



28 February 2014

**Climate Change Related Disaster Risk Reduction Scheme In Developing Countries**

Input Paper

Prepared for the Global Assessment Report on Disaster Risk Reduction 2015

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# Introduction

In recent years, the world has experienced many disastrous climatic events. Natural resources and the environment are being impacted negatively by climate change. Vulnerability to future disasters will be determined by climate change and poverty factors, as well as the ability of people to take action to minimize the negative impacts and maximize any benefits from such changes. For example, the poorest of the poor people in India, Bangladesh, Pakistan, and many other Asia countries are already forced to stay in the most disaster‐prone areas, such as flood plains, low‐lying and unprotected coastal areas, and eroded hillsides. Even modest changes in climatic hazards will quickly push households beyond their ability to flexibly adapt and cope with the situation.

Natural disasters adverse impacts on natural and physical environments have been affected by human induced climate change. A changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of weather and climate extremes, and can result in unprecedented extremes. As well, weather or climate events, even if not extreme in a statistical sense, can still lead to extreme conditions or impacts, either by crossing a critical threshold in a social, ecological, or physical system, or by occurring simultaneously with other events(Seneviratne, S.I., et al, 2012). This issue has made the risk reduction more complex especially in developing countries with more vulnerable parts.

Disaster risk reduction scheme in developing countries is different to developed countries because of different infra-structures, high vulnerability and exposure. In order to study all playing parameters in this regard, three main issues are important including: Disaster risk components, risk management and level of actions. These three issues are different in developing countries in comparison to developed world.

Developing regions are vulnerable both because of exposure to weather- and climate-related extremes and their status as developing economies. However, disaster impacts are unevenly distributed by type of disaster, region, country, and the exposure and vulnerability of different communities and sectors (Handmer, J., 2012).

Economic, including insured, disaster losses associated with weather, climate, and geophysical events are higher in developed countries. Fatality rates and economic losses expressed as a proportion of gross domestic product (GDP) are higher in developing countries with high confidence.

During the period from 1970 to2008, over 95% of deaths from natural disasters occurred in developing countries. Middle-income countries with rapidly expanding asset bases have borne the largest burden. During the period from 2001 to 2006, losses amounted to about 1% of GDP for middle-income countries, while this ratio has been about 0.3% of GDP for low-income countries and less than 0.1% of GDP for high-income countries, based on limited evidence. In small exposed countries, particularly small island developing states, losses expressed as a percentage of GDP have been particularly high, exceeding1% in many cases and 8% in the most extreme cases, averaged over both disaster and non-disaster years for the period from 1970 to 2010.

Agriculture is also an economic sector exposed and vulnerable to climate extremes. The economies of many developing countries rely heavily on agriculture, dominated by small-scale and subsistence farming, and livelihoods in this sector are especially exposed to climate extremes. Droughts in Africa, especially since the end of the 1960s, have impacted agriculture, with substantial famine resulting.

Coastal settlements in both developed and developing countries are exposed and vulnerable to climate extremes. For example, the major factor increasing the vulnerability and exposure of North America to hurricanes is the growth in population and increase in property values, particularly along the Gulf and Atlantic coasts of the United States. Small island states are particularly vulnerable to climate extremes, especially where urban centres and/or island infrastructure predominate in coastal locations. Asia’s mega-deltas are also exposed to extreme events such as flooding and have vulnerable populations in expanding urban areas. Mountain settlements are also exposed and vulnerable to climate extremes.

Some researchers argue that poorer developing countries and smaller economies are more likely to suffer more from future disasters than developed countries, especially in relation to extreme impacts.

Impacts transmitted through an increase in the price of food can be especially challenging for the urban poor in developing countries. The economies of many developing countries rely heavily on agriculture, dominated by small-scale and subsistence farming. People’s livelihoods in this sector are especially exposed to weather extremes.

A further concern for low and middle-income cities as a result of flooding, particularly in developing countries, is human waste, as most of these cities are not served by proper water services such as sewers, drains, or solid waste collection services.

