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NATURAL DISASTERS  
AND ADAPTIVE CAPACITY

by

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## PREFACE

Natural disasters (drought, earthquake, epidemics, floods, windstorms) pose a growing threat to developing economies, both in terms of their frequency and of the damages associated with them. These shocks, in addition to causing death and injury, also give rise to long-lasting damage, as buildings, homes and infrastructure are destroyed and scarce resources are diverted to coping with reconstruction. Effective risk management is therefore a pressing concern for development agencies and developing-country governments. Indeed, the extent to which resources are effectively applied to mitigating and coping with disasters has immediate consequences for growth and development.

In its current work programme, the Development Centre seeks to explore ways that developing countries can enhance their “adaptive capacity”, defined as a country’s ability to grapple with negative shocks from outside the economy, such as financial contagion, terms of trade shocks, and natural disasters. In the case of natural disasters, adaptive capacity can be defined as the vulnerability of a society before disaster strikes and its resilience after the fact.

The report reminds us that the adaptive capacity of a country is not in fact “exogenous”, but related to its level of development. Unfavourable economic and social conditions such as irregular urban settlements, and weak regulatory practices including poor enforcement of building standards can render a society much more vulnerable and less resilient to any given shock.

Given the limited scope for diversifying against such risks at the household or community level, there is an *a priori* case for public action. For this to be effective, a partnership of multiple stakeholders needs to be forged.

To reduce the *ex ante* vulnerability to shocks, it is important for governments to increase the human capital and physical assets of poorer members of society and to monitor and enforce building codes and standards. Enhanced resilience can be achieved by implementing a series of precautionary measures that would lower the cost of relief (e.g. social safety nets, improved communications), and preparing adequate contingency plans for rapid medical and humanitarian responses.

International agencies and the private sector can play their part by exploring ways to create innovative financial instruments to pool disaster risk and to provide insurance against it. Such joint actions would accelerate return to a sustainable growth path.

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13 August 2004

## RÉSUMÉ

Les catastrophes naturelles (sécheresses, tremblements de terre, épidémies, inondations, ouragans) sont nuisibles au bien-être, tant par leurs retombées immédiates et de long terme que par la nuisance provoquée par l'insécurité qui leur est associée chez les individus adverses au risque. Ainsi, la gestion des effets des catastrophes naturelles, de même que celle du risque de leur déclenchement, sont des questions urgentes pour le développement économique. Ce document fournit un cadre conceptuel pour mieux comprendre les catastrophes naturelles. Celles-ci impliquent des coûts humains tragiques et se distinguent des situations à risque, qui sont des événements tels que les tremblements de terre ou les inondations : les situations à risque ne deviennent des catastrophes que lorsque les sociétés leur sont vulnérables. Par conséquent, les politiques publiques internationales pour le développement peuvent contribuer à réduire leur coût en visant sur la vulnérabilité. Un examen de deux catastrophes récentes — les tremblements de terre en Turquie en 1999, et l'ouragan Mitch en Amérique centrale en 1998 — illustre que l'urbanisation précaire et la dégradation environnementale augmentent la vulnérabilité aux catastrophes naturelles. De plus, ces épisodes démontrent une hétérogénéité dans la capacité de s'adapter : des situations à risque semblables ont des conséquences sociales largement différentes dans des pays différents. La capacité d'adaptation est fonction de la vulnérabilité *ex ante* au risque de catastrophe naturelle et de la résilience ou résistance *ex post*, une fois que le désastre a frappé. Trois dimensions saillantes de l'action de l'état sont mises en évidence : les politiques nationales par opposition aux politiques internationales ; les mesures *ex ante* par opposition aux mesures *ex post* ; et les efforts publics par opposition aux efforts privés. Le document conclut avec un examen des propositions innovantes visant à atténuer le risque des catastrophes naturelles et à élargir la gamme de produits.

