Advanced Review

Climate hazards and disasters: the need for capacity building

Gordon McBean* and Caroline Rodgers

Climate and climate-related hazards such as floods, storms, and droughts have served as trigger events for more than 75% of the disasters that have occurred globally over the past decade. Proportionately, these disasters affect the least developed countries most intensely, proving to be especially harmful to poverty stricken populations. In the future, a changing climate is likely to exacerbate these effects and could make development unsustainable in many places. It is necessary to develop the capacity of all countries to combat hazards so that they do not become disasters. The international framework connects climate change and development, mainly within the UN Framework Convention on Climate Change. The Millennium Development Goals and Hyogo Framework for Action on Disaster Risk Reduction, and most recently the Declarations of the G8 and the Major Economies Forum on Energy and Climate provide further mandates for action. Climate hazards are now clearly linked with issues such as food security, migration, and national security. The linking of climate change adaptation and disaster risk reduction provides a framework for responding. The development of capacity for knowledge-based reduction of hazards and disasters risk demands an integrated approach that recognizes the changing nature of natural hazards. Further, capacity development must also recognize the limitations in governmental response and facilitate alternate ways to overcome barriers. For example, the role of resilience is examined in order to demonstrate the tools available for policymakers and individuals, to respond to hazards as they occur. The path forward to sustainable development depends on investments in the development and then the utilization of knowledge-based, integrated approaches that factor in the future in balance with the present needs of societies. *WIREs Clim Change* 2010 1 871–884 DOI: 10.1002/wcc.77

INTRODUCTION

Through all periods of human development, the natural environment has been both an asset and a liability. Initially, it provided sustenance for the few inhabitants, and later, with the development of agricultural practices, the environment made it possible to grow crops and raise certain species of domesticated animals for consumption. Societies adapted both to the resources the earth could provide and the challenges created by the climate. In his popular book *Collapse*,[1] Diamond examines how climate and climate-related events, as well as other factors, have led to the evolution and development of societies and, in some cases, to their collapse. Given this background, the subtitle 'how societies choose to fail or succeed' is both interesting and provocative and the topic will be revisited in greater detail later in this article. The lessons of *Collapse* are particularly relevant today. Our benevolent climate has begun to change,[2] increasing the number of stressors that societies must adapt to. Short-term events such as storms and floods are affecting greater numbers of people, although their impacts are generally minor and can be borne out in shelter or on higher ground. Longer term stressors such as a drought can lead to prolonged famine and either migration to friendlier climes, if possible, or perhaps the end of that society. Importantly, as PR Erlich asserts, 'Collapse provides us with insights into how to avoid the grim fate of those past societies that failed to meet their

*Correspondence to: gmcbean@uwo.ca

Institute for Catastrophic Loss Reduction, Departments of Geography and Political Science, The University of Western Ontario, London, Ontario, Canada

DOI: 10.1002/wcc.77

environmental challenges'.[3] If the present society fails to learn the lessons of the past, they may suffer the same fate.

The human and economic losses caused by natural disasters in 2008 were very large, continuing a trend that has developed over the last few decades. Although the Centre for Research on the Epidemiology of Disasters (CRED) and the Munich Re Data Service NATHAN recorded different disaster occurrences and economic losses, their analyses proved similar in identifying a rising trend.[4,5] CRED recorded 354 natural disasters of which 322 were weather–climate related (climatological, hydrological, or meteorological) with about 166 million victims (people killed or affected) and economic costs exceeding US$ 104 billion. The two most disastrous events were Cyclone Nargis with major impacts in Myanmar and the Sichuan earthquake in China. In contrast, NATHAN[a] recorded 750 disasters in total although their ratio of weather–climate-caused events related to the total (including geophysical) was the same—about 90%. Additionally, the total cost of weather-climate events in the NATHAN database was US$ 134 billion. Despite differing numbers, both studies noted an upward trend in both human and economic losses due to climate-related hazards.

Although disasters are a possibility in all nations, weather–climate-related events are most often recorded in Asia. Of the four categories, six catastrophes of 2008, for example, two were in Asia, one in the US, and one in the Caribbean. This trend is especially important due to the population density of the most vulnerable nations. An event in India or China is likely to affect more people than in one of the smaller, less densely populated nations as there is likely to be less inhabitants in any given site. However, the number of victims per 100,000 inhabitants list was led by Djibouti, Tajikistan, Somalia, and Eritrea. 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).

In addition to reviewing case studies and trends, it is important to establish some definitions. Primarily, in an attempt to encompass all related natural hazards, climate hazards will be used to refer to all weather-, hydrological-, and climate-related hazards. Further, climate change adaptation and disaster risk reduction will be used to refer to the processes and policy surrounding national response to a changing climate and climate-related hazards. Finally, a main theme of the review is the need to link disaster risk reduction and climate change adaptation in order to better address natural hazards. Part of this process will involve the building of capacity within nations and communities so that they are better able to implement the measures needed to avoid 'collapse'. This process is important because overall development is dependent on a nation's ability to constrain the effects of a natural hazard, ensuring that it does not become a disaster.