While the countries with highest income account for most of the total economic and insured losses from disasters, in developing countries there are higher fatality rates and the impacts consume a greater proportion of GDP. This in turn imposes a greater burden on governments and individuals in developing countries. For example, during the period from 1970 to 2008over 95% of deaths from natural disasters occurred in developing countries

(Handmer, J., 2012).

Developed countries are better equipped financially and institutionally to adopt explicit measures to effectively respond and adapt to projected changes in exposure, vulnerability, and climate extremes than developing countries. Nonetheless, all countries face challenges in assessing, understanding, and then responding to such projected changes (Lal, P.N., 2012).

Natural disasters adverse impacts on natural and physical environments have been affected by human induced climate change. This issue has made the risk reduction more complex especially in developing countries with more vulnerable parts. Disaster risk reduction scheme in developing countries is different to developed countries because of different infra-structures, high vulnerability and exposure. In order to study all playing parameters in this regard, three main issues are important including: Disaster risk components, risk management and level of actions.

The first issue includes disaster characteristics (frequency of occurrence, severity, spatial extents, and timing), exposure, and vulnerability. Adaptation and resilience options decrease exposure as well as vulnerability. Mitigation will affect disaster characteristics via climate system in long term. Vulnerability and exposure are high in developing countries. So these communities need more efforts and gain more from these activities.

The second issue is disaster risk management. There phase are given in risk management; Pre-occurrence, during occurrence, and post-occurrence phases. For each phase suitable actions are applicable. In developing countries most of the actions are related to during and post occurrence phases. The pre-occurrences activities include adaptations options that should be highlighted.

Finally the level or scale of the action is important. From the point of view of scale, there major levels are important including global (international level), Regional level, and national (local level). The national level also consists four sub-levels including central government, state/provincial authorities, local societies (including Nomads) and individuals. For developing countries the most important actions are regional cooperative activities among neighbours’ countries.

The climate change related disaster risk reduction scheme in developing countries includes these 3 major and important components. Integration of these is a key rule to combat adverse effects of climate change and also opportunities.

Developing countries with fewer resources, experts, equipment, and infrastructure have been shown to be particularly at risk (see Chapter 5). Developed nations are usually better equipped with technical, financial, and institutional support to enable better adaptive planning including preventive measures and/or quick and effective responses (Cutter, S.,2012).

Data on natural disasters and disaster risk reduction are lacking at the local level, which can constrain improvements in local vulnerability reduction (high agreement, medium evidence). This is the case in all areas but especially so in developing countries. Local knowledge systems are often neglected in disaster risk management. There is considerable potential for adapting geographic information systems to include local-level knowledge to support disaster management activities. The information gap is particularly evident in many developing countries with limited capacity to collect, analyze, and use scientific data on mortality and demographic trends as well as evolving environmental conditions.

The lack of research on disaster loss estimates in developing countries creates problems of under reported economic losses or over estimation of disaster losses depending on political or other interests. This is a big research gap (Cutter, S., 2012).

In developing countries, structures are often built using prevalent local practices, which may not reflect best practices from disaster risk reduction or adaptation perspectives. These prevalent local practices usually do not include the use of national building standards or adequately account for local climate conditions (Lal, P.N., 2012).

Some studies claim that one of the potential barriers for identifying the most vulnerable regions and people in developing countries under future climate change is the limited human resource capacity regionally to downscale global and regional climate projections to a scale suitable to support national-level planning and programming processes(Lal, P.N.,2012).

In many developing countries, there is little in terms of insurance for disaster risks, yet novel index-based micro-insurance solutions have been developed and are starting to show results (Lal, P.N.,2012).

Lack of locally useable climate change information about projected changes in extreme weather events remains an important constraint in managing weather-related disasters, especially in developing countries. Therefore there is a need to develop regional mechanisms to support in developing and delivering down scaling techniques and tools (see Section 3.2.3 for details on down scaling regional climate models) and transferring them to developing countries. (Burton, I., 2012).

