCCI) of SCP/LA21. Below is given some outputs of these efforts in order to illustrate vulnerability of different cities in climate change and preparedness for future changes.

SOROSOGON, Philippine (2009): Sorsogon City lies at the southernmost tip of Luzon, the largest of the 7,100 islands of the Philippine archipelago and is nestled between the Pacific Ocean and the South China Sea. Of its 64 barangays (lowest level of government) covering 31,292 hectares, 37 lie along the seacoast. The city is particularly at high risk to tropical cyclones and storm surges, extreme rainfall/flooding, increased precipitation, temperature variability and sea level rise. Nine urban coastal barangays are very vulnerable to climate-induced hazards, given their location, aging and previously damaged seawalls and inadequate drainage facilities, while 24 barangays along the coast/rivers with a population of 55,452 (36.6%) risk flooding. Prevalence of red tide (poisonous algae) in Sorsogon Bay is caused by climate related changes. Adverse climate would also impact on the income of more than 50 beach resorts as well as small traders and micro-entrepreneurs linked to tourism. The disastrous combination of a city lacking the proper Disaster Risk Reduction equipment, tools and facilities and a general public that has limited knowledge on Climate Change related hazards and risks and leaves the poor (43% of city population), who mostly populate high-risk areas and are inadequately covered by social protection schemes, particularly vulnerable.

KAMPALA, Uganda, (2009): Kampala, the capital of Uganda, is located on the northern shores of Lake Victoria covering an area of 195 sq. km and is situated at an average altitude of 3,910 ft (1,120 m) above sea level. It is situated on 24 low flat topped hills that are surrounded by wetland valleys. Kampala is characterized by urban sprawl and increasing informal settlements resulting from increasing population pressure and inadequate land use planning. The settlements are located in high risk areas with poor sanitation and prone to flooding. Due to the high water table, most of the wells/springs are contaminated by fecal matter resulting in safe water coverage of only 55% that is exacerbated by inadequate solid waste collection which currently stands at 55%. Increased construction with hard paving is taking place on the hill tops and lack of water harvesting mechanisms has caused degradation of the fragile hill slopes.

There is excessive use of wood fuel as a major source of energy for cooking, over dependence on reused vehicles and use of leaded fuel leading to air, land and water pollution. Encroachment on fragile ecosystems and blockage of the drainage systems has increased the occurrence of flash floods in the city. Given these vulnerable conditions, the city dwellers are exposed to water borne diseases such as malaria, cholera and other ailments such as respiratory tract infections.

ESMERALDAS, Ecuador (2009): Esmeraldas, a medium sized coastal city located in the northwestern corner of Ecuador, covers a land area of 16,155.97 km2. The Teaone and Esmeraldas Rivers flow on one side of the city, and with the Pacific Ocean on the other side they make up the hydrological system of the canton. Esmeraldas is part of the Choco microregion that has one of the highest rates of biodiversity in the world. The annual population growth of Esmeraldas is 3.5% in comparison with the national average of 1.9%. The city and province of Esmeraldas is considered one of the most vulnerable regions to the effects of climate change in Ecuador. In 2007, almost 60% of the population lived in areas with medium to high risks of floods or landslides. Informal settlements, housing 21% of the canton's population experience devastating effects from mudslides and river overflows during the rainy season. Mangroves, which form a buffer area against the rising river levels, are gradually being lost due to logging, and main forest areas are disappearing due to accelerating deforestation and mono-crop farming. Poor management of the city's natural resources adds to the devastating consequences of climate change.

4. Adaptation and Preparedness of Cities to Climate Change

City adaptation measures vary depending on political, cultural, historical and climatic conditions. Such measures can include: placing a greater emphasis on coastal resource management, especially the protection of mangrove and natural reef ecosystems; to a concerted "hardening up" of infrastructure, including storm-drainage systems, water supply and treatment plants, protection or relocation of solid waste management facilities, energy generation and distribution systems. Coastal cities will likely need to plan for and invest in heavy physical infrastructure projects specifically related to sea-level rise. These include: sea-surge protective barriers and dams, the reconstruction of harbour facilities, better early warning and rapid response systems to prepare for disaster preparedness as well as building better levees, flood barriers and prevention facilities and improving flood and coastal defence management. In regions where droughts are more likely to occur, better water saving and water management measures will be required (UNEP, UN Habitat, 2009; Simonovic, 2009).

While the problems are as individual as the cities themselves, it was soon realized, that a common approach brought solutions applicable in different cities. Issues tackled by the cities started with the provision of basic urban services, road construction, and managing urban growth and went all the way to open spaces, coastal protection and other environmental objectives [UEPB 2009]. Hence, illustrating a CCA and DRR combined approach to mitigate hazards (Henstra and McBean, 2008). UN-HABITAT's experience dealing with sustainable urban development facilitated the local and global levels exchange with global Sustainable Urban Development Network (SUD-Net) and the Cities in Climate Change Initiative (CCCI). Partners in developing countries, are deeply concerned that their towns and cities are not well prepared for the impacts of climate change and that they are lacking the skills and resources to implement mitigation and adaptation measures. The threats climate change poses are becoming clearer and many mayors and local governments want to take action in line with their national governments or even at a faster pace [UNEP, UN HABITAT, 2009].

In addition to physical and infrastructural adaptations, a broad range of targeted vulnerability reductions also contribute to climate change adaptation. These include: local economic development strategies; better shelter options and in-situ slum upgrading; relocation of urban populations to appropriate or improved locations when in-situ upgrading is not feasible; as well as better health facilities and better public health interventions and additionally, the improvement of agricultural production systems including the promotion of urban agriculture and strengthening rural-urban linkages [UNEP, UN Habitat, 2009].

However it is important to acknowledge that because of their concentrated form and efficiencies of scale, cities offer major opportunities to reduce energy demand and minimize pressures on surrounding lands and natural resources. If cities can harness the energy and creativity of their citizens and build on the inherent advantages that urbanization provides, they can, in fact, be part of the solution to the global problems of poverty and environmental degradation. [http://www.wri.org/publication/content/8570]

4.1. Case on Sorsogon City, Philippine

In 2008, UN-HABITAT started a pilot project in the city on building climate-resilient human settlements. By "designing and building with nature" - so the project title - possibilities of climate change adaptation for coastal cities is to be explored. As a first step, a climate change vulnerability and adaptation assessment was conducted and presented at city-wide stakeholder meetings. As a response, the city Mayor set up a technical working group comprising of municipal staff across key municipal departments. Based on the vulnerability assessment, the team developed a comprehensive climate change action plan that include the adaptation of land use plans, zoning regulations over the development of appropriate shelter plans, disaster risk reduction and the set-up of early warning systems.

The city is currently developing a plan to rehabilitate the seawall and will benefit from technical assistance to ensure that the construction is done in an eco-efficient manner. It is envisaged to support the residents in the informal settlements with techniques that would allow them to take down the house, in case of a typhoon warning, and to reassemble it after the typhoon. Eventually the resettlement of the populations along the coast may be inevitable. The city is setting land aside and will be starting consultations with the affected populations to ensure a people friendly process.

This MDG-Fund Joint Programme in the Philippines is one example of the "UN delivering as One" to combat climate change: Jointly with UN HABITAT, UNEP, the UNDP and the Food and Agricultural Organization aim to mainstream measures for climate risk reductions into key national and local development plans. {Sorsogon, 2009); http://www.unhabitat.org/ccci

4.2. International initiatives for cities and climate change

United Cities and Local Government (UCLG) is the global voice of cities and the main local government partner of the UN, spearheading the UN Advisory Committee of Local Authorities (UCLG, 2009). The Cities for Climate Protection (CCP) campaign – operated by ICLEI - Local Governments for Sustainability - has a membership of 1100 local governments from 68 countries around the world. It provides cities with tools and assistance for policies and quantifiable implementation measures on emission reductions, better air quality and more liveable cities; and organized the first World Congress on Resilient Cities bringing together all level stakeholders around cities and climate change (http://www.iclei.org). The Local Government Climate Roadmap is a process started by global local government associations, which advocates a strong and comprehensive post-2012 climate agreement. It emphasizes the critical role of cities in implementing climate change policies.

UNEP, UN HABITAT Sustainable City Programme directly helps local authorities and their partners to achieve a well-managed urban environment as part of a sustainable urban development process that empowers all city dwellers promoting good environmental governance at all levels: (i) Locally, by supporting partners in cities to apply a well proven four stage Environmental Planning and Management Process; (ii) Nationally, by supporting national partners to replicate local-level best practices into national scale and to integrate lessons of experience into national policy and legal frameworks; (iii) Regionally, by facilitating city-to-city exchanges and technical cooperation amongst developing countries through partner networks and regional meetings; and (iv) Globally, by combining the complementary strengths of UN-HABITAT and UNEP in applying specialized expertise and synthesizing experiences for awareness building, policy formulation and national replication (UNEP, UN HABITAT, 2009).

The United Nations International Strategy for Disaster Reduction (UN ISDR) is working with its partners to raise awareness and commitment for sustainable development practices as a means to reduce disaster risk and to increase the wellbeing and safety of citizens- to invest today for a safer tomorrow. Building on previous years' campaigns focusing on education, school- and hospital safety, ISDR partners are launching a new campaign in 2010 – Making Cities Resilient – to enhance awareness about the benefits of focusing on sustainable urbanization to reduce disaster risks. The campaign will seek to engage and convince city leaders and local governments to be committed to a checklist of Ten Essentials for Making Cities Resilient and to work on these together with local organizations, grassroot networks, private sector and national authorities. (UN ISDR, 2010)

5. Relationship to Key Messages

The case study on cities and climate change is relevant to key messages of chapters 2, 4, 5, 6, 7 and 8. There are some comments:

- Chapter 5: **Terminology** “Climate smart disaster risk reduction”: This terminology is not used in UN cities and climate change initiatives. They use Sustainable City Development (UN Habitat, UNEP) or “Resilient Cities” (UNISDR).
- Chapter 5: **Key findings**: “Climate smart disaster risk reduction means new organizational, institutional and governmental arrangements at sub-national to international scales, but these may constrain local actions and limit coping capacity and adaptation”: New International level efforts are not limiting, but supporting local level capacity and adaptation. These efforts are to link international, regional, national and local levels to build and strengthen local capacity. New organizational, institutional and governmental arrangements are needed at all levels. New arrangements are collaboration, partnership, networking, innovation, good governance, integration of climate change adaptation and mitigation, environmental planning and management towards city sustainable development.
- Chapter 5: **Key findings**: “Shared responsibilities for coping and adaptation are needed to harness local knowledge, experience, and action and integrate this into the more top-down strategies emanating from national and international disaster risk reduction/management strategies.”: “Top-down” is relevant to process rather than strategy itself. Cities and climate change cases show “bottom-up and participatory approach”.
- Chapter 7: “Perhaps DRM and CAA can achieve more when integrated than both separately.”: Integration is not only for DRM and CAA, but also land use and urban planning, housing and infrastructure development, environmental management etc. all towards sustainable development.

6. Research Gaps and Needs

Limitation of existing climate change projection models for cities:

- Low spatial scale (30km, national) and long term (20, 40, 100 years) projection
- Projection of average value that is difficult to understand, interpretate, evaluate, etc.
- Lack of socio-economic input, and no consideration of local specifics
- Not clear how to link outputs with governance, development program, action plan, projects, etc.
- High resolution local information is required for city level climate change
- Required city level climate change model specification:
- Downscaled to local level: Spatial resolution: up to 1-5 km and temporal resolution: 4-8 years
- On the example of high risky areas (more populated cities, slum areas, etc.)
- Open, modular, more socio-economic input and local contribution, traditional knowledge, adaptation and mitigation options, use of advance of information technology in analysis, design and developments, etc…
- Simple for socio-economic interpretation, provide policy recommendation and decision options with cost-benefit calculations, etc.

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Case Study 9.10. Small Islands Developing States

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1. Introduction

Small Island Developing States (SIDS) are small island and low-lying coastal countries that share some similar development challenges, including small but growing populations, lack of resources, remoteness, susceptibility to natural disasters, excessive dependence on international trade and vulnerability to global economic developments. SIDS are also among the most vulnerable to the impacts of climate change. In addition to susceptibility to natural disasters, they face the prospect of inundation from rising sea levels, loss of land due to coastal erosion, and contamination of agricultural land due to saltwater intrusion. Low-lying atolls are especially at risk, some from complete submersion.

In addition, they suffer from lack of economies of scale, high transportation and communication costs, and costly public administration and infrastructure, which hold back their growth and development. SIDS were first recognized as a distinct group of developing countries at the United Nations Conference on Environment and Development in June 1992. In April 1994, the first Global Conference on Sustainable Development of SIDS was convened in Barbados. The conference adopted the Barbados Programme of Action (BPoA) that set forth specific actions and measures to be taken at the national, regional and international levels in support of the sustainable development of SIDS. Currently, the United Nations Department of Economic and Social Affairs lists 52 small island developing states. These are broken down into three geographic regions: the Caribbean; the Pacific; and Africa, Indian Ocean, Mediterranean and South China Sea (AIMS). Each of these regions has a regional cooperation body: the Caribbean Community, the Pacific Islands Forum and the Indian Ocean Commission respectively, which many SIDS are members or associate members of. In addition, most (but not all) SIDS are members of the Alliance of Small Island States, which performs lobbying and negotiating functions for the SIDS within the United Nations system.

The acute-onset sea level rise event that occurred in Lukunoch Island, Micronesia in 2007 is an example of the potential extreme impacts associated with shoreline inundation and saline intrusion for low-lying island communities (Keim, 2010). The impact of the three consecutive 4-5 category tropical cyclones (hurricanes Gustav, Ike and Paloma) in less than two weeks, late summer 2008, that affected Haiti, Dominican Republic and Cuba demonstrated the region’s existing vulnerability to weather-related hazards and also highlighted the importance of planning and adaptation. The most extreme example of sea level rise can be illustrated by the inhabitants of Tegua, Vanuatu who had to abandon their island in 2005. Thus, SIDS are particularly vulnerable to natural as well as environmental disasters and have a limited capacity to respond to and recover from such disasters. While SIDS are among those that contribute least to global climate change and sea level rise, they are among those that would suffer most from the adverse effects of such phenomena and could in some cases become uninhabitable. Therefore, they are among those particularly vulnerable States that need assistance under the United Nations Framework Convention on Climate Change, including adaptation measures and mitigation efforts. SIDS share with all nations a critical interest in the protection of coastal zones and oceans against the effects of land-based sources of pollution. Limited freshwater resources, increasing amounts of waste and hazardous substances, and limited facilities for waste disposal combine to make the reduction of pollution, waste management and the trans-boundary movement of hazardous materials critical issues for SIDS.

2. Vulnerability

In the disaster reduction context, vulnerability can be defined as "the conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards" (UN/ISDR, 2004, definition 42). WHO (2002) defines vulnerability as "the predisposition to suffer damage due to external events”. Recognising and understanding vulnerability in the context of disaster preparedness are fundamental to attempts at appropriate capacity building and long term recovery. Emergency aid, such as general food supplies, delivered by agencies outside the affected community, may be crucial at certain stages of the disaster management process. However, the content of the food rations and the manner of delivery may not always be culturally appropriate or acceptable; and aid cannot, and should not, be provided indefinitely. To enable affected communities to take steps towards self-sufficiency, international and non-governmental aid organisations need to be listening to the local community. Hoffmaster (2006) expressed the thought-provoking contention that our responses tend to focus on what we are doing for the person, rather than on persons and their vulnerability of themselves. Understanding the key vulnerabilities that have contributed to the disaster in the first place should help those who provide assistance to pinpoint why the community is unable to cope and then to try to ensure that those gaps in coping ability are targeted.

Webb & Harinarayan (1999) draw attention to the danger of making generalisations. There may not be a uniform level of vulnerability throughout an entire country, or across a continent. In 1995, hurricane Luis caused £330m in direct damages to Antigua, equivalent to 66% of GDP. This can be contrasted with a larger economy of Turkey that lost between £9 - $13bn in direct impacts from the Marmara earthquake in 1999, but whose national economy remained largely on track" (UNISDR, 2010). Despite the overall trend for the most vulnerable to be women and young children, this does not mean that all women and children are vulnerable. Nor does it mean that no one in other population groups is vulnerable. Studying trends in vulnerability over time is important as it may vary dynamically through the disaster continuum, from the acute onset where the focus is on rapid response to the rehabilitation period which is more akin to community development.

3. SIDS and their Vulnerabilities

Many SIDS face specific disadvantages associated with their small size, insularity, remoteness and proneness to natural hazards. These factors render the economies of these states as very vulnerable to forces outside their control - a condition which sometimes threatens their very economic viability. A relatively high GDP (or GNP) per capita of these states may conceal the reality of its vulnerabilities. Threatened by the turbulence of globalization and the uncertainties of climate change, the SIDS have been for decades struggling against the odds to develop their economies and improve the diets, health and livelihoods of their people. In a background document prepared for a Special Ministerial Conference convened by FAO in November 2005, FAO lists eight specific vulnerabilities that SIDS countries share. For example, they are all vulnerable to their environmental situations because of their narrow natural resource bases. Their remoteness and propensity for climatic related disasters limit the options SIDS have to address their natural and man-made hazards and their ability to diversify their economic activities. SIDS small national economies make them more reliant on trade and, thus, especially susceptible to external shocks. According to the above background document, SIDS have very diverse economies and levels of development between themselves, with some depending on agriculture, forestry and fisheries and others relying primarily on sectors such as tourism for their overall security. Instability in agricultural production and exports coupled with increasing dependence on food imports by SIDS has led to vulnerabilities caused by events that are often outside their control.

The economies of SIDS may also be highly vulnerable to exogenous shocks such as; fluctuation of commodity and energy prices, the erosion of preferential market access, the introduction of more stringent non-tariff barriers, and international fluctuations of interest rates. If these countries' have high levels of poverty and dependence on limited exports and sectors, as well as a weak supply-side capacity, it may heighten such vulnerabilities. The recent downturns in the global economy plus increased terrorist attacks and natural hazards have all contributed to a worldwide decline in the travel industry. This can have a dramatic effect on a SIDS if it is dependent on tourism for its income. In the Maldives, the contribution of Travel & Tourism to Gross Domestic Product is expected to decline from 63.4% (MVR10,762.6mn or US$840.8mn) in 2010 to 60.3% (MVR19,328.6mn or US$1,510.1mn) by 2020.

The remoteness and fragile economies of the SIDS, exacerbated by the exposure to such hazards as tropical cyclones, SIDS tend to obtain the majority of their income through their natural resources – sun and white sandy beaches. This attracts tourists for short periods and has led to a boom in some of these islands economies. These niche markets however can suffer at the occurrence of such hazards and become a concern for Island States. At the height of Meena and Nancy on the Cook Islands, while nationals were preparing for the cyclones, visitors were trying to demand for flights out of the country, knowing very well that aviation can be disrupted by hurricane force winds. The lesson here being that these niche markets can be affected if visitors are not made aware of the risk they have to ensure in case such events occur in vulnerable areas.

Moreover, SIDS are particularly vulnerable to the physical impacts of climate change including droughts, floods, and hurricanes. Indeed, their key economic sectors such as agriculture, fisheries and tourism are among the most susceptible to the impacts of climate change. Therefore, climate change threatens to exacerbate existing vulnerabilities and be an obstacle to their socio-economic development. The hazards associated with climate change include sea-level rise due to the thermal expansion of the world's ocean and extreme weather events caused by increasing surface temperatures of the oceans. Low-lying atoll communities, such as the Maldives and Cook Islands, are especially vulnerable (Woodroffe, 2007). (Ebi, et al 2006) As a result, small island states and particularly atoll countries are likely to experience erosion, inundation and saline intrusion resulting in ecosystem disruption, decreased agricultural productivity, increased vulnerability to extreme weather events, changes in disease patterns, economic losses and population displacement (Nurse, Sem, 2001).

Small islands are particularly susceptible to changes in atmospheric and oceanic circulation which can be especially apparent during El Niño phases. In the Pacific, El Niño events have resulted in water shortages and drought in Papua New Guinea, Federated States of Micronesia, Samoa, Tonga, and Fiji, and a greater chance of cyclones affecting Tuvalu, Samoa, Tonga, Cook Islands and French Polynesia. A warming of the ocean surface around small island states has already been detected, and this trend is expected to continue. Projections show that this warming will be accompanied by an increase in heavy rainfall events and other temporal and spatial changes in precipitation patterns, and by more intense or frequent cyclones/hurricanes. Arable land, water resources and biodiversity are already under pressure from increases in population on small island states and the unsustainable use of available natural resources.

With climate change the possible impacts on SIDS are huge but specific areas are expected to be;

- Coral reefs will be reduced by rising sea surface temperatures and acidification.
- Mangroves maybe destroyed by sea level rise and an increase in extreme weather events.
- Water resources are expected to be stressed by changes in precipitation patterns.
- Economic losses from reduced agricultural yields
- Reduction in freshwater availability due to decreased rainfall and saltwater intrusion;
- The risk of oil spills due to their proximity to shipping routes carrying large oil tankers cruise ship discharges.