This review will first discuss the observed and projected changes in climate, hazards, and disasters and then the international framework for responding to them. It will additionally explore the impacts of climate hazards on human health and well-being with a focus on vulnerable areas and societies with low adaptive capacity. An important section will describe the possibilities for response. Reducing impacts and losses can be done through both disaster risk reduction and climate change adaptation and importantly, with the effects of climate change on natural hazards, the linkage of the two is essential. Next, governmental response and its limits are examined. These lead to the need to build capacity for knowledge-based disaster risk reduction. Some new international developments and guidance for incorporating climate change adaptation into development provide optimism for the future. The review ends with a summary and conclusions.

OBSERVED AND PROJECTED CHANGES IN CLIMATE, HAZARDS, AND DISASTERS

The Intergovernmental Panel on Climate Change's (IPCC) 2007 Fourth Assessment Report has concluded that the 'warming of the climate system is unequivocal' [Ref 2, p. 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 [Ref 2, p. 3].

Simultaneously, the number of disasters impacting global society is increasing exponentially, from about 200 per year in the 1980s to closer to 300 per year in the 1990s to over 400 per year for the period 2000–2008.[4] The rate of occurrence has now doubled to the point where there is more than one

such event per day. The enormity of the problem is outlined by Wahlström 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'.[6] Although the increase in these events cannot be attributed solely to climate change, the significant increase is consistent with the long-term patterns and projections: severe storms, more heavy rainfall, and a greater tendency toward flooding.[b]

The importance of the warming trend lies in its impacts on human life and national economies. During the period 2000–2008,[4] for instance, the 360 climate-related disasters per year resulted in about 220 million of victims (deaths plus people affected) and accumulated US$ 82 billion in damages. Despite the fact that an upward trend can be identified with regard to the scope and magnitude of disaster impacts, it is difficult to confidently project costs because the numbers are highly influenced by the occurrence of 'mega-disasters' affecting tens of millions of people and/or causing billion of dollars worth of economic damage. However, MunichRe, which categorizes disasters on a scale of 1–6, has shown that the number of Category 5 events, called devastating catastrophes with more than 500 deaths and/or overall losses of more than US$ 500 million, has increased from 5–15 events per year in the 1980s to 15–25 events per year in the period 1990–2005 to 28–41 events per year in the 2006–2008 period (2008 had 41 devastating catastrophes, the largest number ever).[c]

Given the impacts of climate-related hazards in the past, and the apparent relationships with the past changing climate, what is the outlook for the future? For realistic emissions scenarios, the projected warming over the next few decades will be about 0.2°C per decade [Ref 2, p. 12]. By about 2040, the projected temperatures start to diverge with a lower emissions scenario leading to warming by 2100 between 1 and 6°C, depending on the scenario and including the present scientific uncertainty [Ref 2, p. 13]. The IPCC assessment stated that these trends were likely to lead to greater incidence of natural hazards, especially the increase in heat waves which was given a 90% probability rating. In addition to these concerns, more recent studies[7–10] have identified new areas for consideration. Sea level rise is a critical parameter for the billions of people who live on or near the coasts. Post-IPCC 2007 results[11] have raised the IPCC projected range to estimates of closer to a meter rise by 2100. Some coastal cities[12] are, in a sense, under a triple jeopardy with rising sea levels leading to coastal flooding which will be intense during the stronger typhoons. Hence, the need for disaster risk reduction strategies and plans, and the capacity to develop and implement them, will be even larger in the future.

INTERNATIONAL FRAMEWORK FOR RESPONDING TO CLIMATE CHANGE AND DISASTERS

By the late 1980s politicians were sufficiently aware of 'global warming' that they folded the issue into international environmental negotiations. In 1987, the World Commission on Environment and Development, through its report 'Our Common Future', brought forward the concept of sustainable development as an integrating approach toward society, the economy, and the environment, for present and future generations. Additionally, the 'Our Changing Atmosphere: Implications for Global Security' Conference held in Toronto in 1988 agreed to the statement 'Humanity is conducting an unintended, uncontrolled, globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war'.[13] Later that year, the Intergovernmental Panel on Climate Change was created with a mandate to assess the state of knowledge of climate change as a basis for policy responses.[14] The Second World Climate Conference in late 1990, responding to the first IPCC assessment, called for an international convention to address the threat of climate change.

The resulting United Nations Framework Convention on Climate Change (UNFCCC—the Climate Convention) was signed at the 1992 Earth Summit with its objective (Article 2) of '. . .stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner'.[d] The wording of this excerpt clearly links danger and economic development for the first time. Although the focus of the Climate Convention is on emission reductions, cooperation is a strong theme, linked to preparation for adaptation, research and observations, training, education, and public awareness. The Kyoto Protocol, which also focuses on emissions reductions, does include under its section on commitments (Article 10) the need for measures to facilitate adequate adaptation to climate change and under the Clean Development Mechanism (Article 12), it is proposed that a share of the proceeds be used to 'assist developing country Parties that are particularly vulnerable to the adverse effects of climate

change to meet the costs of adaptation'.[e] The 2001 Seventh Conference of the Parties (Marrakech) further developed the adaptation agenda. A Least Developed Countries (LDC) Fund was established to address: the low adaptive capacity of the least developed countries; preparation of National Adaptation Programmes of Action; and support institutional capacity building.