## SUMMARY

Natural disasters (droughts, earthquakes, epidemics, floods, wind storms) damage well-being, both in their immediate and long-term aftermath, and because the insecurity of exposure to disasters is in itself harmful to risk-averse people. As such, mitigating and coping with the risk of natural disasters is a pressing issue for economic development. This paper provides a conceptual framework for understanding natural disasters. Disasters, which imply tragic human costs, are distinguished from hazards, which are events like earthquakes or flooding: hazards only translate into disasters when societies are vulnerable to them. Consequently international development policy can play a role in reducing the costs of disasters by addressing vulnerability. A review of two recent disasters — the Turkish earthquakes of 1999, and Hurricane Mitch in 1998 — illustrates the importance of precarious urbanisation and environmental degradation for increased vulnerability to natural hazards. These cases furthermore demonstrate the heterogeneity in adaptive capacity to disasters, as similar hazards have vastly different social consequences in different countries. Adaptive capacity is a function of countries' *ex ante* vulnerability to natural-disaster risk and their *ex post* resilience once such disasters have struck. Three key dimensions of public action are highlighted: domestic versus international policies; *ex ante* versus *ex post* measures; and private versus public efforts. The paper closes with an overview of innovative proposals to mitigate disaster risk and broaden the range of insurance instruments available to households and firms.

## I. NATURAL DISASTERS IN THEIR ECONOMIC CONTEXT

Poor households in developing countries, whether in the rural or urban informal sectors, live in a perpetual state of economic insecurity. They can be buffeted by shocks that include unemployment, disease and disability, failure of their home-based enterprises, or (the subject of this paper) natural disasters. Should such shocks occur, they can lead to immediate hardships; these might be followed by long-term consequences as when a household decides, following a natural disaster, to withdraw a child from school. But households' very exposure to such shocks can lead them to make decisions that, while they might reduce exposure to the shock, depress long-term livelihood (this is the practice of "consumption smoothing by income smoothing"; see Morduch, 1995). This occurs even if the disaster never comes: thus a poor farming household might choose lower-yielding but less-variable seed varieties, rather than higher-yielding but riskier seed varieties, for example.

Like poor households, fiscally-strapped governments in poor countries are buffeted by shocks — financial contagion, changes in international prices, civil conflict and of course, natural disasters. Just as at the household level, such shocks, once they occur, can lead to painful episodes of economic crisis. And like the poor household confronting such shocks, poor countries with poorly-developed governance capacity can be led to undertake policies before the fact that might reduce their exposure to the shock, but also the long-term trend growth path of national income. These shocks might even leave in their wake long-term effects on the development potential of the economy, forever displacing it from a relatively good to a poor growth path (as in the multiple-equilibria models of Matsuyama, 1991; Rodríguez Clare, 1996; Bardhan and Udry, 1999, ch. 16).

This paper focuses on the variety of country experiences with what John Stuart Mill (1878) referred to as Nature's "injustice, ruin, and death" — droughts, earthquakes, epidemics, floods, wind storms — in the developing world. It is reported that the amount of aid channelled into disaster relief has increased by a factor of five in recent decades (Buchanan-Smith and Maxwell, 1994, cited in Owens *et al.*, 2003); against the backdrop (until quite recently) of stagnating aid flows generally (World Bank, 2001, 189-191), this means that disaster relief as a component of aid looms larger than ever before. As a consequence donors are especially pressed to ensure the cost-effectiveness of disaster-relief efforts.

There is furthermore a growing concern that the magnitude of the human consequences of such disasters is growing with time. Global climate change, for example, might be increasing the frequency of El Niño events, which lead with regularity to drought, fires, flooding and famine. The warming of the surface of the Atlantic Ocean might be increasing the frequency and severity of hurricanes. Settlement of previously unpopulated forest environments may lie behind



the proliferation of hitherto unknown diseases, including avian flus, sudden acute respiratory syndrome (SARS) and the human immunodeficiency virus (HIV), which were likely transmitted from animal carriers. Indeed, two of the “emerging systemic risks” identified by the OECD International Futures Programme — natural disasters and infectious diseases — fall within the domain of this report [the others are technological accidents, terrorism related risks, and food safety (OECD, 2002)].

This paper poses, and seeks to answer, two questions. First, is the risk of natural disasters a *development* issue? The second question is whether there is a role for domestic and international development policy to address the risk of natural disasters. Demonstrating the link between disasters and development, as well as distilling lessons from a review of relevant research requires a clearer understanding of natural disasters. For that reason, this report proposes a conceptual framework for understanding the economic aspects of natural disasters. In particular, this paper defines *adaptive capacity* as a combination of a society’s *ex ante* vulnerability to damages from natural hazards and its *ex post* resilience or ability to cope with the damages that result<sup>1</sup>. The paper considers a range of policies with respect to their impact on adaptive capacity. The relationships among disasters, development, and policy-making are illustrated by looking more closely at the experience of two recent disasters: the Turkish earthquakes of 1999 and Hurricane Mitch in 1998.