The rapid urbanization of the sub-national populations and the growth of megacities, especially in developing countries, have led to the emergence of highly vulnerable urban communities, particularly through informal settlements and inadequate land management, presenting challenges to disaster management(Cutter, S.,2012)

# **Disaster risk components**

Disaster risk includes disaster characteristics, exposure and vulnerability. Disaster risk specifies the economical damage and life lose of a given disaster. These components are defined by Crichton in 1999 and they are shown in chart1 (Crichton, D. 1999). The concept of risk combines an understanding of the likelihood of a hazardous event occurring with an assessment of its impact, for example:

Hazardous events can be either naturally occurring, such as earthquakes, tropical cyclones or coastal erosion, or they can be human-made, such as water pollution or terrorist attack. In addition, events can be sudden as in the case of an earthquake, or they can occur over time as in the case for most environmental hazards.

The impact of a hazardous event depends on the elements at risk, such as; population or buildings and their associated vulnerability to damage or change as a result of the event. Estimating risk is an uncertain science because it involves forecasting events for which the time and the location may be largely unknown. This uncertainty is captured mathematically in terms of probability.

The total risk may be decreased by reducing the size of any one or more of the three contributing variables, the hazard, the elements exposed and/or their vulnerability. This can be illustrated by assuming the dimension of each of the three variables represents the side of a triangle, with risk represented by the area of the triangle.

In the risk triangle below, the larger, yellow area portrays each of the variables as being equal while in the smaller, green space the total risk has been mitigated by halving both exposure and vulnerability. The reduction of any one of the three factors to zero consequently would eliminate the risk (URL1).

Adaptation and resilience options decrease exposure as well as vulnerability. Mitigation will affect disaster characteristics via climate system in long term. Vulnerability and exposure are high in developing countries. So these communities need more efforts and gain more from these activities.



Chart 1 : The risk, hazard, exposure, vulnerability relationship

Each disaster has its special characteristics, however generally they are frequency of occurrences, severity, spatial extents, and timing. Some disasters like tropical thunderstorms also have the path also.

Adaptation and resilience options decrease exposure as well as vulnerability. Mitigation will affect disaster characteristics via climate system in long term. Vulnerability and exposure are high in developing countries. So these communities need more efforts and gain more from these activities.

# 2-1- Hazard

Hazard is different to risk. There are many definitions of risk, but in broad terms disaster risk refers to the impact of natural hazards on communities, infrastructure, and agricultural lands. For example, maps are frequently produced showing regions of high hazard - regions that are more or less likely to experience earthquakes, floods, cyclones, and so on. However, to really understand the potential impact of natural disasters on communities, provinces and countries, it is necessary to move beyond this understanding of just hazard to a more comprehensive appreciation of the risks posed to communities. For example, rather than simply identifying which provinces have the highest chance of an earthquake or flood, risk assessments can provide information on which communities are most vulnerable to earthquakes or how many people would be left homeless by a 1 in 100 year flood or a magnitude 6.5 earthquake.

There is no difference for this component of risk in developed and developing countries. In other words the disasters occur at the same severity and duration, etc in all of the world countries including developing and developed ones. What differs the risk is differences in exposure and vulnerability levels that depends on how much is a country is developed.

# 2-2- Exposure

Exposure, also sometimes referred to as the elements at risk, are those elements within a given area that have been, or could be, subject to the impact of a particular hazard. For example, elements at risk might include the population, buildings and civil engineering works, economic activities, public services, utilities and infrastructure which are at risk in a given area. The elements at risk can be expressed as a population size or in monetary terms such as replacement cost. The exposure is influenced by the number of people, buildings and other infrastructure within an area.