Climate change is now recognized as a risk that devastates both environmental systems and society.[10] Given the enormity of the problem, however, global differences threaten to provide a barrier too steep to surmount. As Hulme[15] discusses in his provocatively titled book 'Why We Disagree About Climate Change', cooperation is limited by varying: values; beliefs and fears of people; the challenges of development; and approaches to governance. In addition to this barrier, climate change is acting as a threat multiplier for international issues such as poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women, thus complicating existing development issues. In 2002, the World Summit on Sustainable Development adopted a Summit Plan of Implementation as part of the strategy to meet the Millennium Development Goals.[f] The report drew connections between international development and climate change. The report also connected international development and natural hazards: 'An integrated, multi-hazard, inclusive approach to address vulnerability, risk assessment and disaster management, including prevention, mitigation, preparedness, response and recovery, is an essential element of a safer world in the twenty-first century'.[g] The Summit called for actions to improve techniques and methodologies for assessing the effects of climate change and the development and strengthening of disaster management systems.

In order to address these problems, the United Nations International Strategy for Disaster Reduction (ISDR)[h] was created to follow and build upon the United Nations International Decade for Disaster Reduction (IDNDR). Additionally, the 2005 World Conference on Disaster Reduction led to the Hyogo Framework for Action[i] which called for actions to 'Strengthen the technical and scientific capacity…' and 'Strengthen disaster preparedness for effective response at all levels'. In 2007, the Chair's summary[j] of the UN ISDR Global Platform on Disaster Risk Reduction noted that 'a core challenge in disaster risk reduction is to scale up proven practices' making clear the importance of capacity building of all types.

Finally, the 2007 Bali Action Plan[k] continued the discussion, including a section on enhanced action on adaptation by linking disaster risk reduction and climate change adaptation: '(1) international cooperation to support urgent implementation of adaptation actions, (2) risk management and risk reduction strategies…, (3) disaster reduction strategies…, (4) economic diversification to build resilience'. The need for integrated approaches coping with environmental hazards in the context of climate change and international development was made clear. This convergence is starting to happen. The Intergovernmental Panel on Climate Change[l] is preparing a Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation which is expected to bring a scientific focus to bear on the linkages between the two issues.

CLIMATE HAZARDS, FOOD SECURITY, AND HUMAN HEALTH AND WELL-BEING

The Intergovernmental Panel on Climate Change has identified the impacts of climate change on human health and the evidence continues to mount[16–19] with suggestions that climate change represents the biggest potential threat to human health in this century[20] with the impacts mostly felt by lower socioeconomic groups. Climate change indirectly affects human heath through waterborne and insect-borne diseases and conditions linked to air quality such as asthma. Some national reports are linking the impacts with adaptive capacity.[21,22] Climate-sensitive vulnerability depends on a wide range of individual, community, and geographical factors with the poor likely to be more vulnerable.[23] One measure of the effects of climate change on human well-being is the impacts on migration and displacement. Unfortunately, the evidence shows that these numbers are mounting.[24] How many will be on the move in the future is uncertain but the scope and scale could vastly exceed anything that has occurred before. Climate change as a disaster will affect the least developed countries and island states first and the most.

VULNERABLE AREAS AND SOCIETIES WITH LOW ADAPTIVE CAPACITY

Although these hazardous events have clear impacts on all countries, their impacts on developing countries are larger.[25] The UN ISDR Global Assessment Report on Disaster Risk Reduction-2009[26] included in its key findings and recommendations:

- Global disaster risk is highly concentrated in poorer countries with weaker governance.

- Weather-related disaster risk is expanding rapidly both in terms of the territories affected, the losses reported, and the frequency of events.
- Climate change is already changing the geographic distribution, frequency, and intensity of weather-related hazards and threatens to undermine the resilience of poorer countries and their citizens to absorb and recover from disaster impacts.
- The governance arrangements for disaster risk reduction in many countries do not facilitate the integration of risk considerations in development.

With global populations increasing and communities more exposed, a changing climate leads to more people at risk. In particular, the steady growth of population has contributed to overcrowded urban areas, causing people to live, by choice or circumstance, in more hazardous zones; along coasts, riverbanks, and mountain slopes. This trend has put more people and communities at risk, particularly in geographically vulnerable locations such as low-lying or polar regions. Additionally, there has been growing inequality between poorer and wealthier sectors of society and the poorer sectors are more vulnerable. In urban regions (and particularly in very large cities), the complex infrastructure systems that make life and economic activity possible increase the vulnerability of populations to disruptions caused by natural hazards.[27] The density of buildings has been growing and most infrastructures are aging, leaving them more susceptible to damage under stress. Additionally, commercial activities have become more interdependent, relying to a much greater extent on the transportation of people and goods, and thus more vulnerable to a break in the supply lines or disruption of travel routes. Human interventions in the environment can also increase vulnerability to natural hazards. Examples include changes in land cover that increase risks of landslides, or flooding and destruction of mangroves that increases the susceptibility of coastal areas to storm and tsunami damage.[m] Globalization results in a world more closely interconnected, with changing senses of responsibility toward countries and regions. This effectively means that hazard repercussions can be felt at a greater distance.

