Rethinking disaster risk management

Don Gunasekera
CSIRO Marine and Atmospheric Research
Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Canberra, Australia

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Major natural disasters caused at least US$ 40 billion in economic damages in 2009 adversely affecting many countries. Increasingly there are concerns about other types of potential disasters associated with pandemics, spread of emerging infectious diseases and the threat of biological agents.

The focus of this background paper is on minimising disaster-related vulnerabilities through risk management activities, early warning initiatives and enhancing the role of governments and international relief and monitoring agencies. Reducing disaster-related vulnerabilities could help address the adverse development dimensions of disasters in developing economies.

Risk management instruments such as index insurance schemes are emerging as useful tools, despite the difficulties associated with insurance affordability in developing economies. There is a growing need to increase the efforts between individual governments and international agencies to refocus disaster assistance to support risk management initiatives that leverage disaster-aid with public and private contributions and that promote reduction of losses.

Introduction

The focus of national governments, the international community and emergency management agencies in developing options to respond to actual and potential consequences of natural hazards and environmental change is increasingly being influenced by climate change, adaptation and disaster risk management approaches (Birkmann *et al* 2008).

Disasters are ‘situations or events which overwhelm local capacity, necessitating a request to a national or international level for external assistance; an unforseen and often sudden events that cause damage, destruction and human suffering’ (CRED 2010). Similarly, a disaster can be defined as ‘a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources’ (UNISDR 2004a).

According to the CRED (2010), 335 natural disasters (excluding biological disasters) were reported globally in 2009. Nearly 11 000 persons were killed and 119 million others were affected by these disasters. The economic damages associated with these natural disasters were estimated to be just over US$ 40 billion. Hydrological disasters (e.g. floods) (54%) remained the most common disasters in 2009, followed by meteorological disasters (e.g. storms) (25%). The impact of climatological disasters (e.g. extreme temperature, drought, wildfires) remained relatively small in 2009 compared to previous years. In 2009, geophysical disasters (e.g. earthquake, volcano eruptions) accounted for less than 3% of reported natural disaster victims globally. The threat of biological disasters (e.g. epidemics, pandemics, insect infestations) continues to be a potential risk in many parts of the world.

In 2009, a total of 111 economies were directly affected by natural disasters globally. Out of these, eighteen economies represented 79%, 95%, and 87% of the total 2009 reported number of deaths, victims and economic damages respectively. Eight out of these eighteen economies are located in the Asian region. They represent 60%, 87% and 34% of the global reported number of deaths, victims and economic damages from natural disasters respectively. For example, Indonesia, India, China, Chinese Taipei and the Philippines accounted for 80% of economic damages in the Asian region and 28% of global economic damages due to natural disasters in 2009. Of all continents, Asia was most prone to geophysical (56%), meteorological (49%) and hydrological (40%) disasters in 2009 (CRED 2010).

In 2005, 1.2 billion people (23% of global population) lived within 100km of the coast. In 2030, 50% of the global population is estimated to do so. In 2005, 10 million people experienced coastal flooding annually due to storm surges and landfall typhoons. 50 million people are estimated to be at such risk by 2080 due to climate change and increasing population densities. These populations are potentially exposed to specific hazards such as coastal flooding, tsunamis and hurricanes. Two thirds of the coastal disasters recorded each year are associated with extreme weather events such as storms and floods that are likely to become more pervasive threats due to shifts in climate and sea level rise (Adger *et al* 2005).

It is important to recognise that although the cost of natural disasters in terms of economic damage and lives at risk are expected to increase through time, the observed increases are also caused by changing social vulnerabilities as much as by changing physical hazards (Adger *et al* 2005). There is a growing need to address the underlying factors and preconditions that make human populations vulnerable to disasters in order to mitigate the potential adverse impacts and create resilient and sustainable communities (CRED 2010).

The purpose of this paper is to discuss disaster risk management measures that could help minimise disaster-related vulnerabilities.

Disaster risk management

There are many risk management measures available to address natural disasters. In the following discussion, we highlight the usefulness of three broad groups of measures including adaptive measures, risk transfer approaches and the applicability of new approaches and technologies. The growing concern about biological hazards is also raised.

