DFID Department for International Development

Natural Disaster and Disaster Risk Reduction Measures

A Desk Review of Costs and Benefits

Draft Final Report

8 December 2005

Delivering sustainable solutions in a more competitive world

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Department for International Development

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A Desk Review of Costs and Benefits

December 2005

For and on behalf of Environmental Resources Management	
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EXECUTIVE SUMMARY

1. This report has been prepared by Environmental Resources Management on behalf of the Department for International Development. The objective of the report is to present a high-level, desk-based assessment of the economic costs of disasters, and of the costs and benefits of various approaches to managing the risks of natural disasters, normally known as Disaster Risk Reduction (DRR). The desk-based research has been supplemented by limited consultations with NGOs active in disaster prevention and relief.

2. The report is prepared in the context of increasing donor and NGO activity in DRR. The reasons for this increased level of activity include:

- A growing awareness of the links between natural disasters, socio-economic development and poverty outcomes.

- An apparent increase in the number of natural disasters. The increase is at least partly caused by increasing human settlement in areas vulnerable to disasters, and by the exacerbation of natural events (such as floods) by inappropriate development (and in that sense, not all 'natural disasters' are truly 'natural'). However, changes to the global climate are also widely believed to be a contributing factor.

3. DRR measures can be categorised in various ways. For this study, we have developed the following typology:

- policy and planning;
- physical preventative measures;
- physical coping and/or adaptive measures; and
- community capacity building.

4. A key finding of the literature review is that research into the costs of natural disasters and the costs and benefits of DRR measures is not well developed, and that much of the evidence is anecdotal. However, there is a sufficient body of research to draw some initial conclusions.

5. Natural disasters have been shown to have major impacts at the macro-economic level. Research has tended to focus on the costs of physical damage and clean up. Further research has been undertaken on more indirect effects, such as the value of lost output and the consequences diverting government expenditure to relief efforts and increased indebtedness.

6. The studies show that developing countries suffer far greater economic costs because of natural disasters (in relative terms), with World Bank estimates suggesting annual costs of 2 to 15 percent of GDP for affected countries. Macro-level assessments also show a high benefit to cost ration for DRR measures. For example, the US Geological Survey and the World Bank

estimated that an investment of $40 billion would have prevented losses of $280 billion in the 1990s. However, it should be noted that consistent methodologies have not been used to prepare these estimates, and hence the figures should be treated as indicative.

7. Bottom-up, or micro-economic assessments, or DRR measures have also been undertaken. These typically examine a proposed package of DRR measures for a specific area. Such studies have identified a wide range of DRR measures with positive benefit-cost ratios. The benefit-cost ratios are obviously heavily dependent upon local circumstances (for example construction cost, efficacy of DRR measure, value of assets and numbers of persons affected), but the studies demonstrate the potential for economically effective DRR measures in developing countries.

8. Another finding is that DRR measures often have significant development benefits, even in the absence of natural disasters. For example, raised flood shelters in Bangladesh are used on a day to day basis as schools or clinics, whilst boreholes to protect against droughts also have the benefit of providing water that is both cleaner and easier to access than alternative sources.

9. The literature suggests that a systematic assessment of the benefits and costs of DRR measures is certainly possible and, where significant funds are being spent, such a process could help ensure best value for money. This view has been corroborated by NGOs active in the field of disaster prevention.

10. Systematic comparisons of economic impacts of natural disasters in countries with and without well-developed DRR measures have not been undertaken. However, the more general literature on natural disasters does indicate that there are significant benefits to be realised from well developed DRR strategies. For example, major investments in DRR measures in Bangladesh in the 1990s, following catastrophic loss of life as a result of flooding in 1970 and 1991, have hugely decreased the fatalities associated with comparable storm events. Similarly, average fatalities caused by major earthquakes in developed countries have fallen from about 12,000 in the period 1900 to 1949 to 2,000 in 1950 to 1992, largely as a result of better structural engineering and preparedness. However, in developing countries, the average number of deaths per disaster has remained constant at about 12,000.

11. This study has therefore found that limited research has been undertaken on both the costs of natural disasters, and on the costs and benefit of DRR measures. This body of evidence strongly suggests that there can be positive economic returns from DRR measures, and that additional development benefits can be realised. However, the research is not comprehensive, and consistent methods have not always been used. The existing research is also of little practical help to those seeking to implement DRR programmes and projects.

1 *INTRODUCTION*

As part of the UK Department for International Development's (DFID) broad-based strategy for the integration of disaster risk reduction (DRR) into mainstream development programming, a policy paper was presented to the DFID Development Policy Committee for approval in mid-November 2005. Further evidence was required in order to support some aspects of the policy paper, in particular economic evidence that DRR represents a sound and cost-effective development investment. This is due to the lack in evidence relating to the costs and benefits of DRR measures, as well as the need to justify increased expenditure to the donor community on DRR.

DFID have therefore commissioned a short desk-based study to address this evidence gap and provide input to the policy paper. This study is driven by the following objectives:

- to provide an understanding of the economic impacts of disasters, at both macro and local level; and

- to assess the associated costs and benefits of Disaster Risk Reduction (DRR) measures.

The study used a literature review, as well as interviews with NGOs active in the field, to provide an initial assessment of the existing evidence on the costs of disasters, focusing on the quantifiable impacts as well as the costs and benefits of DRR measures (*Section 2)*. Despite the clear need for increased documentation of the economic argument for DRR, the literature review revealed a significant scarcity of concrete studies and data. As a result, the remainder of the paper elaborates on the potential benefits that could be associated with DRR and how their impacts can be measured in order to provide further concrete evidence of DRR (*Section 3*). The study concludes with a description of several case studies highlighting the benefits associated with implementing comprehensive DRR programmes, using cyclonic winds and earthquakes as examples (*Section 4*).

There are three annexes attached to the report, on the following:

- The economic impacts of the Asia Tsunami (*Annex A*)
- Disaster preparedness in Bihar, India (*Annex B*)
- A typology of disaster risk measures (*Annex C*)

2 THE COST OF DISASTERS: A SUMMARY OF THE LITERATURE

2.1 INTRODUCTION

This section presents a brief overview of the existing literature on the costs and benefits of disasters and DRR measures. A DFID (2004) scoping study found that poverty alleviation, development and disaster risk reduction (DRR) are highly correlated. It was argued that inadequate attention to DRR can hinder progress in poverty alleviation and development. Historically, the focus of international attention has tended to come after disaster events, rather than on preparing for disasters before they occur. This has been largely due to the lack of evidence of the effectiveness of DRR, as well as the organisational and historic separation of humanitarian relief and development activities. Furthermore, there are limited data and resources in developing countries to help demonstrate the effectiveness of DRR.

The development and donor communities are showing an increased commitment to reducing disaster risk and vulnerability, and towards *integrating* or *mainstreaming* disaster preparedness, or DRR, into development planning. As part of this process, several studies have examined the overall economic impact of disaster events. The following section provides a summary of the reported macro-level economic impacts, followed by a section on micro- (or local/project-) level economic impacts of DRR measures. Macro-level estimates are based on the impact to macro-economic variables, costs of reconstruction etc at the national level, whereas project-level estimates relate to the costs and benefits of specific DRR measures.

2.2 MACRO-LEVEL ESTIMATES OF THE COSTS OF DISASTERS

2.2.1 *Overview*

Natural disasters can have a significant impact on the welfare of an entire nation. Estimates for these impacts can be broken down in terms of direct costs, indirect costs and secondary impacts:

- *Direct* costs come in the form of damages to stocks of physical and human capital, and include the costs of relief, rehabilitation and reconstruction. Examples include damage to buildings, crops and economic and social infrastructure.

- *Indirect* costs are secondary impacts which take the form of, for example, lost output and investment, macroeconomic imbalances caused by disasters and resulting incidences of debt and/or poverty. These occur as a result of the direct impacts, for instance as a consequence of the physical destruction affecting households and firms. The main indirect economic impacts can be split into first and second order effects. First order indirect effects include diminished production and service due to interruption of economic activity, increased prices due to interruption of economic activity leading to reduction of household income, increased costs as a consequence of destroyed roads. Second order effects include impacts on overall economic performance, including the reallocation of planned government spending and increased indebtedness and changes in the pattern of income distribution or the scale and incidence of poverty.

Several studies provide estimates on the macro-level impacts of disasters. These include impacts on key macro-economic variables (eg GDP growth), impacts on particular sectors of the economy (eg agriculture), and total damage costs to physical and human capital at the national level. The size of these impacts depends on the size and duration of disasters, the structure of economy, measures taken ex-ante to mitigate any impact, the government's policy response to the shock, and the amount and form of external assistance.

Most assessments of disaster impacts only focus on quantifying immediate direct damages (Twigg, 2002) and only in financial terms (ie the non market economic costs, such as the value of lives lost, are not addressed). The economic costs consist mainly of immediate damage assessments in order to provide governments and aid donors with estimates of the amount of funds required to address emergency and reconstruction needs (see for example IMF, 2005), as well as by insurance companies. Long-term indirect costs in the flows of goods and services, reduced levels of production and non-market impacts such as environmental damage and psychosocial effects are frequently omitted from such assessments (UNDP, 2004). This focus on direct damages and loss of life is largely due to the fact that there are difficulties in accounting for indirect and non-monetary damages and because economic studies of this nature are, not surprisingly, a low priority in the post-disaster recovery effort.