4. Examples of Impacts on the Vulnerable System of SIDs and Measures Taken to Reduce the Vulnerability

As a result of torrential rain in January 2004 a serious flood occurred at Au Cap District, one of the districts on Mahe island of Seychelles. The heavy rain caused extensive damages to properties and other infrastructure. The President of the Republic put together a Task Force to study the problem and come up with solutions and associated costs. The study showed that Seychelles will need about 4 million Rupees (US$ 800,000) to remedy drainage problems in Au Cap District alone. Other than Au Cap other districts also suffered from inundation including Victoria the capital resulting in restriction of mobility on roads for pedestrians and vehicles as well as damages to properties and closure of business. The public should be sensitized about disasters and how to cope with such events. This should help to reduce panic and also contribute towards an efficient handling of the situation. Activities envisaged included: setting up early warning systems; updating the emergency management plan; a maintenance programme on drainage systems; capacity-building in emergency management and technical fields such as Hydrology and flood forecasting. The main obstacles faced were the lack of technical and financial capacity to predict flooding. The flooding caused severe economic impacts, extensive damage to properties, damages to the agriculture and businesses of which they had to claim from insurance companies and the economic impact of no action would have been catastrophic.

As in many SIDS, the availability of sufficient fresh water is a major concern for the Republic of the Marshall Islands (RMI). Since the Marshall Islands lack the financial and technical resources to implement seawater desalination for all their population, efficient sustainable freshwater recovery from groundwater has been an elusive goal. Since simple abstraction of freshwater from thin groundwater lenses, typical in oceanic atolls, often results in upward coning of saltwater, which in turn causes contamination of the water supplies, a new welling procedure was required. Thus, with the help of the United Nations and the North American National Weather Service (part of the

National Oceanic and Atmospheric Administration, NOAA) a new scavenger technology for wells was introduced. This technique was an inexpensive practical solution to prevent upward coning and contamination by saltwater when groundwater is withdrawn. In 2002 a UN DESA mission to Majuro in the RMI was conducted to demonstrate the applicability of scavenger wells in optimizing fresh groundwater recovery from thin freshwater lenses residing in oceanic atolls. The scavenger well technique proved to be of great help against saltwater contamination of withdrawn freshwater in three different test locations. Since the technique is relatively simple, it is a potential solution against saltwater contamination of freshwater lenses in a wide range of coastal regions. However finding suitable spots for the scavenger well technique requires testing and analysis. Lenses develop where topological and geological conditions permit: where the underlying rock is sufficiently permeable to allow rainwater to percolate underground, but not so porous that the infiltrated rainwater immediately drains to the sea without forming lenses.

The women in Bulelavata, a small, remote village in the Western Solomon Islands accessible only by sea, used to live a subsistence lifestyle typical of women in tens of thousands of other villages across the Pacific Islands. Then, in 1998, the community chose to begin the process of establishing an energy-for-development project. In 2001, the community-owned micro-hydro system, funded by the Australian International Greenhouse Partnerships, Caritas, and the Provincial Government, was officially opened by the Provincial Premier. The system produces 24kw and has 1.5 km of high voltage transmission line, enabling the community to sell power to the Provincial Secondary School. For the women of Bulelavata, the energy project has had some significant and profound impacts, ranging from the practical, quantifiable advantages of lighting and community income to qualitative outcomes such as solidarity and empowerment. The project design of the Bulelavata community micro-hydro scheme used a women's participatory action agenda, exploiting "action learning" (or learning-by-doing) as they were able to ground the workshops within the context of the occurring project in their lives. The workshops were comprised of policy support, female project management, female role modelling at varying levels, specific women's awareness and training workshops, visits by women to other villages, management committee positions for women, a new village institution for women, technical team leadership by women, and logistical project support teams being given equal status to technical project teams. This affirmative agenda was designed to encourage and facilitate active and meaningful opportunities for participation by the village women. It operated within existing Melanesian cultural and village religious mores while at the same time challenging the boundaries of perceived gender roles through the medium of the new technology. The Bulelavata village men say that the electricity project has changed their women; they are pleased that women are now more confident and outspoken and participate more in community development activities.

The southwest Indian Ocean (SWIO) is characterized with strong southeast monsoon variability which impacts negatively on the water resources, activities and economy of the islands. To improve a deeper understanding of the transient equatorial convective waves during southern hemisphere winter will form an important component of the research in enhancing scientific understanding on the causes and mechanisms governing climate variability in the SWIO during southeast monsoon. The results could be useful for strengthening numerical model performances in the near equatorial tropical region of the Indian Ocean. Results will be made available to forecast centres, policy makers, water resource managers, agricultural and tourist managers to ensure wide application such that national capacities related to disaster mitigation, prevention and preparedness are strengthened and future risk of climate are reduced. The final report will contain recommendations for downstream enhancements to the monitoring network to improve environmental data base in the region. Outcomes are expected to provide platforms for improved prediction skills, better water resources management, and improvement in environmental data observation in the Southwest Indian Ocean and in formulating downstream enhancement of water storage facilities. The study will make use of climate reanalysis data, ocean general circulation model (oGCM) assimilated data (ocean surface and subsurface), high resolution satellite data and insitu-data to study extreme cases of dry and wet spells in the southeast monsoon and its relation with the global–regional ocean climate environment. Numerical models will be validated and the water resource responses will be assessed. Statistical associations will be studied and predictive models for rainfall and water flow level will be developed and verified. The stability of the climate indices will also be evaluated.

In order to improve the living standards in the outer islands of Kiribati; and to reduce the migration to the capital South Tarawa, a Solar Energy for Outer Islands Project was implemented. The installation of 1710 solar home systems was completed on 18 islands; the next phase will be the installation of 96 solar systems to the maneaba (village meeting hall) on the 18 islands. After the complete installation of the solar home systems the feedback collected by the energy survey carried out by the Energy Planning Unit of the Ministry of Public Works and Utilities was as follows: 1) The households no longer worry about buying kerosene for lighting, kerosene is used in the rural areas mainly for lighting as cooking is done using fuel woods. 2) Safety from fire has been increased 3) Children and elderly house members are able to obtain lighting for themselves 4) Work can continue during the night for any income related business or school work 5) The feels secured as the lighting also provide security 6) GHG emissions is lower than using kerosene 8) The health impacts have improved as well without having to breath in kerosene fumes.

5. Analysis of Information Available about the Vulnerable Systems

In the past five years, SIDS have been dramatically been affected by hazardous events such as:

- In January 2010, the Solomon Islands were hit by a 7.2 magnitude earthquake, which resulted in a tsunami as high as 10 feet in some parts of the islands.
- The January 2009 floods in Fiji killed 11 people and left an estimated 9000 displaced.
- In September 2009 an earthquake of magnitude 8.1 hit American Samoa and caused a tsunami in American Samoa, Samoa and Tonga.
- In 2004 and 2005, hurricanes Ivan and Emily devastated Grenada, battering and destroying 90 percent of homes, and inflicting damages worth US$1.1 billion – more than twice the country's GDP.

In September 2008, three storms hit Haiti in less than 21 days, killing more than one thousand people, and leaving up to one million homeless. This left the country devastated and vulnerable to future hazards that were realised in January 2010 when a 7.3 magnitude earthquake struck. It resulted in more than 200,000 dead; 3 million displaced and will take $11.5 billion to re-build. In contrast in Cuba the human cost of the three hurricanes was only 7 persons, but the economic costs reached nearly 20 % of the Cuban GDP, around 10 000 millions of dollars (50 % due to destroyed houses) more than 0.5 millions houses affected (Cuban Government press release, Journal "Granma"). The striking difference in the scale of the human loss in these two countries illustrated that Cuba has a more extensive adaptation plan in place. It manages an effective and efficient Early Warning System and a successful Risk Reduction System designed for managing the natural and anthropogenic risks. Due to the engagement of its citizens, government to local organisation coordination, vulnerable population identification and guarantee of properties, damages to human livelihoods are dramatically reduced.

To strengthen the capacity of Pacific island countries in climate prediction, a US$ 2.2 million 3 year project is being implemented in the Pacific island countries which includes Fiji, Vanuatu, Samoa, Tuvalu, Tonga, Cook Islands, Solomon Islands, Kiribati and Niue. The project aims to upgrade the National Meteorological Services of participating island countries to enable them to provide better climate prediction support to industry government and the people of the Pacific island region. The project provided PC-based stand-alone statistical climate prediction services software SCOPIC (Seasonal Climate Outlook for the Pacific Island Countries) that are tailored as far as possible within the scope of the project to meet clients planning needs.

The latest version of SCOPIC was released in early October 2005. SCOPIC has been created and maintained by the contracted software specialist, Queensland Department of Primary Industries & Fisheries. The software is used to extract the statistical relationship between historical climate data in each country with a set of predictors (either SSTs (Sea Surface Temperatures) or SOI (Southern Oscillation Index) to produce local seasonal climate forecasts. Forecast verification can also be done by the software. The software has the flexibility to incorporate other historical input data that would enable NMS personnel and their clients to explore opportunities for extending predictions to variables such as crop production, fish catch and water resources.

The Maldives consists of 1,192 islands with at least 80 percent of them are 1 meter or less above sea level, and only three have a surface area of more than 500 hectares. These characteristics make them highly vulnerable to sea level rise and extreme storm events. Tourism, which accounts for about 33 percent of GDP, creates employment for roughly half of the population and stimulates economic activity in other sectors such as agriculture, construction, and services. About 20 percent of the population depends on subsistence fisheries. The economic and survival challenges of the people of the Maldives were evident after the 2004 tsunami caused damage equivalent to 62 percent of national GDP. As of 2009, the country still faced a deficit of more than US$150 million for reconstruction.

6. Policy and Management Practices

Adapting to climate change requires building economic resilience to cope with external shocks. Economic resilience is the "ability of an economy to recover from or adjust to the negative impacts of adverse exogenous shocks and to benefit from positive shocks". In order to build their economic resilience, SIDS need to implement actions to improve their competitiveness and enhance their supply-side capacities, while targeting environmental and social goals, and promote economic diversification to reduce the negative and augment the positive impact of climate change and achieve sustainable development. Indeed, enabling supply-side policies that facilitate the diversification of production and exports, technological upgrading, and the value added are instrumental to foster economic resilience in these countries. Trade, trade policy and rules can also play an important role in constructing and strengthening the supply-side and in enhancing and/or limiting the capacity to build economic resilience and adaptive capacities in SIDS. Indeed, through trade policy, countries could stop subsidizing polluting activities and provide incentives for innovation and diffusion of green technologies, such as non-renewable energies. Currently, however, many countries are largely subsidizing highly inefficient and polluting sources of energy generation and/or "bad" agricultural practices (from an environmental and/or social perspective). Moreover, intellectual property (IP) rights could play an important role in stimulating innovation, especially in low income countries. Although deeper analysis needs to be conducted, some research highlights that for vulnerable developing countries to diversify their production and move up the value chain, certain IP rules will need to become more flexible.

However, the vulnerability of SIDS is not just an environmental issue but has immense social and economic implications, as exemplified by the devastating consequences of many natural disasters that have occurred in the developing world, including the latest tsunami in East Asia. By the same token, the threat of climate change is not only geophysical but also poses grave risks to the social and economic viability of SIDS. Adaptation to environmental vulnerability and climate change is vital but will force difficult choices and tradeoffs in policy-making, involving, for example, further intensive coastal development or its possible limitation or restriction.. The choice is limited to remaining on the island/atoll or not.

The importance of disaster risk-reduction strategies is apparent. The need to move from post-disaster reaction to building the capacity for prevention is necessary. The establishment of early warning and information systems, including at regional and sub-regional levels is needed. The need for setting up regional climate observation systems to better enable monitoring of climate variations is also required. It has been noted that the tsunami that struck East Asia has united the world and created a political momentum that should be used to further expand international cooperation for the development of early warning and information systems within the context of broader disaster prevention efforts. But any such system must be sensitive enough to meet the needs of small States, especially the SIDS.

Disaster reduction strategies are aimed at enabling societies at risk to become engaged in the conscious management of risk and the reduction of vulnerability. It is important to acknowledge that communities may have chosen to live with this risk because the costs of mitigating them are simply unobtainable to them. Macro scale diversification needs to filter down to the root level so that vulnerable communities can obtain the means to mitigate for disasters. Therefore these policies should be culturally and gender sensitive and need the necessary political commitment. They involve the adoption of suitable regulatory and other legal measures, institutional reform, improved analytical and methodological capabilities, financial planning, education and awareness. Member States and international organizations need to ensure that development plans and poverty reduction strategies in SIDS include disaster risk assessment as an integral component and increase their investments to reduce risk and vulnerability if development gains are not to be wiped out. For disaster risk reduction to be strengthened in SIDS it needs to be both a humanitarian and a development responsibility in line with the Millennium Development Goals. Member States are encouraged to support the process of consolidation of ISDR in SIDS as an essential instrument for sustainable development.

The Development Assistance Committee (DAC) of the Organization for Economic Cooperation and Development (OECD) in 2001 provided a set of key principles for sustainable development strategies. These principles were: a) *The strategic approach* which included the consensus on long-term vision, comprehensive and integrated strategies, and strategies targeted with clear budgetary priorities; b) *The strategic process* which included the priorities based on comprehensive and reliable analysis, and incorporation of monitoring, learning and improvement; c) *Linking national and local levels* which included building on existing mechanisms and strategies, and develop and build on existing capacity; and d) *Ownership* which included Country-led and nationally-owned strategies, people-centered strategy, high-level government commitment and influential lead institutions, and effective participation.

7. Research Gaps and Needs

SIDS have ongoing projects and some are in the pipeline which will implement adaptation measures to help increase resilience to the impacts of climate change on a global, regional and national level. These projects involve strengthening of institutions, policy and regulations, but also ground-level tasks such as water storage and drought resistant crops. Many follow on from, or are acting in synergy with, projects for the mainstreaming of adaptation. Some completed adaptation projects date back to the 1990s and have published outcomes which can be used as a resource for SIDS investigating adaptation approaches. However, in spite of the wide range of adaptation options that could be successfully implemented in SIDS, there are constraints that can limit the choices of options and their implementation such as inadequate data and technical capacity, weak human and institutional capacity and limited financial resources. Mal-adaptation, caused by governments underestimating or overestimating the climate impact, can also hinder the adaptation process, since it can be used as a reason for going through with adaptation options.

8. Summary and Conclusions

SIDS will continue to be vulnerable to many forms of hazards unless a comprehensive DRR and CCA strategy is implemented into all facets of society. The coalition of these islands provides an opportunity to learn from each other and transfer knowledge especially in regards to Cuba's efficient disaster management system. However, funding will have to be made available from the governments to allow a bottom up approach to develop which may be difficult in the current economic climate and outside funding may have to be sought.

An example of DRR and CCA being incorporated is seen when CBDP (community based disaster preparedness) programme came to Wajo, Indonesia, which is heavily affected by flooding. The risk of damage by water hyacinths was reduced by building a barrier of concrete poles to prevent the plants from hitting houses. A group of selected local villagers were also trained as members of Red Cross/Crescent community based action team. New infrastructure, equipment and facilities and health-care improvements were introduced: towers for clean drinking water in the villages, the provision of information and 24-hour health centres. "Though the CBDP programme here was not directly involved with climate change in the beginning, there are components of climate change issues that PMI integrated into its preparedness, prevention and response action plans," said Arifin Muh Hadi. "There is no single climate change standard, but it should be mainstreamed or integrated into each specific programme," he continued.

Viewing DRR and CCA as separate entities will not allow for major steps to be made. They both have the same goal: to reduce risk. Education on the science of climate change and disaster management throughout all levels of society will increase the awareness of the communities to their rights in a disaster, how to mitigate one and how to re-build afterwards. This will create a culture of prevention and initiate proactive measures that decrease the risk and vulnerability of the population.

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Case Study 9.11. Vulnerable Regions: Case Study: The Arctic

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1. Introduction

In recent years, most Arctic regions have been experiencing the most rapid rates of climate warming on the planet (Anisimov et *al*., 2007; Furgal and Prowse, 2008; Huntington et *al*., 2005; McBean et *al*., 2005; Overpeck et *al*., 2005; Ford and Pearce, 2010). This rapid change exacerbates an existing vulnerability due to the fact the in the harsh climate of the Arctic, everything is designed or built with the special demands of the territory in mind (Ford, 2009; Instanes et al, 2005; NRTEE, 2009; US Arctic Research Commission Permafrost Task Force, 2003). As the climate warms, there are major implications for the society that is built upon it. Thawing permafrost could cause disruption of the ground surfaces, which could upset the structures on it (US Arctic Research Commission Permafrost Task Force, 2003). Considering the sheer number of structures, roads, railways, powerlines, piping systems and mining operations that are at risk, serious disruption could destroy large industries as well as homes and communities. Additionally, the rapid change in climate has implications for health, social and economic processes, travel, and biodiversity among others. Current lifestyles and practices are threatened. This case study will focus on two examples of vulnerability: the built environment; and hydrologic processes. Both impacts are increasingly common in many Arctic communities and may be responsible for their inability to continue to reside in their historic location or in their lifestyle, given ever-increasing vulnerability.

2. The Built Environment

The main issue surrounding the built environment in Arctic communities, is the fact that everything including infrastructure such as roads, houses and buildings, pipelines, energy transmission facilities etc have been built on the assumption that the ground would be permanently frozen. As permafrost melts, the ground is less able to support the structures and systems that are built upon it, leaving a trail of twisted and broken infrastructure (US Arctic Research Commission Permafrost Task Force, 2003). This type of problem permeates every aspect of life in Arctic region. In terms of transportation for instance, roads and bridges, airports and train rails are all vulnerable to instability once the permafrost melts (Infrastructure Canada, 2008). Additionally, ice roads are a common form of transportation during the winter months. For instance, the government of Manitoba relies on over 2,000 km of ice roads in order to supply remote communities during the winter months (Infrastructure Canada, 2008). With the warming weather and melting permafrost, ice roads are likely to soften and/or collapse entirely, requiring alternate routes to be established. While there are some alternatives to the aforementioned forms of transportation, namely barges, there are limits that cannot be overcome. For instance, the port infrastructure might not be able to accommodate the increased demands on it (NRCan, 2007). Additionally, there are numerous areas and industries that are established well inland and would not be accessible by water (NRCan, 2007). With most forms of transportation in the Arctic region thus affected by climate change, the communities of the Arctic are isolated even more so than they were (Paskal, 2010).

An additional complication is the fact that infrastructure in the Arctic regions rarely has the level of redundancy (a key factor in resiliency of most infrastructure) that is present in more Southern regions (NRTEE, 2009). When combined with the isolation of communities, these factors add to the vulnerability of the region. Having such a complex and overarching vulnerability necessarily complicates the adaptation process since efforts and funding must be dispersed in order to address the problem areas.

2.1. Case study: Kivalina, Alaska

Like many other coastal communities, the community of Kivalina, Alaska has experienced problems with coastal erosion and melting permafrost causing the collapse of buildings and crumbling infrastructure. Rates of erosion are among the highest in areas of melting permafrost (Anisimov et *al*., 2007) and permafrost-ridden coasts are the most likely to erode, as ice under the seabed and shoreline melts upon contact with the warmer air and water (Instanes et al, 2005). When added to the threat of rising sea levels, coastal erosion is a major problem for coastal communities

(Walker, 1998). Permafrost thaw was also a danger and threatens many parts of the Kivalina community. When combined, the people of Kivalina were threatened on all sides. Their infrastructure was weak and breaking apart, their coasts were eroding, sometimes so severely that houses and other buildings were gradually falling into the sea. Additionally, they were isolated, so patchwork and upgrading infrastructure became a difficult undertaking. The costs of rebuilding and repairing a community to better withstand permafrost thaw, coastal erosion and sea-level rise are debilitating (US Arctic Research Commission Permafrost Task Force, 2003). In some cases, as in Kivalina, no amount of patchwork is able to accommodate the amount of damage that was done.

Given the circumstances and the costs involved on both the relocation and the adaptation sides, the decision was made to relocate the entire community (Anisimov et *al*., 2007; Arctic Research Commission Permafrost Task Force, 2003). At an estimated cost of $54 million, the relocation was an expensive option but it would save money and hardship in the meantime (US Arctic Research Commission Permafrost Task Force, 2003).

3. Geographic Location and Hydrologic Processes

Part of the reason that the Arctic region is so vulnerable is that the geographic location allows for some extreme events, not common in other regions. One such threat is that of ice jams. Ice jams are widely distributed in most northern countries and are the reason for some cases of catastrophic flooding (Burakov et al., 2007; White et al., 2007). Ice jams occur when there are northerly flowing rivers in cold climates. As the climate changes, the occurrences and characteristics of these events are changing. One of the most dramatic natural events that take place in a river (Eliasson and Gröndal, 2008), ice jams can lead to localized and regional flooding in the area behind the blockage, and the sudden failure of an ice jam can release large quantities of water and ice that may cause damage to nearby structures, croplands, and wildlife habitat downstream. Water levels are greatly increased after the ice jam formation and ice jams often lead to impacts on human activities along the banks of the river. The mechanism of ice jams formation was described in details by Parizet (1966), Uzuner (1974), Tatinclaux (1978), Tatinclaux and Lee (1978), Beltaos et al (1983, 2000), Belikov (2004), Buzin (2007) and other researchers. The main cause of breakup-jam formation is the obstruction of the downstream movement of ice blocks by segments of still intact ice cover. An ice jam can therefore form anywhere in a river; however, there are certain geomorphic or anthropogenic features that are highly conducive to jamming. These include sharp bends and abrupt reductions in slope or flow velocity (e.g. a reservoir entrance, a river mouth, or a channel constriction). Frequently the ice jams are formed on one and the same stretch of rivers.