REDUCING THE IMPACTS AND LOSSES

Disaster Risk Reduction

Historically, public policy in this area has been heavily concentrated on responding to the disasters after they have happened, reflecting a belief that disasters are 'acts of God' or 'acts of Nature'—unfortunate but random calamities beyond our control.[28] It is clear from disaster research, however, that these events result from the intersection of hazards and vulnerable communities. This leads to the formal definition of disasters as social phenomena which stem from interaction between two key elements: *hazards*—triggering agents stemming from nature, as well as from human activity, and *vulnerabilities*—susceptibility to injury or loss influenced by physical, social, economic, and cultural factors.[29–32] Thus, it is characteristic of a disaster to overwhelm the capacity of communities to respond and cause 'extensive loss or disruption to the physical, social and, administrative infrastructure' of a nation.[33]

The nomenclature and standardized approaches used to address hazards and disasters are built around the key themes of traditional disaster management: mitigation (lessening or limitation of adverse impacts), preparedness (capacities to effectively anticipate, respond to and recover from the impacts), response (services and public assistance during or immediately after a disaster), and recovery (restoration, and improvement where appropriate, of communities).[33–35] Although it has been recognized in several studies, that all four themes are necessary, most national disaster management plans focus funding on one or two. Too often, the emphasis has been on response and recovery efforts to the exclusion of mitigation or preparedness measures. There are a number of reasons for this trend. Primarily, governments are often more willing to put funding into response instead of prevention and preparedness because, although they must be seen to be responding to tragic events that have occurred, investments to prevent future events that may not occur are more politically risky. Further, developing countries are often limited to these strategies as although they are often able to garner aid for response efforts, funding for prevention measures is more difficult to obtain. In addition to being reactive, these strategies are further limited in their effectiveness due to existing policies. For example, post-hazard recovery regulations often stipulate that damaged areas must be restored to pre-disaster conditions without making investments to reduce the risk of future disasters.[30,36] There will, unfortunately, always be need for response and recovery but the focus on disaster management is and should be shifting toward the inclusion of mitigation and preparedness efforts.

On the other hand, despite investments in mitigation and preparedness, disasters continue to occur, causing far-reaching damage in many nations that claim preparedness. Moreover, it is often difficult for governments to convince the public that preparatory

measures are legitimate expenditures. This has led to the focus on disaster risk reduction which is defined as: 'the concept and practice of reducing disaster risk[n] through systematic efforts to analyze and manage the causal factors of disasters including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and environment, and improved preparedness for adverse events'.[37] Disaster risk reduction is based on knowledge of the prevailing hazards and the patterns of population and socioeconomic development.

Importantly, the concept of resilience has been introduced as a focus for disaster risk reduction strategies. Resilience is defined as 'the capacity of a system, community, or society potentially exposed to hazards to adapt, by resisting or changing in order to reach and maintain an acceptable level of functioning and structure',[37] and implies learning from past experiences to improve future protection and 'risk reduction measures'. Thus, although it emphasizes the response and recovery elements, resilience also entails preparatory (mitigation and prevention) actions. As current abilities to predict and prevent natural hazards are insufficient, building resilience is an integral part of any disaster management plan. The changing nature of hazards and disasters, the limitations of governmental protection, and the ability of resilience to protect against future breakdowns highlight the need to build capacity in this area. The definition of capacity used here is: 'The combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals'.[37] Thus, capacity development is the 'process by which people, organizations and society systematically stimulate and develop their capacities over time to achieve social and economic goals, including through improvement of knowledge, skills, systems, and institutions'.

Climate Change Adaptation

Adaptation, in the climate change community, is defined as 'the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities'.[37] The Canadian National Assessment defines adaptation slightly differently, however, asserting that it is: 'making adjustments in our decisions, activities and thinking because of observed or expected changes in climate, in order to moderate harm or take advantage of new opportunities'.[38] These definitions are very similar to that for disaster risk reduction, although limited to climate-related hazards. Adaptation measures can be classified into the following generic options or categories[39]:

1. Bear and/or share the losses. In many less developed societies, there may be no option other than to bear the loss and try to continue. Sharing the losses could come through family or community assistance at the local level. In more developed societies with additional resources, sharing the losses could be through public relief, rehabilitation, and reconstruction paid for from public funds. Insurance, either through public or private companies, is another way of sharing losses.
2. Modify the threat and/or prevent the effects. For some threats such as floods it is possible through flood control works (dams, dikes, levees) to modify the threat or prevent the effects. In agriculture measures such as changing crop, management practices can prevent the effects of a drought or rainy season, such as increased irrigation water, additional fertilizer use, and pest and disease control. For climate change, the major modification possibility is to slow the rate of climate change by mitigation.
3. Change use and/or location. Crop land could be used with different crops or the crop being threatened could be grown in a different location. Both measures assume that these are possible recognizing that economics, competitive uses, national politics, or international conflict may make these impossible.
4. Research/filling existing knowledge gaps. New focused research can provide new technologies and new methods of adaptation essential for dynamic adaptation strategies.
5. Encouraging behavioral change through education, information, and regulation. This strategy has been little recognized and has received low priority in the past. These approaches need to assume more importance with research into their optimum effectiveness as part of the approach.