The main databases for information on direct costs are provided by Swiss Re, Munich Re, the Economic Commission for Latin America and the Caribbean (ECLAC) and the EM-DAT database from the Centre for the Epidemiology of Disasters (CRED) in Brussels. The CRED also accounts for health effects, such as lives lost and people affected. Swiss Re and Munich Re publish data on the worldwide direct economic and insured losses on an annual basis.

2.2.2 *Global Estimates for the Cost of Disasters*

There are several well recognised estimates regarding the overall costs of disasters. These are summarised as follows:

- The World Bank estimated that from 1990-2000, natural disasters resulted in damages constituting between 2 to 15 percent of an exposed country's annual GDP (World Bank, 2004). This is based on 'large' scale disasters as interpreted by the countries affected. The damages represent the costs of replacing physical assets at current prices.

These estimates are consistent with those provided by the IMF, which demonstrated that between 1997 and 2001 the damage per large disaster(1) was over 5 percent of GDP on average in low-income countries (IMF, 2003). *Table 2.1* shows the impact of natural disasters in terms of the percentage of annual GDP for several countries around the world. These are estimated in the same way as the averages presented above by the World Bank (2004).

Table 2.1 Impact of Natural Disasters on GDP, 1990-2000

Country	**Percentage of GDP**
Argentina	1.81
Bangladesh	5.21
China	2.5
Jamaica	12.58
Nicaragua	15.6
Zimbabwe	9.21

Source: World Bank (2004)

- Over time, it has been reported that the economic cost of natural disasters has dramatically increased, and that the frequency of disasters has increased also(2). In the past two decades alone, direct reported economic losses from natural disasters have multiplied fivefold in real terms to US$629 billion (World Disasters Report, 2003), although it should be acknowledged that this may be due to greater reporting, greater human settlement in areas vulnerable to disaster and ownership of higher value assets and goods as incomes have increased.

- Real annual economic losses have averaged US$75.5bn in the 1960s, US$138.4bn in the 1970s, US$213.9bn in the 1980s, and US$659.9bn in the 90s (UNDP, 2004).

- An important finding is that low-income countries bear the heaviest burden of these costs in terms of average annual damage relative to GDP – 11 percent of the people exposed to natural hazards live in low human development countries, but they account for more than 53 percent of the total recorder deaths resulting from natural disasters (UNDP, 2004).

- However, for small island states the average annual damage relative to GDP due to disasters has declined sharply since the late 1970s, possibly reflecting more effective action to plan for and mitigate disasters (IMF, 2003). For instance, following hurricanes in 1998 (Gilbert), 1998 (Mitch) and 2000 (Michelle), the Cayman Islands built preparedness and

(1) A disaster is classified as large if it causes damages of at least half a percent of national GDP, or affected at least half a percent of the population (IMF, 2003)

(2) It should, however, be noted that the definition of natural disaster is anthropocentric – ie a natural event is not a disaster unless humans are adversely affected. The increase in disasters is at least partly due to the increasing spatial extent of human settlement, which has led to human populations moving into areas that are more vulnerable to natural disasters, such as flood plains. Another factor is development that increases the incidence of seemingly natural events, such as the creation of unstable artificial slopes when settlement occurs on hills, which can lead to landslides. In this sense, many natural disasters are not in fact 'natural', but rather the result of human modifications to the landscape.

community resilience through changes in the rules and governance of hurricane risk, changes in the organisation of early warning systems, and the promotion of self-mobilisation of civil society. As a result, the economic and ecological impacts of Hurricane Ivan (2004) were reduced through the dramatically improved resilience of the islands (Adger et al, 2005).

It is important to note that these studies vary in terms of methodological approach and accuracy. For instance, the impact on GDP is often used as an indicator of the impact of disasters. However, it is important to draw correct conclusions from GDP indicators. GDP represents the flow of goods and services in an economy, and not the stock of assets. Post-disaster reconstruction booms are common and reflect large scale reconstruction projects of damaged infrastructure. In GDP terms this positive increase does not reflect an increase in national physical assets. Other concerns relate to the damage estimates where there is room for potential double-counting in adding direct and indirect impacts (Rose 2004; van der Veen 2004, cited in Mechler, 2005).

Also worth noting is that natural disasters often have positive effects. Examples include an increase of pasture area for raising livestock, increased water availability or replenishment of aquifers, and indirect effects on economic sectors such as agriculture (increase in livestock numbers), or in the construction sector (reconstruction boom post-event). However, it is likely in most cases that the adverse impacts of disasters overshadow these positive effects.

According to the World Bank and the US Geological Survey, if $40 billion had been invested in physical or engineering DRR type measures eg adequate design of buildings or bridges(1), then $280 billion of economic losses worldwide from natural disasters would have been avoided in the 1990s.

Furthermore, in China it is estimated that the $3.15 billion spent on flood control over the past four decades of the 20 century actually averted losses of about $12 billion (World Bank, 2004). These statistics provide the outlines of a compelling economic case for investing in DRR.

The following sections provide a focus on each of the natural disaster event types, for cyclonic winds, flooding and drought. A separate and more detailed assessment of studies examining the 2004 Asian Tsunami is presented as *Annex A*.

(1) This is based on a conversation with Saroj Kumar Jha, Senior Infrastructure Specialist, Hazard Risk Management Team, The World Bank, December 2005

2.3 *NATIONAL LEVEL ESTIMATES OF THE COSTS OF DISASTERS*

2.3.1 *Disaster Case Studies – Cyclonic Winds*

Fiji: Impact of Cyclone Ami, 2003

In Fiji the government performed a comprehensive assessment of Cyclone Ami. This included an analysis of damage to housing, education, health, agriculture, business, tourism, the sugar industry, infrastructure, telecommunications, and power supply. For all sectors the assessment tended to focus on direct impacts. The assessment of the impact of Cyclone Ami estimated that the total cost of damage amounts to US$55.3 million, but only a limited number of deaths (Mckenzie et al, 2005). However, the extent of damages goes beyond direct impacts.

The agricultural sector appeared to be most affected, in terms of the impact on crop and sugar industries. 60 to 80 percent of subsistence crops were damaged at a cost of US$488,130. This estimate is based on market prices from weekly agricultural price surveys. For commercial crops the damage cost is estimated to be US$20.8 million. The sugar industry also suffered total direct damage costs estimated at US$7.2 million. This consisted of a loss of 150,000 tonnes of sugarcane, at a cost of US$4.0 million, and damage to Fiji Sugar Corporation's infrastructure and equipment, valued at US$3.18 million.

The operating costs of the Fiji Sugar Corporation increased in 2004 due to the cost of employing 400 extra staff to help with the clear up and repair work. The estimated extra personnel costs amount to US$468,520. The Fiji Sugar Corporation estimates the cost of debris clearing (excluding extra personnel costs) in the sugar sector was approximately US$60,738.

Estimates for damages to the education sector were also included, relating to the direct damage to school infrastructure, such as buildings, equipment and materials. The cost of this damage was estimated at US$2.5 million, valued at replacement and repair cost (Mckenzie et al, 2005a).

Niue: Impact of Cyclone Heta, January 2004

In January 2004 Cyclone Heta hit Niue, a microstate in the South Pacific, and is considered to be the most destructive in Niue's recent history. The assessment of damages from Cyclone Heta was based on the impact on three broad areas: civil society, the private sector and the public sector. A national survey was conducted in which disaster-affected businesses and households were asked to list the cost of direct damages suffered. The method of valuation was based on replacement costs using current market values in the construction industry. No assessment of macroeconomic effects was made. The total damage inflicted by Cyclone Heta was estimated at US$24.8 million (Mckenzie et al, 2005a).

This cyclone had a major impact on the private sector through damage to housing, the public sector through impacts on public service facilities, and on tourism. Out of 1002 houses on the island (432 are occupied), about 90 percent were damaged during Cyclone Heta. Damage to housing and personal property was estimated to be US$2.7 million. The total damage to the private sector was estimated at US$3 million. Total official estimated damage and losses in the public sector amount to US$17 million. The value of the damage to the public sector was roughly double Niue's estimated GDP for 2002.

The impacts on tourism include the cost of repairing damaged tourist accommodation and infrastructure, estimated at US$198,000. The cost of replacing tourist accommodation and infrastructure that was totally destroyed was estimated at a value of US$1,815,000. Furthermore, the value of damage to scenic sites and access roads was estimated at a value of US$191,228, based on the cost of clearing the access roads and rehabilitating scenic sites to a 'visitable' quality. Indirect impacts came through a fall in the number of tourist visitors by 6 percent between 2003 and 2004. The resulting lost income for 2004 was approximately US$68,488, based on income derived per visitor from tourist expenditure of US$439 per visitor (2003 figure).

2.3.2 *Disaster Case Studies – Flooding*

Bangladesh

Bangladesh has experienced a number of severe floods in the recent past. For instance, he 1998 floods had a devastating impact with total losses to output and infrastructure estimated at US$2 billion, equivalent to 6 percent of 1997/98 GDP. Furthermore, rehabilitation costs were estimated at US$1.5 billion (UNDP and Bangladesh 1998; in Benson and Clay 2004). In terms of the impact on the agricultural sector, natural disasters in Bangladesh lead to decreases in the sector's annual growth rate. However, this was not the case after the 1998 floods (Benson and Clay, 2004).