3.1. Case study: ice jams in Lensk, Russia

In the Russian Federation, the resulting floods have resulted in huge losses to the economy and populations of the Yakutia Republic and improved techniques for forecasting ice jams are needed (Belikov and Zaitsev, 2004). The Lena River flows mainly from the south to the north and ice jams form along its extent during the periods of ice drift; particularly so when ice cover thickness reaches 1.5-2 m. These ice jams are frequently characterized by large extent (up to 80-100 km in length) and duration, up to 5-8 days (Kiljaminov, 2007). The winter of 2000-2001 was cold with thick ice and 140% of normal snow water equivalent in the upper basin. At the beginning of May, 2001, as a result of sharply increasing air temperatures, the most destructive ice-jam flood occurred on Lena River affecting the town of Lensk. The generated freshet wave of water destroyed the strong ice cover on a 800km length of the river in 2 days. The flooding of Lensk started on May 13, 2001 when an enormous ice jam more than 15 m high formed near the Batamai Island located 40 km downstream on the river. There were many attempts to break this jam including bombardment from military helicopters and aircraft but all in vain. From May 13 to May 17 the water level of the Lena River rose by about 19 m above the average long-term value for 68 years of observation by 9.5 m (Russian Federation Nat. Report, World Conference on Disaster Reduction, 2004) and Lensk was completely flooded. Most of the inhabitants were evacuated 200 kilometers north to Mirny and there was also a large rescue operation involving 12,000 people. About 1,700 houses were totally ruined by the flood and another 400 were simply swept away by the torrent. The damage to economy in Lensk was about 4 billion Rubles (about $US150M) and the total damage to related ice-jam floods in the area that year exceeded $US240M with seven deaths and more than 50 thousand people affected.

4. The Arctic Vulnerable Region

Kivalina, Alaska and Lensk, Russian Federation are just two of many areas in the Arctic that are vulnerable to climate change. Vulnerability is defined here as *the degree to which a system is susceptible to, or unable to cope with adverse effects of stress* (McCarthy et *al*., 2005) to climate change. The accelerated rate of climate change makes adaptation efforts extraordinarily challenging due to the dynamic nature of the environment (Anisimov et al., 2007). The physical changes that will result from such extreme temperature changes will affect all aspects of society from infrastructure to traditional life and health which are interdependent (NRTEE, 2009). In the Arctic communities and inhabitants are often isolated from each other and the rest of their country, making it difficult to receive aid. Ford and Pearce (2010) provide an extensive literature review of what is known, not known and needed to be known about climate change vulnerability in the western Canadian Arctic.

5. Analysis of Information Available about the Vulnerable Systems and Role of DRR or CAA to Reduce Vulnerability and Impacts

A number of adaptation methods, in addition to relocation, have been attempted in order to stem the impacts on Arctic communities. In the coastal hamlet of Tuktoyuktak, for example, efforts to prevent erosion have been undertaken. Its location as a low-lying town with a peninsula makes it vulnerable to both permafrost thaw and the accelerated erosion that process contributes to (Lonergan et al, 1993). Weighing three options ranging from $2.8 million for an annual replenishment of the sand banks to $9.1 million devoted to concrete mats bound together with chains, the community opted to tackle the issue from this angle (Johnson et al, 2000).

Additionally, several adaptation techniques have been developed and implemented in order to repair and defend existing structures against the ever-changing earth. Several of these examples can be noted in Yellowknife, Capital of the Northwest Territories, Canada. When the local airport runway began to show signs of stress under the gradual permafrost thaw, an extensive restoration was undertaken installing an insulated liner four meters beneath a 100 metre section of the runway (Infrastructure Canada, 2008). Additionally, new bridges are being installed to act in the place of ice roads that are no longer stable (Infrastructure Canada, 2008). When bridges are not plausible, millions of dollars have been put into building all-weather roads and/or airlifting supplies into the city (Infrastructure Canada, 2008).

Other examples of adaptation techniques used to reduce the thaw and gradual warming are heat pumps, convection embankments, passive cooling systems and winter-ventilated ducts (Instanes et al, 2005; Couture et al, 2003; Smith S et al, 2001). More popular, buildings are often put on pillars (US Arctic Research Commission Permafrost Task Force, 2003). These adaptive measures are not ideal. First, they are incredibly expensive, since they attempt to retrofit existing structures. Secondly, they are not long-term solutions to a problem since they merely attempt to slow the process of warming or shifting. If climate change continues to warm the earth and air, inevitably these measures will be outgrown as the earth continues to shift beyond the projections.

Deciding whether to retrofit an older structure or design and build new infrastructure requires good projections on changing climate and implications for permafrost, sea ice and level and river flows. Barriers to adaptation, including financial resources and social-cultural issues have been identified (Ford and Pearce, 2010). Climate change adds another layer of complexity to adaptation efforts. As it is changing at an unpredictable rate and so estimations needed to determine the type of adaptive measure are often incomplete. This complication ensures that any measure introduced will merely serve as a stop gap, requiring further attention in the future, or significant expense like a relocation.

The NRTEE (2009) has provided a comprehensive report on recommendations to promote the resilience of northern infrastructure and its ability to adapt to a changing climate. It is recommended that there be a "mainstreaming" adaptation into policy and integration climate risks into existing government policies, processes, and mechanisms. One example is to ensure the effectiveness of codes and standards for infrastructure design, planning, and management to address climate risks, and that this be regularly assessed in light of new climate information. The role of private insurance in managing climate risks to infrastructure, potential changes in access to coverage of insurance as new climate risk factors emerge, and the need for mandatory disclosure of financial risks that climate change poses to the industry is also needed. Because of the specific needs of the people in the north and the north in general, there should be a dialogue and engagement between risk management practitioners (codes, standards, and related instruments; insurance; disaster management) operating in Canada's North and the climate change adaptation community.

Investigations have shown that the increase of water resources in the Basin of Lena River, as a result of climate change, will significantly increase the risk of extremely high water levels caused by ice jam formation, which may exceed current extreme values (Kimstach et al, 2004). Preventive and mitigation actions include the need to reduce the ice cover solidity by, for example, sawing the ice cover in the most dangerous areas or blackening the surface of the ice cover by ashes, dusty coal or sand. In each case, determination of the type of measures which can be applied for mitigation of negative consequences needs study.

Communities in the North need stronger adaptive capacity to deal with climate change. The vulnerability of northern infrastructure and related services is plainly evident. Reliable infrastructure is central to sustainable regional development and human security. Governments need to support community-based infrastructure-risk reduction through activities such as building awareness of the linkages between disaster management and climate change adaptation, critical infrastructure mapping, and developing and tracking of vulnerability indicators.

6. Relationship to Key Messages

There are relationships to many key messages. In the Arctic, with its complexities, risk and vulnerability are very complex and dynamic and context dependent. Responding to climate change impacts requires effective government responses and building a culture or approach to adaptation across a wide range of issues and effective disaster risk management in a changing climate will be facilitated by anticipatory strategies within and between sectors and across institutions. Clearly, adaptation and disaster risk reduction is a long term issue which requires climate smart disaster risk management.

7. Research Gaps

Though there are numerous case studies and reports on adaptation to climate change in the Arctic, there are few specific studies on permafrost thaw and infrastructure damage. Considering the importance of the industry in the Arctic, the hardship for communities of the North and the expense involved in short term, ineffective stop-gap measures, there should be more of an effort from the appropriate governments and organizations to base decisions on good research. Science is at the heart of climate change knowledge and trends. The NRTEE (2009) Ford and Pearce (2010) note the need to know more about the nature and extent of climate change in Canada's North and how it will affect infrastructure and communities. The NRTEE specifically recommends: investment in expanding the weather and permafrost data stations in Canada's North; continued investment in climate science and modelling, and in climate change impacts and adaptation research. It is important that climate change projections, and climate design values to support infrastructure decisions be regularly improved and made available.

8. Conclusion

The Arctic is a vulnerable region for many reasons. Their geographic location leaves them isolated and climate change is exacerbating permafrost thaw at an accelerated rate. The communities that inhabit the area are thus very vulnerable and, as the damages to infrastructure have already started to occur, it is important that work is done to close the research gaps and find longer-term solutions.

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Case Study 9.12. Least Developed Countries and Fragile States

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1. Description of a Vulnerable Group

Since the early 1970s, Senegal has suffered from recurring droughts and a chronically severe economic situation and in 2001 it became one of the Least Developed Countries (LDCs). Global trade factors and internal political transformation have accentuated the impacts of the degradation of the physical environment—a primary asset of a country that is dependent on its natural resources and agricultural output. Sixty percent of Senegal's population works in the agricultural sector, and 95 percent of the crops are dependent on rainfall, which has been irregular and often insufficient.

Senegal suffered from a major drought in 1972, and since then it has experienced drought in 1976, 1979 and from 1982-1986, with a record-low rainfall total in 1984. Rainfall has declined by 30-40 percent since the 1970s, destroying plant cover and aggravating wind erosion. The Cape Verde peninsula risks the erosion of up to 50 percent of its beaches, and the Saloum estuary, which is vulnerable to flooding, may lose more than half of its ecosystems by 2050.

Due to lower adaptive capacity, poor communities are more vulnerable to the negative effects of climate change, including drought, which is a concern given that climate-related disasters have become more frequent (Seck et al. 2005, UN 2009). Due to a lack of data and insufficient computational power, there are relatively few regional and sub-regional climate scenarios for Africa based on regional climate models or downscaling (Boko et al., 2007). Of the models that do exist, here is some discrepancy: some predict significant drying (which may be exacerbated by land use changes and degradation); some predict progressive wetting; and some predict more frequent extremely dry and extremely wet years (Boko et al. 2007).

In response to these potential threats, Senegal has submitted a US$ 8.6 million project proposal to the Adaptation Fund Board, a multilateral fund created by the Parties to the Kyoto Protocol. The project is intended to implement measures identified in Senegal's National Adaptation Plan of Action (NAPA) to protect agricultural livelihoods, which are concentrated in coastal areas, from erosion and saltwater intrusion (Senegal, 2010). Senegal has also sought financing from the Government of Japan's Africa Adaptation Programme to fund a US$ 3.0 million adaptation project designed to reduce the negative impacts of climate change on:

- Human health
- Poverty eradication
- Food security
- Scarce water resources
- The littoral zone (UNDP, 2010).

Both of these proposed projects build upon existing disaster risk reduction policies because the NAPAs are designed to focus on urgent and immediate needs—those for which further delay could increase vulnerability or lead to increased costs at a later stage (UNFCCC 2010).

2. Analysis of Information Available on DRR and CCA in LDCs and Fragile States in Specific Cases

2.1. Title??

Some (Tschakert, 2007) have argued that Senegal's hazard- and exposure-oriented approach is misdirected and that it should instead incorporate more non-climatic factors such as sources of livelihoods, assets, access to resources, institutional networks, education, gender, race, ethnicity, poverty and self-protection. Approaches that focus on building resilience to climatic stressors are supported by disaster trend analyses (UN, 2009). However, other studies show that economic disaster losses rise with per capita incomes—up to a certain threshold (Kellenberg and Mobarak, 2008).

Disaster risk is configured unevenly and is concentrated in the poorest countries, and among the poorest communities within countries (UN, 2009; Adger et al. 2007). For example, at the global level low-income countries represent 13 percent of the exposure and 81 percent of disaster mortality risk (UN, 2009). Small Island Developing States (SIDS) and Land-Locked Developing States (LLDCs) suffer higher relative levels of economic loss from natural hazards—and they are less resilient to those losses so that one extreme event can set back decades of development gains (UN, 2009; Kelman, 2010).

Due to low resilience, high susceptibility to harm, and limited adaptive capacity, the poor are particularly vulnerable to climate hazards and the negative impacts of climate change (Adger, 2006). Much current research has emphasized that there are multiple stressors and multiple pathways of vulnerability, particularly those that address the social and institutional dynamics of social-ecological systems—for example, while some famines may be triggered by extreme climate events such as drought or floods, vulnerability researchers have shown that famines and food insecurity are more often caused by disease, war or other factors (Adger, 2006). In short, the social and economic characteristics by which LDCs are defined (education, income and health, for example) effectively lower the threshold for extreme climate events (Adger et al 2007).

Underdevelopment and susceptibility to disasters are mutually reinforcing: disasters not only cause heavy losses to capital assets, but also disrupt production and the flow of goods and services in the affected economy, resulting in a loss of earnings. In both the short and the long-term, those impacts can have sharp repercussions on the economic development of a country, affecting gross domestic product (GDP), public finances, foreign trade as well as price indices, thus contributing further to increasing levels of poverty and indebtedness (Mirza, 2003; Ahrens and Rudolph, 2006).

2.2. Title??

Several Himalayan glacial lakes have witnessed significant expansion in size and volume as a result of rising temperatures. This increases the likelihood of catastrophic discharges of large volumes of water in events which are known as Glacial lake Outburst Floods (GLOFs). One of the most dangerous glacial lakes in Nepal had been the Tsho Rolpa lake whose size increased by 6,000 percent from the 1950s to the 1990s (Sperling and Szekely, 2005).

The Tsho Rolpa glacial lake project is an example of disaster risk reduction and anticipatory adaptation. Tsho Rolpa was estimated to store approximately 90-100 million cubic meters of water, a hazard that called for urgent attention. A 150-meter tall moraine dam held the lake, which if breached, could cause a GLOF event in which a third or more of the lake could flood downstream.

The likelihood of a GLOF occurring at Tsho Rolpa, and the risks it posed to the Khimti hydropower plant downstream was sufficient to spur the Government of Nepal to initiate a project in 1998 to drain down the Tsho Rolpa glacial lake. To reduce this risk, an expert group recommended lowering the lake three meters by cutting an open channel in the moraine. In addition, a gate was constructed to allow water to be released as necessary. While the lake draining was in progress, an early warning system was established in 19 villages downstream of the Rolwaling Khola on the Bhote/Tama Koshi River to give warning in the event of a Tsho Rolpa GLOF (Sperling and Szekely, 2005).

Local villagers have been actively involved in the design of this system, and drills are carried out periodically. The World Bank provided a loan to construct the system. The four-year Tsho Rolpa project finished in December 2002, with a total cost of USD 2.98 million from The Netherlands and an additional USD 231,000 provided by Government of Nepal. The goal of lowering the lake level was achieved by June 2002, which reduced the risk of a GLOF by 20% (Sperling and Szekely, 2005).

2.3. Title??

Malawi, another LDC, is one of the more drought-prone countries in southern Africa, and its predominantly smallholder farmers are severely affected by rainfall risk resulting in food insecurity. In the past, the government has responded to recurrent drought-induced food crises by providing ad hoc food relief. Until recently, droughts and a lack of credit have prevented Malawian farmers from planting higher-yielding seed types, but an experimental weather insurance programme (based on a precipitation index and bundled with loans) allowed farmers to access hybrid groundnut seeds. Such safety nets have allowed farmers to plant the higher-yielding seeds (Linnerooth-Bayer and Mechler, 2007).

Since 2004, the Government of Ethiopia (another LDC) and its international partners have also been piloting a weather index risk financing programme as a form of drought risk mitigation and transfer. Ethiopia's innovation was to link the short-term relief (insurance) with the Government's employment-based Productive Safety Nets Programme (PSNP), which addresses the predictable needs of chronically vulnerable groups who require assistance during the hunger gap season even in good years (Maxwell et al., 2010).

2.4. Title??

The effective use of available climate information, such as seasonal forecasts, can improve agricultural yields and reduce rural communities' vulnerability to the impacts of drought (Dilley, 2000; Challinor, 2008). For example, awareness of the impacts of El Niño on climate fluctuations in southern Africa grew during the 1990s due to the nearly continuous El Niño that lasted from 1991 through 1995. As a result of this repeated exposure, governments and the public paid greater attention and detected the phenomenon earlier when it recurred in 1997, and as a result the drought impacts were reduced (Dilley 2000). Similarly, greater computing power has led to more accurate seasonal forecasts, but for this information to be useful it must be calibrated to the appropriate context and it needs to be perceived as useful by potential beneficiaries (Challinor, 2008).

2.5. Title??

Adjusting livelihood systems to persistent drought has been slow and difficult, but over time the humanitarian community has improved its response capacity to agricultural droughts (Kates, 2000). Unfortunately, rather than focusing on livelihoods, the proposed adjustments are often technical improvements, they are sometimes contradictory, and they seldom address the locally specific factors and policies that render a country or community vulnerable to drought in the first place (Kates, 2000).

On the contrary, the bottom-up approach to disaster risk reduction and adaptation is based on enhancing the capacity of local communities to adapt their livelihoods to and prepare for extreme events (Allen, 2006; Blanco, 2006). Although climate change may be incorporated in this approach through awareness raising and the transmission of technical knowledge to local communities, bridging the gap between scientific knowledge and local application is often a challenge (Blanco, 2006).

3. <u>Relationship to Key Messages</u>

In most LDCs in Africa, the most pressing need is to halt the decline in agricultural yields and increase food security by producing more food and taking measures to deal with irregular rainfall through improvements in storage and distribution of agricultural products, because the relative increase in agricultural production has not been due to better production methods but mainly to territorial expansion (Davidson et al., 2003). For example, the removal of trees for agricultural reasons—the primary cause of deforestation and soil erosion—has become an essential act to meet the food needs of a rapidly growing population, and even this success is highly qualified (Davidson et al., 2003; Kates, 2000).

Although climate change seems marginal compared to the pressing issues of poverty alleviation, hunger, health, economic development and energy needs, it is becoming increasingly clear that progress toward the development goals can be seriously hampered by climate change. This is why the linkages between development and climate change now receive more and more attention in scientific and policy circles (Davidson et al., 2003; OECD, 2010).

Catastrophic and irreversible damage to humans can result even from modest changes in natural systems or relatively small climate hazards. The impact on a community depends on the latter's adaptive capacity, which is in turn shaped by the community's policies and institutions (Heltberg et al., 2008). Complicating matters, the interests of poor communities are not necessarily the same as those of poor government (Kates, 2000). Some (Kates, 2000; Carmen Lemos and Tompkins, 2008; Davies et al., 2008, Heltberg et al., 2008) have argued that policy instruments based upon social protection are best suited for adaptation and long-term risk reduction because they generate net benefits under all future climate scenarios and they are rooted in the specific needs of a particular community and can therefore build resilience by addressing the root causes of vulnerability.

Progress in carrying out analyses and identifying what needs to be and can be done can be documented, but action on the ground to mainstream adaptation to climate change remains limited, particularly in the least developed countries. National policy making in this context remains a major challenge that can only be met with increased international funding for adaptation and disaster management (Yohe et al, 2007; Ahmad and Ahmed, 2002; Jegillos, 2003; Huq et al., 2006)

Socio-economic and even environmental policy agendas of developing countries do not yet prominently embrace climate change (Beg et al., 2002) even though most developing countries participate in various international protocols and conventions relating to climate change and sustainable development and most have adopted national environmental conservation and natural disaster management policies (Yohe et al, 2007). Social and environmental (climate change) issues are, however, often left resource-constrained and without effective institutional support when economic growth takes precedence (UNSEA, 2005).

4. Research Gaps and Conclusion

Burton et al. (2002) posed 21 questions about adaptation research in order to stimulate further investigation, such as:

- What is the extent of adaptation in practice and what are the barriers, obstacles or incentives to adaptation?
- How does public policy with respect to climatic hazards relate to the economic and sustainable development policies and strategies in place?
- What are the prospects for adaptation and how much can vulnerability be reduced?
- What will be the distribution of the benefits and costs of adaptation?

Even though progress has been made answering some of these questions, many are still relevant.

In particular, one of the central problems is a better understanding of adaptation and adaptive capacity, and of the practical, institutional, and technical obstacles to the implementation of adaptation strategies (Schneider et al., 2007). Both development agencies and NGOs have developed best practices based on decades of experience, but further research is needed to analyze why these guidelines are so often ignored (James, 2010).

Central to nearly all the assessments of key vulnerabilities is the need to improve knowledge of climate sensitivity—particularly in the context of risk management—the right-hand tail of the climate sensitivity probability distribution, where the greatest potential for key impacts lies (Schneider et al., 2007). In addition, relatively few regional and sub-regional climate change scenarios have been derived from regional climate models or empirical downscaling for Africa, primarily due to restricted computational facilities and a lack of human resources and climate data (Boko et al. 2007). Global climate models are unable to simulate the teleconnections and feedback mechanisms responsible for rainfall variability in Africa, and other factors (dust aerosol concentrations, sea-surface temperature anomalies) complicate African climatology (Boko et al 2007).

There is broad recognition, especially among small island developing states whose existence is threatened by sea-level rise, that climate change is a matter of national security. However, there has been insufficient systematic analysis of climate change as a security issue, particularly on the social, economic and environmental drivers of armed conflict (Barnett, 2003).

Finally, despite renewed momentum and commitments by governments to reduce disaster risk in the face of major catastrophes, preventive approaches continue to receive less emphasis than disaster relief and recovery (Davies et al., 2008). To the extent that disaster risk reduction and are advocated as cost-effective means of preventing future negative impacts on development investments without simultaneously addressing equity and rights-based arguments, they may fail to capitalize on potential synergies (Davies et al., 2008).

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9.3.3. Management Approaches

Case Study 9.13. Risk Transfer – The Role of Insurance and Other Economic Approaches to Risk Sharing

Authors: G. McBean, P. Kovacs, R. Mechler, K. Warner, J. Linnerooth-Bayer

1. Introduction

The human and economic losses caused by climatological, hydrological or meteorological (hereafter climate-related) disasters have continued an upward trend that has developed over the last few decades (Centre for Research on the Epidemiology of Disasters (CRED) , Rodriguez et al., 2009; Munich Re Data Service NATHAN[12]; Gall et al., 2009). The enormity of the problem is outlined by Wahlström (2009) who stated "*Over the last two decades (1988-2007), 76% of all disaster events were hydrological, meteorological or climatological in nature; these accounted for 45% of the deaths and 79% of the economic losses caused by natural hazards*."

