The importance of measuring the social costs of natural disasters at a time of climate change

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Introduction

Most events, including natural disasters, can be described in a variety of ways. A disaster can be described in terms of the number of deaths, the number of buildings collapsed, tons of food-crops destroyed, the kilometers of roads washed away, the number of bridges lost, tons of soil dumped, tons of topsoil lost, inches of rain accumulated, number of power transmission towers downed, and so on. These are the *descriptors* of such an event. Some of these descriptors refer to damages that will have to be made good, if the social life of the community is to return to normal. Typically the community might seek some outside assistance. After all, that is the defining characteristic of a disaster.

But there is also intrinsic merit in seeking to determine the total *social losses* associated with a particular disaster. However, we suggest an important additional reason: global climate change is likely to increase the severity and frequency of disasters that are climate related (Etkin 1995, 1998; White and Etkin 1997). Thus the cost of disasters will be an important input in the broad measures required for adaptation to climate change. In this paper we argue that for that purpose, existing cost estimation methodologies do not generally provide for a full accounting of disaster impacts, and therefore undervalue the need for adaptation. (Smit 1993; Smith and Tirpak 1989; Watson et. al. 1986; Ross 1996; Rowntree 1993).

The cost estimation methodology recommended by the US National Research Council (NRC) and accepted by the (US) Federal Emergency Management Agency (FEMA) does not take all costs into account and can be improved.

Trends in natural disaster

Disasters are sometimes classified by their country or region of origin. In particular, the distinction between developed and developing countries is useful since the vulnerabilities of these societies tend to be very different. Though the costs of natural disasters has been rising worldwide over the past few decades, the data shows that the loss of life has increased in developing countries, but decreased in developed countries. Generally, developing countries are more vulnerable for a number of reasons, including poverty and an inequality of wealth. In addition, programs in poor countries to share risk such as insurance or government disaster assistance are not well developed. Moreover, development often takes place without consideration of risks resulting from natural hazards, and their infrastructure is often less resilient. Thus while Hurricane Andrew in 1992 killed 62 people and cause damage of US$27 billion, mostly in the US, Hurricane Mitch killed an estimated 11 000 people in Central America and caused damage estimated to be only US$5 billion (Lighthill et al 1997).

In 1998, according to the World Bank, natural disasters killed more than 50,000 people and destroyed $65 billion worth of property and infrastructure (see Wolrd Bank web site). Some 95 percent of disaster-related deaths occurred in developing countries, where the poorest of the poor are the worst affected. The World Bank has lent more than $19 billion for post-disaster reconstruction over the last 20 years, often more than once to the same country after successive disasters. The 1998 flooding of the Yangtze River in China was the most costly disaster of the year, claiming 4,150 lives, affecting 223 million people and causing $30 billion in damage. (Data source: IDNDR web site)

In developed countries, the 1990s have seen an increase in the cost of natural disasters resulting from storms and floods. During 1989-90, a series of intense winter storms struck northern Europe causing over 200 deaths and billions of dollars in damage. In July 1996, a low-pressure system dumped 200mm of rain in the Saguenay River region of Quebec in Canada and the resulting flash floods killed at least 10 people. Some 16,000 people had to be evacuated and losses were over US$500 million. In 1998, the worst ice storm in the history of Canada caused wide spread havoc (Kerry et al 1999). In Canada alone it is estimated to have killed 25 people, and the present authors (Dore 1999; Dore and Etkin 2000) conservatively estimate the total social loss to exceed $4.2 billion (1998 Canadian dollars). The 1998 El Niño was the most intense on record; it caused drought in Central Brazil, southern Africa and southern Asia and a record warm winter in Canada (Timmerman et. al. 1999).

The 1990s was also the decade for disaster reduction, especially in the developing countries, and the UN General Assembly even established a special secretariat in Geneva called International Decade for Natural Disaster Reduction (the IDNDR). The mandate of that body has now come to an end. A new program called the International Strategy for Disaster Reduction (ISDR) will succeed it. The strategy was introduced at the final meeting of the IDNDR in July 1999, with the title 'A Safer World in the 21st Century: Disaster and Risk Reduction'.