The estimated value of damages[1] to physical infrastructure in previous years for major floods in 1987, 1988 and 1995 is US$451 million, US$775 million and US$530 million respectively (UNESCAP, 1998). The cost of flood damage as a percentage of the total GDP value is estimated at 3 percent in 1987, 5.1 percent in 1988 and 2.6 percent in 1995. Furthermore, the impacts of these floods appears to be greater in non-agricultural than in agricultural (crop) sectors. In 1988, damage to crops was 21 per cent of total damage, while damage to dwellings was 41 per cent, damage to roads, bridges and embankments 26 per cent, and damage to livestock 0.06 per cent (UNESCAP, 1998).

Cambodia

In Cambodia one-fifth of Cambodia's rice crop was destroyed by a flood followed by a drought in 1994. Prior to the flood and drought in 1994 agriculture accounted for just under 50 percent of GDP. The effect of the flood and drought led to a 20 percent reduction in the volume of rice crop produced,

(1) The monetary value of flood damage has been estimated by applying average unit values of damage costs for the respective years at constant 1985 price

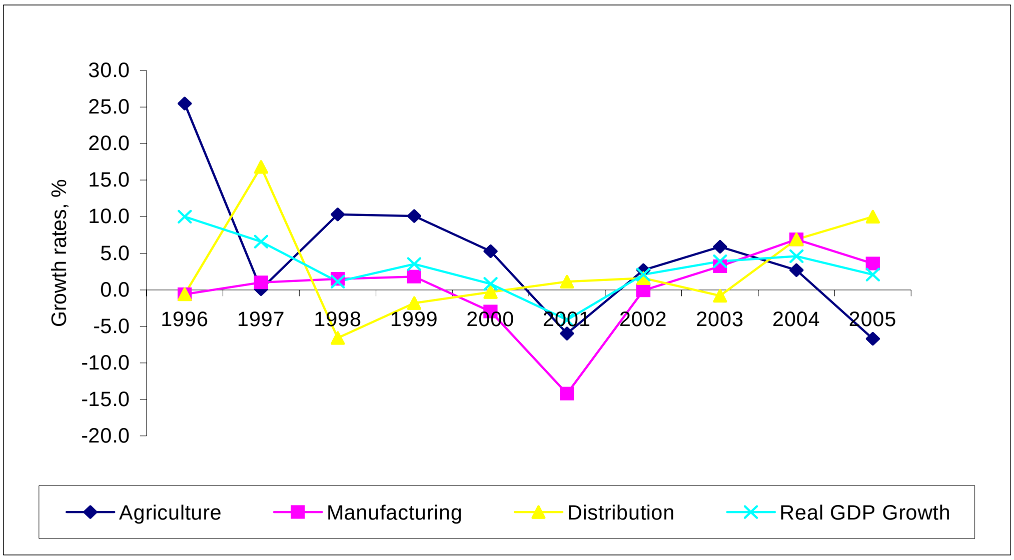
which resulted in a reduction in the overall share of GDP by 2 percent (IMF, 2003).

2.3.3 *Disaster Case Studies – Drought*

Malawi

An analysis of six African countries showed that the 1991-92 drought reduced real income by 2 percent in South Africa and 8 percent in Malawi (Benson and Clay, 1998). In the case of Malawi, the most significant droughts occurred in 1981-1982, 1992-1993 and 2001-2002 ie roughly every ten years. These droughts have had a direct impact on growth in the agricultural sector, and it is evident from *Figure 2.1* below that this has also had a knock-on effect on other sectors, such as manufacturing, distribution and the overall growth of the economy.

Figure 2.1 ***Real GDP Growth Rates by Sector, 1996-2005***



Source: Government of Malawi, cited in Botolo, 2005

Zimbabwe

In late 1991 and early 1992, Zimbabwe experienced a severe drought which had devastating impacts on the agricultural sector. As a result, real GDP was reduced by 9 percent, with an increase in food prices by 72 percent. Other impacts on macro-economic variables include an increase in the balance of payments deficit from 6 to 12 percent of GDP between 1991 and 1992; the fiscal balance deficit increased also from 7 percent in 1991-2 to 10 percent in 1992-3 (IMF, 2003).

The impact on poverty was significant, and this was evident through a range of indirect indicators relating to people's livelihoods. Real wages decreased by 23 percent in 1992, with the sharpest decline in agricultural wages by 42 percent; expenditure on health and education by households and the government were reduced, with resulting increases in school drop-out rates;

child malnutrition and birth weight were negatively affected; import prices for food increased; and drought relief programmes only covered 12 to 15 percent of household food needs. All these had a negative impact on poverty (IMF, 2003).

2.4 BOTTOM-UP ASSESSMENTS OF THE COSTS AND BENEFITS OF DRR

2.4.1 Overview

There is a limited number of studies which highlight the relative costs and benefits of DRR at the project level. The studies can be split into two types: those that appraise the potential benefits of such measures before implementation, and others that evaluate the actual benefits after a disaster occurrence. *Table 2.2* lists the most recent studies based on a comprehensive review by Mechler (2005).

Table 2.2 Summary of Evidence on Net Benefits of Disaster Risk Management projects

Source and type of analysis	Actual or potential benefits	Result/return
EX-ANTE APPRAISAL (assessment before implementation)		
Kramer (1995): Appraisal of strengthening of roots of banana trees against windstorms in St Lucia	Increase in banana yields in years with windstorms	Expected return negative as expected yields decreased, but increase in stability as variability of outcomes decreased
World Bank (1996): Appraisal of *Argentinean Flood Protection Project*. Construction of flood defence facilities and strengthening of national and provincial institutions for disaster management	Reduction in direct flood damages to homes, avoided expenses of evacuation and relocation	Internal Rate of Return (IRR): 20.4% (range of 7.5%-30.6%)
Vermeiren et al. (1998): Hypothetical evaluation of benefits of retrofitting of port in Dominica and school in Jamaica	Potentially avoided reconstruction costs in one hurricane event each	Benefit/cost ratio: 2.2 – 3.5
Dedeurwaerdere (1998): Appraisal of a range of different prevention measures (mostly physical) against floods and lahars (volcanic flows) in the Philippines	Avoided direct economic damages	Benefit/cost ratio: 3.5 – 30
Mechler (2004a): Appraisal of risk transfer for public infrastructure in Honduras and Argentina	Reduction in macroeconomic impacts	Positive and negative effect on risk-adjusted expected GDP dependent on exposure to hazards, economic context and expectation of external aid

Source and type of analysis	Actual or potential benefits	Result/return
Mechler (2004b): Prefeasibility appraisal of Polder system against flooding in Piura, Peru	Reduction in direct social and economic and indirect impacts	Best estimates: Benefit/cost ratio: 3.8 IRR: 31% Net Present Value (NPV): US$77.7 million
Mechler (2004c): Research-oriented appraisal of integrated water management and flood protection scheme for Semarang, Indonesia	Reduction in direct and indirect economic impacts	Best estimates: Benefit/cost ratio: 2.5 IRR: 23% NPV: US$45.5 million
EX-POST EVALUATIONS (assessment after implementation of measures)		
Benson (1998): Ex-post evaluation of implemented flood control measures in China over the last four decades of the 20th century	Reduction in direct damages to property and agricultural land	US$3.15 billion spent on flood control have averted damages of about $12 billion
ICRC (2002): Ex-post evaluation of implemented *Red Cross mangrove planting project* in Vietnam for protection of coastal population against typhoons and storms	Savings in terms of reduced costs of dike maintenance	Annual net benefits: US$7.2 million. Benefit/cost ratio: 52 (over period 1994-2001)
Venton & Venton (2004) Ex-post evaluations of implemented combined disaster mitigation and preparedness programme at the community level in Bihar, India and Andhra Pradesh, India	Reduction in direct social and economic, and indirect economic impacts	Bihar: Benefit/cost ratio: 3.76 (range: 3.17-4.58) NPV: US$814,000 (US$55,000-129,800) Andhra Pradesh: Benefit/cost ratio: 13.38 (range: 3.70-20.05) NPV: US$46,200 (US$8,800-74,800)
ProVention (2005): Ex-post evaluation of *Rio Flood Reconstruction and Prevention Project*, Brazil. Construction of drainage infrastructure to break the cycle of periodic flooding	Annual benefits in terms of avoidance of residential property damages.	IRR: > 50%

Note: This summary was provided by Mechler (2005)

There is, however, large variation in the methodologies employed and considerable uncertainty involved in these estimates. For instance, only some of the studies account for the probabilistic nature of natural disaster risk.

The studies covered in *Table 2.2* can be found from the references listed separately in the *Bibliography*, whilst more detail on the study of a Disaster Management Programme in Bihar (India) is provided in *Annex B*.

3 *DISASTER RISK REDUCTION MEASURES*

3.1 *INTRODUCTION*

Decisions to allocate resources to DRR tend not to be based on associated costs and benefits of these measures. Even if investment is made in DRR measures, it is often the case that the most cost-effective options are not chosen.