[INSERT FOOTNOTE 12 HERE: MunichRe 2006 Topics Geo - Natural catastrophes 2006 Analyses, assessments, positions. Copyright 2007 Münchener Rückversicherungs-Gesellschaft, Königinstrasse 107, 80802 München, Germany, Order number 302-05217 (available at www.Munichre.com)]

Although all countries have been impacted by natural disasters, the relative impact on human lives is usually larger in developing countries and larger in economic costs in developed countries (Mileti, 1999). Despite this trend, while the absolute dollar costs of disasters in highly-developed countries are large, the damage as a percentage of Gross Domestic Production (GDP) is much larger in the developing countries (Handmer, 2003). Further, mortality figures are a good indicator of severity of impact. In highly developed countries, the average number of deaths per disaster is 23, while the number increases dramatically to about 150 deaths per disasters in medium and to over 1000 deaths per disaster in less developed countries (Mutter, 2005). To a certain extent, this statistic can be accounted for by considering issues of population density and infrastructure quality however, this is not always the case. For instance, although an event in India or China is likely to affect more people than in one of the smaller countries, the number of victims per 100,000 inhabitants list was led by Djibouti, Tajikistan, Somalia and Eritrea (Rodriguez et al., 2009). This demonstrates that in addition to population density and area of vulnerability, the economic ability of a nation to respond is an important factor in assessing the potential impact of any natural hazard. Developing nations often have minimal preventative measures and are unable to respond adequately in the immediate aftermath. Additionally, the attempt to recover from such events may be economically debilitating as well. For instance, the events in Myanmar and Tajikistan resulted in damages exceeding 20% of their Gross Domestic Production (GDP). These results highlight the important roles of insurance and other economic approaches to risk transfer and sharing so that climate-related events do not overwhelm a country or a community of people within a country.

2. Description of Thematic Approaches

The process of recovering from extreme events is expensive and can take years or even decades. Financing mechanisms supporting economic recovery include insurance and humanitarian assistance. These systems, however, have been challenged and sometimes overwhelmed in recent years by a combination of climate change, increasing populations living in areas of risk, ageing infrastructure and other factors. This case study describes a number of recent examples seeking to strengthen and enhance the financial and humanitarian systems in place to support recovery for extreme weather events. Warner et al. (2010) provide a review of the connections between climate change adaptation and disaster risk reduction in the context of insurance and risk transfer mechanisms, which provided the basis for this case study report.

There are several examples of financial mechanisms for managing risks at different scales, from local to national to international levels. At the local level, the focus is on individual households, small-to-medium sized enterprises (SMEs), farms and similar institutions or organizations. At national, including sub-national, the focus is on governments while at the international level, development organizations, donors, non-governmental organizations and others need to be considered. Broadly-speaking**,** risk transfer mechanisms can be grouped as non-insurance and insurance mechanisms. In this case study, the main focus is on insurance mechanisms but a short description of non-insurance mechanism will be given first.

[INSERT TABLE 9-1 HERE:
Table 9-1: Examples of mechanisms for managing risks at different scales**.**]

3. Description of Risk Transfer Tools and their Relation to Disastrous Events

There are several forms of risk transfer tools (Cummins and Mahul, 2009) and these include:

- (Traditional) Insurance - is a contractual transaction that guarantees financial protection against potentially large loss in return for a premium.
- Micro-insurance (e.g., Morelli et al., 2010) - is characterised by low premiums or coverage and is typically targeted at lower income individuals who are unable to afford or access more traditional insurance. Micro-insurance tends to be provided by local insurance companies with some external insurance backstop (e.g. reinsurance).
- Catastrophe Reserve funds - are typically set up by governments, or may be donated, to cover the costs of unexpected losses.
- Risk pooling or pools - aggregate risks regionally (or nationally) allowing individual risk holders to spread their risk geographically. Through spreading risks, pooling allows participants to gain catastrophe insurance on better terms and access collective reserves in the event of a disaster.
- Insurance-linked securities - most commonly catastrophe (cat) bonds which offer an avenue to share risk more broadly with the capital markets.
- Weather insurance typically takes the form of a parametric (or indexed-based) transaction, where payment is made if a chosen weather-index, such as 5-day rainfall amounts, exceeds some threshold. Such initiatives minimise administrative costs and moral hazard and allow companies to offer simple, affordable and transparent risk transfer solutions.

4. Non-Insurance Mechanisms

In addition to humanitarian assistance and disaster relief programs from governments which provide partial assistance for those without insurance or replace public infrastructure, there are also three groupings of non-insurance mechanisms: solidarity; informal risk sharing; and savings and credit (which work for inter-temporal risk spreading). Solidarity mechanisms are those that provide help from actors with a common interest. This can include help from neighbours and local or community level organizations, through to government post-disaster assistance and/or guarantees and bailouts play important roles. Similarly, at the international level, bi-lateral and multi-lateral assistance are mechanisms through which international assistance is provided to those in need. Informal risk sharing can be done through extended family relationships and other mutual arrangements. Savings and credit approaches can work though micro-savings and credit, food storage, and national reserve funds.

5. Insurance Mechanisms

Insurance is the primary source of funds to support recovery from extreme weather events in developed countries. Today insurance covers 40 percent of disaster losses in the industrialised counties compared to only around 3 percent in developing countries (Hoeppe and Gurenko, 2006). The share is higher for homeowners and businesses, and for many events covers all of the damage incurred. In contrast, most governments and their agencies typically choose not to purchase insurance coverage for the risk of damage to public infrastructure.

However, insurance markets are only emerging in most developing nations. Affluent homeowners and businesses account for most and perhaps all of the insurance market in many countries. Public infrastructure is largely uninsured. Although a number of factors continue to constrain the rate of convergence, spending on insurance is growing faster in most developing countries than in industrial countries. One constraining factor is that property owners in developing countries have not yet have developed knowledge about insurance and its role in managing risk. In addition, the current state of insurance regulation is weak in most developing countries relative to international standards of best regulatory practice and consumers do not yet have confidence in financial institutions. To date most actions to bring insurance to the world's poorest people have initially focused on life and health insurance products, like funeral and disability coverage, and motor vehicle insurance. This may, in time, create the basis that can be extended eventually to address risks to property and crops. It is not yet clear whether the role of humanitarian assistance and international relief following a disaster, which have largely been directly to address the urgent priorities of rebuilding schools, hospitals and public infrastructure, undermines the responsibilities of the local governments to address these concerns on an ongoing basis.

6. Analysis of Information Available on the Role of Thematic Approach in Specific Cases

Over the past decade there have been a number of examples of insurance mechanisms emerging in developing countries that will support recovery from future extremes. In each area there have been encouraging signs that insurance may, over time, grow to support the risk management needs in developing countries like that in place in industrial countries. Despite the growth in this sector, there are still market gaps and failures that exist, making the contributions of national governments and the international community an important factor in disaster recovery.

6.1. Caribbean Catastrophe Risk Insurance Facility

The Caribbean Catastrophe Risk Insurance Facility (Young, 2009), the world's first regional insurance fund, was launched in 2007, with sixteen participating countries securing insurance protection against damage from catastrophic hurricanes and earthquakes, the two most serious risks in the area. Seven of the participating countries represent almost one third of the countries identified by the World Bank as experiencing the greatest economic losses from disasters during the period from 1970 to 2008 when measured as a share of GDP.

The Caribbean Facility focuses primarily on insuring participating governments seeking to pay 50 percent of the costs that the governments are expected to incur and thus provides an incentive for governments to invest in risk reduction and other risk transfer tools. The cost of participation is determined for each participating country based upon estimates of the expected risk and extent of damage. Pooling the risks of 16 countries has reduced by 40 percent the costs relative to the price each government would have paid if they negotiated individually in the commercial insurance market. Funding for the program is the responsibility of participating countries and has largely been supported a donor conference hosted by the World Bank.

The experience with the Caribbean Facility shows that programs must reflect the needs of the participating countries. Severe weather risk is a growing dimension of the risks facing governments in developing countries but there will be circumstances where it is appropriate to establish mechanisms that also address other hazards. The Facility also provides an example where international assistance can be provided to support disaster management yet designed to support a transition where local government assume a possibly growing responsibility.

6.2. Micro-insurance

A recent report (Morelli et al., 2010) has reviewed the role of micro-insurance in disaster risk management. There are many examples of micro-insurance emerging to cover life, health and motor insurance needs in developing countries, but the application to disaster risk management is only beginning. Loster and Reinhard (2010) focus on the relationship between micro-insurance and climate change. Most examples of micro-insurance involve organizations active in communities without insurance that develop insurance products and evolve this into formal insurance companies. While some early micro-insurance companies operate on a for profit basis, many are not for profit. Most are based on the expectation that the pool of participants will provide payments that cover the costs incurred, including expected damage claims, administrative costs, taxes, regulatory fees, etc. The expected damage claims from most people with low incomes are very low because claim events are rare, by definition, and these people typically have fewer possessions that may be damaged.

A major challenge for the micro insurance operations that have been established recently has been controlling the cost of administration. Some organizations have addressed this issue by selling insurance to groups of people. Some programs are linked to loans, increasing their credit-worthiness. Bhatt et al (2010) describe the how micro-insurance has emerged in a policy environment that has made recent progress towards disaster risk reduction and can put cash into the hands of affected poor households so they can begin rebuilding livelihoods. Recent insurance regulatory reforms within the Indian Government and the prioritization of risk reduction by national and global practitioners have contributed to the viability and advancement of micro-insurance for the poor. In Malawi, smallholder farmers can purchase index-based drought insurance linked to loans used to enhance their farm productivity. An index-based insurance program in Bolivia promotes risk reduction by encouraging farmers to assess their practices relative to a reference farmer to determine if poor outcomes are due to environmental factors, triggering an insurance payout, or other factors within the farmer's control.

6.3. Index-based insurance in Bolivia

The Fundación PROFIN has developed a scheme in four provinces in the north and central Altiplano regions of Bolivia that combines incentives for pro-active risk reduction and an insurance index mechanism. In this scheme the index is based on the production levels of reference plots of farmland in areas which are geographically similar in terms of temperature, precipitation, humidity, and type of soil. A group of farmers identify a peer who is considered to use the best available methods. That farmer serves as a technical assistance agent and provides an indicator reference plot, to help other farmers reduce their risks and improve their yields. The system encourages other farmers to match the reference farmers in implementing risk reduction efforts to reduce the effects of drought, excess rains, hailstorms and frost. The objective becomes to perform or out-perform the reference plot by improving agricultural practices and reducing risk of damage from weather hazards (Hellmuth et al., 2009).

7. Role of Disaster Risk Reduction and Climate Change Adaptation Related Activities

Risk knowledge and public awareness of that risk are foundations of any risk management strategy. Insurers and public authorities can work together in increasing public awareness by collecting and providing high quality information about hazard risks and helping to translate this awareness into real action. Potential barriers and challenges include the technical difficulties related to risk assessment, dissemination of appropriate information and overcoming education and language barriers in some areas. It is important that premiums appropriately reflect the risk as otherwise this can provide a disincentive for risk reduction. The Caribbean Disaster Mitigation Project (CDMP) is an example of poor take-up while flood-risk, low-lying polder areas in The Netherlands are a positive example (Botzen et al., 2009).

Insurance solutions and the involvement of the insurance industry can contribute to the establishment of appropriate regulatory frameworks, for example through building codes and planning practices that account for relevant risks and climate change impacts. Examples are the Florida state premium discount initiative, Association of British Insurers case, Turkish Catastrophe Insurance Pool and the All India Disaster Mitigation Institute which ties micro-insurance to disaster prevention and reduction measures. Barriers to effective regulation may be a lack of good governance, institutional capacity or adequate legal and enforcement structures. Public intervention in insurance markets must also be balanced to facilitate the development of competitive markets (e.g. to keep costs down) and to ensure that insurance is allowed to be actuarially sound. The United Nations Environment Programme Finance Initiative (2009; p. 20) has proposed expanding the application of insurance mechanisms for adaptation.

8. Relationship to Key Messages

The use of insurance and financial mechanisms is part of effectively preparing for, responding to, and recovering from extreme events and disasters. Additional understanding of current and projected risks, including exposure to extreme events and increasing vulnerability is needed. Knowing and be able to project risk in order to ascertain effective financial mechanisms is part of risk transfer mechanisms. Actual or potential barriers to implementing these methods exist and there are considerable challenges constrain the effectiveness of current risk management strategies and policies.

9. Research Gaps and Needs

There are only a small number of examples as yet, of programmes that contribute to risk reduction, and use insurance tools. These do indicate that it is possible to design measures to work towards that aim but there is need for research into how to more effectively bring disaster risk reduction and insurance together, building on experience mostly from industrialised countries.

10. Summary and Conclusions

The current experience in developing countries of the benefits of insurance for in managing risks from (climate-related) natural hazards and in promoting risk reduction remains promising but limited. Insurance is growing rapidly there but it is not clear whether all programmes spontaneously achieve the benefits of reaching the most vulnerable, building resilience and reducing indirect and longer-term losses.

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Case Study 9.14. Disaster Risk Reduction Education, Training, and Public Awareness to Promote Adaptation

Author: S. Llosa

1. Introduction

Disasters can be substantially reduced if people are well informed and motivated towards a culture of disaster prevention and resilience (UNISDR 2005). Disaster risk reduction education encompasses primary and secondary schooling, training courses, academic programmes, and professional trades and skills training (UNISDR 2004), community based self-assessment, public discourse involving the media, awareness campaigns, exhibits, memorials and special events (Wisner 2006). Given the broad scope of the topic, this case study identifies a few elements for effective education that can be useful in advancing adaptation. It then illustrates their implementation through practices in primary school education, training programmes and awareness-raising campaigns in various countries.

2. Overview of Education, Training, and Awareness

The Hyogo Framework calls on States to “use knowledge, innovation and education to build a culture of safety and resilience at all levels” (UNISDR 2005). States, however, report minor progress in implementation (ISDR 2009). Challenges noted include the lack of capacity among educators and trainers, difficulties in addressing needs in poor urban and rural areas, the lack of validation of methodologies and tools and little exchange of experiences. On the positive side, the 2006-2007 international disaster risk reduction campaign “Disaster Risk Reduction Begins at School”,[13] furthered and raised awareness of the importance of the education agenda across some countries *(*ISDR 2009).

[INSERT FOOTNOTE 13 HERE: The 2006-2007 international disaster risk reduction campaign ‘Disaster Risk Reduction Begins at School at: http://www.unisdr.org/eng/public_aware/world_camp/2006-2007/wdrc-2006-2007.htm]

2.1. Eliciting behavioural change that reduces risk

The goal of disaster risk reduction education, whether formal or informal, is ultimately behavioural change. The factors that promote this change include both *perception* and *knowledge* of risk (Paton 2005, Shaw et al 2004, Johnston et al 1999, Bonifacio et al 2010). Risk perception is shaped by psychological, social, cultural, institutional and political processes, which must be understood and accommodated for effective behavioral change (Paton 2005). In addition to risk perception, risk preparedness is shaped by amount of relevant information, level of past damages, salience of hazard and level of knowledge about the threat (Johnston et al 1999). Effective risk reduction education moves the individual from knowledge of the hazard and the risk posed to perception of the risk at individual, family and community levels, to willingness to take action to reduce risk (Shaw et al 2004). Behavioural change can be effected by undergoing the following processes: attention, comprehension, interpretation, confirmation, acceptance and retention (Enders in Shaw et al 2004).

Understanding risk perception enables the development of more effective education efforts. When faced with disaster risk information, people may overestimate existing knowledge, overestimate the effectiveness of risk-mitigation measures, or attribute the need for preparedness to others, all of which results in people underestimating risk (Paton 2005). The use of distressing images in risk communication messages can reinforce people’s belief that disasters are too catastrophic for personal action to be effective (Keinan, Sadeh and Rosen 2003; Lopes 1992; Paton and Johnston in press), reducing their outcome expectancy. This belief reflects people’s perception of disaster loss as being caused by uncontrollable, catastrophic natural forces (Paton 2005). Conversely, individuals or organisations infer from their ability to cope with a minor impact the ability to cope with any future occurrence or assume that future events will not exercise an adverse effect on them. Consequently they may not undertake necessary risk reduction and preparedness actions (Johnston et al).

Risk education efforts can be designed to counter these perceptions and elicit risk reduction behaviour. Two important elements are to personalize hazard information and to disseminate it in ways that engage people in debate about the personal consequences that hazards might have for them; this approach is much more effective than disseminating general risk information (Paton 2005). General information (e.g. pamphlets, media advertisements) represents a passive form of communication that fails to address the diversity of needs and expectations within a community (Ballantyne et al. 2000 in Paton 2005). To change the perception that disaster is unavoidable, risk communication efforts can present scenarios that demonstrate that hazard intensity and its impacts are unevenly distributed and that the level of damage to be expected is a function of the interaction between choices people can make to reduce risk (such as storm proofing their houses) and the hazard (Paton 2005). Thus, education should seek to convey an understanding of the natural and environmental conditions and the human actions and inaction that lead to disaster to stimulate changes in individual and group behaviour (Bonifacio et al. 2010).

2.2. Effectively communicating risk information

Based on experience of public education campaigns for disaster risk reduction, some working axioms have been demonstrated (Ross *et al*. (1991), Paton *et al*. (2005), and McClure (2006) in Bonifacio et al. 2010):

1) People need to understand who is at risk, the potential and likely physical, economic, communal and cultural heritage losses, within a specific timeframe.
2) When people are clearly informed about what they can do to reduce their risks, before, during and after a disaster, they are quite capable of understanding and remembering the basics.
3) When people are convinced that their actions will make a difference, and that they have the skills needed to reduce vulnerability, they are more likely to act.
4) Most people are motivated more by positive examples than by fear.
5) Culture is shaped by language, stories and traditions. Therefore, local knowledge can be used to transmit information.
6) Children can be engaged in active, inquiry-oriented learning through exploration and play.
7) Lectures, sermons and moral exhortations are not as effective as when people participate in a solution, when they believe it is their own idea.

3. Disaster Risk Reduction in School Curriculum

To personalize information and elicit behavioural change as described above, risk reduction programmes in schools would ideally "impart knowledge of the natural hazards themselves but also involve students in inspecting the school buildings, going outside to map the surroundings, venturing beyond to interview elders about extreme natural events in the past. Such learning could be done in ways that reinforce basic skills in listening, writing and reporting, mapping. It could integrate or be integrated into the study of history, geography, and natural science (Wisner 2006). Thus, disaster education should not be confined within the school itself, but shall be promoted to family and community (Shaw *et al*., 2004). Lectures can create knowledge, particularly if presented with visual aids and followed up with conversation with other students. Yet it is family, community and self learning, coupled with school education, which can transform knowledge into behavioural change (Shaw et al 2004).

Countries are increasingly incorporating disaster risk reduction in the curriculum (ISDR 2009). The following programme in the Philippines brings together disaster risk reduction and climate change education.

3.1. Integrating disaster risk reduction and climate change in the curriculum

The Asian Disaster Preparedness Centre (ADPC) and UN Development Programme (UNDP), with the National Disaster Coordinating Council and support from ECHO, assisted the Ministry of Education in Philippines, Cambodia and Lao PDR to integrate disaster risk reduction into the secondary school curriculum. Each country team developed its own draft module, adapting it to local needs. The Philippines added climate change and volcanic hazards into its disaster risk reduction curriculum. The relevant lessons addressed "what is climate change, what is its impact, and how you can reduce climate change impact." Other lessons focus on the climate system, typhoons, heat waves, landslides, among other related topics (ADPC 2008).

The Philippines' final disaster risk reduction module was integrated into 12 lessons in science and 16 lessons in social studies of first year of secondary school (Grade 7). Each lesson includes group activities, questions to be asked to the students, the topics that the teacher should cover in the lecture, a learning activity in which students apply knowledge gained and methodology for evaluation of learning by the students (ADPC 2008).

Under this project, 1020 students, including 548 girls, were taught the disaster risk reduction and climate change module. 23 teachers participated in the four-day orientation session. An additional 75 teachers and personnel were trained to train others and replicate the experience across the country (ADPC 2008).

4. Training

In order to effectively include disaster risk reduction and adaptation in the curriculum, teachers require (initial and in-service) training on the substantive matter as well as the pedagogical tools (hands-on, experiential learning) to elicit change (Wisner 2006, Shiwaku et al 2006).

Education programme proponents might have to overcome teachers' resistance to incorporate yet another topic into overburdened curricula. To enlist teachers' cooperation partnership with the ministry of education and school principals can be helpful (UNISDR 2007, World Bank 2009). The following programme in Indonesia and the evaluation results from Nepal demonstrate the importance of engaging teachers for effective education.

The subsequent example from Nepal, Pakistan and India focuses on training builders through extensive hands-on components in which new techniques are demonstrated and participants practice these techniques under expert guidance (World Bank 2009).

4.1. Teacher training in Indonesia

The Disaster Awareness in Primary Schools project was launched in Indonesia in 2005 with German support and is ongoing. By 2007 through this project, 2200 school teachers had received disaster risk reduction training. Project implementers found that existing teaching methods were not conducive to active learning. Students listened to teacher presentations, recited facts committed to memory and were not encouraged to understand concepts and processes. The training took teachers' capabilities into account by emphasizing the importance of clarity and perseverance in delivering lessons so as to avoid passing on faulty life-threatening information (such as on evacuation routes). Scientific language was avoided and visual aids and activities encouraged. Teachers were asked to take careful notes and to participate in practical activities such as first-aid courses, thus modeling proactive learning. Continuity with the teachers' traditional teaching methods was maintained by writing training modules in narrative form and following the established lesson plan model. Moreover, to avoid further burdening teachers' heavy lessons requirements and schedules, the modules were designed to be integrated into many subjects, such as language and physical education, and to require minimum preparation (UNISDR 2007).