Although adaptation can be spontaneous, it is important that adaptation become a conscious part of the decision-making process. Giddens,[40] for example, stresses the importance of what he calls pro-active adaptation as adaptation oriented to possible futures.

Linking Disaster Risk Reduction and Climate Change Adaptation

Reflecting the separation of the two communities of practice, the disaster management term mitigation

has a meaning quite different from that for climate change. Indeed, the practice of mitigating disasters is closely connected instead to climate change adaptation. Recently, the separation of these communities of practice has begun to break down, a necessary step in order to better address the issues of climate-related hazard. As Birkman et al. explain, there are challenges that emerge when linking disaster risk reduction and climate change adaptation. One issue is the mismatch of scales—temporal, spatial, and functional. Although disaster risk reduction, particularly the response and recovery aspects, is usually related to events of short-term duration, the climate change community is mostly focused on longer term perspectives.[41] A shared challenge is the fact that investment and resulting benefits are usually far beyond any political electoral cycle. With one occurring at a mainly local or regional level and the other operating on the global scene, the organizations that oversee disaster management and those that contribute to climate change adaptation are very different. The lack of coordination between agencies and ministries is a factor that often leads to mismatches in addressing the problem with appropriate solutions.[41]

LIMITATIONS IN GOVERNMENTAL RESPONSE

Building capacity for disaster risk reduction and resilience within a nation is important because in the face of a disaster, governments are often limited in the steps they can take beforehand to prevent and prepare, as well as afterward to respond and assist recovery. This is an important consideration as governments are often assumed to bear full responsibility for the disaster and individual safety.[42] Due to the changing nature of natural hazards, however, there is 'a growing understanding that authorities cannot prevent all disasters from occurring, or alternatively, shield people from all their consequences'.[43] Thus, as Adger and Tompkins assert, 'resilience in the face of climate change requires adjustment by governments, by individuals acting as citizens and through market exchange, and by civil society through collective action'.[44]

The government is still responsible for a number of tasks, including the provision of disaster education, information, and warning; the development of standardized methods for communities: building codes, emergency management plans, etc; and finally, to identify vulnerable parts of society including groups and infrastructure and produce plans that address their special needs.º Thus far it has been difficult to achieve these goals due to political and funding issues. Specifically, the ability to predict hazards is limited,[45,46] thus restricting the governments ability to prepare and identify vulnerable areas.[35] Further, the uncertainty on the need for investment is deepened by the fact that any benefits associated with mitigation (which are only realized in the event of a disaster) must be weighed against immediate and potentially significant costs.[30,34] Unless located in an area where disasters occur frequently, there is generally a low demand for investment in mitigation or disaster risk reduction.[47–50] There are opportunities immediately following a disaster[51] but the post-disaster policy window is transitory.[52]

The primary goal of any politician is re-election. In the process of ensuring political success, however, preventative and preparatory measures are often under-emphasized due to the fact that they are not politically popular. Although those living in areas at risk are very willing to invest in these types of mitigation techniques, even demanding action in many cases, others in so-called 'safe zones' are reluctant. This is an important consideration for governments because, changing natural hazard characteristics and patterns indicate that science may be unable to accurately identify at-risk areas. It is essential then, that precautionary action is taken in all regions regardless of their perceived risk. In addition, governments in developing nations are limited by their own lack of funds and the nature of international aid. In their own budgets, allocating funds to preventative measures will necessarily entail cuts in other vital areas. Knowing that international aid will flow in the aftermath of a disaster, but that none is offered for the prevention or preparatory actions, many developing governments must choose to gamble that if disaster strikes, they will be assisted. In this scenario, social resilience and adaptation at a local level is often a key element in ensuring individual safety.[53]

As hazards usually occur locally and many of the most effective tools to reduce vulnerability to hazards, such as land use regulation and building code enforcement are at the local level, local governments are perhaps best-positioned to implement disaster risk reduction[54,55] but they are also the least likely to see it as a priority for the reasons above.[49,50] This makes intergovernmental collaboration essential for the development and implementation of disaster risk reduction policies[56] although it is difficult to organize and sustain.[57] Moreover, because insurers and senior governments shoulder most of the financial costs of recovery, local governments appear to have weak economic incentives to invest in loss reduction measures.

Building resilience, especially in response to governmental limitations, as explored above, is the only real way to ensure that natural hazards do not

turn into disasters. As the government is limited in their participation in these procedures, social resilience takes on a greater importance. In order to achieve this type of adaptation and prevention, education on the threats and potential strategies needed to address them are required.[58] Additionally, preparedness must be achieved on both the individual (emergency plan, food in storage, and potential household dangers addressed-windows boarded, high furniture affixed)[42] and community (safe zones, warning systems, pre-arranged collaborative actions) levels. These types of actions not only represent efforts to prepare for disasters but also to rebound after their occurrence. Although preventative measures are still very difficult to implement due to their incident-specific nature, preparedness refers to measures that would ensure safety or quick recovery from any disaster. Additionally, social resilience can be built in any community regardless of their economic status. This is clearly demonstrated by the innovative ways in which developing nations have gone about building this capacity. In Bangladesh, community-based organizations are used to identify vulnerabilities and produce strategies.[59] These efforts among others have contributed to a significant reduction in mortalities relating to typhoons and flooding.[p] Similarly, in India social networks have been very productive. They have created a disaster risk reduction mission that teaches masonry techniques that have proven successful at preventing damage from earthquakes. Additionally, disaster micro-insurance for low-income groups has been very successful.[59] These examples demonstrate how social networks are creating resiliency and interdependence as a means of protecting themselves. Although these characteristics of social resilience are not as prevalent in developed nations, it is important that effort is put into building capacity in these regions. Society's ability to use their internal resources and competencies to respond to demands, as well as their learned resourcefulness [Ref 32, p. 47], will work in tandem with the emergency services, to ensure that there is a measure of social preparedness and an adequate ability to respond and recover.