Outlining the benefits of risk reduction in terms of damages avoided and other associated benefits can help change such attitudes. Cost benefit analysis (CBA) can be used in this way to asses the likely costs and benefits of DRR measures, mostly at the project level eg construction of flood defence facilities, strengthening roots of banana trees, retrofitting buildings etc.

This section presents the various levels of disaster risk reduction measures followed by a description of the benefits of implementing DRR measures, as well as ways in which to estimate these benefits.

3.2 *TYPOLOGY OF DISASTER RISK REDUCTION MEASURES*

DRR measures consist of policy and planning as well as physical components. *Policy and planning* measures are implemented at the national or regional level and help to integrate DRR into the policy framework. *Physical measures* are designed to reduce the vulnerability and exposure of infrastructure to natural hazards (prevention) as well as to provide coping and adaptive infrastructure in case of a disaster event (coping / adaptive). Increasing importance is given to measures that are designed and implemented at the community level, particularly the strengthening of communities to better respond and cope to a disaster event through training and *capacity building*.

Examples of these types of DRR measures include:

- *Policy and planning*: eg institutional, policy and capacity-building measures designed to increase the abilities of countries to manage disaster risks.
- *Physical (prevention)*: eg building sea-walls as part of flood defence mechanisms.
- *Physical (coping / adaptive)*: eg flood shelters for use during a disaster event.
- *Capacity building (at the community level)*: eg developing a disaster preparedness committee.

Annex C provides a more detailed account of DRR measures categorised in this way for flooding, cyclonic wind and drought disaster events. Furthermore, for each DRR measure a description of the associated costs of implementing these measures is provided.

3.3 THE BENEFITS OF DISASTER RISK REDUCTION MEASURES

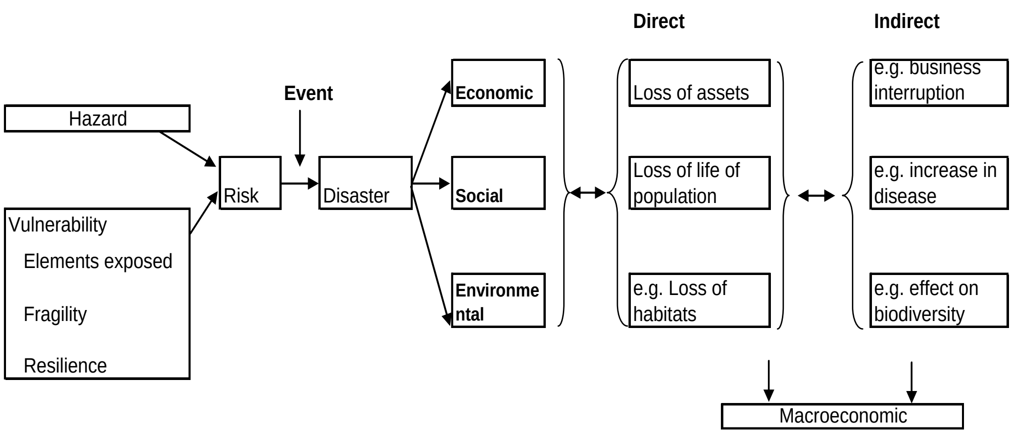
3.3.1 *Overview*

The impacts of disasters on a country's growth rate and incidence of poverty (as demonstrated in *Section 2* above) may be so substantial that action to reduce risk to disasters can have a high return. Therefore the benefits of DRR can be seen as equivalent to the *avoided costs* of disasters. Moreover, DRR measures are seldom implemented in isolation, and also have the potential for deriving *additional* development benefits.

3.3.2 *Avoided Costs*

The avoided costs through DRR measures can be classified into economic, social and environmental impacts. These impacts are also triggered directly by the event or occur over time as indirect or macroeconomic effects. *Figure 3.1* below illustrates the range of costs that can be avoided through effective DRR. The figure is based on Mechler (2005), and has been modified slightly in order to incorporate the cross-correlations between the economic, social and environmental impacts.

Figure 3.1 Natural Disaster Risk and Categories of Potential Disaster Impacts



Source: Adapted from Mechler (2005)

Economic impacts are experienced through the damages or destruction to assets or "stocks", resulting from the disaster itself, or from events in the aftermath of a disaster. In the household sector, the main loss is the damage to houses and apartments and building contents. In the public sector the main impacts are on facilities such as schools, health facilities and other infrastructure such as transport (roads, bridges) and irrigation, drinking water, sewage installations and electricity. In the business sector there are damages to buildings, but most important is the loss of machinery and other productive capital. Indirect effects refer to the impacts on the output of goods and services, for example lower output from factories that have been destroyed or damaged.

Social impacts may affect individuals or have a bearing on the societal level. Most relevant direct effects are: the loss of life, people injured and displaced and loss of or damage to important cultural and heritage sites. Main indirect social effects are: increase of diseases (such as Cholera and Malaria), increase in stress symptoms or increased incidence of depression, disruption in school attendance, disruptions to the social fabric and loss of social contacts and relationships.

Environmental impacts tend to fall into two categories. The category concerns the environment as a provider of goods or services – for instance water for consumption or irrigation purposes, soil for agricultural production. The second category relates to the environment as creating non-use or amenity values based more on more ethical reasons. Effects on biodiversity and natural habitats fall into this category where there is not a direct, measurable benefit. Note that these impacts are also interlinked. For instance, damage to soil or water resources can lead to economic impacts, particularly if sources of livelihood come from natural assets, eg fishing and agriculture.

3.3.3 Additional Benefits

Disaster risk management projects may have other additional benefits. For example, flood protection structures can also yield additional benefits such as the provision of irrigation or drinking water and electricity. In the case of the Polder in Piura (along the northern coast of Peru), flood waters diverted into the Polder retention basin are to be used for irrigation purposes in an area that generally lacks sufficient irrigation. In Semarang (Java Island, Indonesia), a dam is planned upstream of a major river for flood control purposes, but will also provide water and will act as a source of electricity through hydroelectricity generation (Mechler, 2005).

Other examples of the additional benefits of DRR measures include:

- Improvements in networks and linkages across civil society, as a way to strengthen the capacity to respond to natural disasters, can also have the more long term added benefit of improved governance and more organised society.

- Proper planning processes, to prevent development on flood planes or the creation or development of unstable slopes, are more likely to be able to deliver basic necessities, such as potable water, drainage/sewerage, power and community facilities, than informal settlement activity.

- Shelters, such as the raised flood shelters constructed in Bangladesh, can serve as community facilities (eg schools or clinics) for the majority of the time when natural disasters are not occurring.

- The improvement of water supply systems in rural areas. These improvements are part of DRR programmes aimed at ensuring sufficient potable water supply during floods or droughts. The additional benefits are that water supply is improved regardless of a disaster event occurring.

- The construction and use of drainage pumps as an example of strengthening the capacity to cope with floods, has the added advantage of improving irrigation practices for instance, possibly leading to more efficient and effective agricultural practices.

- Community based disaster preparedness often emphasises the important role of women. This has the added benefit of improving women's involvement in community level activities.

- Installing more resilient wireless (rather than fixed lined) communications plays a more general role in enhancing access to telephony and electronic data services, which has been shown to have positive socio-economic development impacts (see papers in Vodafone, 2005).

- Training farmers to diversify the use of crops, as a strategy to survive droughts, can have the added advantage of generally reducing vulnerability to poverty.

- Better monitoring of food supplies (as a preparedness strategy to droughts) has the added advantage of improving the food supply chain and possibly making it more cost-effective.

3.4 *ESTIMATING THE BENEFITS OF DRR MEASURES*

3.4.1 *Overview*

Estimating the benefits of DRR measures will inevitably entail an assessment of the damage costs of disasters, ie the benefits of DRR measures equates to the 'avoided' cost of disasters. There are a number of techniques available to estimate the economic, social and environmental impacts of disasters. The 'avoided costs' are then estimated as a proportion of these, depending on the extent to which the DRR measures actually avoid these costs.

3.4.2 *Economic Effects*

Assessments of direct economic effects are usually based on estimates of the damage incurred to buildings and infrastructure etc. These assessments are usually applied by local, regional and national governments, industry and commercial groups and disaster management authorities. Macro-level estimates for these are already provided in *section 2.2* above.

Assessing indirect economic effects is more problematic because, in most cases, it would require an assessment conducted over time, eg during a 5 year time period after an event. These indirect effects can be estimated after an event by taking a *bottom-up* approach to assessing indirect effects, possibly involving surveys after the event, of available data or on the people and businesses affected.

3.4.3 *Social Effects*

Social impacts are more difficult to estimate. These would involve at the very least the loss of life and injury. Attempts have been made to assess the value of statistical life (VOSL), using various methods such as assessing the willingness to pay for avoiding premature death, costs of dealing with fatal accidents and revealed preference studies, where real world trade-offs between cost and risk reduction are observed. In terms of injury, one approach is to estimate the number of days lost from work, and thus the level of income foregone as a result of the injury. Treatment costs are also typically included.