4.2. Evaluation of teacher training in Nepal

A survey of 130 teachers in 40 schools in Nepal revealed that disaster risk education depended on the awareness of individual teachers. Teaching focused on the effects of disasters that the teachers could relate to from personal experience. The study concluded that teacher training is the most important step to improve disaster risk education in Nepal. Eighty percent of social studies teachers reported a need for teacher training but the study recommends that training programs should be designed to integrate DRR into any subject rather than taught in special classes (Shiwaku et al 2006).

4.3. Training of builders in Nepal, India, and Philippines

The National Society for Earthquake Technology (NSET) in Nepal conducted large-scale training for masons, carpenters, bar benders and construction supervisors over a five-month period to train them on risk-resilient construction practices and materials. Participants from Kathmandu and five other municipalities formed working groups to train other professionals. As the project was successful, a mason-exchange program was designed with the Indian nongovernmental organization SEEDS. Nepali masons were sent to Gujarat, India, to mentor local masons in the theory and practice of safer construction. Also in India, the government of Uttar Pradesh trained two junior engineers of the rural engineering service in each district to carry out supervisory inspection functions and delegated the construction management to schools principals and village education committees. Similarly, the Department of Education of Philippines mandated principals to take charge of the management of the repair and or construction of typhoon-resistant classrooms. Assessment, design and inspection functions are provided by the Department's engineers, who also assist with auditing procurement (World Bank 2009).

5. Public Awareness Campaigns

In addition to the insights on the psychological and sociological aspects of risk perception, risk reduction education has benefitted from lessons in social marketing. These include: Involving the community and customizing for audiences using cultural indicators to create ownership; incorporating local community perspectives and aggressively involving community leaders; enabling two-way communications and speaking with one voice on messages (particularly if partners are involved); and evaluating and measuring performance (Frew 2002). The following examples from Brazil, Japan and the Kashmir region illustrate good practice in raising awareness for risk reduction.

5.1. Public awareness initiative: Santa Catarina, Brazil

Between 2007 and 2009, the Santa Catarina State Civil Defence Department with the support of the Executive Secretariat and the state university undertook an initiative in this southern Brazilian state to reduce social vulnerability to disasters induced by natural phenomena and human action (SCSCDD 2008a,b).

During the two-year initiative, 2000 educational kits were distributed free of charge to 1324 primary schools. Students also participated in a competition of drawings and slogans that was made into a 2010 calendar. As the project's goal was public awareness of risk, the project jointly launched a communications network in partnership with media and social networks to promote better dissemination of risk and disasters (SCSCDD 2008a,b).

The initiative also focused on the most vulnerable populations. A pilot project for 16 communities precariously perched on a hill prone to landslides featured a 44-hour course on risk reduction. Community participants elaborated risk maps and reduction strategies. Shortly into the course, heavy rains battered the state triggering a state of emergency. 10 houses in the pilot project area had to be removed and over 50 remain at risk. Participants were surprised how quickly they had to put to use their risk reduction knowledge. Their risk reduction plans highlight the removal of garbage and large rocks as well as the building of barriers. The plans identified public entities for partnership and costs for services required. The training closed with a workshop on climate change and with the community leaders' presentation of the major risk reduction lessons learned (SCSCDD 2008d).

On international disaster risk reduction day, representatives of the community, Civil Defence and other public entities, visited the most at-risk areas of the hill community, planted trees, installed signs pointing out risky areas and practices, distributed educational pamphlets and discussed risk. One of the topics of discussion was improper refuse disposal and the consequent blocking of drains, causing flooding (SCSCDD 2008c).

5.2. Public awareness campaign in Saijo, Japan

In 2004, Saijo City in the Ehime Prefecture of Shikoku Island was hit by record typhoons that led to flooding in its urban areas and landslides in the mountains. A small city with semi-rural mountainous areas, Saijo City faces unique challenges in disaster risk reduction. First, Japan's aging population represents a particular problem. Young able-bodied people are very important to community systems of mutual aid and emergency preparedness. And as young people tend to move away to bigger cities, smaller towns in Japan have an even older population than the already imbalanced national average. Second, smaller cities like Saijo City are often spread over a mix of geographic terrains – an urban plain, semi-rural and isolated villages on hills and mountains, and a coastal area (Yoshida et. al, UNISDR 2010).

To meet both of these challenges, the Saijo City Government launched in 2005 a risk awareness programme targeting schoolchildren. Focusing on different physical environments of the city, from the mountainside to the town, the 'mountain-watching' and 'town-watching' project takes 12-year olds, accompanied by teachers, local residents, forest workers and municipal officials, on risk education field trips. The young urban dwellers meet with the elderly in the mountains to learn together about the risks Saijo City faces and to remember the lessons learned from the 2004 typhoons. Additionally, a 'mountain and town watching' handbook has been developed, a teachers' association for disaster education was formed, a kids' disaster prevention club started, and a disaster prevention forum for children was set up (Yoshida et. al, UNISDR 2010).

The programme was conceived and implemented by the city government and is an example of a local government leading a multi-stakeholder and community-based disaster risk awareness initiative that can then become self-sustaining. The government supported the programme through providing professionals from disaster reduction and education departments, funding the town and mountain watching, and putting on an annual forum (UNISDR 2010).

5.3. Public awareness campaign: DRR and climate change education in Himalayas

CEE Himalaya is undertaking a disaster risk reduction campaign in 2,000 schools and 50 Kashmir villages. In the schools, teachers and students are involved in vulnerability and risk mapping through rapid visual risk assessment and in preparing a disaster management plan for their school. Disaster response teams formed in selected schools have been trained in life-saving skills and safe evacuation (CEE Himalayas 2010).

CEE Himalaya celebrated International Mountain Day 2009 with educators by conducting a week-long series of events on climate change adaptation and disaster risk reduction. About 150 participants including teachers and officials of the Department of Education, Ganderbal, participated in these events (CEE Himalayas 2010).

Participants worked together to identify climate change impacts in the local context, particularly in terms of water availability, variation in micro-climate, impact on agriculture/horticulture and other livelihoods, and vulnerability to natural disasters. The concept of School Disaster Management Plans (SDMP) was introduced. Participants got a hands-on opportunity to prepare SDMPs for their schools through group exercises, and discussed their opinions about village contingency plans (CEE Himalayas 2010).

Some of the observations on impacts of climate change in the area discussed by participants included the melting, shrinking and even disappearance for some glaciers, drying up of several wetlands and perennial springs. Heavy deforestation, decline and extinction of wildlife, heavy soil erosion, siltation of water bodies, fall in crop yields, reduced availability of fodder and other non- timber forest produce were some of the other related issues discussed (CEE Himalayas 2010).

Participants watched documentaries about climate change and played the Urdu version of "Riskland; Let's Learn to Prevent Disasters". They received educational kits on disaster risk reduction and on climate change, translated and adapted for Kashmir (CEE Himalayas 2010).

6. Relationship to Key Messages

This case study supports the messages that improving current risk management can facilitate adaptation to climate change, and that there are unrealized opportunities for synergies between disaster risk reduction and climate change adaptation. As shown above, there is abundant experience in educating, training and awareness raising to reduce disaster risk. Knowledge of the psychological and sociological factors that influence risk perception would also likely apply to climate change impacts; hence, climate change education programmes could use this knowledge in programme design. Likewise knowledge of effective risk-communication techniques and the elements for behaviour-changing education can be immediately utilized for adaptation education. Finally, the initiatives undertaken around the world, including those described here, could easily include climate change information to deliver robust education on climate and nonclimate risks.

7. Research Gaps

Education programmes, training initiatives and awareness campaigns are rarely empirically assessed for their effectiveness in changing behaviour for risk reduction (with exceptions such as the evaluation by Shiwaku et al 2006 of Nepalese DRR education). Good practices worldwide are documented in publications aiming to foster replication of activities in other locales; however, success is evaluated on the basis of the number of output activities achieved or students reached. Future research should evaluate the effectiveness of programmes in qualitative terms to then identify the elements of those programmes that make them most effective for target audiences. In addition, it would be useful to learn whether disaster risk perception differs significantly to climate change impact risk perception. The outcome of such research would assist in better targeting education initiatives.

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Case Study 9.15. Multi-Level Institutional Governance

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1. Description of Thematic Approach

Southeastern Spain has a semi-arid Mediterranean climate and experiences droughts that put stress on irrigated agriculture, the region's most important economic sector. According to the IPCC's Fourth Assessment Report, the Iberian Peninsula is one of the regions most prone to an increased drought risk and irrigation water demand because Mediterranean droughts are expected to start earlier in the year and last longer (Alcamo et al., 2007).

The Segura River Basin in southeastern Spain experienced a severe drought from 2005-2010, the region's second drought in the last two decades. Due to successful drought risk management by local authorities, the 2005-2010 drought has had a smaller impact on the region's agricultural production than the previous drought even though it was both longer and more severe: in the first year after the onset of drought (2005-2006), agricultural yields fell by 2.1 percent compared to a decline of 7.1 percent experienced in 1993-1994. The local authorities were able to meet the additional demand for irrigation by:

- Increasing the use of recycled water
- Reducing water loss and urban water demand
- Purchasing water rights from individual owners
- Transferring water from another river
- Desalinizing seawater
- Supplementing water supply by digging drought wells.

The European Commission's Water Framework Directive (2000) delegates drought risk management to member states, and in 2001 Spain enacted legislation to implement this directive and to decentralize drought risk management even further by making it the responsibility of river basin districts and local governments (Spain, 2001). Spain's National Drought Plan was the culmination of fifteen years of groundwork and planning (Spain, 2001), and in the case of the Segura River Basin the federal government delegated the responsibility for drought risk management to a local agency with nearly 70 years of experience managing drought risk. This devolution of authority is based upon the "subsidiary" principle, which allocates responsibilities for policy development and implementation to the lowest level of government that can meet a given policy's objectives (Inman and Rubinfeld, 1998). Through the EC Water Framework Directive, the local authorities in the Segura River Basin are supported a network of experts from the EU. At the federal level the Government of Spain supported this process of decentralization through a royal decree that gave the local water boards the authority and resources to implement emergency policies, and which established a multi-level institutional framework connecting the individual water boards with one another and with the Ministry of the Environment (Spain, 2005).

2. Description of Multi-Level Institutional Governance and its Relation to Hazardous Events

Most extreme risks are managed centrally; yet, a broad range of research reflects that decentralization is critical to effective responses. Therefore, a tension exists between devolution or centralization of the extreme risks of climate change. While on the one hand centralization is necessary to overcome compartmentalization (Wisner 2003), ad hoc decision-making, and the concretization of localized power relations (Naess et al. 2004), devolution is critical because it results in more accountable, credible, and democratic decision-making. These decisions about governance approaches are critical because they shape efficiency, effectiveness, equity, and legitimacy of responses (Adger 2003). In addition, motivation for management at a particular scale promises to influence how well extreme impacts are managed, and therefore affect disaster outcomes (Tsing et al., 1999). Finally, decisions made at one scale may have unintended consequences for another (Brooks and Adger 2005), meaning that governance decisions will have ramifications across scale and contexts. In all cases, the selection of a framework for governance of extreme impacts may be issue or context-specific (Sabatier 1986).

Current management practices have tended to be centralized at the federal level. This may be, in part, due to the ways in which many climate extremes affect environmental systems that cross political boundaries resulting in scale discordance if solely locally managed (Cash and Moser 2000), or because human reactions cross local boundaries, such as migration that in response to extreme events, necessitating national planning (Luterbacher 2004). In addition, in situations where civil society is flattened due to poverty, marginalization, or historical political repression, regional and federal governments with access to resources may be most important in instigating public action (Thomalla et al. 2006). National-level policies can facilitate otherwise impossible localized strategies through the establishment of resources or legal frameworks (Adger 2001) and often shape what localities can accomplish within existing governance frameworks (Keskitalo 2009).

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

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

Since environmental systems relate to risks for local population and since environmental management functions across scales (Berkes 2002), the creation of effective multi-level governance and management systems that span these scales are critical in responses to extreme impacts (Adger et al. 2005; Olsson and Fulke 2001). Devolution of activities for climate change threat reduction can also be managed by cities that develop plans for multiple communities, such as that in Dhaka, Bangladesh where urban-level plans have advanced community resilience (Roy 2009). Such city-level plans can be communalized through the incorporation of participatory approaches (Laukkonen 2009). When necessary, localized plans should be supported by the integration of multiple levels of management, although questions about how to scale up from localized assessments to national-level plans still remain (van Aalst et al. 2008).

3. <u>Analysis of Information Available on Multi-Level Institutional Governance in Specific Cases</u>

3.1. Drought risk management in the United States

Drought risk management is also decentralized in the United States, with authority resting with state governors. As opposed to the example above from the EU, in which responsibility devolved intentionally, drought risk management in the U.S. was decentralized despite an effort from several states, federal agencies, and research institutes to pass a proposed law creating a national drought risk management plan in 2000. As a result, responsibility for drought risk mitigation and response remains with individual states, many of whom have adopted drought contingency plans.

Drought risk reduction activities vary from one state to another due to the diverse regional differences, the unique institutional arrangements, differences in drought impacts, and the wide range of agencies involved (Wilhite 1997; Wilhite and Vanyarkho, 2000). Nebraska's drought risk mitigation plan is well regarded for its comprehensiveness, and a number of its actions have been extremely successful at reducing drought impacts on agricultural production (Hayes et al. 2004). Nebraska's plan was adopted in 2000 and is a revision of the state's previous programme. To create the current plan, officials spent two years consulting with stakeholders from federal, state, and local agencies, as well as tribal governments, the private sector, and individuals (Hayes et al., 2004). More importantly, this new plan links agencies at every level of government and assigns each with potential actions, and experts have worked closely with farmers and provided workshops and trainings around the state for vulnerable communities (Hayes et al., 2004).

3.2. Multi-level flood risk reduction in France

In 2007, the European Commission endorsed a flood risk directive that, like its Water Framework Directive, is based on the subsidiarity principle and which calls upon each of its Member States to assess, map, and prepare for flood risk within their country (EC, 2007). By this time, the French Government had already established general framework for coastal flood risks at the sub-national and local level. This framework for decentralized flood risk management was developed with input from all levels of government, and this process is being reinforced through legislation (The Grenelle of the Environment) and financing by the Barrier Fund for natural risk prevention, which is in turn funded by obligatory contributions based on the *CatNat* insurance premiums (Deboudt, 2010). The decentralization process has been strengthened by legislation (the Bachelot Law) that requires:

- The dissemination of guidance material and decision-support tools
- Local capacity development
- Multi-level, integrated coastal zone management policies for the French littoral
- Development of Predictable Natural Risk Prevention Plans through multi-stakeholder dialogues
- Clearly defined responsibilities for implementation (France 2003; Deboudt, 2010).

The decentralization of flood risk management has been adopted by many different countries, in principle, but the institutional arrangements vary significantly due to differences in public awareness, the degree of civil society and private sector participation, the institutional inertia of precursor regimes, and the transaction costs of changing to new arrangements (Meijerink and Dicke, 2008).

3.3. Chile

Dryland communities in Chile have created local committees to manage extreme events when national and regional level institutions did not effectively communicate or collaborate with them (Young et al. 2010).

3.5. Cayman Islands

The Cayman Islands responses to Hurricane Ivan in 2004 after three prior events, Gilbert, Mitch, and 2000 Michelle, demonstrated that adaptation planning at community and national levels was necessary to improve preparedness and resilience (Adger et al. 2005). These measures included improving localized social cohesion and diversifying adaptation strategies (Tompkins 2005).

4. Research Gaps and Needs

Biesbroek et al. (2010) identified the following gaps including, but not limited to: research scaled to meet local, subnational, and national policy needs; research on the roles of institutions and on the mechanisms and responsibilities involved in multi-level governance of disaster risk reduction and adaptation; research comparing sectoral and cross-sectoral measures; research on different policy instruments and frameworks for evaluating adaptation policies.

Downscaled climate models and disaster loss data are needed to develop locally scaled risk assessments and adaptation plans. And more research is needed to determine the optimal scale and institutional balance for dealing with hazards. There are numerous papers analyzing the decentralization of drought and flood risk management, but more research is needed for multi-institutional management of other climate hazards, such as cyclones.

More research is needed on the enabling environment for effective decentralization of disaster risk reduction and climate change adaptation planning. Considering the management of environmental hazards, Karlsson (2007) found that stakeholders' value systems would need to be shifted to a more selfless global concern in order for effective multi-level governance to be possible. Numerous other analyses of decentralization in a variety of locations and contexts (Ribot, 1999; Lane et al., 2004; Oyono, 2005; Meijerink and Dicke, 2008) support these findings and reveal that decentralization and multi-level governance have, in some cases, institutionalized conflicts between local stakeholders and unintentionally reinforced the hegemony of local elites.

Studies of the enabling environment also need to consider institutional inertia and policy resistance. Mexico has adopted a decentralized approach to disaster risk reduction, but Arellano-Gault and Vera Cortés (2005) have found that the Civil Protection National System (CPNS) still functions in a very centralized, top-down manner because the devolution of political authority was not accompanied by comparable decentralization of financial or administrative capacity. Disaster preparedness/response budgeting is still highly centralized; the armed forces, which are nominally responsible for playing only a coordinating role, instead impose military rules and decision-making structures on everyone else, and once deployed they act as the final arbiter and enforcer (Arellano-Gault and Vera-Cortés 2005). In the same vein, an OECD review (2004) found that decentralization of poverty eradication has had little discernable impacts on poverty levels, and a separate analysis of decentralization in 19 countries also found that where state capacity is lacking, decentralization of poverty eradication programmes can even increase rural poverty (Jütting et al. 2004).

5. Summary and Conclusions

Adaptation to the impacts of climate change, such as increased exposure to climate extremes, is a challenge at administrative, temporal, and spatial scales (Adger et al., 2005; Urwin and Jordan, 2008). It requires the involvement of a variety of stakeholders from the public and private sectors and civil society, and there is a growing recognition that successful adaptation practices require the integration of strategies across sectors and within multiple scales of governance in a coordinated manner (Biesbroek et al., 2009; Biesbroek et al., 2010; Gopalakrishnan and Okada, 2007). Effective decentralization and multi-level governance of disaster risk reduction must be accompanied by transfer of capacity and resources to newly accountable local actors, and parallel support is needed for civil society organizations that hold local governments accountable and fill the void when those governments fail (Mitchell et al., 2008). Examples of this type of formal coordination include National Adaptation Strategies and National Platforms for Disaster Risk Reduction.

Procedural dimensions, such as participatory models, that allow for involvement for a wider range of local stakeholders provide a mechanism to mitigate existing power dynamics that might otherwise be concretized in localized planning (Paavola and Adger 2002; Oyono 2005). If multiple levels of planning are to be implemented, mechanisms for facilitation and guidance on the local level are needed to ensure that procedural justice is guaranteed during the implementation of national policies (Thomas and Twyman 2005).

The decentralization of disaster risk reduction and climate change adaptation must be complemented with increased autonomy of local agencies and enhanced support of these actors from national governments and regional institutions, such as the EU (Baker and Refsgaard, 2007; Gopalakrishnan and Okada 2007). Taking these ideas into account might allow national governments to help facilitate programs where local community members jointly engage in risk management (Perez et al.1999). Such programs may allow for an integration of bottom-up and top-down approaches that overcomes each approach's strengths and weaknesses (Urwin and Jordan 2008).

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Case Study 9.16. Disaster risk reduction legislation as a basis for effective adaptation

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1. Introduction

Governments will need to assess in the short term whether existing national legislation to reduce and manage disaster risk is adequate for adapting to climate change. A majority of States have some form of disaster risk management legislation or are in the process of enacting it (UNISDR 2005, UNDP 2007). This case study examines framework legislation in South Africa, Colombia and the Philippines and identifies elements that may be useful in strengthening legislation by integrating climate change provisions into existing disaster risk management law or in developing stand-alone climate change adaptation legislation.

2. Status of Disaster Risk Management Legislation Worldwide

In their reports on implementation of the Hyogo Framework, Governments reported that, between 2005 and 2009, good progress had been made in strengthening disaster risk management legislation to address deficiencies in disaster preparedness and response (ISDR 2009). The majority of this legislation was drafted or reformed since the mid-1990s, falling within the UN International Decade for Natural Disaster Reduction (1990–1999) and the subsequent International Strategy for Disaster Reduction (from 2000 onwards) (Pelling and Holloway 2006; UNDP 2007). Policies and legal frameworks addressing disaster risk generally exist in each sector in high- and middle-income States (ISDR 2009); however, many low-income States, particularly in Africa, report a lack of adequate financial, human and technical resources as the major reason for underachievement concerning effective legislative systems. In addition, while many States report the existence of sector policies and legal instruments, national-level policy and legislation on disaster risk reduction remains weak (ISDR 2009). Moreover, burgeoning national legislation for *disaster management* does not necessarily include a *disaster risk reduction* orientation (Pelling and Holloway 2006). However, in keeping with the global paradigm shift from disaster response to prevention (Britton 2006, Benson 2009), countries such as South Africa, Colombia and the Philippines are reviewing and adapting their risk management laws to a reflect a more preventive focus. Key elements of these norms, and the processes to develop the laws, are here reviewed.

3. Pre-Conditions for the Development of Effective Legislation

A comparison of different country experiences shows that legislative changes often take years to succeed and require transformative and sustained energy and engagement, which is often triggered by major disasters or political shifts, the engagement of particularly dynamic individuals, a well-educated population and citizen participation in a decentralized environment (UNDP 2007).