The stated objective of ISDR is to enable communities to become resilient to natural hazards and to proceed 'from an approach of protection against hazards to the management of risk.' The strategy is structured around four main themes for action: public awareness; commitment by public authorities; disaster resilience; and the reduction of socio-economic loss.

It remains to be seen what the dimensions of disaster resilience will be defined to include, and how reductions in socio-economic losses will be achieved.

A recent initiative undertaken by the World Bank was the establishment of its 'Disaster Management Facility (DMF)' which was formed in July 1998 to provide operational support, promoting capacity-building, and establishing partnerships with the international and scientific community working on disaster issues.

The specific objectives of the DMF are to:

- improve management of vulnerability in risk-prone member countries and reduce vulnerability in the World Bank portfolio
- promote sustainable projects and initiatives that incorporate effective prevention and mitigation measures
- promote the inclusion of risk analysis and disaster prevention mechanisms in the World Bank operations, analysis and country assistant strategies
- promote training in the areas of disaster prevention, mitigation and response
- identify policy institutional and physical interventions aimed at reducing catastrophic losses from natural disasters through structural and non-structural measures, community involvement and partnerships with the private sector

In every region of World Bank involvement, lending in response to both sudden onset events such as earthquakes, floods and slow onset events such as droughts has increased greatly over the last decade to about $8.8 billion. Statistics indicate that developing countries suffer the greatest when disaster hits. More than 95 percent of all deaths caused by disasters occur in developing countries. Losses due to natural disasters are 20 times greater (as a percent of GDP) in developing countries than in industrial countries.

Realizing the gravity of the problem of accelerating natural disasters in the 1990s, the World Bank announced yet another initiative. In February 2000, the World Bank and an international coalition of governments, international organisations, private insurance companies, universities, and non-governmental organisations launched a new international consortium, called ProVention Consortium, designed to reduce the human and economic costs of natural disasters in the developing world. The aim of the ProVention Consortium, will be to equip developing countries with the means to cope with natural disasters such as earthquakes, hurricanes and floods, and reduce the loss of life and property.

Thus the level and scale of natural disasters in the 1990s seems to have propelled the international community to undertake a number of initiatives, though we have not yet seen a dovetailing of these with global climate change policy. The Kyoto Protocol, the main standard bearer of action on climate change, remains unratified by most of the developed world, and the most recent meeting of the parties in Berlin (Conference of Parties 5, or COP 5) was a failure, as was COP 4 a year earlier in Argentina.

The Kyoto Protocol was signed under the 1992 UN Framework Convention for Climate Change (UN FCCC), but it looks increasingly as if the Protocol will lapse, unless serious action is taken particularly by the US to formulate a climate change policy that is consistent with the UN FCCC. In the meantime, most countries should be making preparations for *adaptation,* i.e. adapting to the inevitable climate change. Adaptation requires greater preparedness for more 'extreme weather and climate events.' As part of the preparedness, it is necessary to make policy makers aware of the *magnitude* of the social costs of such disasters. It is therefore essential that a consistent and systematic methodology for estimating social losses be developed and adopted by the community concerned with international climate policy and by the professionals involved with disaster preparedness.

Consequently the rest of this paper concentrates entirely on developing a consistent methodology for estimating the social losses associated with natural disasters. The next section comments on the methodology recommended by the National Research Council of the USA (NRC, 1999).

Cost estimation methodology of the US National Research Council

In 1996, FEMA commissioned a special report for assessing losses resulting from the impacts of natural disasters[1]. For this purpose, a committee was set up drawing on the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine, with the National Research Council (NRC) serving as the main operating arm on behalf of the three bodies that administer the NRC.

In particular, FEMA asked the group to identify:

'the costs components that, when combined, would most accurately reflect the total cost of a natural disaster event. To the extent possible the committee will identify the relative importance of the components for accurate characterisation of an individual event and the significance of different components across the spectrum of hazards. The committee will also suggest possible sources for accurate cost information, regardless of whether data are generally available from these sources at present.'