A major issue resulting from this analysis is the different values estimated between developed and less-developed countries. The estimates are based on willingness to pay which is (stated or revealed) and cost of accidents. As values are partly related to income (ie ability to pay), estimates are likely to vary significantly from country to country. Many would argue that these differences are unjustifiable from a moral or ethical point of view, as they may imply that a life in one country is worth less than a life in another.

3.4.4 *Environmental Effects*

Environmental effects of disasters are generally difficult to attach a monetary value to, given that environmental goods and services often are not traded in the market place. However, the environment has both use and non-use values:

- *Use values*: the environment as a provider of goods and services for human consumption, eg food, water, recreation, maintaining biodiversity

- *Non-use values*: these consist of an option value (the environment may have future value either as a good or a service), existence value (value of knowing a certain species exists), and bequest value (knowing that something will exist for future generations).

Use values can be estimated by providing a value for the goods and services lost due to a disaster event. If these are items traded in the market place then the market price can be used as a proxy of the value of environmental goods and services. For services not traded in the market place, eg recreational value derived by the natural environment, and non-use values eg value of knowing that a certain species will not become extinct, these can be estimated through a more survey-based approach such as contingent valuation method (CVM).

3.4.5 *Scenarios for Estimating the Benefits of DRR Measures*

The aim in this section is to identify ways in which the benefits of DRR measures at the project level can be estimated, by providing a range of scenarios. These are based on interviews with key NGOs involved in DRR activities, as well as a review of the available literature.

A range of potential DRR scenarios for floods, cyclonic winds and droughts are presented in the following tables, which include:

- A description of the DRR measure.
- A description of the possible methods employed in order to estimate benefits of DRR measures in monetary terms.

The aim is to provide an outline assessment of the types of appraisal tools that could be adopted for *ex-ante* economic assessments. At this stage, given the number of 'real' case studies we have identified, we have not sought to develop hypothetical cases as we considered that this would add little value.

Table 3.1 Building a Sea Wall

Potential Benefits ('avoided cost')	**Methods to quantify benefits**
Loss of life	• Value of a Statistical Life (VOSL)
Injury and Illnesses	• Medical expenses • Lost in wages through time spent out of work
Reduction in economic activity	• Estimate loss in earnings by comparison of forecast economic activity (without disaster), and actual economic activity in the event of a rise in sea level
Damage to the environment	• Contingent Valuation Method, eg to estimate the recreational value of a coastal area
Damage costs	• Replacement costs • Value of time spent during clean up
Emergency services costs	• Necessary provision of equipment and people • Incident specific costs (staffing, fuels, materials)

Table 3.2 Retrofitting Buildings to Prevent Damage from Floods

Potential Benefits ('avoided cost')	**Methods to quantify benefits**
Damage to property	• Value of damaged property
Loss of household possessions	• Compare damage to goods with and without retrofitted buildings
Injury and Illnesses	• Medical expenses • Lost in wages through time spent out of work
Reduction in economic activity (for commercial buildings)	• Loss in earnings, eg from estimated drop in number of customers
Clean-up	• Estimate the cost of labour and material for clean-up
Emergency services costs	• Necessary provision of equipment and people • Incident specific costs (staffing, fuels, materials)

Table 3.3 Cyclone Shelters

Potential Benefits ('avoided cost')	Methods to quantify benefits
Avoid loss of life	• Value of a Statistical Life (VOSL)
Avoid injury and illnesses	• Medical expenses • Lost in wages through time spent out of work
Greater sense of security	• (very difficult to quantify)
Emergency services costs	• Necessary provision of equipment and people • Incident specific costs (staffing, fuels, materials)

Table 3.4 Crop Diversification, to Better Cope with Droughts

Potential Benefits ('avoided cost')	Methods to quantify benefits
Avoid losses in livelihood, for income and subsistence	• Estimate losses in income by comparison with baseline data • Increases in medical costs • Lost earnings through illness
Avoid loss of life	• Value of a Statistical Life (VOSL)

These outlined scenarios suggest that cost-benefit approaches could be used for each of the scenarios and, presumably, for many more. The DRR measures identified have been taken from actual programmes on the ground (often sponsored by DfID money), suggesting that robust case studies of DRR measures should be possible.

4 *CASE STUDIES FOR ESTIMATING THE EFFECTIVENESS OF DRR PROGRAMMES*

4.1 *INTRODUCTION*

The aim in this section is to estimate the extent to which DRR programmes reduce the impacts of natural disasters, through case studies examining the effectiveness of DRR programmes in managing the impacts of cyclonic winds and earthquakes.

In order to isolate the contribution of DRR measures to any reduced impacts of disasters, it is important to chose two similar countries (in terms of population density) that have been subjected to the same (or similar) disaster events so that the reduced impacts cannot be attributed to any other factors. However, this is not always possible given that the characteristics of natural disasters as well as the countries affected by them vary considerably. Therefore, it is useful to identify three alternate approaches to the analyses:

1. A comparison of the impacts of a given disaster across two countries, one with poor DRR measures and one with well developed DRR measures;

2. A comparison over time of several disaster events in one given country, where DRR measures have been developed over that time period; and/or

3. A comparison of two similar disaster events in two separate but similar countries.

This analysis is largely descriptive, although quantitative data on the impact of disasters and the effectiveness of DRR measures have been presented where possible. The objective in each of the case-studies is to analyse the following:

- The nature of the disaster event and the country (or countries) affected by it;

- The impact of the disaster event, in terms of loss of life, people displaced, human health as well as economic and longer term development impacts; and

- A description of DRR measures put in place before the disaster event (ex-ante DRR measures), as well as an outline of the costs of implementing these, where possible.

The following sections present case studies for two types of disaster – cyclonic winds and earthquakes – which have been selected as examples. The approach taken is based where possible on one of the three approaches outlined above, depending on the nature of the disasters, the countries affected and the data available.

4.2 CYCLONE PREPAREDNESS PROGRAMME IN BANGLADESH

4.2.1 *The Impact of Cyclones in Bangladesh*

A total of 119 million people are exposed every year to tropical cyclones, which in some countries can occur more than four times a year. Such events caused more than 250,000 deaths worldwide between 1980 and 2000. A total of 84 countries are exposed to tropical cyclones, with the countries most at risk having highly populated coastal areas and deltas, such as Bangladesh, China, India, the Philippines, and Japan (UNDP, 2004). Even though some countries are exposed to similar cyclonic events, the differences in terms of the loss of life can be significant. For instance, Hurricane Andrew struck Florida in 1992 with 23 people loosing their lives. Whereas a similar tropical wind storm hit Bangladesh in 1991, resulting in 100,000 deaths and the displacement of millions of individuals from widespread flooding (Adger et al, 2005).

A very large proportion of the population of Bangladesh is exposed to tropical cyclones, particularly the heavily rural communities along the fertile delta at the head of the Bay of Bengal. Bangladesh accounts for more than 60 percent of the total registered deaths in the period 1980-2000 (UNDP, 2004:37). In particular, only 5 percent of cyclones form in the Bay of Bengal, but loss of lives and property is about 85 percent of the global total (Bangladesh Red Crescent Society, 2001).

The cyclone of 1970 took the lives of 300,000 people but the cyclone of the same intensity of 1991 killed 138,000 people, and the cyclones of 1997 and 1998 resulted in only 111 and 19 deaths respectively, as shown in *Table 4.1*.

Table 4.1 *Impact of Cyclones in Bangladesh*

Year	Scale	Deaths	Affected / Displaced	Total Damages (US$ ' 000s)
1970	Similar to 1991 and 1997	300,000	3,648,000	86,400
1991	235 kmph	138,000	15,438,849	1,780,000
1997	250 kmph	111	3,052,738	Not available
1998	150 kmph	19	108,944	Not available

Source: Bangladesh Red Crescent Society (2001) and EM DAT www.em-dat.net
Note: The cyclones of 1970, 1991 and 1997 were of the same intensity

4.2.2 *The Bangladesh Cyclone Preparedness Programme (CPP)*

In response to this the devastating impact of cyclones in Bangladesh, a cyclone preparedness programme was developed in 1970, following a major cyclone and ensuing storm surge in that year. This was launched by the International Federation of Red Cross and Red Crescent Societies (IFRC), the Bangladesh Red Crescent Society, and the Government of Bangladesh. The major components of the programme include cyclone shelters, early warning systems and community-based preparedness measures. It is widely claimed that the programme has dramatically reduced Bangladesh's vulnerability to cyclones.

The CPP presently covers eleven Districts in the coastal area and can send warning signals to approximately eight million people living there, of whom four million people can be assisted by the CPP.

The annual operating cost of the CPP is US$460,000 (of which the government of Bangladesh contributes 56% and the International Federation of Red Cross 44%). The cost of constructing a cyclone shelter is approximately US$78,000, with running costs of US$780 per year (Bangladesh Red Crescent Society, 2001).

It is difficult to attribute any apparent reductions in the impacts of similar disaster events to the disaster risk reduction programmes. However, there has been a considerable reduction in the impact of cyclonic winds in Bangladesh since 1970, which is when the CPP was first implemented. The major cyclonic winds of 1997 was almost the same scale as the 1970 cyclone, except that there was a fully functioning network which assisted with evacuation, allowing one million people to take refuge in shelters before the cyclone hit. This drastically reduced the number of casualties as demonstrated in *Table 4.1*.