Adaptive measures

Synergies exist between climate change adaptation and disaster risk reduction

There is a growing recognition of the need to consider the effects of climate change along with underlying factors that contribute to natural disasters. Climate change is projected to exacerbate environmental degradation and increase disaster risks as storms, floods and droughts become more frequent and more intense. Long term environmental degradation often results in the loss of biodiversity and environmental and ecosystem services making communities more vulnerable to environmental hazards and weakening their resilience. Given that, a possible disaster risk management option is to incorporate disaster risk reduction into climate change adaptation planning (UNEP 2010).

According to UNEP (2010), synergies exist between disaster risk reduction and adaptation to climate change. For example, drought tolerant crop varieties can reduce farmers' vulnerability to disasters such as persistent droughts. Disaster reduction measures such as improvements to water storage infrastructure are being used to help communities adapt to gradual climate change in developing economies where people are threatened by both floods and droughts as glaciers melt (UNEP 2010).

By 2050, global population is projected to increase to around 9 billion people with most of the increase occurring in developing economies. In the face of a growing population in many developing economies, the environmental stresses of climate change and its potential effects on future natural disasters and income inequality is likely to worsen in many regions. There are few indications that least developed economies are ready to take advantage of the synergies that exist between disaster risk reduction and adaptation to climate change. National Adaptation Programmes of

Action (under the UNFCCC), which least developed economies have prepared to identify priority actions to adapt to climate change, seldom address disaster planning explicitly, and rarely consider equity as a desired outcome of adaptation. This highlights the need for policy innovations to foster the synergistic linkages between disaster risk management and climate change adaptation measures (Mutter 2010).

Reforms to natural resource management governance can reduce disaster risks

Natural resource systems such as floodplains, forests, mangroves and coral reefs can reduce the adverse impacts of natural hazards. Although natural resource systems cannot provide total protection, they can play an important role in reducing the adverse socio-economic impacts of hydro-meteorological hazards. There is an increasing recognition of the links between declining environmental quality and the increasing vulnerability of communities to hazards, and hence the importance of effective and improved natural resource management to reduce potential disaster related risks. However, often these links are not being made explicit in natural resources management planning. Hence, reforms to existing governance arrangements in this area are needed to improve sustainable natural resource management so that such efforts could help reduce disaster risks (UNDP 2010).

It is noteworthy that natural resource management related reforms identified in Indonesia after the 2004 Indian Ocean tsunami involve the establishment of mangrove plantations in light of the heightened awareness of the value of environmental systems and services (Birkmann *et al* 2008).

Adaptive responses are needed to cope with key natural disasters

As indicated earlier, coastal regions are likely to be adversely affected by a range of potential natural disasters in the coming decades due to climate change and other environmental regime shifts. Hence, there is an increasing need for adaptive responses to cope with the disaster related pressures expected in coastal regions. Developing adaptive responses in coastal regions require a better understanding of the linkages between ecosystems and human societies. Adaptive responses will need to focus on reducing the vulnerabilities and enhancing the resilience of the linked systems in coastal regions. Enhancing the resilience involves improving the capacity of linked socio-ecological systems to absorb recurrent disturbances such as hurricanes or floods in order to retain essential structures, processes and feedbacks. Improving the capacity particularly in vulnerable developing economies will involve developing and maintaining effective institutions, governance and management frameworks and early warning systems to confine the potential disaster related impacts to manageable proportions. Furthermore, improved communications and awareness can help strengthen resilience to disasters when they occur and improve responses (Adger *et al* 2005).

One of the key lessons from the 2004 Asian tsunami is that resilient socio-ecological systems reduced vulnerability to the impacts of the tsunami and encouraged a rapid and positive response. However, where ecosystems have been undermined, the ability to adapt and regenerate has been severely eroded. For instance, through-out the coastal regions in Asia, deforestation of mangroves for intensive shrimp farming has reduced the livelihood options available to local communities. In many locations, environmental degradation such as land clearing, coastal erosion, overfishing and coral mining has reduced the potential for economic recovery from the tsunami. The challenge for social-ecological systems in vulnerable economies is to enhance the adaptive capacity to deal with disturbances and to build preparedness for living with change and uncertainty (Adger *et al* 2005).