Advocates of the Disaster Management Act and Framework in South Africa persevered over eleven years to develop a comprehensive disaster risk reduction and risk management law now internationally reputed for its emphasis on prevention and its comprehensive approach to disaster risk reduction. Galvanized by devastating floods and droughts, and the country's high motivation for change in the post-Apartheid era, the first steps undertaken were public consultation on a green and white paper on disaster management. Challenges included inconsistent public consultation in the drafting and the exclusion of local authorities; insufficient interdisciplinary engagement; and limited executive authority to promote interdepartmental integration (Pelling and Holloway 2006). The will to complete the Act and Framework in South Africa was stimulated by public concern about worsening disasters that stirred political interest, skilled political leadership that championed the cause, continuous commitment by highly capable disaster risk reduction professionals, and local professional interest in aligning South African legislation with international frameworks (Pelling and Holloway 2006). The process led to the passing of three disaster management bills and the promulgation in 2003 of the Disaster Management Act No. 57 of 2002 and of the National Disaster Management Framework in 2005 (SANDMC 2006; Pelling and Holloway 2006).

The Philippines' experience is similar. Reflecting the international paradigm shift in emphasis from a disaster management to a disaster *risk* management approach and as a result of rising concern about increasing disasters in the country (Benson 2009), dozens of bills were submitted to Congress over the last ten years with the aim of changing the primarily reactive 1978 disaster management legislation to a more pro-active, preventive law (Benson 2009, Britton 2006, World Bank 2004). However, it was only in 2009 that new disaster risk management legislation was passed, the Disaster Risk Reduction and Management Act 10121. Progress in passing a bill was stymied in part by lack of coordination among the many, often conflicting bills, as well as additional submissions for piecemeal change around specific issues (Benson 2009). As in South Africa, a number of individuals and focus groups, such as senators and other parliamentarians (Benson 2009), Philippine specialists and international consultants (Britton 2006) were crucial for success.

Though skilled, high-level political champions can provide needed impetus for building commitment to disaster risk reduction and for mainstreaming it into development, political champions of disaster risk reduction are rare (Benson 2009). Even in the Philippines, the Climate Change Act 9729 of 2009 was enacted after only 2 years of consideration by the Fourteenth Congress, in contrast with the frustrating decade invested in trying to modernize disaster risk management law, which reflects the higher political interest generated by climate change (Benson 2009).

4. Key Elements of Comprehensive Disaster Risk Reduction Legislation

4.1. A legal framework for risk reduction

Although some countries successfully implement disaster risk reduction through a number of sectoral laws, such as Sweden[14] and Slovenia[15], an overarching, comprehensive legal framework is considered a requisite for the effective implementation of disaster risk reduction (ISDR 2009, UNDP 2007). Most importantly, an overarching framework can help in striking the balance between a multitude of sometimes contradictory laws and decrees, such as 20,000 legal acts in Kyrgyzstan (UNDP 2007), or over 120 different pieces of disaster risk management related legislation in Indonesia (UNDP 2009).[16]

[INSERT FOOTNOTE 14 HERE: e.g. The Seveso Act, The Environmental Code; The Planning and Building Act, The Land Code, the Water Directive, The Flooding Directive, And The Civil Protection Act]

[INSERT FOOTNOTE 15 HERE: e.g. The Protection Against Natural • and Other Disasters Act 3535 Official Gazette of the Republic of Slovenia, 64/94, 51/2006., The Fire Protection Act 3636 Official Gazette of the Republic of Slovenia, 71/93, 3/2007, The Fire Service Act 3737 Official Gazette of the Republic of Slovenia, 1993, 2005, The Slovenian Red Cross Act 3838 Official Gazette of the Republic of Slovenia, 7/93, The Recovery from the Consequences of Natural Disasters Act 3939 Official Gazette of the Republic of Slovenia, 75/2003, The Protection against Drowning Act 4040 Official Gazette of the Republic of Slovenia, 42/2007]

[INSERT FOOTNOTE 16 HERE: The latter was addressed in the 2007 Disaster Management Bill that aims to provide leadership for comprehensive disaster risk reduction (UNDP ILS Indonesia 2009).]

Effective disaster risk management legislation "draws a line" around the minimum acceptable level of action and responsibility; it enables actors and agencies to take calculated risks and initiate needed action. Moreover, without comprehensive and binding laws, essential tasks will not be undertaken and the status quo will be maintained (Britton 2006). The law can be used to provide penalties and incentives by enforcing standards, to empower existing agencies or establish new bodies with new responsibilities, and to assign budget lines (Pelling and Holloway 2006).

In South Africa, the 2002 Disaster Management Act provides such a comprehensive framework for disaster risk reduction implementation at all levels, and explicitly avoids subsuming disaster risk reduction within the disaster management paradigm (Pelling and Holloway, 2006)**.** The South African Act defines the structure that governs disaster risk management in the country through a hierarchical disaster management structure including a cabinet committee at the apex; an advisory forum with representatives from national and provincial departments, local government, business and civil society; as well as disaster management centres at national, provincial, metro and district levels. It also establishes disaster management frameworks for all levels of government with clear roles and responsibilities, mandates the development of disaster management plans for each government level and the creation of a national disaster management information system (SANDMC 2007).

Similarly, Colombia has framework legislation that organizes disaster risk management in the country at all levels of government. Yet Colombia has also enacted dozens of sector-specific laws that govern and support disaster risk reduction (Vásquez 2006, Ministerio 2009). Colombia's framework legislation, Law 46 of 1988 and Decree 919 of 1989, created the National System for Prevention and Response to Disasters, the SNPAD, for its Spanish-language acronym, which is supported by a national plan that establishes a holistic policy within the framework of sustainable development planning and implementation (Cardona and Yamín 2007). The SNPAD created committees at all levels of government with defined roles and responsibilities, taking an approach that is systemic, participatory and decentralized. This approach has been supported by a number of norms in the 1990s in other sectors, in particular environment, land use, housing and urban development, and education, among others (Vásquez 2006).

4.2. Positioning of DRR legislation

A factor that affects the political authority of the national disaster risk management body is its positioning in relationship to the highest level of government (UNDMTP 1998, UNDP 2007, ISDR 2009). National disaster risk management offices attached to prime ministers' offices usually can take initiatives vis-à-vis line ministries, while their colleagues operating at the sub-ministerial level are likely to face administrative bottlenecks (UNDP 2007). High-level support is particularly important to enable disaster risk reduction legislation to provide a framework for strategies to build risk reduction into development and reconstruction (Pelling and Holloway 2006). Many governments delegate the establishment and coordination of institutional systems for disaster risk reduction to civil defence and protection organisations traditionally responsible for emergency response, which usually do not have the competence in development planning and regulation necessary to engage with other sectors nor the necessary political authority within government to do so (World Bank 2008).

South Africa's Intergovernmental Committee on Disaster Management is established by the president and accounts to the president through Cabinet on response once a disaster has occurred (SANDMC 2007). In Colombia, the original robust institutional structure for risk reduction was weakened through a series of reforms that have reduced its standing in the hierarchy and diminished its political power, although recently the president convened entities at all levels to motivate them to fulfill their disaster risk reduction mandates (Ministerio 2009). Bolivia and Nicaragua, hybrid versions of Colombia's disaster risk reduction structure, give maximum authority to the national committee headed by the president and including representatives from the major ministries, the national department of planning, civil defence, the Red Cross Society and private sector members (UNDP 2007).

Creating an active link to the development sphere, the South African Act mandates the development of risk management plans to form an integral part of the Integrated Development Plan (IDP) of each municipality. South Africa is among the world's few to have made a legal connection between disaster risk reduction and national development planning frameworks. Others include Comoros, Djibouti, Ethiopia, Hungary, Ivory Coast, Mauritius, Romania and Uganda (Pelling and Holloway 2006).

In the Philippines, the highest policy-making and coordinating body for disaster management, the National Disaster Coordinating Council, which was renamed National Disaster Risk Reduction and Management Council under the new Act of 2010, sits within the Department of National Defense. As such it is focused on disaster preparedness and response and does not have sustainable development and poverty reduction responsibilities. Consequently it is less effective as an advocate of mainstreaming disaster risk reduction into development (Benson 2009). However, the new Act of 2010 attempts to redress this issue by including experts from all relevant fields as members of the Council (Act 10121, Sec.5; Sec 11(2)) and expressively defining its mandate on mainstreaming disaster risk reduction into sustainable development and poverty reduction strategies, policies, plans and budgets at all levels (Act 10121, Sec. 2).

4.3. Budget allocation and adequate funding for prevention

Funding is the ultimate litmus test of government commitment to disaster risk reduction (UNDP 2007). Integration of disaster risk concerns into government budgets should be tackled from two angles, ensuring that levels of public expenditure on risk reduction are sufficient and that there are adequate financial arrangements to manage the residual risk (Benson 2009).

In South Africa, eight years after the promulgation of the Act, most district municipalities have not established the centres required by the Act and do not have disaster risk reduction plans in place (SACoGTA 2009) mainly due to a lack of resources to cover the costs of activities stipulated for funding in the Framework (SACoGTA 2009, Visser and Van Niekerk 2009). Reasons for the lack of funding include a lack of clarity of the Act on the funding sources for developing and maintaining the centres it establishes at all levels and the management plans they are to prepare (Visser and Van Niekerk 2009). Moreover, the Act and Framework do not provide adequate guidance to municipalities on funding arrangements for disaster risk reduction, response and recovery. Though the Act states specifically that the legislation must provide a framework within which organs of the state may fund disaster management, with emphasis on preventing or reducing disaster risk, it is not clear which processes should be followed by municipalities to access funding, especially when it should be provided by national or provincial government. It is also not clear to what extent municipalities should fund disaster risk management out of their own budgets (Visser and Van Niekerk 2009).

Similarly, in Colombia, more than 80 percent of municipalities are able to assign only 20 percent of their own unearmarked resources to risk reduction and disaster response. Because the law does not stipulate percentages and amounts, municipalities allocate minimal sums for disaster risk reduction (Ministerio 2009) given competing infrastructure and social spending needs (Cardona and Yamín 2007). Colombia's National Fund for Calamities lacks clear rules for capital accumulation and disbursement; its funding stems from unreliable sources and the national government has been reducing its budget allocation. As a result, SNPAD's actions are limited, and the Fund's resources are directed to emergency response rather than prevention (Cardona and Yamín 2007).

In the Philippines, the new Act 10121 renames the Local Calamity Fund as the Local Disaster Risk Reduction and Management Fund and stipulates that no less than 5 percent shall be set aside for risk management and preparedness. Thirty percent shall be allocated for quick response to disasters (Act 10121, sec 21 and 22). Further, to carry out the provisions of the Act, the Commission allocated one billion pesos or 21.5 million USD (Act 10121, Sec 23). These changes reflect lessons learned to date when disaster-related budgetary allocations were primarily intended for post-disaster response through calamity funds and were inadequate to meet response and risk reduction needs (Benson 2009).

South Africa's and Colombia's experiences are replayed around the world. Except for some high-income countries, Governments report a lack of systematic policy or institutional commitment to providing dedicated or adequate resources for disaster risk reduction, in particular in the absence of legislation that makes financial allocations legally binding (ISDR 2009). Even in countries, such as those discussed here, in which funding for disaster risk management is mandated by law, actual resource allocation for disaster risk reduction remains low and is concentrated in preparedness and response (UNDP 2007). Allocations to address the underlying risk factors by development sectors are not adequately documented and accounted for (UNDP 2007).

4.4. Public participation, information, education

Public awareness and a functioning legal system are essential to assign accountability for disaster losses and impacts (UNDP 2007). South Africa's and the Philippines' Acts have provisions for the involvement of NGOs, traditional leaders, volunteers, community members and private sector in disaster risk reduction. In line with the finding that relatively few States actively involve business despite its crucial role in effective disaster risk reduction (UNDP 2007), South Africa does not explicitly mandate the private sector to incorporate disaster risk reduction in its working processes. Some positive examples can be found in the Philippines' legislation, which includes representatives of the private sector as members of the disaster risk management council (Act 10121, Sec 5), and Indonesia's legislation which requires businesses to comply with disaster management organization policy, report to the government, transparently inform the public and support humanitarian activities financially (UNDP 2009). The Philippines' legislation gives great importance to the local level by mandating the establishment of provincial, city, and municipal disaster risk reduction and management councils, as well as local disaster risk reduction and management offices in every province, city and municipality, in addition to a *barangay* disaster risk reduction and management committee (Act 10121, Sec12(3)).

Closely connected to public participation, South Africa's Act includes mandates for capacity building, training and education, research and the inclusion of traditional knowledge. The development of these provisions aligns South Africa with internationally agreed good practice. The Hyogo Framework, which was agreed by governments after South Africa's Act was promulgated, states: "The starting point for reducing disaster risk and for promoting a culture of disaster resilience lies in the knowledge of the hazards and the physical, social, economic and environmental vulnerabilities to disasters that most societies face, and of the ways in which hazards and vulnerabilities are changing in the short and long term, followed by action taken on the basis of that knowledge" (UNISDR 2005).

5. Linking DRR and Adaptation in Legislation: The Philippines

When crafting climate change legislation, policymakers might chose to strengthen existing risk reduction legislation by integrating climate change provisions, thus resulting in a robust framework for reducing existing risks and adapting to those related to climate change. Alternatively, legislators might enact new, stand-alone adaptation legislation, in which case a review of the country's experience in both developing and implementing disaster risk management laws would be helpful to avoid previous pitfalls and benefit from lessons learned. The Philippines is at the forefront of this development: not only does the new disaster risk reduction legislation address climate change, the Climate Change Law of 2009 addresses disaster risk reduction. As stated above, parliamentarians, in particular the "Manila Call for Action of Parliamentarians on Disaster Risk Reduction and Climate Change Adaptation" (IPU 2009) were instrumental for the quick adoption of the law. Further political support was provided in 2010, when the Inter-Parliamentary Union adopted a resolution to inter alia, "foster the strong political will and allocate the budget funds needed to develop a national legal framework designed to ensure synergy between disaster risk reduction and climate change adaptation, and between disaster risk reduction and poverty reduction and socio-economic development, so as to protect the best interests of those vulnerable to geological and climate-related disasters" (IPU 2010).

The Philippines Climate Change Act states at the outset: "As a party to the Hyogo Framework for action, the State likewise adopts the strategic goals in order to build national and local resilience to climate related disasters…Further recognizing that climate change and disaster risk reduction are closely interrelated and effective disaster risk reduction will enhance climate change adaptive capacity, the State shall integrate disaster risk reduction into climate change programs and initiatives." (Act 9729, Sec 2). Likewise, the Philippines Disaster Risk Reduction and Management Act incorporates several linkages to climate change (Act 10121, Sec 2 (a), (d), (e), (g)).

In line with the Disaster Risk Reduction and Management Act, the Climate Change Act creates a Commission to be chaired by the President and attached to the President's Office, thus ensuring highest political support for collaborative implementation. The Commission is composed by the Secretaries of all relevant departments as well as "(h) Secretary of the Department of National Defense, in his capacity as Chair of the National Disaster Coordinating Council;" and representatives from the disaster risk reduction community. Main functions of the Commission include to "Ensure the mainstreaming of climate change, in synergy with disaster risk reduction, into the national, sectoral and local development plans and programs" (Act 9729, Sec 9 (a)) and to create a panel of technical experts, consisting of practitioners in disciplines that are related to climate change, including disaster risk reduction" (Act 9729, Sec 10).

Finally, the Act devolves substantial power to local government units and calls upon them to formulate, plan and implement climate change action plans and expressly authorizes local government units to appropriate and use funds from their internal revenue allotment. Additional funds of about 1.075 million USD are allocated for the implementation of the Act.

6. Relationship to Key Messages

This case study supports the message that improving current risk management can facilitate adaptation to climate change. As shown above, the robustness of South Africa's and Colombia's legislation and its focus on risk reduction garnered international recognition yet experience gained through implementation reveals elements that could be strengthened. Lawmakers can learn from these experiences, as Philippines aims to do with its two new laws, in particular to make clear provisions for adequate funding for implementation and responsibilities at every administrative level. Robust and flexible legislation for disaster risk reduction may not require modification for climate-smart management if, for example, such legislation harnesses local knowledge and experience, promotes strategic action including at sub-national level, as illustrated by the South African and Philippine examples. Some aspects for which climate change may require adjustments to existing legislation are to ensure the gathering of baseline/science information, promote iterative learning and respond flexibly to change. The legislation of South Africa, Colombia and the Philippines explored here support the message that climate change adaptation should take into account and learn from the evolving body of disaster risk management theory and practice, with the aim to increase resilience to extreme and non-routine events.

7. Research Gaps and Needs

Preparation of this case study revealed a dearth of analysis about existing disaster risk reduction laws and their effectiveness. Although most States have national disaster risk reduction and management laws, most of which are available online, an analytical review of the global body of disaster risk reduction laws has not been undertaken. UNDP's 11-country study (UNDP 2005) and the ISDR's Global Assessment Report (ISDR 2009) of government reports are good first steps. Nevertheless, comparative studies of particular provisions and their effectiveness across States' disaster risk reduction laws should be undertaken. For instance, comparative studies of provisions for budgetary allocation, as well as decentralized management, could yield important lessons to improve legislation for both disaster risk reduction and adaptation. It would be most useful to undertake legislative analysis to ascertain the pros and cons of the two prevalent legislative models: comprehensive disaster risk reduction legislation versus provisions for risk reduction integrated into the laws of all relevant sectors without an overarching framework. Moreover, evidence should be gathered to validate the view that the achievement of multi-sector commitment depends on disaster risk reduction being overseen and headed at the highest levels of government—a provision usually specified in the law. Finally it would be most useful to document and analyse the development, enactment and implementation of legislation for adaptation, whether governments chose to strengthen existing disaster risk management legislation or to develop new laws specifically for adaptation based on local experience reducing disaster risk. As appropriateness is likely to vary by national circumstances, studies on effectiveness of both approaches would be helpful to legislators worldwide.

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Case Study 9.17. Hard and Soft Defense in Coastal Zones Adaptation

Authors: Avelino Suárez, Sohel Saikat. Gordon Mc Bean.

1. Introduction

Waves and storm surges can erode shorelines, damage dykes, and flood coastal communities, rice paddies, and aquaculture facilities. Sea level rise increases those impacts. The impacts of other extreme events on coastal zones, like tropical cyclones (typhoon or hurricane), are expected to increase because of sea level rise and changes in intensity, larger peak winds and more heavy precipitation associated with climate change. The IPCC Synthesis Report (2007) considered the mangroves, the salt marshes and the coral reefs ecosystems are *likely* to be especially affected by climate change.

2. Coastal Defenses

The coastal defenses have traditionally relied upon "hard defense" structures such as sea walls, dykes and tidal barriers. Those adaptation strategies dependent on engineering and technology can have significant high economic cost and negative impacts on biodiversity (Campbell *et al*, 2009). It was recognized in the IPCC (2007) that those structures can alter sediment deposition; prevent inland migration of vegetation in response to seal level rise and impact upon salt marshes. There will also be impacts on fisheries by impeding migration to and from the tidal flood plain. There is evidence that these structures, both through physical destruction during infrastructural development and by altering the ecological niche and salinity regime, threaten the mangrove ecosystems (Gilman *et al*, 2007 and Gilman *et al,* 2008) and impact negatively the salt marshes and dunes (Glick, *et al, 2009)*

The coastal protection adaptation strategies range from "hard defense" to "soft defense" such as natural resources management (Adger *et al* 2007). Soft engineering solutions incorporate activities such as dune and wetland restoration, planting of marsh vegetation and mangroves, and the conservation and/or sustainable management of those mentioned ecosystems, including coral reefs and sea grasses. From a practical point of view, both hard and soft defenses need to be integrated to facilitate adequate adaptation. However one element is crucial in order to strengthen 'soft defense' approach and to reduce over dependency on hard defense is building up of 'resilience' of habitant through inland infrastructure and careful land use planning. Flexibility in food security of the local population is key in succeeding with 'soft defense' as the economies of these populations tend to be biomass-based.

A Rich biological diversity can play an important role in the "soft coastal defense" solutions. Coastal wetlands can absorb wave energy and reduce erosion and direct wind effect. (Day, Jr, *et al, 2007)*. Mangroves forests can provide physical protection to vulnerable coastal communities whilst providing ecosystem good and services such as productive fisheries and harvesting shellfish to the most vulnerable people (Adger *et al,* 2005, and Reid and Huq 2005). In addition coastal mangroves act as safety barriers against natural hazards such as floods, cyclones, and tsunamis although severe cyclones may destroy the mangroves themselves, while wetlands filter pollutants and serve as water recharge areas and nurseries for local fisheries (Kerr and Baird 2007; Sale et al. 2008).

3. Value of Coastal Ecosystems

In economic planning, coastal ecosystems tend to be undervalued, usually because only their direct goods and services have been included in economic calculations (e.g. forestry resources), but this represents only a minor part of their total values. A number of studies, however, support the ecological and social role of mangroves and other coastal ecosystems and the cost-effective benefits of restore and conserve them. The Red Cross of Viet Nam (IFRC, 2002) began planting and protecting mangroves with support from the World Bank under the leadership of the Vietnamese national and provincial governments. Restored mangroves have been demonstrated to attenuate the height of waves hitting the shore, and to protect properties and people life from damaging cyclone Wukong in 2000 and the severe storm events in 2005 and 2006. Nearly 12,000 hectares of mangroves were planted in Viet Nam at a cost of US$ 1.1 million. These investments saved an estimated $7.3 million per year in dyke maintenance whilst providing protection against a typhoon that devastated neighboring areas (Reid, H. and Huq, S. 2005; and Tallis *et al. 2008*).). Loss of mangrove area has been estimate to increase in expected storm damages on the coast of Thailand by US $585,000 or US $187,898 per km2 (in 1996 $), based on damage data from 1979□96 and 1996□2004 respectively (Stolton et al, 2008). Recent studies in the Gulf of Mexico suggest that mangrove□related fish and crab species account for 32 percent of the small□scale fisheries landings in the region and that mangrove zones can be valued at $37,500 per hectare annually (Aburto□Oropeza et al., 2008). In Surat Thani, Thailand, the sum of all measured goods and services of intact mangroves exceeded that of shrimp farming from aquaculture by around 70 percent ($60,400) (Balmford et al., 2002).