4.3 DISASTER RISK MANAGEMENT IN CUBA

In order to assess the extent to which some countries are better equipped to deal with hurricanes, two similar hurricanes and their associated impacts are compared across Cuba and Honduras(1).

In 1998 Hurricane Mitch had a devastating impact on Honduras, in terms of the death toll, people affected and the damage costs (see *Table 4.2* below). Nearly one third of the highway network was affected, with cities and productive centres being left isolated, and thousands of households were destroyed.

Table 4.2 Comparison between Honduras and Cuba

	Honduras (Hurricane Mitch 1998)	**Cuba (Hurricane Michelle 2001)**
Speed of Winds (km/per/hour),	270	250
Total number killed	14,600	5
Total number affected(2)	2,112,000	5,900,012
Damage estimate (US$ '000)	$3,793,600	$87,000
Source: EM DAT		

(1) Note that a comparison of the impact of Hurricane Mitch on both Cuba and Honduras was not selected due to the lack of comparable data.
(2) Total number affected is the sum of the injured, affected (ie people requiring immediate assistance after a disaster) and left homeless.

In contrast Hurricane Michelle, a hurricane with similar intensity which hit Cuba in November 2001, had much less of an impact even though it was the worst hurricane to hit Cuba since 1944. Almost half of the Cuban territory was affected, with resulting impacts on people and physical assets as described summarised in *Table 4.2* above.

The impact of the hurricanes between the two countries is strikingly different with impacts in terms of fatalities, the number of people affected and the damage cost estimates in much higher magnitudes for Honduras than for Cuba. Furthermore, it is interesting to note that the ratio between the number killed and the number affected is considerably lower in Cuba as compared to Honduras. This could demonstrate how quickly people are evacuated to safer areas, and therefore the effectiveness of disaster management programmes. In fact about 700,000 people were evacuated to more safe areas as a result of disaster planning and preparedness (IFRC, 2002).

These statistics reflect favourably on Cuba's ability to respond to natural disasters. This is largely to the presence of a well established disaster management programme, and a full time disaster management coordinator. Moreover, early warning systems are well developed, with public announcements being made on television in advance of hurricanes – these announcements are often made by the President.

4.4 EARTHQUAKES

4.4.1 Introduction

Estimating the extent to which DRR measures have reduced the devastating impact of earthquakes is more difficult, for the following reasons:

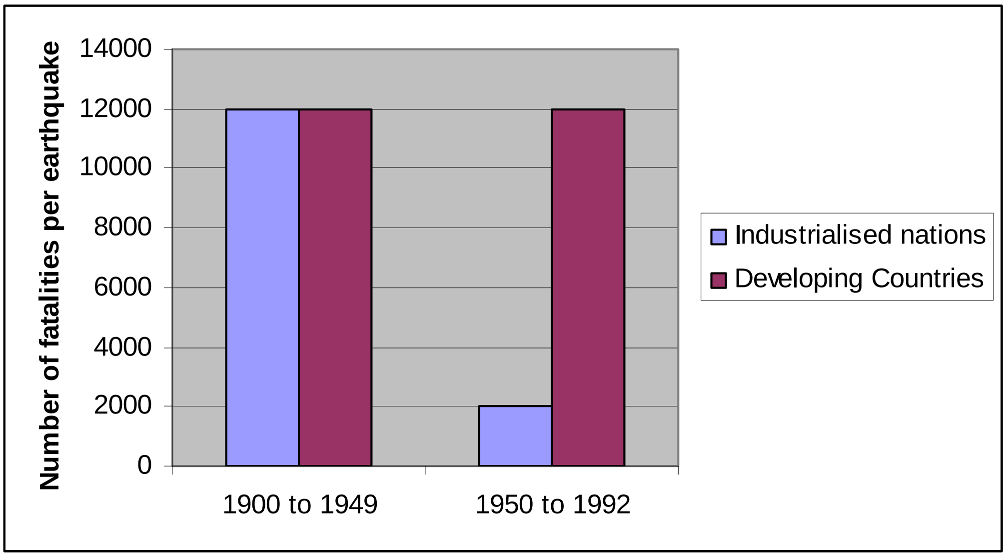
- They occur randomly (cyclonic winds happen frequently and to some extent there is a pattern);
- Most comprehensive DRR programmes are implemented after a major earthquake, and therefore there is little evidence to link DRR measures with reduced impact; and
- Even if same earthquakes are found of the similar scales, the impacts vary according to a variety of factors such as underlying geology and what areas are affected, ie very densely populated not, therefore making it difficult to find like-for-like comparisons.

However, there are some studies which provide some interesting analyses and data.

4.4.2 *Effectiveness of Earthquake Engineering in Industrialised Nations*

Over the last century, the average number of deaths per fatal earthquakes in the United States and Japan plunged, while for earthquakes in developing countries this has remained relatively high. *Figure 4.1* shows that both developing and industrialised nations suffered approximately twelve thousand deaths per lethal earthquake in the first half of the 20th century, although this dropped significantly for industrialised nations in the latter half of the century, with no corresponding decreases for developing nations (GeoHazards International, 2001).

Figure 4.1 ***Number of Fatalities Per Earthquake***



Source: GeoHazards International (2001)

One explanation for the difference is that very little of the world's spending on earthquake engineering research is aimed at the needs of developing countries. Earthquake engineering involves the study of how to reduce the impact of earthquakes through the improvement of the design of building and structures. It is estimated that over the last 50 years only 15 percent of the world's annual earthquake engineering research focused on the needs of developing countries (Tucker et al, 1994). Partly as a result, engineering solutions to earthquake risks tend to be expensive, and require strong enforcement through buildings control or planning regulations, which are often weak or absent in developing countries.

5 POTENTIAL FURTHER RESEARCH

At the request of DfID, ERM has set out some general recommendations for potential future research in this area. The recommendations are presented in the context of an increasing flow of development-related resources into DRR measures.

- It is early days in terms of assessing the effectiveness of DRR measures – data are limited and it is very difficult to make like-for-like comparisons. There may therefore be scope for developing core indicators of performance and a standard typology of disasters to enable a better assessment of both baseline trends and the performance of DRR measures.

- More information on the extent to which ex-ante DRR measures reduce the impact of disasters is needed. This could take the form of a "ready reckoner", which would take account of factors such as nature of hazard, the number of persons affected, local geography etc to help identify or prioritise appropriate types of DRR measure.

- Similarly, a manual for simplified project appraisal at DRR project level may be useful to help those implementing DRR measures to select the best options, and to help programme sponsors evaluate expenditure (NGOs consulted during the course of this study have expressed an interest in this).

- An analysis of which DRR measures also yield significant non-DRR development benefits (or costs), and the extent to which they do so, could potentially help mainstream DRR into other development programmes.

- The role of the private sector in DRR and disaster management could also yield useful lessons. For example, the majority of major extractive and manufacturing industry sites have DRR measures and disaster management plans for site related disasters (normally referred to as technical disasters in the NGO and development literature on disasters). There may be opportunities to partner with private firms to provide a level of DRR that may not possible with public funds only.

- More guidance on disaster proofing critical social and economic infrastructure (such as hospitals, emergency services, key transport routes and telecommunications) would be useful. Methods of disaster proofing, and assessment of the costs and benefits of protecting critical infrastructure are the subject of much debate within the DRR community at present.

BIBLIOGRAPHY

Adger et al (2005) "Social-Ecological Resilience to Coastal Disasters" 12 August 2005, Vol 39, Science www.sciencemag.org

Athukorala P. & B. Resosudarmo (2005) "The Indian Ocean Tsunami: Economic Impact, Disaster Management and Lessons". Forthcoming in Asian Economic Papers.

Bangladesh Red Crescent Society (2001) Cyclone Preparedness Programme (CPP) at a Glance. CPP Brochure, Edited by Abdul Wahid Miah. Dhaka, 2001.

Benson C. & E. Clay (1998) "The impact of drought on sub-saharan african economies: a preliminary examination" Technical Paper No. 41, World Bank, Washington, D.C.

Benson C. & E. Clay (2004) "Understanding the economic and financial impacts of natural disasters". Disaster Risk Management Series, No. 4. IBRD/WB, Washington D.C.

Botolo B. (2005) "Macroeconomic shocks and policy responses: the case of Ghana ." Ministry of Economic Planning and Development, Accra

Department for International Development (2004) "Disaster risk reduction: A development concern. A scoping study on links between disaster risk reduction, poverty and development" DFID, London

Centre for Research on the Epidemiology of Disasters (CRED) 'Emergency Disaster Database' http://www.em-dat.net/

GeoHazards International & United Nations Centre for Regional Development (2001) "Global Earthquake Safety Initiative (GESI) Pilot Project"

International Federation of Red Cross and Red Crescent Societies (2003) World Disasters Report, 2003. Kumarian Press, Bloomfield

International Monetary Fund (2005) "Preliminary Assessment of the Macroeconomic Impact of The Tsunami Disaster on Affected Countries, and of Associated Financing Needs." Prepared by the International Monetary Fund in cooperation with the World Bank, February 4, 2005

McKenzie, E. J., Prasad, B. C., Kaloumaira, A. (2005) "Economic impact of natural disasters on development in the Pacific. Volume 1: Research Report". Joint Contribution Report 179a. University of the South Pacific, South Pacific Applied Geoscience Commission, Australian Agency for International Development

Mechler R. (2005) "Cost-benefit Analysis of Natural Disaster Risk Management in Developing Countries" Working paper for sector project "Disaster Risk Management in Development Cooperation", GTZ.