Analysis of risk to a community requires the development of extensive datasets which define the most vulnerable components of communities. The data which provides the basis for vulnerability assessments and ultimately allows the determination of the potential impact of an event include:

* building construction classifications and distributions
* building codes, construction practices and costs
* infrastructure such as roads, water, power and sewage
* institutions such as emergency facilities, hospitals, educational and government bodies
* distribution of population, income, and other statistical information such as age, occupation, disability and education
* economic data on business sectors including turnover, employment, industrial production, exports and imports
* emergency management arrangements for disaster response and recover

# 2-3- Vulnerability

Vulnerability to natural hazards is an integral factor in understanding the true extent of risk. Although there is no single definition for vulnerability, it generally refers to the impact a hazard has on people, infrastructure and the economy. The concept of vulnerability is complex and cannot be comprehensively answered by a single research method. However, aspects of vulnerability to natural hazards can be measured, which is a value adding feature to hazard models, providing a greater understanding of total risk.

Exploring quantitative methods for assessing vulnerability is essential to ongoing risk research, in particular risk decision making, which is a fundamental part of natural hazards risk management. Vulnerability factors can be divided into three main areas; physical, social and economic.

A comparative study of the impact of sea level rise on coastal inundation across 84developing countries showed that the greatest vulnerability to a 1 m sea level rise in terms of inundation of land area was located in East Asia and the Pacific, followed by South Asia, Latin America, and the Caribbean, the Middle East and North Africa, and finally sub-Saharan

Africa (Seneviratne, S.I., et al, 2012).

In terms of the nexus between development and disaster vulnerability, researchers argue that poorer developing countries and smaller economies are more likely to suffer more from future disasters than developed countries, especially in relation to extreme impacts(Handmer, J., 2012).

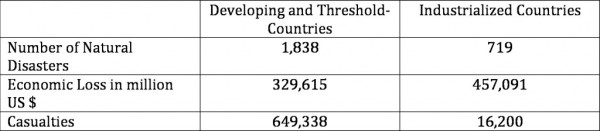


Table1 : Analysis of number of disasters, economic loss and casualties between 1991 and 2000

# 2-3-1- Physical vulnerability

This refers to the potential for physical impact on the built environment or infrastructure and population. This aspect is relatively easily quantified because it depends directly on the physical impact of a hazard event. The best developed vulnerability models have focussed on the behaviour of buildings as the most significant component of the built environment, but in general such models require development and validation using empirical data, post disaster reconnaissance and laboratory testing, such as from shake tables and wind tunnels, as well as computer simulation techniques.

Information can be acquired from countries such as the United States and Europe, but different building techniques, standards and materials adopted in Australia require significant model calibration and testing under Australian conditions. Casualty models have been developed based primarily on assumptions linked to the likelihood of occupants being injured or killed in the event of building damage or failure.

These models draw on the well developed HAZUS risk assessment model used throughout the United States to determine risk from earthquake. The vulnerability of communication lines and other infrastructure has been studied internationally using past disasters as case studies. However, there are limitations on the value of this knowledge being applied to any specific infrastructure systems because it is often the complex network of interactions which dictate the extent of impact and the duration of recovery.

# 2-3-2-Social vulnerability

Each day, risk managers and risk researchers make decisions about the well being of communities based on available data, anecdotal evidence, training and personal experience. Individuals within communities also make decisions about their own vulnerability to natural disasters and about mitigation and recovery. Approaches to determining social vulnerability rely on the complementary integration of quantitative and qualitative methodologies.

Qualitative approaches have explored the capacity of communities to manage risk information to cope with natural events. Quantitative methods to assess social vulnerability explore the integration of subjective information and analytical processes to develop measures of vulnerability. Such quantitative methods may also be useful when exploring decision making processes concerning socio-economic and community factors. However, as with all vulnerability models, when data from past events is available it should be used to calibrate and validate results.

# 2-3-3- Economic Vulnerability

Broadly, economic loss tends to be classified as tangible and intangible and sub-categorised into direct and indirect loss.Key drivers of economic vulnerability are low levels of income and GDP, constrained tax revenue, low domestic savings, shallow financial markets, and high indebtedness with little access to external finance (Bensonand Clay, 2000).

In terms of estimating loss for natural hazards, tangible direct loss is defined as loss resulting from the impact of the event such as physical damage to buildings and their contents, vehicles and infrastructure. Tangible indirect loss relates to the disruption to business, transport, utility networks, clean up costs, emergency response and relief incurred as a consequence of the event.