Risk transfer approaches

Financial risk management tools could help reduce vulnerability to disasters

Droughts, floods and other climate related hazards adversely affect the livelihoods of farmers, rural communities and other vulnerable groups in many regions, and especially those in developing economies. The adverse effects manifest in several forms including fall in agricultural output, decline in rural incomes and reduced access to rural credit that farmers need to purchase improved seeds and other farm inputs such as fertilisers and agrochemicals.

Financial risk management tools such as index-based insurance schemes (which are typically based on rainfall, temperature, humidity or average crop yields) and other risk transfer instruments can be used to safeguard farmers from crop and income losses in the face of higher frequency of slower onset disasters such as droughts (Hellmuth *et al* 2009). Under the index-based insurance arrangements, farmers may be able to purchase an index-based weather derivative. This is a contingent contract with a payoff determined by future weather events such as a specified lack of precipitation measured at a weather station. Because of this physical and uncontrollable trigger, farmers have an incentive to reduce potential losses through for instances by diversifying their crops (Linnerooth-Bayer *et al* 2005 and UNDP 2010). The index-based insurance schemes are still at a subsidised pilot stage in several developing economies, and they are supported by key international donor agencies. If they can be up-scaled sufficiently, they hold considerable promise for the more than 40% of farmers in developing economies that face threats to their livelihoods from adverse weather related disasters (Linnerooth-Bayer *et al* 2005).

It may be argued that subsidising insurance programs in developing economies will distort prices and create the wrong signals for avoiding risk exposure. However, this argument is hardly relevant for poorer communities, which have few affordable options for relocating or otherwise reducing their exposure to disaster risk. Hence, in the absence of options such as subsidised insurance instruments, these communities will continue to rely on international aid. However, the argument against subsidised insurance programs emphasises the importance of explicitly tying pre-disaster support to affordable loss prevention and phasing out the subsidies as recipient economies develop (Linnerooth-Bayer *et al* 2005).

It is important to recognise that risk sharing and risk transfer tools can reduce the risk of disasters under certain conditions, and that such measures are only a part of the solution to reduce vulnerability to disasters. Those tools are most effective when used along with other relevant disaster risk reduction measures (UNDP 2010).

Donor-supported risk-transfer programs can help to cope with disasters

There is less recognition of the need to support risk-pooling and risk-transfer programs that ensure readily available post-disaster funds for relief and reconstruction in developing economies, in general. Governments, households and businesses in many developing economies cannot easily afford commercial insurance to cover their disaster risks. Only 1% of households and businesses in low-income economies and only 3% in middle-income economies have catastrophic insurance coverage, compared with 30% in high-income economies (Linnerooth-Bayer *et al* 2005).

In the face of the increasing number and intensity of natural disasters, the 'business as usual' approach to donor assistance is unlikely to help meet the post-disaster needs of many developing economies. Hence, Linnerooth-Bayer *et al* (2005) argue that the donor community should consider refocusing disaster assistance to support risk management programs that leverage disaster-aid with public and private contributions and which promote loss mitigation (UNISDR 2005).

Linnerooth-Bayer *et al* (2005) argue that the donor community could help make index-based insurance schemes discussed earlier, viable in two ways: first by subsidising index-based insurance premiums used in developing economies; and second by providing back up capital to reduce the risk to private or public insurance providers. The implementation of these public-private risk transfer programs is feasible mainly due to the advances in computerised modelling that make it possible to better estimate and price low-probability extreme event risks for which there are limited historical data. Catastrophic models typically generate probabilistic losses by simulating stochastic events based on the geophysical characteristics of the hazard and combining the hazard data with analyses of exposure in terms of values at risk and vulnerability of assets (Linnerooth-Bayer *et al* 2005).

It is important to recognise that the idea of refocusing disaster assistance is not to replace it with unaffordable private insurance but rather to complement post-disaster humanitarian aid with pre-disaster support of risk management programs that link prevention and risk transfer. There are many challenges for implementing donor-supported disaster risk-transfer programs on a large scale and ensuring that they genuinely provide affordable security to the poor. One of the key challenges is to promote good governance and sound regulatory practices as prerequisites for any risk-transfer program (Linnerooth-Bayer *et al* 2005).