In addition to allowing quicker recovery and minimizing loss, creating this type of resilience prevents against greater damage caused by further breakdowns of different systems or additional hazards. This is especially important given that a break down in a city or region will cause faltering decision making and slow responses, making communities more vulnerable to disasters [Ref 32, p. 4]. Finally, and most importantly, the importance of creating resilience in a nation lies in the sustainable protection it can offer to the population. Resilience is not a one-time state of being but rather a process that involves continuous maintenance and thus, provides continual protection. In the next few paragraphs, resilience is examined as a means of reducing the negative impacts of a hazard or disaster.

The concept of resilience works with the notion that natural hazards are going to occur. Although it accepts that there may be nothing that can be done to prevent the event, it aims to reduce the incurred damage and thus, the chances of deterioration into a disaster. It does this in a number of ways. First, by focusing on preparation for such events and fostering the ability to adapt to new circumstances, resilience ensures that the breakdown of one system (for example, power distribution) does not necessarily have to result in the crash of all systems (for example, communication and transportation infrastructure, security). Secondly, by encouraging and maintaining this type of behavioral change, resourcefulness and cooperation, resilience cultivates a long-standing ability to respond to hazards effectively.

Focusing on the first function, it is possible to observe the basis of this correlation if the four properties of resilience are examined. These components, robustness (or strength to withstand), rapidity (speed of recovery), redundancy (having other suitable means of achieving a goal), and resourcefulness (ability to involve community and draw upon internal resources to achieve goals) represent the necessary components of a resilient city.[60] They can be split up into two groups of preparatory and adaptive measures. Robustness and rapidity deal primarily with preparing a community to withstand challenges specifically focusing on the development of stronger infrastructure and programs/plans designed to make any response quicker and more efficient. In contrast, redundancy and resourcefulness are of particular significance in the context of adaptation. Specifically, they address the interconnectedness of the infrastructural, technological, social and economic systems and the idea that a malfunction or 'hit' in one of these areas could bring down all the others as they struggle to cope. For example, if the communication system of a city was taken out during a hurricane, warnings would be very difficult to deliver thus putting the infrastructural system at risk and making it hard for the social network to respond in any effective manner. The concept of redundancy then, is used to ensure that there are multiple means of providing warning or coordinating. By achieving this 'backup plan' as it were, for all major systems, governments can ensure that a hazard will not completely debilitate a region. When combined with built-in social and economic resilience at a more individual or local level, this type of preparedness can

reduce casualties; ensure speedy recovery and limit economic damage.

Similarly, resourcefulness is an important part of resilience as it demands that internal resources are used to repair, reorganize, or respond to any challenges that might arise as a complication of the hazard event. Not only does this reduce the time taken to get essential services back up and running, but, building capacity in this area helps to ensure a very flexible response and recovery initiative, designed to deal with issues as they arise. This is especially important because, as Godschalk explains, 'people and property fare better in resilient cities struck by disaster than in less flexible and adaptive places with uncommon stress'.[34] If this is achieved, total system crash becomes far less likely due to the fact that procedures, technology, or networks can be altered or adapted to the new situation. As Maguire and Hagan explain, this type of creativity does not just entail returning to the initial equilibrium point, but 'rather by adapting to new circumstances and learning from the disaster experience, higher levels of functioning can be attained'.[43] Thus, examining redundancy and resourcefulness allows a better understanding of how they contribute to a community's ability to rebound and regain normal function, as well as the ways in which they can help to reduce negative impacts associated with natural hazards.

BUILDING THE GLOBAL CAPACITY FOR KNOWLEDGE-BASED DISASTER RISK REDUCTION

Of particular concern is the fact that capacity building for disasters has not been implemented in all nations. There are many barriers that account for this trend. First, as the Global Assessment Report on Disaster Reduction-2009 asserts, disaster risk is 'highly concentrated in poorer countries with weaker governance'.[26] Other barriers in the design and implementation of strategies for capacity development include how priorities should be set, what role each level of government should play, how strategies should be coordinated, and how outcomes should be evaluated. Finally, the substantial amount of uncertainty surrounding hazards, vulnerability and the prediction of future events, proves to be a significant barrier to global capacity building.[39,45,46,61] Risk analysis can lead to the optimum decisions but the setting of priorities is still difficult as there are political and social problems with divergent interpretations of what the problems and response options really are.