Tucker, B., G. Trumbull, and S. Wyss (1994) "Some Remarks Concerning Worldwide Urban Earthquake Hazard and Earthquake Hazard Mitigation." In *Issues in Urban Earthquake Risk*, edited by B. E. Tucker *et al*. Dordrecht, Netherlands: Kluwer Academic Publishers.

Twigg, J. (2002) "Lessons from Disaster Preparadness" Benfield Greig Hazard Research Centre, University College London

United Nations Development Programme (2004) "Reducing Disaster Risk: A Challenge for Development", UNDP, New York.

UNESCAP (1998) "Integrating environmental considerations into the economic decision making process: Bangladesh". UNESCAP, Bangkok, www.unescap.org/drpad/publication/integra/modalities/bangladesh/4bl00 0ct.htm

World Bank (2004) "Natural disasters: counting the cost" Feature story 2nd March 2004, www.worldbank.org

World Bank (2005) "Natural Disasters Hotspots: A Global Risk Analysis" IBRD, WB and Columbia University, Washington

Items in Table 2.2 on Cost Benefit Analysis

Benson, C. (1998). The cost of disasters. Development at Risk? Natural Disasters and the Third World. J. Twigg (ed.). Oxford, Oxford Centre for Disaster Studies, UK National Coordinated Committee for the International Decade for Natural Disaster Reduction (IDNDR): 8-13.

Dedeurwaerdere, A. (1998). Cost-benefit Analysis for Natural Disaster Management - A Case-study in the Phillipines. Brussels, Belgium, CRED

FEMA (1998). Protecting Business Operations: Second Report on Costs and Benefits of Natural Hazard Mitigation. Washington, DC: Federal Emergency Management Agency, August.

IFRC (2002). World Disasters Report 2002. Geneva, IFRC.

Kramer, R. A. (1995). Advantages and Limitations of Benefit-Cost Analysis for Evaluating Investments in Natural Disaster Mitigation. Disaster Prevention for Sustainable Development: Economic and Policy Issues. M. Munasinghe and C. Clarke. Washington DC, The International Bank for Reconstruction and Development/The World Bank: 61-76.

Mechler, R. (2004a). Natural Disaster Risk Management and Financing Disaster Losses in Developing Countries. Verlag fuer Versicherungswissenschaft, Karlsruhe.

Mechler, R. (2004b). Piura case study. Interim report for GTZ.

Mechler (2004c). Semarang case study. Interim report for GTZ.

ProVention Consortium (2005). Successful disaster prevention in LAC. http://www. proventionconsortium.org/goodpractices/

Venton, C & P. Venton (2004). Disaster preparedness programmes in India. A cost benefit analysis. Humanitarian Practice Network, ODI, London.

Vermeiren, J. et al. (1998). Costs and Benefits of Hazard Mitigation for Building and Infrastructure Development: A case study in small island developing states. Conference of The International Emergency Management Society.

Vodafone (2005). Africa: The Impact of Mobile Phones. Vodafone Public Policy Paper Series, Number 2. www.vodafone.com/africa

World Bank (1996). Staff Appraisal report: Argentina Flood Project. Washington DC, World Bank.

Annex A

The Economic Impact of the Asia Tsunami

The 2004 Tsunami was the most significant natural disaster to take place in Asia in recent years. The estimated number of people dead and missing was 300,000 and approximately 1.5 million people were displaced. This section summarises the findings of an IMF and WB preliminary assessment of the likely macro-economic impacts of the disaster (IMF, 2005). These are mostly 'direct' impacts as defined above. *Table 1.1* provides a summary of the cost of the Asian Tsunami, focusing on some key indicators economic and other indicators.

Table 1.1 The Cost of the Asian Tsunami: Key Indicators

Key Indicators	
Indonesia	
Number of people dead (and missing)	225,000
Number of people rendered homeless	425,000
Damage estimate (US$ billion)	$4-5
Maldives	
Number of people dead (and missing)	107
Damage estimate (US$ million)	$406
India	
Number o f people dead (and missing)	16,800
Number of people displaced	500,000
Damage estimate (% of GDP)	0.25%
Sri Lanka	
Number of people dead (and missing)	37,000
Number of people affected (million)	1-2
Damage estimate (US$ billion)	$1.0
Damage estimate (% of GDP)	4.5%

GDP growth rates are shown in *Table 1.2* for the years before and after the Tsunami. Although there are many factors that contribute to GDP growth rates, it is clear that reported growth rates declined soon after the Tsunami. There are also reported increases in GDP eg Maldives. Care must be taken in drawing any conclusions about the economic welfare benefits of these reported increases. These increases are likely to be the result of dramatic increases in reconstruction spend and foreign aid, and therefore do not necessarily reflect net changes in productive assets.

Table 1.2 *GDP growth before and after the Asian Tsunami*

	2004	**2005 (Pre-tsunami estimate)**	**2005 (Post-tsunami estimate)**	**2005 Decline in GDP growth** (1)	**2006**
Indonesia	5.0%	5.5%	5.25 – 5.5%	**0-0.25%**	6.0%
Maldives	8.8%	6.5%	1.0%	**5%**	9.0%
Sri Lanka	5.2%	6.0%	5.3%	**0.7%**	6.0%

In *Indonesia* the damage estimate is $4 to $5 billion. 60 percent of this constitutes damage costs (direct costs) and 40 percent to losses in terms of income flows to the economy (indirect costs) (Athukorala & Resosudarmo, 2005). However, overall macro-economic impact and growth is likely to be limited. This is largely due to the increased reconstruction spend, much of it financed from abroad, which will off-set the negative supply-side effects. Furthermore, Aceh accounts for only 2 percent of national GDP, and the oil and gas sector (which accounts for almost half of regional GDP) was not damaged. At the national level, the net impact, including the effect of reconstruction spending is estimated to reduce GDP growth by between 0 to 0.25 percentage points, with inflation remaining at around 6 percent.

The economic impact in the *Maldives* is likely to be substantial with the destruction of 14 of about 200 inhabited islands, around 5 percent of the population losing their homes, one-quarter of tourist resorts being closed, and 8 percent of fishing boats being damaged. Tentative estimates suggest a decline in GDP growth of over 5 percentage points. Revenue losses, including from tourism taxes and import duties, are anticipated to be about 5 percent of GDP and reconstruction costs borne by the government are estimated at 13 percent of GDP in 2005. Net losses to the balance of payments are estimated at around $160 million (19 percent of GDP).

In India, the economic impact is expected to be limited at a national level – only a small portion of the country was affected and because the affected regions were non-industrial.

In Thailand estimates of physical damage are about $0.8 billion (0.5 percent of GDP), although the macro-economic impact is likely to be limited.

In the Seychelles estimated damage to physical infrastructure and private property is estimated to be around $33 million (5 percent of GDP). Similarly the impact on growth is expected to be limited. This is due to reconstruction spend largely off-setting losses in the tourism sector.

(1) Compared to pre-tsunami estimate for 2005

Annex B

Cost-benefit analysis of Disaster Mitigation and Preparedness (DMP) in Bihar

The objective of this study was to analyse the net benefits resulting from Disaster Mitigation and Preparedness (DMP) interventions against flooding in the Dharbanga District of Bihar, so as to assess the cost-effectiveness of these interventions (Venton and Venton, 2004).

The DMP consisted of a mix of physical interventions and capacity-building as follows:

- Physical: construction of an escape route; provision of boats for evacuation; installation of raised hand pumps

- Capacity building: establishment of a Village Development Committee, as well as smaller groups, eg a village rescue and evacuation team, a flood evacuation centre management group etc

Village development funds were created through contributions from households. These were deposited into a local bank and supervised by the committee. Funds were used for boat repairs and medical treatment for example.

Cost-benefit analysis was applied to the DMP programme of interventions. The net benefits are derived from a comparison of two scenarios: 'without' and 'with' DMP.

Data were collected by holding a series of focus group sessions to assess the impacts of flooding (based on Tearfund's Participatory Disaster Risk Assessment methodology), and how these impacts had changed with the implementation with DMP intervention. Local NGOs were also used as a key source of data for both costs and benefits of DMP interventions. NGOs provided fixed and variable cost data for their DMP programmes, as well as contributed to the 'without' DMP scenario.

Qualitative costs and benefits of the DMP interventions were identified first, and where feasible these were quantified. Total fixed costs for the DMP programme were estimated at US$8,250, with total yearly variable costs at US$5,005.

Table 1.1 *1.1* provides a description and an estimation of the benefits of the DMP interventions. The benefits were estimated by comparing 'with' and 'without' scenarios of DMP interventions. For instance, raising the hand-pumps was part of the DMP – the idea being to maintain adequate access to water supplies in the event of a flood. The benefits were derived from the fact that no repairs would be needed, compared with 20 percent of villages having to repair the hand-pumps in the event of a flood.