New approaches and technologies

Use of new technologies can help improve early warning systems

Early warning systems have been used increasingly to provide advance warnings on impending natural disasters in many parts of the world. UNEP (2010) highlights the potential usefulness of GIS (geographic information systems) technologies in analysing a range of data and information from climate models to develop future disaster risks. Such analysis can be used to inform the design of key infrastructure or help insurers assign a price to low-probability risks associated with high loss potential.

There is a growing need to make early warning systems more user-friendly. Disaster preparedness and planning need to consider the requirements of the target audience, so that warnings provided by satellites, computer models and other technologies are received by the relevant and appropriate communities and then acted upon (UNEP 2010).

Greater attention is needed on post-disaster measures and opportunities

Post disaster changes can come in the form of formal and informal responses. Formal responses may manifest in the form of new legislation, organisational reform or policy innovation. For example, the establishment of a National Plan for Disaster Management, introduction of New Disaster Management Law (UU 24/2007), setting up of early warning systems and integrating disaster risk reduction into reconstruction strategies (e.g. spatial planning, evacuation plans, buffer zones) are some of the formal responses observed in Indonesia during the aftermath of the 2004 Indian Ocean tsunami (Birkmann *et al* 2008).

Birkmann *et al* (2008) argue that future global environmental changes may not be able to be managed with the current structures and organisation in many developing economies. For example, slow onset processes such as sea level rise, coastal erosion or salt water intrusion will require new approaches for identifying and assessing risks and dealing with them. The development of methodologies for assessing change after disasters seems to be a valuable objective for fostering a more systematic approach for tracking lessons learnt and understanding societal responses to environmental risks.

Reliable and transparent data relating to disasters are vital for risk analysis

There are many challenges for implementing risk-transfer programs on a large scale and ensuring that they effectively provide affordable security to the most vulnerable. For instance, the science underpinning the risk estimates associated with disasters must be independent, transparent and viewed as reliable by insurers, investors and donors. In spite of the advances in data collection and verifications with satellite technology, changes in climate, urbanisation, and land use practices create large uncertainties in estimating risks. These uncertainties add to the reluctance of the private sector to invest in risk-transfer instruments (Linnerooth-Bayer *et al* 2005).

The effectiveness of reliable estimation of disaster risks is underpinned by the treatment of the required basic inputs such as climate information as a public good. This implies free and unrestricted exchange of such information to everyone. For example, climate information embodies two important features of a public good. First, climate information is said to be non-rivalrous: once generated, the marginal cost of reproducing and supplying climate information to another user is very low; and the use of climate information by one user does not infringe on its usage by others. The cost of disseminating climate information will continue to fall in the current digital age. Second, climate information is non-excludable. This means, it is difficult and potentially very expensive to exclude users from benefiting from the climate service.

Given the unprecedented challenge of climate change driven pressures including natural disasters, the success of reliable and transparent disaster risk estimation is predicated on significant public and private sector commitments on basic research and innovation-driven solutions for the public good.

Interdisciplinary scenario analysis can help respond to disaster related crises

During major disasters, response time is critical, conditions change rapidly, quantitative models and/or their requisite data may be unavailable, and many factors are unknown. In such circumstances, scenario building provides a useful framework for developing responses. The framework for a disaster scenario analysis may include several elements and phases including for example, stress to the natural-human environment, time horizons of the disaster, major management response phases (emergency, restoration and reconstruction) and any potential gaps in response capacity. Disaster scenario analysis has several advantages. These include: the capacity to systematically examine possible futures and cascading consequences that may be complex and uncertain; and the ability to indentify alternative futures rather than predict new-state conditions (Machlis and McNutt 2010).

Machlis and McNutt (2010) have used the example of a scenario building exercise undertaken during the recent oil spill in the Gulf of Mexico to highlight the potential applicability of interdisciplinary science-based scenarios to help respond to similar environmental crises or disasters. Disaster scenarios could be developed by using/adapting the already available information and literature from coupled natural-human systems to identify key variables of interest. They may not be limited to discrete physical, chemical, and/or socio-cultural consequences but the focus may be on these various aspects interacting with each other in shaping possible trajectories of the overall system affected by a disaster. The scenario framework may incorporate the extent of the stresses on the disaster affected natural-human system spread over key time horizons through recovery. For example, baseline stress in the Gulf of Mexico was treated as increasing before the oil spill due to nutrient loading, wetland loss, climate change, fishing pressures, effects of past hurricanes etc. At the time of the oil spill and explosion systems stress began to rapidly accumulate. Long term recovery involves some reorganisation of the system rather than full return to pre-existing states (Machlis and McNutt 2010).