The extent of the indirect cost is dependent on the availability of alternative sources of supply, markets for products and the duration of any disruption to production. Intangible indirect losses from natural disasters include death, injury and loss of memorabilia. Intangible direct losses incorporate health effects and household disruption to activities such as schooling and social life. There are no market values for intangible losses, but non market valuation techniques can be applied to provide proxy values.

Ideally, an economic assessment of potential or actual losses from a disaster will incorporate all these loss categories. However, in the first instance, tangible loss is likely to be sufficient to provide conservative estimates of economic loss. Intangible loss is more complex to estimate because of the need for proxy values. Direct tangible losses are the simplest to obtain because they follow more directly from the physical impact and are the most readily developed and applied on a regional and national scale.

There is general consensus that, as compared to developed countries, developing countries are more economically vulnerable to climate extremes largely because:

1. developing countries have less resilient economies that depend more on natural capital and climate-sensitive activities
2. (ii) they are often poorly prepared to deal with the climate variability and physical hazards they currently face (World Bank, 2000);
3. (iii) more damages are caused by maladaptation due to the absence of financing, information, and techniques in risk management, as well as weak governance systems;
4. (iv) there is generally little consideration of climate-proof investment in regions with a fast-growing population and asset stocks (such as in coastal areas) (IPCC, 2001; Nicholls et al., 2008);
5. (v) there is an adaptation deficit resulting from the low level of economic development (World Bank, 2007) and a lack of ability to transfer costs through insurance and fiscal mechanisms; and
6. vi) They have large informal sectors.

However, in some cases like Hurricane Katrina in New Orleans, United States, developed countries also suffer severe disasters because of social vulnerability and inadequate disaster protection (Birch and Wachter, 2006; Cutter and Finch, 2008). (Handmer, J., 2012).

# Adaptation and DRM in Developing countries

Estimates of adaptation costs to climate change exhibit a large range and relate to different assessment periods. For 2030, the estimated global cost ranges from US$ 48 to 171 billion per year (in 2005 US$) with recent estimates for developing countries broadly amounting to the average of this range with annual costs of up to US$ 100 billion(Handmer, J., 2012).

Adaptation is adjustment in natural or human systems in response to actual or expected climatic *Stimuli* or their effects, which moderates harm or exploit beneficial opportunities.

For developing countries the most important types of adaptations are advisable including

1. Anticipatory Adaptation;
2. Autonomous Adaptation;
3. Planned Adaptation;
4. Private Adaptation;
5. Public Adaptation;
6. and Reactive Adaptation.

In developing countries, particularly where the government is weak and has limited resources, bilateral and multilateral agencies play a significant role in supplying financial, technical, and in some cases strategic support to government and nongovernment agencies to tackle the multifaceted challenges of disaster risk management and climate change adaptation in the context of national development goals(Lal, P.N.,2012).

Four types of methodologies or approaches to disaster risk reduction (DRR) and climate change adaptation (CCA) are recommendable for developing countries including:

1. Early warning systems;.0

A need for improving international cooperation and investments in forecasting was recognized in some of the case studies but equally the need for regional and local early warning systems was heavily emphasized.

1. effective legislation;
2. risk transfer;
3. and education,
4. training, and public awareness initiatives
5. Adaptation and DRM in Developing countries

Mitigation and adaptation are two main categories of human responses, that help to reduce the risks of climate change. Mitigation involves actions that are intended to reduce the magnitude of our contribution to climate change and strategies to reduce greenhouse gas sources and emissions and enhance greenhouse gas sinks. Adaptation consists of actions undertaken to reduce the adverse consequences of climate change, as well as to harness any beneficial opportunities. Adaptation actions aim to reduce the impacts of climate stresses on human and natural systems.