The report of this committee was published as NRC, 1999. At the same time a second study entitled 'The Hidden Costs of Coastal Hazards: Implications for Risk Assessment and Mitigation' was prepared by the Heinz Center. This study was published in November 1999 (Heinz Center, 1999). Space limitations do not permit comment on this study, which will be considered in another paper. This comment is confined to the NRC methodology.

The NRC Committee chose an arbitrary distinction between *Losses* and *Costs* that lacks rigor from the perspective of standard economic theory. It defines four concepts:

1. **Impacts:** It uses this as the broadest term, which includes 'market-based and non-market effects' (p. 3). It includes market-based impacts as… 'the destruction of property and a reduction in income and sales.' The non-market impacts include environmental damages and psychological distress associated with disasters. But it also suggests that some impacts could be 'positive', but that the net impacts of disasters would be 'predominantly undesirable' (p. 5).
2. **Losses:** The definition is worth quoting in full: 'The *losses* of disasters represent market-based negative economic impacts. These consist of direct losses that result from the physical destruction of buildings, crops, and natural resources and indirect losses that represent the consequences of that destruction, such as temporary unemployment and business interruption.'
3. **Costs:** 'The *costs* of disasters, as the term is conventional used, typically refers to cash payouts by insurers and governments to reimburse some (in certain cases all) of the losses suffered by individuals and business. Losses suffered by those who are uninsured, those whose losses do not make them eligible for insurance payments, and those who do not receive government relief should be counted in any complete compilation of the impacts of a disaster—but these losses are not included as 'costs', as that term is used in this report.'
4. **Damages:** 'The *damages* caused by disasters refer to the physical destruction, measured by physical indicators, such as the numbers of deaths and injuries or number of buildings destroyed. **When valued in money terms, damages become direct losses'** (p. 5).

These definitions are arbitrary; they are certainly not conventional in economics or even in accounting. In economics, one would be concerned with *social losses, both direct and indirect.* Social losses

Note

1. See also Howe and Cochrane 1993; Fairbairn 1996.

would reflect what society loses, and what would have to be *made up later, out of later production.* Payments made by the insurance industry are not social losses; the insurance companies have been paid insurance premia, and the payouts are disbursements from that accumulated fund. If it so happens that the disbursements exceed the accumulated fund, then that is due to an error on the part of insurance companies on assessing the actuarial risk (Etkin and White 1997). Therefore, if one is consistent with economic theory, social losses are what the NRC calls 'impacts.' And in the NRC report, costs refer only to 'cash payouts.' On the above definition, 'costs' is a subset of 'damages' which defines direct losses, as there will be many uninsured lives and many uninsured buildings. Thus direct damages may exceed costs.

Therefore one may ask: what does the concept of cost amount to in the NRC report? It amounts to a concept for which "forms" can be filled! Indeed, by their own admission the NRC committee's main contribution is their Table 2-2, on page 29, reproduced below. The report also contains 5 recommendations, but these deal with reporting and administrative mechanisms only.

It seems clear that the Committee did not deal with the responsibility that was assigned to it; that is, the formal charge which was 'to identify… the total cost of a natural disaster event…' (see the full quotation above). The committee was also asked to identify possible sources for accurate cost information, regardless of whether data are generally available from these sources at present. It does not seem that the Committee did that in the report.

One is led to the conclusion that the committee did not avail itself of the services of economists, and seemed mainly preoccupied with bureaucratic reporting procedures. In the next section, we outline an alternate methodology for estimating losses due to a natural disaster, which we applied to the 1998 Ice Storm in Canada.

		Who Initially Bears the Loss				
Type of Loss		Insurers	Government[1]	Business	Individuals	NGO
Property:	Government					
	Structures					
	Content					
Business:	Structures					
	Content					
Residential:	Structures					
	Content					
	Landscape					
Autos, Boats, & planes						
Infrastructure:	Utilities					
	Transportation					
Agricultural products:	Crops					
	Livestock					
Human Losses:	Deaths					
	Injuries					
Cleanup and response costs[2]						
Adjustment Costs, temporary living aid[3]						

Reproduction of Table 2-2: Sample Tada on Direct Impacts for Each 'Major' Event (dollar amounts should be entered in each cell in the table, except for human losses)

Note: If possible, direct primary and secondary losses should be tabulated separately
[1] Ideally losses of federal, state and local and tribal governments should be separately collected and recorded.
[2] Cost of added police protection immediately after the event.
[3] Includes expenditure of charities such as the Red Cross.