Disaster scenario analysis can provide decision makers with possible intervention points such as those which are likely to reduce negative impacts and/or increase resilience and positive recovery responses (e.g. improved monitoring or targeted income support for those affected by a disaster). The Gulf of Mexico oil spill scenario analysis revealed potential surprises that might be initially overlooked by decision makers (e.g. fishing closures leading to rebound of previously stressed fish populations). Furthermore, disaster scenario analysis can identify potential new monitoring needs for disaster impacts and responses. In general, disaster scenario analysis provides a valuable interdisciplinary strategic framework that could help policy makers to plan and implement disaster recovery and prepare for future environmental crises (Machlis and McNutt 2010).

Biological hazards are a growing concern

Biological hazards involve processes of organic origin or those conveyed by biological vectors, including exposure to pathogenic micro-organisms, toxins and bio active substances. These may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation (UNISDR 2004b). In general, biological threats/disasters can range from highly contagious infectious diseases and pandemics to bio-terrorism.

The focus here is on emerging infectious diseases (EIDs). In the distant past cholera, plague and small pox have been the major biological disasters in different communities. More recently the highly pathogenic avian influenza and the pandemic H1N1 influenza have received high level of attention across many parts of the world.

In recent years there has been a continuing interest in issues such as emerging infectious diseases, potential biological threats of animal origin and the epidemic dynamics at the human-animal interface (Lloyd-Smith *et al* (2009) and Jones *et al* (2008)). It is important to recognise that only a few infectious diseases are entirely human-specific. Most human pathogens also circulate in animals or else originated in non-human hosts. Over half of all the recognised human pathogens are zoonotic and nearly all of the most important pathogens are either zoonotic or originated as zoonoses before adapting to humans (Lloyd-Smith *et al* (2009)).

According to Jones *et al* (2008), emerging infectious diseases (EIDs) (including zoonotic EIDs) are a significant potential burden on the global economy and public health. The origins of EIDs are generally related to socio-economic, environmental and ecological factors. Population density has been identified as a common significant predictor of EID events in general. The analysis of these relationships has provided a basis for identifying 'EID hotspots' regions where new EIDs are most likely to originate.

At present most of the scientific and surveillance effort is focussed on developed country regions where the next potentially important EID is least likely to originate (Jones *et al* (2008). This contrasts with potential 'EID hotspots' in lower latitude developing country regions where zoonotic pathogens from wildlife and vector-borne pathogens are more concentrated. Hence, there is a growing need for re-allocation of global and regional resources for 'smart surveillance' of 'EID hotspots' in lower latitudes such as tropical Africa, Latin America and Asia, including targeted surveillance of at-risk groups to identify early case clusters of potentially new EIDs before their large scale emergence and spread (Jones *et al* (2008)). Also, further work is needed to better understand the relationship between EID events and climate change.

There is a continuing need for improving regional epidemiological and environmental information, diagnostic networking, trend analysis and intervention against EIDs and epidemic animal diseases. International prevention, preparedness and response require multidisciplinary teams working in an environment of intergovernmental cooperation (Lubroth 2006).

Concluding remarks

Different approaches to minimising the disaster-related vulnerabilities are discussed in this paper. These measures range from adaptive response techniques, financial risk management tools, reforms to natural resource management governance, application of new technologies in early warning systems, donor-supported risk-transfer programs, and enhancing the role of governments and international agencies. Reducing disaster-related vulnerabilities could help address the development dimensions of disasters in many developing economies.

Risk management instruments such as index insurance schemes are emerging as useful tools, despite the difficulties associated with insurance affordability in developing economies. There is a growing need to increase the efforts between individual governments and international agencies to refocus disaster assistance to support risk management initiatives that leverage aid with public and private contributions and that promote reduction of losses.

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