The impacts of a changing climate or disaster events are largely determined by a society's or community's vulnerability; a function of its exposure to climate and other hazards, its sensitivity to the stresses they impose, and its capacity to adapt to these stresses.[62] Vulnerability can be reduced through actions to minimize exposure, reduce the sensitivity of people and systems, and strengthen the community's adaptive capacity. Each of these actions requires an integrated approach and their implementation will necessitate surmounting barriers and constraints. For example, there are four factors important for building adaptive capacity; these are

- access to information,
- expertise with information, analyses, and translation information into policy,
- fiscal capacity, and
- political will to act,

which cover a range of issues and organizations. Designing policies for adaptation to climate change, disaster risk reduction and sustainable development all require: assessments of the effectiveness, costs and feasibility of measures to reduce vulnerability; stakeholder analyses to identify targets and beneficiaries of interventions; analyses of the consequences of inaction; and other factors. One difficulty with regard to the fiscal capacity is that at least some level of public expenditure will be needed and that will be limited by competing demands on scarce economic resources. In the end, a critical issue will be generation of the political will to act which will most likely come with more general recognition that adaptation and disaster risk reduction are necessary and possible and that they are not only desirable but also necessary toward sustaining development. Intergovernmental collaboration is considered to be vital in order to ensure capacity is built on a global level, but this is difficult due to the lack of common interests.

Recognizing the impacts of hazards on society, the International Council for Science (ICSU) established a planning group to develop an international scientific framework for an integrated global research program.[63] Now, with the co-sponsorship of ICSU, the International Social Sciences Council,[q] and the United Nations International Strategy for Disaster Reduction (ISDR), a new international research initiative—Integrated Research on Disaster Risk (IRDR)—has been created and is now underway with a mandate to address the challenge of natural- and human-induced environmental hazards.[64] Focusing on disaster risk reduction, the research will be aimed at integrated risk analysis, including consideration of relevant human behavior and decision-making processes in the face of risk. The IRDR is guided by three-broad

research objectives. (1) Characterization of hazards, vulnerability, and risk; with sub-objectives: identifying hazards and vulnerabilities leading to risks; forecasting hazards and assessing risks; and dynamic modeling of risk. (2) Understanding decision making in complex and changing risk contexts with sub-objectives—identifying relevant decision-making systems and their interactions; understanding decision making in the context of environmental hazards; and improving the quality of decision-making practice. (3) Reducing risk and curbing losses through knowledge-based actions [Ref 63, p. 6]. The IRDR research program fulfills the need for an international, multidisciplinary and an all hazard research program emphasized in the Hyogo Framework for Action. The added value of such a research program lies in its coupling of natural sciences' examination of hazards with socioeconomic analysis of vulnerability and mechanisms for engaging the policy decision-making process. The IRDR will draw upon the expertise and scientific outputs of many partners in research with the Earth System Science Partnership.[r] Specifically, it is hoped that IRDR will be able to catalogue and analyze successful capacity building systems and strategies for resilient communities in order to benefit those threatened by climate-related hazards.

An important cross-cutting theme of the IRDR Program is the capacity building efforts which will be done in collaboration with the Global Change System for Analysis Research and Training [START][s] project. START has identified Asia's coastal megacities and the risk of climate change[t] as a focus. Disaster risk management which is defined by UN ISDR as: 'the systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster'[37] requires capacities at all levels: institutions, decision-makers, professionals, and practitioners at national and local levels and it also involves multidisciplinary, inter-institutional, and multi-sectoral perspectives. The IRDR capacity building component has three objectives: to map capacity for disaster reduction; build self-sustaining capacity at various levels for different hazards; and establish continuity in capacity building. One issue is the development of metrics to ascertain what is adequate capacity as that will depend on the hazards, vulnerabilities, and resilience in a region and to document when improvements are made. A case study approach will help determine the most appropriate intervention strategies to enhance disaster risk reduction capacity. Mechanisms are needed for mainstreaming disaster reduction into development programmes. The legacy of IRDR will be an enhanced capacity around the world to address hazards and make informed decisions on actions to reduce their impacts.

NEW INTERNATIONAL DEVELOPMENTS AND GUIDANCE

The concluding part of the quote from Wahlström cited earlier was 'The real tragedy is that many of these deaths can be avoided'.[6] The risks from climate hazards present a growing threat to developing countries that lack the financial capacity or material resources to prevent disasters or mitigate their risks.[65] One of the essential steps toward avoiding these deaths is capacity building and driving international and national actions on capacity building for disaster risk reduction. Major international meetings have called for taking these actions. The Chair's summary of the 2009 Second Session of the ISDR Global Platform linked disaster risk reduction, climate change adaptation and development, and highlighted the following areas as critical for future progress: 'Financing DRR: Proposals included a variety of innovations, such as incentives for retrofitting, risk transfer tools, risk-sensitive development, private sector involvement, debt swap to finance disaster reduction measures and linkages with adaptation financing'.[u]

Stockholm Plan of Action for Integrating Disaster Risks and Climate Change Impacts in Poverty Reduction listed among its priority actions: 'Capacity building is required at local, national, regional and global level again with a focus on Global Facility priority countries that are particularly prone to natural hazards'.[66] The leaders of the Major Economies Forum on Energy and Climate (2009)[v] agreed that there is need to assist the poorest and most vulnerable. The Organization for Economic Cooperation and Development (OECD) has developed guidelines for integrating climate change adaptation into development cooperation. One of the objectives of this policy guidance is: 'identify practical ways for donors to support developing country partners in their efforts to reduce their vulnerability to climate variability and climate change'.[w]

World Development Report 2010[x] notes that developing countries will bear the brunt of the effects of climate change which threatens to deepen vulnerabilities, erode hard-won gains, and seriously undermine prospects for development. The report also raises the risk that actions to limit greenhouse gas emissions may adversely affect them as well. The report's main messages, noting that increasing climate risks will exceed communities' capacity to adapt, call for

national and international support to protect the most vulnerable through social assistance programs and the need to develop international risk-sharing arrangements and promotion of the exchange of knowledge, technology, and information. The Report comments on the need to also overcome behavioral and institutional inertia, implying the need for institutional capacity building.