Typically for developing countries response to disasters has evolved from perspective that stems from natural hazards research and has its focus on the provision of relief in times of disaster or calamity, often by external agencies, and of adaptation. Adaptation means adjustment by human populations to changed circumstances and has recurrent expenditure consequences as communities strive to re-build livelihoods. (Wisner, B., Blaikie, P., Cannon, T., Davies, I. (2003) At Risk: Natural Hazards, People's Vulnerability and Disasters (2nd Ed). Routledge, London)

Disaster management in developed countries is institutionalized and embedded within governance structures. Coping capacity, related to income and insurance is high, even in areas prone to hazard, for example flood plains and storm corridors. Storm events in Florida may cause extensive damage, but mortality rates are usually low (Tobin A.G., (1999) Sustainability and community resilience: the holy grail of hazards planning? Environmental Hazards 1, 13-25, Pergamon).

As opposite developing countries, often with established emergency plans suffer disproportionately to extreme events. As UNDP, 2004 notes that though institutional development for disaster mitigation is normally a component of external aid, often this is fragmented and poorly coordinated. In extreme events communities rely on traditional coping strategies and continued external interventions. Developing countries are at greatest risk to climate related disasters and countries which unable to cope with current climate related disasters will be the most poorly equipped to cope with the adverse impacts of climate change (Adger and Brooks, 2003). Of equal concern are the differential impacts of climate change and the highly skewed costs of adaptation at global and local scales. The vulnerability of societies to climate impacts and the costs of adaptation highlight some pertinent debates in social equity because of the long term and uncertain nature of impacts (Adger et al 2000). The rich world produces the majority of greenhouse gases but the impact will be the most severe on the poorest countries.

There are many different types or categories of adaptation. The most common distinctions concern:

* Timing: *proactive*adaptation if it is done in anticipation of an impact, *reactive* if it is done in response;
* Temporal and spatial scope: *short* term as opposed to *long* term, localised as opposed to widespread;
* Purposefulness*: autonomous*  if it is done unconsciously, *planned*  if it is the result of a policy decision;
* Agent*: public or private*; government, industry, business or individual.

Disaster preparedness or pre-occurrence adaptation with its emergency plans and Early Warning Systems ranked highest in terms of importance for Climate Change Adaptation. Recovery and reconstruction plans ranked second highest, along with procedures to exchange relevant information during disasters and undertake post-event assessment of performance.

**Pre-occurrence adaptation to climate change related disasters**

Pre-occurrence adaptation is the specific measures taken before disasters strike, usually to forecast or warn against them, take precautions when threaten and arrange for the appropriate response.

The aim of disaster preparedness is to develop disaster prevention or risk reduction measures in parallel with emergency preparedness and response capabilities. In this process hazard and vulnerability analyses are the scientific activities which provide the basis for the applied tasks of risk reduction and emergency preparedness to be undertaken in collaboration with planners and the emergency services.

Many techniques have been developed for use in pre-occurrence adaptation, such as vulnerability, hazard and risk mapping, early warning systems, evacuation and recovery strategies. Technological developments have increased the sophistication of many of the techniques, for example the increasing use of Geographical Information Systems that can display, manipulate, merge and analyze datasets over a variety of scales.

**National level DRM**

National systems are at the core of countries’ capacity to meet climate challenges. Effective national systems comprise multiple actors from national and sub-national governments, the private sector, research bodies and civil society, including Community-Based Organisations (CBOs), each playing differential but complementary roles to manage risk according to their accepted functions and capacities. Greater efforts are required to address the underlying drivers of risk and generate political will to invest in disaster risk reduction. Changes in weather and climate extremes also pose new challenges for national DRM systems, which are often poorly adapted to current risks. A recently developed index that measures capacities and conditions for risk reduction shows that low and lower-middle-income countries with weak governance tend to have great difficulty addressing underlying drivers of vulnerability. Legislation at the national level can play a useful role as a driver for change.

Public understanding of risks and vulnerabilities is critical, but insufficient for risk management; early warning systems therefore need to be complemented by preparedness programmes as well as public education and awareness. This requires systematic linkages and integration between early warning systems and contingency planning processes.

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