An alternate methodology

In this section we develop a methodology that is more in tune with economic theory and national macroeconomic accounts. The guiding principle should be an attempt to estimate the 'distortion' due to the disaster of the normal development and expansion path of the economy. Such an analysis is applicable, provided the disaster is marginal, or small in relation to the economy. It would not be applicable to large-scale disasters, such as the destruction of Thira, or the large-scale destruction of Germany or Japan in the Second World War. The essential criterion is the ability to get back to the previous growth path of the economy, projected a few periods forward. *Figure 1* shows that at time a disaster interrupts the growth of per capita real GDP. The question is: at time , what would it take to restore the economy so that per capita real GDP[2] at time would have been the same had the disaster **not** occurred at all.

In practice, the growth of per capita real GDP is never as smooth as that portrayed in *Figure 1*; recessions and other exogenous shocks make the curve 'jagged'. But even that is not a serious statistical problem, as one can fit several auto-regressive moving average (ARIMA) models and take the smallest or the average growth of per capital real GDP. (It should be noted that ARIMA is a sophisticated statistical technique that can forecast a nonlinear future path of a time series. It is now a standard tool used by economists and statisticians.)

The cost of the disaster in *Figure 1* is the loss of value-added over the period. But this value-added is made possible by using the physical and social capital and other infrastructure, which may itself be damaged or lost due to the disaster. When we take these into account, the total social loss can be resolved into:

- the loss of value added over the period due to the disaster[3]
- the loss of capital, destroyed due to the disaster
- the distortion of time allocation of personnel required in order to cope with the emergency
- secondary or indirect losses

Each of the above is discussed briefly below.

The loss of value-added

Value-added is defined as the sum of

Note

2. Ideally we need a some disaggregated or vector-valued indicator of the standard of living. But in the absence of such an index, we can work with per capita real GDP.

3. As value-added is measured at market prices, the loss must include the loss of indirect taxes.

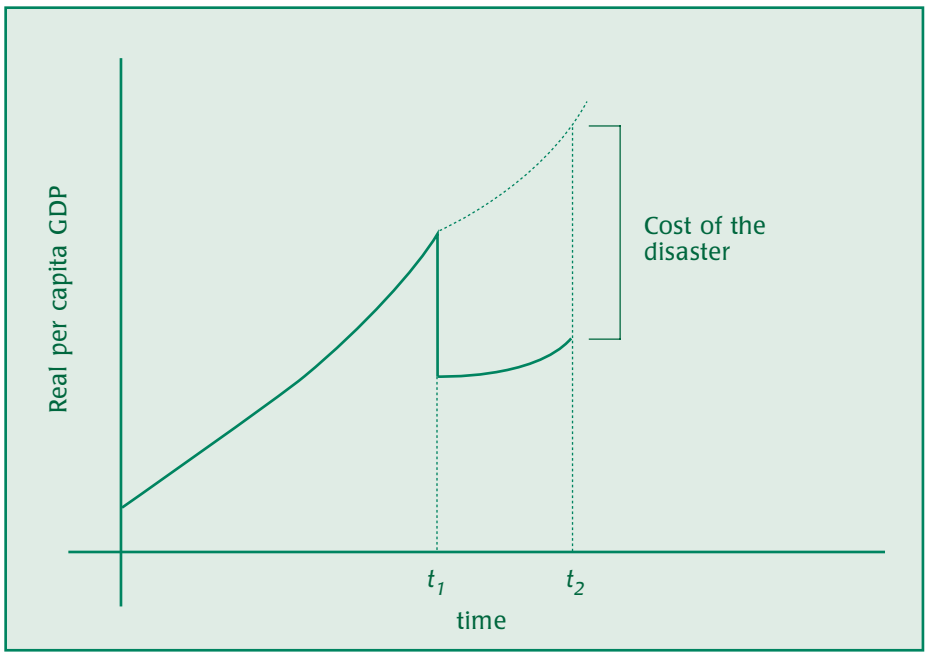

Figure 1. The economic cost of a natural disaster. Disaster occurs at time t_1. Its duration is t_1 t_2. The foregone growth is measured on the vertical axis.