Table 1.1 Quantifying the Benefits

Impact	Magnitude 'without'	Magnitude 'with'	Value	Total yearly benefit (avoided cost)
Raised hand pumps	20% of villages have to repair government hand pumps, others are able to clear through pumping	No villages have to repair DC pumps	Rs6,500 repair costs per government hand pump	Rs39,000 / US$858
Reduced loss of household possessions	All villages affected. 40% of households within each village lose household goods	No household possessions lost	Rs600 per household	Rs129,600 / US$2,851
Reduced loss of tools	Approx 50% of the villages own their own tools, and about 40% of HH lose their tools in the flood*	No tools lost	Rs100 per household	Rs10,800 / US$237
Reduced loss of livestock	Approx 75% of households have at least one goat, and 20% have a buffalo. About 5% is lost in the flood (drowning)**	No livestock lost	Rs400 – goat Rs7,000 – buffalo (replacement values)	Rs45,900 / US$1,010
Reduced loss of life	10 people on average across all 5 villages	1 person across all 5 villages	Daily average wage rate – Rs35	Rs329,249 / US$7,243
Reduced injuries	10% of all people suffer injury†	No one suffers injury	Rs25 per injury requiring bandage and injection, Rs10 bandage only. Assume 50/50 split	Rs4,202 / US$92
Boat rental	Approx 80% of villages have to rent boat for evacuation	Boat provided by DC	Boat rental Rs2,500 per month	Rs30,000 / US$660
Total				**Rs588,751 / US$12,953**

Notes:
* It is understood that tools are replaced quickly and, if delayed, landlords normally lend tools for a short period.
Therefore no loss in income is incurred.
** Livestock are typically replaced within the year.
† Severe injuries rarely lead to lost work due to a lack of employment opportunities at this time of year, and therefore no losses to income are incurred.
Source: Venton and Venton (2004)

A benefit-cost ratio for the DMP programme was calculated by discounting the stream of benefits and costs over the 20 years of the programme lifetime, at

3.17, and with a net present value of Rs 2,449,842 (US$53,897). The benefit-cost ratio demonstrates the effectiveness of any given measure, by comparing the costs to the benefits generated by that measure. If the ratio is greater than 1 then the benefits of the measure outweigh the costs (over the duration of the project). The NPV is the difference between benefits and costs, discounted over the duration of the programme.

Separate analyses were carried out for two other interventions: raising the hand-pump and the provision low-interest loans for reconstruction of 'kutcha' homes (made from bamboo and mud walls with thatched or tiled roofs). The analyses provided favourable cost-benefit ratios and NPVs:

- Raising hand-pump (hard measure): cost-benefit ratio of 3.20 and NPV of Rs 228,330 (US$5,023).

Low-interest loans for reconstruction of 'kutcha': a remarkable cost-benefit ratio of 57.80 and NPV of Rs 635,653 (US$13,984)

Annex C

Typology DRR measures and associated costs

Table 1.1 Floods: Typology of DRR measures and associated costs

Flood DRR Measures	Specific DRR Measures	Cost of DRR measures
POLICY & PLANNING *Building the capacity to respond*	• Implement a national plan for protection against flooding, including preparedness and contingency planning	• Costs relating to Institutional and Capacity building of appropriate national, regional and local institutions eg administrative effort, professional advice, communications systems etc
	• Land-use planning that better incorporates risk of flooding	• (as above)
	• Integrated management of flooding and water supply	• Costs relating to technical assistance, institutional and capacity building
	• Development and implementation of Early Warning System (EWS)	• Costs of increasing capacity for predicting extreme events for the relevant authorities, through the design and implementation of an effective EWS
	• Integrated warning and response system	• (as above)
	• Improving networks / links with local governments	• Cost of awareness raising exercises, training etc
PHYSICAL (Prevention) *Reducing exposure to and preventing hazards*	• Flood defences eg Dam (multipurpose, seaborne etc) and sea wall	• Capital investment costs • Maintenance Costs
	• Natural protection against floods eg reforestation of watersheds	• Opportunity costs in relation to reduced earnings from logging
	• Installation of drainage pumps	• Capital investment costs • Maintenance Costs
PHYSICAL (Coping / Adaptive)	• Flood shelters next to schools	• Capital investment costs • Maintenance Costs
	• Flood proofing of latrines and tube wells	• Capital investment costs • Maintenance Costs
	• Raised platforms (equipped with latrines and drinking water)	• Capital investment costs • Maintenance Costs
	• More resilient roads and infrastructure, eg raised buildings and roads	• Capital investment costs • Maintenance Costs
	• More resilient water supply systems, eg boreholes, raised hand-pumps	• Capital investment costs • Maintenance Costs
	• Design and building of contingency mechanisms for coping with floods, eg boats for evacuation, escape roads, temporary shelters	• Capital investment costs • Maintenance Costs
	• Pre-positioning / strategic stock piling of relief material, eg life boats, life jackets, tools, first aid etc.	• Capital investment costs • Maintenance Costs

Flood DRR Measures	Specific DRR Measures	Cost of DRR measures
CAPACITY BUILDING *at Community level*	• Community based disaster preparedness: Communities trained in disaster preparedness, eg through development of disaster response committees • Public warning system (community based) • Safety nets to ensure that poor households can rebuild productive livelihoods (through building on existing programmes) • Revolving funds managed by the community used to better cope in disaster situations, eg for storing and distributing food	• Training costs through technical assistance • Cost of developing community level initiatives / institutions • Costs of increasing capacity for providing warning to the public • Incremental costs to existing public programmes aimed at providing these safety nets • Cost of administering the fund • Cost of training community members to manage the fund

Table 1.2 Cyclones: Typology of DRR measures and associated costs

Cyclones DRR Measures	Specific DRR Measures	Cost of DRR measures
POLICY & PLANNING *Building the capacity to respond*	• Implement a national plan for protection against cyclones, including preparedness and contingency planning	• Costs relating to Institutional and Capacity building of appropriate national, regional and local institutions
	• Development and enforcement of appropriate building codes	• Costs relating to Institutional and Capacity building of appropriate national, regional and local institutions
	• Better links between national and local government units	• Cost of awareness raising exercises, training etc.
	• Early warning systems including public warning system eg radio system which provides reliable communications for pre- and post-cyclone conditions	• Costs of increasing capacity for providing warning to the public
PHYSICAL (Prevention) *Reducing exposure to and preventing hazards*	• Retrofitting buildings for cyclone proofing	• Capital investment costs • Maintenance Costs
PHYSICAL (Coping/ Adaptive)	• Mobile disaster response units (to support national response teams)	• Training costs • Costs of supplies
	• Design and building of contingency mechanisms for coping with cyclones - Building cyclone shelters (possibly double as school or medical facilities)	• Capital investment costs • Maintenance Costs
	• Adequate storage and access of relief material and emergency stocks	• Cost of storage and distribution
	• Pre-positioning / strategic stock piling of relief material eg tools, first aid, food etc.	• Capital investment costs • Maintenance Costs • Human resource costs
CAPACITY BUILDING *at Community level*	• Community based disaster preparedness: Communities trained in disaster preparedness eg through development of disaster response committees	• Training costs through technical assistance • Cost of developing community level initiatives / institutions
	• Evacuation plans, including simulations	• Cost of training and running simulations
	• Revolving funds managed by the community used to better cope in disaster situations eg for storing and distributing food	• Cost of administering the fund • Cost of training community members to manage the fund

Table 1.3 Drought: Typology of DRR measures and associated costs

Drought DRR Measures	Specific DRR Measures	Cost of DRR measures
POLICY & PLANNING *Building the capacity to respond*	• Implement a national plan for protection against drought, eg through more effective Water Resources Management	• Costs associated with the development, implementation and adjustment to relevant national programmes
	• Climate sensitive land-use planning	• Costs relating to Institutional and Capacity building of appropriate national, regional and local institutions
	• Agricultural and food policies which better take account of the likelihood of droughts, eg promotion of crop diversification	• Costs relating to Institutional and Capacity building of appropriate national, regional and local institutions
	• Development and implementation of systems for disseminating climatic information, eg through Meteorological Forecasting and Climate Change	• Costs of building appropriate dissemination mechanisms
	• Monitoring of food supplies eg grain banks	• Costs of training to effectively monitor and evaluate food supplies
	• Financial mechanisms eg Insurance policies against damages and availability of credit markets	• Institutional and capacity building costs
PHYSICAL (Prevention) *Reducing exposure to and preventing hazards*	• Construction of dam	• Capital investment costs • Maintenance Costs
	• Diesel powered water pumps for irrigation from river water	• Capital investment costs • Maintenance Costs
PHYSICAL (Coping/ Adaptive)	• Pre-positioning / strategic stock piling of relief material food and non-food items eg medical supplies	• Capital investment costs • Maintenance Costs
	• Revolving funds used to better cope in drought eg for storing and distributing food	• Cost of administering the fund
CAPACITY BUILDING *at Community level*	• Training farmers to diversify the use of crops - building resilient livelihoods through income diversification projects eg goat rearing, aquaculture	• Costs associated with training and awareness raising • Opportunity cost of moving away from agriculture i.e. potential loss in earnings
	• Improved coping mechanisms through education, training and awareness raising of community members	• Costs of training, workshops, promotional material etc.

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