Coral reefs are another ecosystem for which conservation and/or sustainable use produces ecological, social and cost-effective benefits. The coral reefs are evaluated by the IPCC (2007) as one of the most vulnerable systems to be impacted to different climatic and non-climatic stresses, including extreme events. The global net value of coral reefs relating to fisheries, coastal protection, tourism, and biodiversity, is estimated to total $29.8 billion per year (Ash, *et al*. 2007). The *Impacts of climate change on coral reefs* of the Cross-chapter case studies (Parry *el al, 2007)* suggest that the "coral reef crisis" is the result of complex and synergistic interactions among global- scale climatic stresses and local scale, human stresses like coastal development, marine pollution, over-exploitation and destructive fishing and sediment and nutrients from inland. A meta-analysis of data from 1977 to 2001 showed a reduction of the reef area on the Caribbean by 17 % in the year after a hurricane and the recovery period could be more than 8 years. Analysis of the coral bleaching in the region showed relationships with the variations in the El Nino Southern Oscillations and the atmospheric dust. The hurricanes undercut local shore protection. The coral degradation has negative impacts on local communities, through the loss of fishing livelihood, protein reduction, and loss of tourism incomes and the increment of the coastal erosion (Ash, *et al*. 2007). A synthesis of economic studies examining exploitation of Philippine reefs demonstrated that, despite high initial benefits, destructive fishing techniques provided fewer benefits than did sustainable fishing. Unsustainable fishing reduced social benefits and had a total economic value of $870/ha. By comparison, a healthy reef which provides tourism, coastal protection and fisheries had a total economic value of $3300/ha (Balmford et al., 2002, 2004). Recent study from Peduzzi, P. *et al*, (2010) quantified the sea grass and the coral reef role for tropical cyclone protection in Jamaica.

4. Coastal Zones Adaptation

The Convention of Biological Diversity (2009) consider the resilience of biodiversity to climate change can be enhanced by reducing non-climatic stresses in combination with conservation, restoration and sustainable management strategies of the ecosystems. This can be achieved through a reduced dependency on hard approach (e.g. intrusive coastal development, alternation, imposed land use practices) while empowering soft approach. To support the sustenance of soft approach, it is necessary to manage/prevent pollution discharge from upland/upstream; control of exploitation of resources and destructive fishing; and sustain fresh water flow through drainage basin. The restoration of the ecosystems and creation of coastal and marine protected areas with local knowledge and local participation are also integral to the overall adaptation approach. There needs to be sufficient political will to bridge between administrative or political boundaries to focus on the "whole coastal ecosystem" rather than species or specific locales. Careful land use planning, adaptive management, enhanced local resilience and participation in resource use and sustenance are fundamental to succeed in adaptation with soft approach.

A number of studies that support the role of the coastal ecosystem based adaptation note that it has limitations (e.g., Kerr and Baird, 2007). The coastal ecosystems will not reduce impacts in all the cases. In the face of dwindling resource base, growing demand/use for resources, and increased environmental extremes, "soft coastal defense" should be promoted with reduced "hard defense" structures (Campbell *et al*, 2009). The biodiversity based adaptation measures coupled with "mixed defenses" are receiving increased attention in the developing countries particularly Small Island Developing States (SIDS), where adaptive capacity is low and local communities depend upon their natural resources (Cherian, 2007). The situation is similar for the Least Developing Countries (LDCs).

5. <u>Conclusions</u>

The scientific literature on the role of the biological diversity to climate change adaptation is insufficient, but there is growing evidence suggesting that coastal ecosystem-based adaptation can be a cost-effective adaptation strategy (Campbell *et al*, 2009 and ProAct Network. 2008). The approach will enhance ecosystem resilience and thus enable continued goods and services provision to communities.

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Case Study 9.18. Linking Disaster Risk Reduction and Climate Change Adaptation – Cyclones in Bangladesh

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1. Introduction

Bangladesh experiences on average a severe tropical cyclone (wind speed 90-119 km/h) every three years (UNDP, 2004; World Bank 2010). Among the many tropical cyclones over the last 4 decades, Bhola in 1970, Gorky in 1991 and Sidr in 2007 proved to be the most severe in terms of their intensity and associated storm surge heights. All these were extreme events but the loss of life and morbidity have been considerably reduced with each succeeding event as shown in Table 9-2.

[INSERT TABLE 9-2 HERE:
Table 9-2: ___________.]

The 1970 Bhola cyclone is the deadliest tropical cyclone ever recorded in Bangladesh and one of the most catastrophic disaster events of the 20th century (Haque and Blair, 1992; GoB, 2008). Although two subsequent cyclones (Gorky in 1991 and Sidr in 2007) had comparable severity in terms of intensity and storm surge, and exposed far greater number of people than Bhola, the loss of life for those events was dramatically reduced compared to Bhola.

2. What Improvements were Made Over the Years?

The disaster management system, led by a full-fledged ministry after independence of Bangladesh (in 1971) has evolved over period with extensive institutional arrangements from national to local level. The key DRR measures that make the national system in Bangladesh increasingly effective against cyclone hazards and associated storm surges may be attributed to three concrete steps led by the Government in partnership with donors, NGOs, humanitarian organisations, and mostly importantly by involving the coastal vulnerable communities themselves.

First, the construction of cyclone shelters in the coastal regions has provided safe refuge to coastal populations. These shelters are multi-storied buildings with varying capacities 500 to 2500 people (Paul and Rahman, 2006) and are raised on platforms above ground-level to resist storm-surges. Also, killas (raised earthen platforms) which usually accommodate 300 – 400 livestock have been constructed in the cyclone-prone areas to safeguard livestock from storm surges (Haque, 1997).

Second, the coastal volunteer network, established under the cyclone preparedness programme (CPP), has proved time and again an effective mechanism for dissemination of cyclone warnings among the coastal communities and for time-critical actions on the ground for safe evacuation of vulnerable populations to cyclone shelters (Paul 2009). They are skilled and equipped volunteers having defined and time-critical responsibilities to help vulnerable coastal population at times of disaster emergency. These volunteers helped evacuation of around 350,000 people to cyclone shelters during Gorky in 1991 and, with an increased number of cyclone shelters and volunteers by sevenfold and twofold respectively, a total of 1.5 million people had been safely evacuated prior to landfall of Sidr in 2007.

Third, there has been a continued effort to improve forecasting and warning capacity in Bangladesh. A Storm Warning Center (SWC) has been established in the Meteorological Department and system capacity has been enhanced to alert to a wide range of user agencies including DMB (Disaster Management Bureau), CPP network, NGOs, the media, and local administration with early warnings and special bulletins soon after the formation of tropical depressions in the Bay of Bengal (Chowdhury, 2002). Periodic training and drilling practices are conducted at the local level for CPP volunteers for effective dissemination of cyclone warning and for raising awareness among the populations in the vulnerable communities. Table 9-3 lists the key improvements in the above three measures for reducing disaster risks from tropical cyclones in Bangladesh.

[INSERT TABLE 9-3 HERE:
Table 9-3: Key improvements for reducing disaster risks from tropical cyclones in Bangladesh.]

Added to these are many other hard and soft measures and local adaptive practices that have contributed to increased resilience of the coastal populations (Paul, 2009). The expansion of embankments and reforestation programs along the coasts and offshore islands has reduced the impact of Sidr significantly. Since 1959, more than 5,500 km of coastal embankments has been constructed in the coastal districts to support agriculture and protect crops and properties from saline tidal flooding (GoB, 2008). The Sundarbans, the world's largest mangrove forest, lies along the south-western coast of Bangladesh. Cyclones Bhola and Gorky had landfall in the middle and eastern coast with limited or no forest barriers. On the contrary, Sidr had landfall in western coast covered by the Sundarbans, which cushioned and reduced the impacts considerably (Paul, 2009).

Sustained and targeted assistance at the community level by Government, NGOs and humanitarian partners and social safety net programmes in the disaster vulnerable regions are reported to have significantly contributed to, and enhanced community resilience and capacity to cope with extreme events (Karim and Mimura, 2008). Coastal reforestation has been a priority intervention in the coastal region for reducing the thrust of storm surges and stabilising the coast (Karim and Mimura, 2008; World Bank, 2010).

3. Can Vulnerability be Further Reduced?

The existing number of cyclone shelters and killas in Bangladesh are reported to be far from adequate to accommodate the increasing size of the number of coastal population and assets (GoB, 2008; Islam, 2004). Sometimes these are located at a distance of more than 3.5 miles (5.6 km) apart. Studies have shown that it is difficult for the coastal populations to take refuge at times of emergency unless the cyclone shelter is located within the proximity of 1 mile (1.6 km) (Paul 2009). A total of 1,576 cyclone shelters (40% of total) were damaged by river erosion or abandoned for their dilapidated conditions due to lack of maintenance. Most of the casualties during Sidr took place in those offshore islands where cyclone shelters are either absent or inadequate in numbers or not in usable condition (GoB, 2008). As reported in an epidemiological assessment, all of those who sought refuge in concrete or building structures survived from Gorky in 1991(Bern et al., 1993). Multi-purpose use of cyclone shelters is now increasingly recognised as an effective way to promote local development as well as to ensure regular maintenance for their effective use during cyclone emergency (Chowdhury 2002).

Proper maintenance of the embankments and polders can further reduce the coastal vulnerability significantly. Lives were saved, and damages and property losses were much lower in places during Sidr where structures had been properly maintained and had not eroded (GoB, 2008).

In the aftermath of Sidr, a number of initiatives are in place in Bangladesh to reduce the future risks from extreme tropical cyclone events. Minimum specification for cyclone resistant houses is now standardized in the recovery efforts in housing sector. The recovery action plan of the Government, supported by its development partners and NGOs, includes DRR as an important element (GoB, 2008).

While the existing risk reduction measures in Bangladesh have achieved significant progress in cyclone preparedness and reduction of mortality, climate change may increase the risk to coastal communities because of the changes in the characteristics of extreme events and sea level rise (IPCC, 2007; Karim and Nimura 2008). Bangladesh is experiencing rising sea level along its coast due to global warming (Unnikrishnan, 2006). An increased number of severe cyclones (category 4 and 5 of Saffir-Simpson hurricane scale) has been observed over the North Indian Ocean in the recent history. Four major cyclones have formed since 2006 as compared to a total of eight major cyclones in the previous 25 years (Webster, 2008). These observed recent increases should be viewed in light of the known deficiencies in the data used to identify them (Ch. 3, section 3.2.1). Numerous data heterogeneities exist in the historical tropical cyclone record (e.g., Landsea et al. 2006). A known heterogeneity was introduced into the Northern Indian Ocean cyclone data as recently as 1998 when the launch of the Meteosat-7 satellite mitigated a longstanding problem with oblique satellite views of the Indian Ocean and associated biases in tropical cyclone intensity estimates (Kossin et al., 2007). Still, attempts at data homogenization have been made, and an increasing trend in the intensity of strongest Northern Indian Ocean cyclones since 1983 has been identified (Elsner et al., 2008). Confidence in projections of tropical cyclone changes at the regional level is low, however, particularly projections of frequency changes (Ch. 3, section 3.4.4.3; Knutson et al., 2010).

The Comprehensive Disaster Management Programme (CDMP) initiative of the Government of Bangladesh is designed to build risk reduction capacity and strengthen the disaster management system by adopting multi-hazard, multi-sector and multi-stakeholder approaches. Climate change is an integral part of the risk reduction model pursued by GoB under this programme.

CDMP is making efforts to institutionalise climate modelling and downscaling in Bangladesh for better understanding and national and sectoral planning for climate change adaptation. Several studies have also been commissioned to guide future actions for adaptation to climate change, for example on the likely environmental costs of climate change, and economic modelling of the likely infrastructure needs in Bangladesh. To support local level adaptation, CDMP has developed tools like community risk assessment (CRA) and local action plans and these are now increasingly used by government and NGOs for systematic and participatory assessment of disaster and climate risks and vulnerabilities.

4. Lessons and Key Messages

The impacts of climate change in Bangladesh can mostly be considered as a magnification of natural and historical risks. Most impacts are not new, but are potentially increased in severity. Bangladesh, at all levels from households through communities to the national government, has always been 'adapting' to these risks and threats (GoB, 2005).

The adaptation process must be localized so that communities can reorganize to address changing pattern of risks caused by climate change. Local level adaptation needs to be framed around adaptive local resources, adaptive capacity, and the empowerment of local social organization for decision-making, with adequate external resources and unhindered by outside constraints (UNU-EHS, 2009).

As with climate change adaptation, the non-negligible potential for an increase in future cyclone intensity combined with projections for sea level rise adds the need for a longer term perspective to DRR (IDS, 2008). Increased flooding associated with sea level rise threatens millions in coastal villages and communities in the region, so that the best and only viable DRR strategy is relocation, or adaptation to such changing conditions (Ahmed et al, 1999; GoB, 2005). Myers (2002) argues that climate refugees from Bangladesh alone might outnumber all current refugees worldwide.

The complexities and critical issues important for climate change adaptation (i.e. how to manage and cope with increased variability of extreme events) share much in common with disaster risk reduction measures. The changes in magnitude, intensity, frequency and spatial distribution of climate-driven extreme events is evolving and accelerating over the long term. The bringing together on DRR and CCA in Bangladesh is a good demonstration of how to make those engaged in CCA more aware and sensitive to extreme events, and also to bring the need for longer term strategies to the attention of those engaged in DRR.

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Case Study 9.19. Early Warning Systems

Authors: Simon Mason, Gordon McBean, Neville Nichols

1. Early Warning Systems for Disaster Risk Reduction and Climate Change Adaptation

Since the early 1990s, the annual number of humanitarian disasters worldwide has more than doubled largely as a result of increases in the frequency of hydrometeorological disasters (most notably flooding events). Regardless of the extent to which this increase is attributable to changes in the frequency and intensity of natural hazards as opposed to increases in vulnerability or exposure to these hazards (e.g., the numbers of people living in areas subject to such hazards), the effect has been a substantial increase in the threat posed by weather and climate extremes on human populations around the world. Despite these increases, improvements in early warning systems have contributed to decreases in the numbers of deaths, injuries, and loss of livelihood over the last thirty years (IFRC, 2009).

An early warning system is defined[17] as "the set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss." This definition encompasses a wide range of factors are that may or, if effective, will contribute to effective responses to warnings, and emphasizes the point that an early warning system involves considerably more than just a forecast of an impending hazard. This need for more than just accurate predictions was stated in the the Hyogo Framework for Action (HFA) 2005-2015[18] which stressed that early warning systems should be *"people centered"* and that warnings need to be*" timely and understandable to those at risk"* and need to "*take into account the demographic, gender, cultural and livelihood characteristics of the target audiences*." Warnings also need to include *"guidance on how to act upon warnings."*

[INSERT FOOTNOTE 17 HERE: UNISDR Terminology on Disaster Risk Reduction, 2009: Available at http://www.unisdr.org]

[INSERT FOOTNOTE 18 HERE: Hyogo Framework for Action 2005-2015: ISDR, International Strategy for Disaster Reduction. www.unisdr.org]

In 2006, the United Nations International Strategy for Disaster Reduction completed a global survey of early warning systems. The executive summary opened with the statement that: *"If an effective tsunami early warning system had been in place in the Indian Ocean region on 26 December 2004, thousands of lives would have been saved. The same stark lesson can be drawn from other disasters that have killed tens of thousands of people in the past few years. Effective early warning systems not only save lives but also help protect livelihoods and national development gains. Over the last thirty years, deaths from disasters have been declining*[19]*, in part thanks to the role of early warning systems and associated preparedness and response systems"*[20]

[INSERT FOOTNOTE 19 HERE: Centre for Research on the Epidemiology of Disasters (CRED), "Thirty Years of Natural Disasters 1974-2003: The Numbers", Presses Universitaires de Louvain, 2004.]

[INSERT FOOTNOTE 20 HERE: Global Survey of Early Warning Systems. Prepared by UN International Strategy for Disaster Reduction for the United Nations, 2006. 46 pp. Available from United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UN/ISDR), International Environment House II, 7-9 Chemin de Balexert, CH 1219 Chatelaine, Geneva 10, Switzerland http://www.unisdr.org]

The focus of early warning systems should be to warn and inform the citizens and governments of changes on a seamless timescale stretching from minutes for immediate threats requiring urgent evasive action; to weeks for more advanced preparedness; to seasons and decades for climate variations and changes, and to provide a basis for disaster risk reduction and sustainable development. To-date most of the early-warning systems have been based on weather predictions, which provide short-term warnings often with sufficient lead-time and accuracy to take evasive action. However, the range of actions that can be taken if early warning systems are informed by no other climate information than short-range predictions is limited. Weather predictions often provide less than 24 hours notice of an impending extreme weather event, and options in resource-poor areas may not extend beyond the emergency evacuations of people. Thus although lives may be saved, livelihoods may still be destroyed, especially those of the poorest communities.

Partly because of the rapid growth in the number of humanitarian disasters, the disaster risk management community has become attentive to the risk of possible changes in weather and climate hazards as a result of climate change, in particular regarding changes in floods, droughts, heat waves and storms. Effective tools for weather and seasonal prediction (and early warning) are among the possible approaches to assist in adaptation to possible increases in the occurrence of weather- and climate-related hazards. However, with increasing uncertainty in the predictions at longer timescales, it is imperative that appropriate response strategies be identified to ensure that confidence is retained in the early warning system when anticipated hazards do not manifest. At the longer timescales, the appropriate responses may involve little more than no-regrets actions with forecasts providing one additional factor in the choice between competing priorities given finite resources (Braman et al. 2010; Tall et al. 2010); at the shorter timescales, as confidence in the prediction of specific anticipated hazards increases, more committed actions can be taken with the understanding that there remains some possibility of the hazardous event not occurring.

2. Examples of Benefits of Early Warning Systems

Predictions of hazardous events can contribute to disaster risk reduction and sustainable development (McBean, 2007; 2010). There are examples in the past of major benefits of early warning systems (Einstein and Sousa 2007). In 1977, a major cyclone resulted in about 20,000 deaths on the east coast of India. In the years that followed, an early warning system was established, complete with meteorological radars and emergency plans, and many lives were saved as a result when the same area was hit again by cyclones of similar strength in 1996, when about 100 deaths occurred, and in 2005, when the death toll was just 27 (UNISDR, 2009). Predictions of land-fall for tropical cyclones are very important (Davis et al., 2008). As presented in Case Study 1 Tropical Cyclones, major reductions in loss of life were achieved "*after the devastating cyclone of 1970, the Bangladesh government initiated several structural and non-structural measures to reduce the cyclone risk (Paul, 2009)*". These measures included implementation of an early warning system. However, accurate predictions alone are insufficient for a successful early warning system as is demonstrated by the case in the United Kingdom, a country which regularly experiences flooding. Severe damage and health problems followed flooding in 2007 due to warning communication that was insufficiently clear, issued too late, and inadequately coordinated, so that people, local government and support services were unprepared (UNISDR, 2009).

While most of the successfully implemented early warning systems to date have focused on shorter timescales [for example, for tornadoes (Doswell et al. 1993)], benefits of improved predictions on the sub- to seasonal scales have been reviewed (Nichols 2001; Brunet et al 2010). Since hazardous atmospheric events occur on timescales from minutes for tornadoes, for example, through seasons and decades in terms of the climatically-changing occurrences of extremes (McBean, 2000), and since planning for hazardous events involves decisions across a full range of timescales, *"An Earth-system Prediction Initiative for the 21st Century"* covering all scales has been proposed (Shapiro et al. 2007; 2010). With improvements in numerical weather models (Simmons and Hollingsworth, 2002) and stochastic design (Medina-Cetina and Nadim, 2008), early warning systems based on medium-range and seasonal forecasts for flood hazards across Europe and West Africa have been considered (Bartholmes et al. 2008; Tall et al. 2010).

Similarly, there have been important developments in recent years in the area of subseasonal and seasonal-to-interannual prediction, leading to dramatic improvements in predictions of weather and climate extremes (Nicholls, 2001). Some of these improvements, such as the use of soil moisture initialization for weather and (sub-) seasonal prediction (Koster et al., 2010), have potential for applications in transitional zones between wet and dry climates, and in particular in mid-latitudes (Koster et al., 2004). Such applications may be potentially relevant for projections of temperature extremes and droughts (Schubert et al., 2008b; Koster et al., 2010). On decadal and longer timescales, predictions are improving and could form the basis for early-warning systems in the future (Meehl et al., 2007, 2009; Palmer et al, 2008; Shukla et al., 2009, 2010).

Methods for improving predictions remain a very active area of research, and significant further progress may be reached in coming years. However, for such predictions to be of use to end users, improved communication will be required to develop appropriate indices relevant for specific regional impacts. For example predictions of the probability of climate variables such as average temperatures in the format of terciles commonly used in seasonal-to-interannual climate predictions may not be the most relevant information for impacts. A better awareness of such issues in the climate modelling community, from improved interactions with the disaster risk management community (and other user communities), may lead to the development of more useful applications for weather and climate hazard predictions. Such prediction systems, if carefully targeted and of sufficient accuracy, can be a useful tool for reducing the risks related to climate and weather extremes.