wages, profits, interest, and rent, which is the sum of returns to all factors of production. For example, in the case of the ice storm, we would estimate the loss of value-added at firms and farms over the duration, until power was restored. It would include the value of milk wasted, but not the amount of cheese that was not made. At the cheese factory-level, only the loss of value-added (not including the milk as input) would be counted.

In the case of the ice storm, the loss of value-added affected the farm sector, the maple sugaring industry, forestry, manufacturing, construction, transport and communications, utilities, wholesale and retail trade, and the Finance, insurance and real estate sector. It should be noted that insurance claim payments made by the insurance industry are not 'losses' due to the ice storm. Insurance policy holders must have paid insurance premiums (over many years) to insurance companies and the claims are paid to policyholders as a result of valid insurance contracts. Such payments are neither 'costs' (incurred by the Finance, insurance and real estate sector) nor are they 'gains' or benefits[4]. However, when the losses are uninsured and the government steps in to compensate farmers or others with the use of tax dollars, it is legitimate to include that as part of the cost.

Note

4. The Conference Board study includes insurance claims as part of the total investment for reconstruction in the aftermath of the ice storm.

The loss of capital

The capital (destroyed as a result of the disaster) is that set of total assets that would permanently lower net value-added, unless it is replaced. The capital destroyed can be subdivided into:

- **Man-made private capital**: this includes buildings, machinery, factories and other capital equipment used by businesses. This category should include private houses, cars, trucks and tractors. For the farm sector it would include all livestock.
- **Man-made social capital**: this includes roads, bridges, ferries and all other public infrastructure including government real property.
- **Natural capital**: this is the valuation of all natural sites that can be said to have an economic or aesthetic value for which an economic return was previously possible. Thus forests, tourists sites, mountains and other natural beauty spots that are destroyed would be included here.
- **Human capital**: most disasters involve loss of human lives. In the case of trained and productive people, whose lives are lost, one must estimate their economic value, perhaps in terms of total income that they would have earned over their lifetime. Other lives, such as those of children and retired people may be more difficult. There is, however, a huge literature on the valuation of human life, and estimates vary between a negative value for a retired person (Henley and Spash, 1993) to 3.84 million British Pounds, or about C$8 million (Meng and Smith, 1990). There are also estimates produced for the US government, which put the value of a life around half a million US dollars. It should be noted that this is clearly a difficult value laden issue, since a retired person with a negative economic value may be priceless from other perspectives—to family, to society as a result of volunteer work, etc.

Distortion of time allocation

The loss due to time allocated for coping with a disaster is not included in the UN manual for the estimation of costs (UN ECLA, 1991, 1999). To our knowledge, such costs are not included in any of the other 'methodologies' of the assessment of economic costs of a disaster. This loss is the allocation of time and personnel of many agencies; it includes the costs incurred by the government disaster relief operations. It also includes the costs of charitable organisations (say, from Oxfam and Christian Aid), as well as those of international organisations such as UNICEF, Red Cross and Red Crescent, and other disaster relief agencies. One must also include the time of government personnel (e.g. the army, the civil service mobilized for a particular disaster), doctors, hospitals and of course the voluntary work of private citizens. All this is labour time allocated to dealing with the pressing problems. All such labour expended has an opportunity cost and must be included in the total loss due to the disaster. Even foregone leisure time has an opportunity cost and must be valued and its cost attributed to the particular disaster.