In the years to come it will be evident whether or not these statements are actually converted into actions and investments are made in capacity building for reducing impacts of climate hazards.

CONCLUSION

Climate hazards generate the largest portion of disasters around the world and these affect the less developed countries and poorest people most. There are major impacts on development and the possibility that they could make development unsustainable. It is therefore necessary to develop the capacity of all countries to combat hazards so they do not become disasters. This is primarily to be done by building resilience in national systems infrastructure, and social networks. Achieving this goal would mean that nations are better able to absorb the shock and destruction delivered by any natural hazard, ensuring that disaster status is not reached.

There is an international framework connecting climate change and development and recent international statements and reports from the Major Economies Forum on Energy and Climate, the OECD, World Bank and others that provide further mandates for action.

The development of capacity for knowledge-based reduction of hazards and disasters risk, built on linking of climate change adaptation and disaster risk reduction is an important step because it ensures greater preparation is possible as climate change threats are taken into account. Finally, it is important that the limitations of governments are recognized and the response subsequently adjusted for such restrictions, making greater use of the population and internal resources.

NOTES

[a]MunichRe Topics Geo 2008. http://www.munichre.com.

[b]Press Release. MunichRe Group. 2007. http: www.munichre.com.

[c]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).

[d]UNFCCC. http://unfccc.int/essential_background/convention/background/items/1353.php.

[e]UNFCCC. *The Kyoto Protocol*. http://unfccc.int/kyoto_protocol/items/2830.php.

[f]Millenium Development Goals—The Millennium Development Goals (MDG) do provide one comprehensive and multi-dimensional development framework and set clear quantifiable targets to be achieved in all countries by 2015 Report of the World Summit for Sustainable Development, Johannesburg, South Africa, 26 August–4 September 2002 (A/CONF.199/20*, www.un.org).

[g]Summit Report, 2002.

[h]United Nations International Strategy for Disaster Reduction (UN/ISDR) (www.unisdr.org).

[i]Hyogo Framework for Action (HFA) [Online]. Available: http://www.unisdr.org/wcdr/intergover/official-doc/L-docs/Hyogo-framework-for-action-english.pdf.

[j]UNISDR Global Platform, 2007 Holmes, John. 'Chair's Summary', *Global Platform for Disaster Risk Reduction* (Geneva, ISDR, 2007). Pg 4 [Online]. Available at http://www.unsidr.org.

[k]13th Conference of the Parties of the UN FCCC (December 2007) held in Bali. UNFCCC website for the documents and reports—www.unfccc.int. See the Earth Negotiations Bulletin for reports on sessions and analysis.

[l]See the Intergovernmental Panel on Climate Change (IPCC); at: <www.ipcc.ch>.

[m]The importance of mangroves was observed in the case of Indonesia during the Indian ocean tsunami. *Cities at Risk*. www.start.org/programs/cities-at-risk.

[n]Disaster risk is 'the potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future time period'.

[o]Applegate David. 'Challenges to Building a Disaster Resilient Nation'. *Science News*. www.sciencenews.org 2008.

[p]Adger N, Hughes T, Folke C, Carpenter S, Rockstrom J. 'Social-ecological resilience to coastal disasters'. *Science* 2005, 309. Found at www.sciencemag.org.

[q]ISSC; URL: http://www.unesco.org/ngo/issc.

[r]ESSP; URL: http://www.essp.org.

[s]START. http:/www.start.org.

[t]START: Cities at Risk: Developing Adaptive Capacity for Climate Change in Asia's Coastal Megacities. 2009. http://www.start.org.

[u]IISD [International Institute for Sustainable Development], 2009: 'A Summary Report of the Second Session of the Global Platform for Disaster Risk Reduction', in: Earth Negotiations Bulletin; 141, 2 (22 June): at: http://www.preventionweb.net/globalplatform/2009/announcements/v.php?id=10427.
[v]MEF—Major Economies Forum on Energy and Climate (2009). http://www.g7.utoronto.ca/summit/2009laquila/2009-mef.html. Accessed July 2009.
[w]Integrating Climate Change Adaptation into Development Co-operation POLICY GUIDANCE, ISBN-978-92-64-05476-9 © OECD 2009 www.oecd.org/publishing.
[x]World Development Report 2010© 2010 The International Bank for Reconstruction and Development/The World Bank, www.worldbank.org.

ACKNOWLEDGEMENTS

The authors acknowledge the Canadian Social Sciences and Humanities Research Council for their support of this research through a Knowledge Synthesis Grant on Climate Security.

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