3. What can We Learn from Experience with Subseasonal and Seasonal-to-Interannual Climate Predictions?

Developing resiliency to weather and climate involves developing resiliency to its variability on a continuum of timescales, and in an ideal world early warnings would be available across this continuum. However, investments in developing such resiliency are likely to be primarily informed by information only over the expected lifetime of the investment, especially amongst poorer communities. For example, in deciding what crops to grow next season, while some consideration may be given to longer-term strategies, the more pressing concern is likely to be the expected climate conditions over the next season. Indeed, there is little point in preparing to survive the impacts of possible disasters a century hence, if one is not equipped to survive more immediate threats. Thus, within the disaster risk management community, preparedness for climate change necessarily involves preparedness for climate variability.

Despite this inevitable focus on shorter-term survival and hence interest in warnings of hazards in the near-term, even in this context the longer timescales cannot be ignored if reliable predictions of climate variability are to be made. For example, considerations of changing greenhouse gas concentrations are important even for seasonal forecasting, because including realistic greenhouse gas concentrations can significantly improve forecast skill (Doblas-Reyes et al., 2006; Liniger et al., 2007). Similarly, adaptation tools traditionally based on long-term records (e.g., streamflow measurements over 50-100 years) under the assumption of stationary climate conditions, may create a bias towards obsolete adaptation (e.g., Milly et al., 2008). Thus reliable prediction and successful adaptation are both impossible as long as a myopic perspective on a single timescale, be that climate change, seasonal, or weather scale, is retained.

While there appear to be obvious potential benefits of early warning systems that span a continuum of timescales, for much of the disaster risk management community the idea of preparedness based on predictions is a new concept: the community has largely operated in a reactive mode, either to disasters that have already occurred, or in emergency preparedness for one that is anticipated to occur with high confidence in the immediate future. The possibility of using weather and climate predictions longer than a few days to provide advanced warning of extreme conditions has been only a very recent development. Despite what has been over a decade of operational seasonal predictions in many parts of the globe, examples of the use of such information by the disaster risk management community are limited, for a number of reasons. Not least of these reasons are the large uncertainties in the predictions, and difficulties in understanding their implications. Most seasonal rainfall predictions, for example, are presented in a so-called probabilistic tercile format: probabilities are provided that the total rainfall over the coming few (typically three) months, and averaged over large areas (typically tens of thousands of square kilometres), will be amongst the highest and lowest third of rainfall totals as measured over a historical period. Not only are the probabilities almost invariably lacking in sharpness (highest probabilities are most frequently around 40% or 45%, compared to the climatologically expected probability of 33%), but the target variable of the seasonal rainfall total does not necessarily map well onto flood occurrence. Although higher-than-normal seasonal rainfall will often be associated with a higher risk of floods, it is possible for the seasonal rainfall total to be unusually high but yet for no flooding to occur because of the frequent occurrence of moderately heavy rain. Alternatively, the total may be unusually low, but yet flooding might occur because of the occurrence of an isolated heavy rainfall event (see also chapter 3 for a discussion of these aspects). Thus even when seasonal predictions are understood properly, it may not be obvious how to use them – the uncertainty in the predictions is very high and the predicted variable may not be of immediate relevance. These problems emphasize the need for the development of tools that can translate such information to quantities directly relevant to end users, and thus for better communication between modelling centres and end users. Where targeted applications have been developed, some success has been reported (e.g., for malaria prediction, Thomson et al., 2006; Jones et al., 2007). Nonetheless, there can be additional obstacles such as policy constraints, which may restrict the range of possible actions that could be taken. Technical constraints, such as limited telecommunications infrastructure, can also limit the utility of predictions.

Notwithstanding these obstacles to the use of seasonal predictions in disaster risk management, the successful use of such predictions has been possible, and can be promoted by attending to the obstacles. For example, the large uncertainty in the information, and, to some extent, some of the policy constraints, may be surmountable by identifying no-regrets strategies. While all preparative actions have some direct cost, and so it is impracticable to be always prepared for all possible eventualities, seasonal predictions can help to prioritize amongst a list of actions. A clear instance of taking such action is provided by the International Federation of Red Cross and Red Crescent Societies (IFRC) West and Central Africa Zone (WCAZ) flood preparedness and response during 2008. In response to a set of predictions for the rainfall season for the region issued in May 2008, actions were taken to pre-position relief items, to improve disaster response capacity through trainings, to develop flood contingency plans, and to launch pre-emergency funding requests for preparedness activities and response. Although it is impossible to quantify the benefits of these actions, evidence suggests that lives were saved and the costs of relief reduced (Braman et al., 2010).

4. Relationship to Key Messages

Early warning systems directly contribute to climate change adaptation and disaster risk reduction and relate to several of the key messages of this Special Report. Early warning systems can increase effectiveness of adaptation strategies and practices by providing information on the type of extreme events that may occur in the near and longer-term futures. This sense of “seeing the future”, including projected risks, anticipatory strategies and actions, is essential towards key messages: (2) effectively preparing for, responding to, and recovering from extreme events and disasters require understanding current and projected risks; (16) Effective disaster risk management in a changing climate is facilitated by anticipatory strategies within and between sectors, with strong co-ordination; and (20) realizing adaptation potentials requires anticipation of vulnerabilities and anticipatory actions.

Key message (9) “risk can never be reduced to zero, but it can be reduced and managed” refers to the problems with assuming a stationary climate. Effective early warning systems on longer timescales will convince disaster risk managers that this is inappropriate. By incorporating longer-term early warning systems into disaster risk management, (key message 11) “improving current risk management can facilitate adaptation to climate change”, noting that managing [rising] uncertainty requires anticipatory action. Early warning systems can also contribute to “climate smart disaster risk management (key message 14).

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9.4. Synthesis of Lessons Learned from Case Studies

This chapter examined case studies of extreme climate events, vulnerable regions and methodological-management approaches in order to glean lessons and good practices. This is an important role because it adds context and value to the information. Warming trends can be predicted and the occurrence of extreme events explained, even identifying the regions that are most at risk. The role of case studies is to contribute a more focused analysis which conveys the reality of the event: the extent of human loss and financial damage; the response strategies and their successes and failures; prevention measures and their effect on the overall event; and even cultural or region-specific factors that may influence the outcome. Most importantly, case studies provide a medium through which to learn practical lessons about success in disaster risk reduction and climate change adaptation. These will prove useful as states and people try to adapt to a continually changing climate.

The case studies in this chapter illustrate and demonstrate issues that need to be improved and they illustrate all three groups of concerns. Throughout the studies several recurring themes and lessons occurred. Since they hold importance in so many different scenarios and against so many different types of threats, it is clear that they should be highlighted for use by policymakers. The first such lesson is to invest in knowledge. In the case studies that dealt with sea-level rise, typhoons, floods and droughts, as examples of extreme events, a common factor was the need for greater amounts of information on threats before the events occur. In certain scenarios, this could mean investing in an early warning system. In others it was a demand for investment into greater and more accurate weather services in order to allow better planning for farms and other agricultural workers. Across the case studies the need for clearer understanding of health impacts and the benefits of safer hospitals and health care facilities is identified. In all cases, the point was made that with greater information available it would be possible to know the risks better and ensure that any response strategies were adequate to face the coming threat. Research is required to improve our knowledge and it needs to include an integration of natural, social, health and engineering science and their application.

The second major lesson was that due to the amount of damage that one extreme event can cause, and further, due to the all-encompassing nature of that damage, an integrated approach is needed in order to properly address these threats. Though present to some extent throughout all case studies, this lesson was particularly evident in the case studies that dealt with intersectoral issues, health, compound events and repetition of events. Here, the point resounded that if an extreme event could be felt in all aspects of life, clearly it was essential to study its impacts in all areas. This would contribute to a better understanding of the impacts of extreme events, which would hopefully allow for better and better-rounded risk reduction strategies. The approaches need to be integrated and multilevel as well as examing both the direct and indirect impacts. With respect to these impacts, they need also to be studied from the persepctive and with those who receive the impact (the victims). There is as yet limited material (scientific and systematic) on how the victims see and understand impacts.

The third lesson of note was the promotion of international cooperation in disaster risk reduction or climate change adaptation strategies. Disaster risk reduction (DRR) and climate change adaptation (CCA) are mutually reinforcing and similar directions in measures are needed. Where there is uncertainty as to the details of climate change in the future, this uncertainty can be reduced, in a sense, through the risk reduction approaches of DRR, noting that the low probability event but with very great consequences needs to be part of the planning and response approach. This was a particularly important message since this type of collaboration can be beneficial in many different ways. Findings in the case studies are clearly transferable into practice for many regions and countries and the positive nature of DRR and CCA, bringing a better coherence is important. Trans-boundary cooperation must happen at global and local level as in the end local adaptation or DRR actions across boundaries will make a difference. There is considerable experience on how to launch trans-boundary collaboration for trade or military action. But how such collaborations can be designed and launched and governed such that they promote integration of DRR and CCA is more difficult and it is suggesed that pilot projects are needed which could be then studied and replciated as appropriate.

Transboundary issues relating to resources such as rivers or lakes, demand cooperation in order to come to mutually agreeable terms on usage and access. Further, because the world is so interconnected, it is important that issues or vulnerabilities within a local area are addressed since they affect not only the state they belong to but the entire region or, in some cases, the international community at large. For instance, a drought in Indonesia, the Philippines or Vietnam, could seriously impact the availability of rice in China or Japan since they must import rice to feed their populations. This is especially relevant given the food shortages of the last few years. The case study regarding risk transfer provided a good example of how closely bound countries can work together to relieve their collective vulnerability. Finally, international cooperation is demanded because of the unequal nature in which the impacts of climate-related extreme events will be felt. As stated in various sections throughout the chapter, the most vulnerable areas are poor, coastal nations. Given that they are unable in many cases, to institute adaptation or risk reduction measures, it is essential to their survival that the international community contributes to their efforts. In others, it will call for guidance when setting up risk management measures, and in the most extreme cases, it may call for some countries to accept refugees from states who suffer from disasters. Holistic all hazards approaches are vital in DRR and CC and this includes the recognition of previous generational errors in siting cities in vulnerable areas and how or if these decisions can be revisited.

The last lesson for policymakers is that in order to implement a successful DRR or CCA strategy, legal and regulatory frameworks are needed to ensure direction, coordination and effective use of funds. The case studies are helpful in this endeavour as passed legislaturion has created a framework for governance of disaster risks. While this type of suggestion is mainly for national governments, it holds an important message for international governance and institutions as well. Here, cooperating with other countries to attain better analysis of the threat, it is possible to establish frameworks that will allow institutions to change their focus with the changing threat, therefore retaining their usefulness. This cooperation needs to be at the local through national to international levels. Here and in other ways, civil society has an important role.

Repeatedly throughout the chapter, reference was made to ‘smart investment’ with regard to risk management measures. The idea overall was that it is better to invest in preventative and adaptation based tools than in the response to extreme events. This includes the need to invest in primary to higher education and research and monitoring. The reasoning behind such statements was that if the disaster has already occurred, the damage has been done. The main goal of both disaster risk reduction and climate change adaptation is to reduce the risk and vulnerability of people and property. In other words, measure should be taken to reduce the damage that is inflicted as a result of extreme events. Investment in increased knowledge and warning systems, adaptation techniques and tools and preventative measures will cost money now, but save money and lives in the future.

Table 9-1: Examples of mechanisms for managing risks at different scales

	Local *Households, SMEs, farms*	***National*** *Governments*	***International*** *Development organizations, donors, NGOs, …*
Non-insurance mechanisms			
Solidarity	Help from neighbors and local organizations	Government post/disaster assistance; government guarantees/bail outs	Bi-lateral and multi-lateral assistance, regional solidarity funds
Informal risk sharing	Kinship and other mutual arrangements	Government diversions from other budgeted programs	Remittances
Savings and credit (inter-temporal risk spreading)	Savings; micro-savings; fungible assets; food storage; money lenders; micro-credit	National reserve funds; domestic bonds	Regional pools, post-disaster credit; contingent credit; emergency liquidity funds
Insurance mechanisms			
Insurance instruments (risk transfer and pooling)	Property insurance; micro-insurance; crop and livestock insurance; weather hedges	National insurance programs; sovereign risk transfer	Re-insurance; regional catastrophe insurance pools
Alternative risk transfer			Catastrophe bonds; risk swaps, options, and loss warranties

Source: Linnerooth-Bayer and Mechler, 2009

Table 9-2:

Cyclone events	Storm Surge	Maximum Wind Speed	Number of Affected Districts	Number of Affected People	Mortality
Bhola (1970)	6-9 m	223 km/h	5	1,100,000	300,000 – 500,000
Gorky (1991)	6-7.5 m	225 km/h	19	14,000,000	138,000
Sidr (2007)	Up to 10 m	Up to 240 km/h	30	6,900,000	3,400

Sources: Paul, 2009; GoB, 2008; Karim amd Mimura,2008; CRED, 2009

Table 9-3: Key improvements for reducing disaster risks from tropical cyclones in Bangladesh.

Cyclone event	Cyclone shelters (No)	CPP Volunteers	Cyclone Warning System	Population evacuated
Bhola (1970)	Nil	Nil	No warning capacity*	Nil
Gorky (1991)	512	20,000	Limited capacity	350,000
Sidr (2007)	3976	43000	Storm Warning Centre equipped with modern technology and access to mobile phones in coastal regions	1,500,000

(*Forecast was issued by Indian Meteorological authority and communicated to Cox's bazaar in the evening before land fall of Bhola Cyclone. Reliable information is not available)

Sources: GoB, 2008;ISDR, 2009; Sommer and Mosley, 1972; Paul 2009.

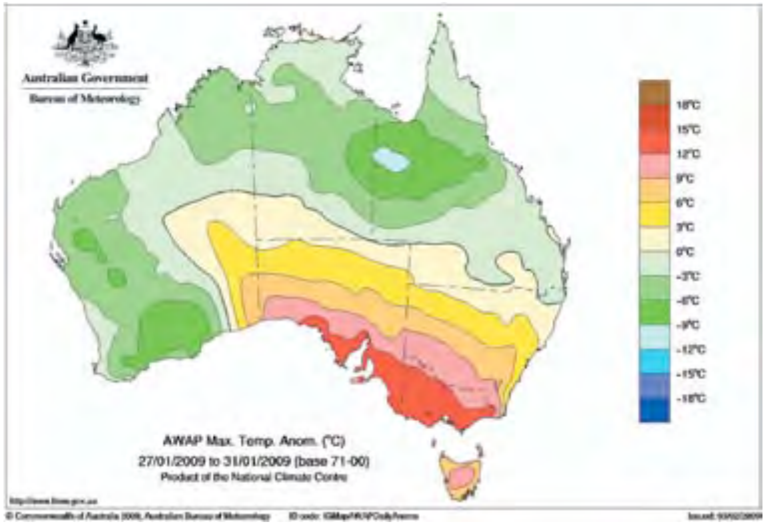

Figure 9-1: Maximum temperature anomalies for the period 27–31 January 2009.

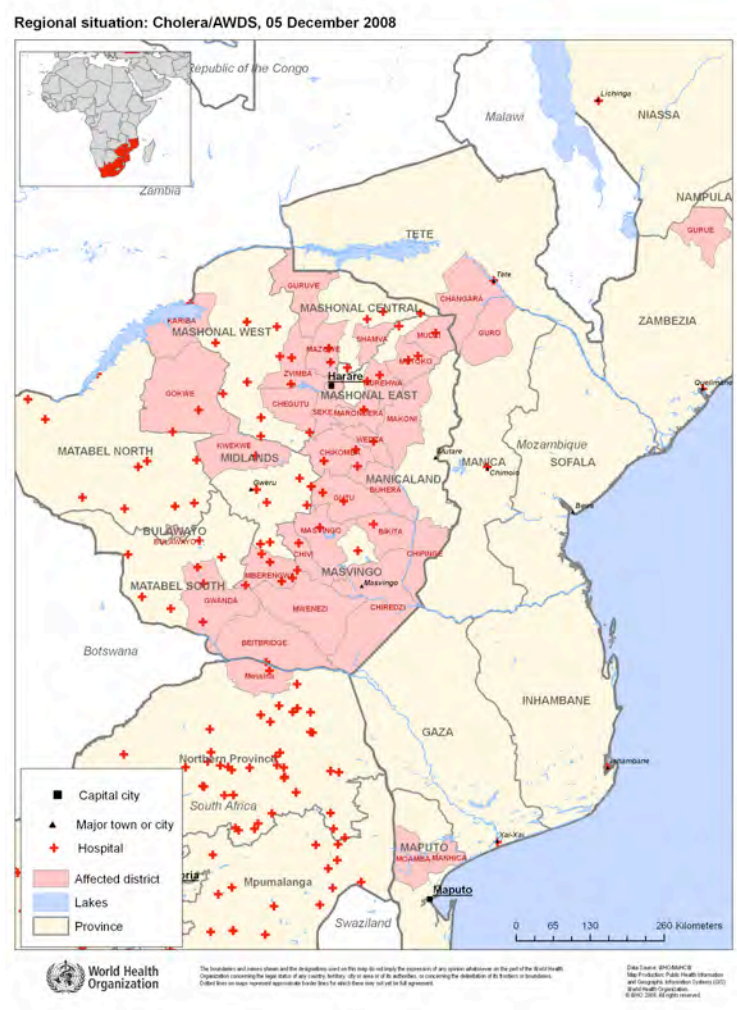

Figure 9-2: Regional spread of the 2008 Zimbabwe epidemic.

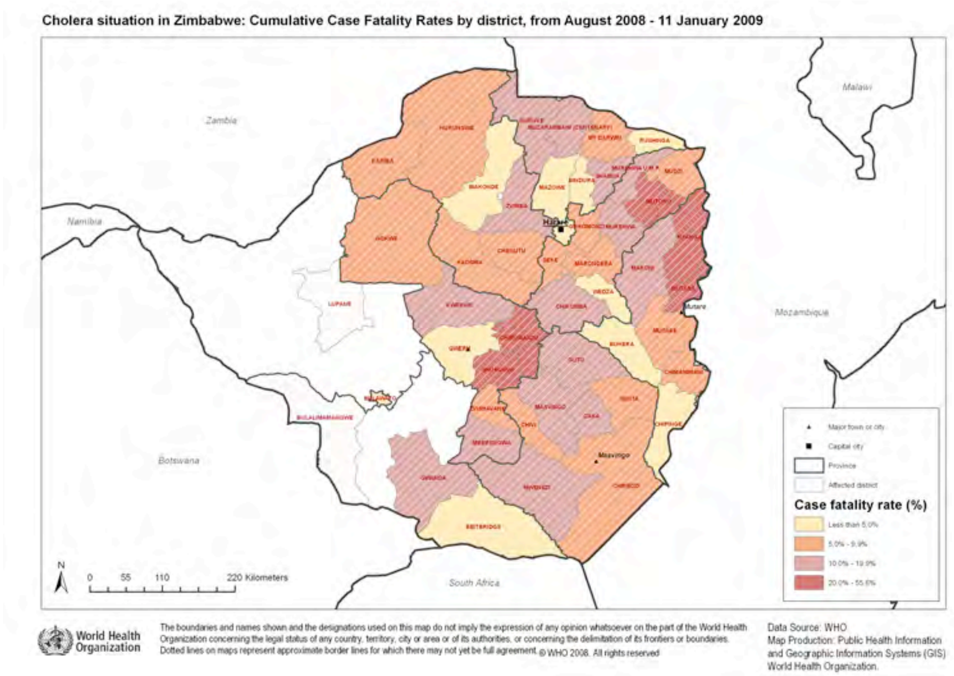

Figure 9-3: Case fatality rates for Zimbabwe by district.

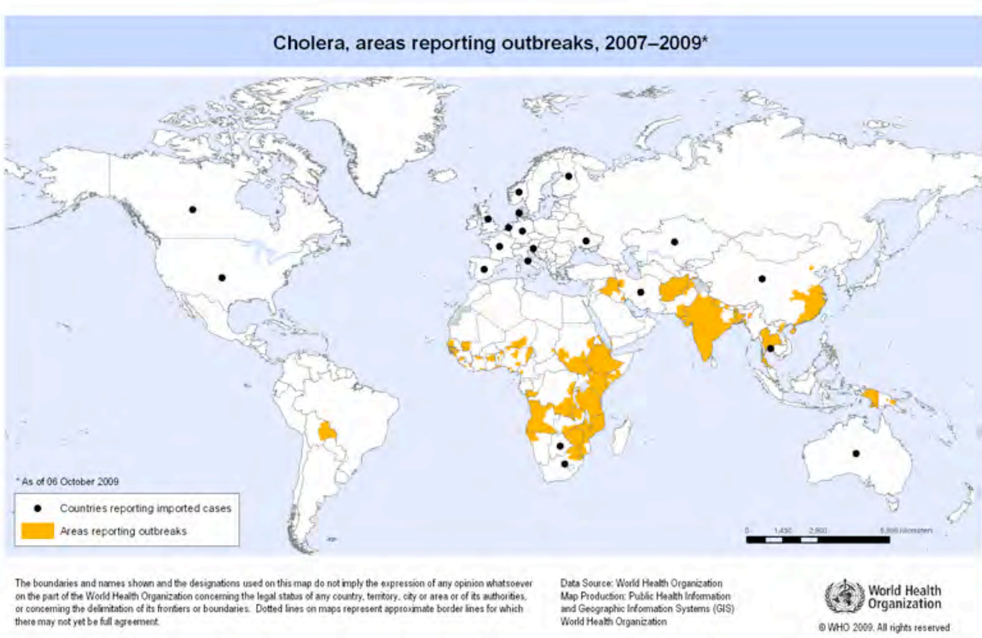

Figure 9-4: Cholera outbreaks, 2007-2009.