Secondary effects

The secondary effects of a disaster have their impact either on the *whole* economy or on areas *outside* the immediate disaster area. Consider first the areas outside the disaster area. For example, cheese factories outside the ice storm area that relied on milk from areas in Quebec would now have to obtain milk, at a higher cost, from other areas in Ontario or the USA. The higher cost of milk is an indirect (or secondary) effect. Consider another example: cheap hydro-electric power from the James Bay region in Quebec and from Churchill Falls in Labrador could not be obtained as the powerlines were down due to the ice storm. This might necessitate Atlantic Canada (i.e. parts not directly affected by the ice storm) having to import power from the South, from the USA at a high cost. The higher cost, i.e. the difference in the cost, is a secondary

effect. In the case of imports, the secondary impact is an unambiguous cost that can be attributed to the disaster. However when the indirect effect is a simple redistribution within a province or a country, then it would be inappropriate to include it as a cost. In that case the redistribution can be included only if distributional effects are explicitly and separately highlighted.

A disaster may sometimes affect the whole economy. In the case of Hurricane Mitch, it is very possible that tourist trade will be down for years as a number of holiday resorts were destroyed. This will also have balance of payment effects for Nicaragua and Honduras and parts of Mexico. The shortage of foreign exchange could affect other sectors within the economy and employment and sales will also be down as a result of Mitch. All such secondary effects must be carefully evaluated and their consequences traced. In the case of a shorter term and more localized disaster (such as the Oklahoma tornado) the secondary effects may be small; but in the case of Hurricane Mitch the secondary effects may be very large indeed (Pielke et al 1998).

Sometimes the secondary effects of a natural disaster can spread to many countries, and indeed sometimes to the whole world. The explosion of Mount Pinatubo in the Philippines reduced sunlight and lowered temperatures over the whole world. If ENSO is treated as a natural disaster, the 1998 ENSO has certainly some disastrous consequences for large parts of Latin American, Africa, Asia, the Pacific island states and Northern Australia. It brought an unusually cold winter to northern Europe but an unusually mild winter to North America. This is a natural phenomenon (a disaster) that had important redistributional consequences worldwide.

Conclusion

We have argued that the final decade of the last millennium was one of severe natural disasters, with most of them being weather- or climate- related. The international community has clearly recognized this fact and undertook a number of new initiatives such as the setting up of ISDR to succeed the IDNDR; the establishment of the Disaster Management Facility at the World Bank; and the setting up (in February 2000) of the ProVention Consortium. Whether or not global climate change diplomacy and international policy succeeds in dealing with the anthropocentric causes of global warming, it is apparent that nations must now take steps to *adapt* to inevitable climate change (Munashinge et al. 1995).

In climate change science, there is a useful distinction between *mitigation* and *adaptation* (see IPCC, 1996). Mitigation is an attempt, through global diplomacy, to try to reduce greenhouse gas emissions and so to slow down climate change. On the other hand it is also recognized that the benefits of mitigation efforts will be felt very slowly, and may even be too late. For this reason, most countries are also planning for *adaptation to climate change.* It is for the development of adaptation policies that we need to be clear just exactly how much natural disasters cost. A prudent adaptation policy will require increased resilience to extreme weather and climate events, because it is through extreme events that climate change will manifest itself and have an impact on society. Extreme events can, and often do trigger disasters, and unless the true social costs of these disasters are known, policy makers will not appreciate the need to invest in adaptation measures. It is therefore imperative that a sound and consistent methodology for estimating the full costs of natural disasters is widely accepted and used. For this purpose, the cost method recommended by the US National Research Council (and accepted by FEMA) is inadequate. We propose a methodology, consistent with economic theory and macroeconomic accounts, be used for estimating the total social costs of natural disasters.

Extreme events can, and often do trigger disasters, and unless the true social costs of these disasters are known, policy makers will not appreciate the need to invest in adaptation measures.

The policy implications of this paper are clear: extreme climate events are natural disasters, which cause damage to capital and infrastructure. A sensible adaptation policy requires preparing to make the capital stock and infrastructure resilient to such extreme events. But resilience will require investment and new regulations such as new or improved building codes. The level of the necessary investment can only be determined if the social costs of disasters are known. However, estimating the social costs of disasters requires a consistent methodology.

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