In the midst of introducing this conceptual framework with which to talk about natural disasters, it will be argued that natural disasters are decidedly a development issue. This is true for at least five reasons. First, natural disasters disproportionately strike developing countries, as the lion’s share of volcanic activity and El Niño-related events occur in developing countries. Second, natural disasters are worse for the poor, whether one means poor countries, or poor households within a given country. Thus a recent United Nations Development Programme report notes that while only 11 per cent of people exposed to natural hazards live in countries classified as “low-human-development” countries, these same countries account for more than 53 per cent of disaster-related deaths (UNDP, 2004, 1). (Low human development countries are those whose human-development index — a score based on health, education and per capita income achievements of the country — is less than 0.5; for 2003, this means countries with human development equal to or lower than that of Cameroon, Nepal and Pakistan (UNDP, 2003, Table 1, 237 ff.). This is a conservative threshold, as it leaves out many medium and high human-development countries also prone to disasters, such as Indonesia, the Philippines or Mexico.)

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1. The authors in Pelling (2003) use the term “adaptive capacity” in the context of natural disasters to mean the efficiency with which development assistance funding is used, a usage not at odds with that of this paper.

Third, natural disasters can dampen growth, by destroying capital and diverting resources toward relief and reconstruction. Fourth, natural disasters depress social welfare more generally, as households' asset stocks are depleted or destroyed; in concrete terms, this means people lose their homes or take their children out of school<sup>2</sup>. Fifth, and finally, natural disasters are a development issue because development policy — both domestic and international — can credibly make a difference to lessen the impact on poverty, growth and welfare.

Table 1. A Typology of Natural Disasters, 1900-2002

Disaster type	Number	Percentage	Disaster type	Number	Percentage
Drought	782	8.87	Flood	2 390	27.11
Earthquake	900	10.21	Insect infestation	72	0.82
Epidemic	854	9.69	Slide	449	5.09
- anthrax	4	-	- avalanche	76	-
- arbovirus	132	-	- landslide	373	-
- diarrhoeal/enteric	349	-	Volcano	169	1.92
- diphtheria	4	-	Wave/surge	42	0.47
- intestinal protozoal	6	-	- tidal wave	19	-
- leptosporosis	10	-	- tsunami	23	-
- malaria	36	-	Wild fire	270	3.06
- measles	36	-	- forest	183	-
- meningitis	149	-	- scrub	87	-
- plague	16	-	Wind storm	2 547	28.91
- rabies	7	-	- cyclone	411	-
- respiratory	25	-	- hurricane	335	-
- rickettsial	6	-	- storm	793	-
- small pox	11	-	- tornado	174	-
- viral hepatitis	7	-	- tropical storm	83	-
- unknown	56	-	- typhoon	510	-
Extreme temperatures	263	2.98	- winter	241	-
- cold wave	160	-			
- heat wave	103	-			
Famine	77	0.87			
- crop failure	11	-			
- drought	14	-			
- food shortage	51	-			
- other	1	-			
			TOTAL	8 815	100.00

Source: EM-DAT (2004).

- The effects of disasters on households extend beyond the economic, of course: they can influence the very formation and dissolution of households. Cohan and Cole (2002), in a study of counties in the US state of South Carolina, find that the year following Hurricane Hugo in 1998, marriage and divorce rates increased in the 24 counties declared disaster areas, compared with the 22 other counties in the state. Using axiomatic bargaining theory, Dasgupta (1993, 328 ff.) considers household dissolution in the context of famines.

## II. A CONCEPTUAL FRAMEWORK

What can governments and international organisations learn from the varied experience of preparing for and recovering from natural disasters in the past century? Answering this question requires some understanding of what is meant by natural disasters, of social risk management, and of the link between disasters and poverty.

### Natural Hazards and Natural Disasters

By now there is a lively literature averring that natural disasters are not entirely natural, nor indeed exogenous shocks. The enormous meteorite that is believed to have struck a remote and virtually unpopulated region of Siberia in 1908 was about as close to a truly exogenous shock, and naturally-occurring to boot, as one can come. But it was not a natural disaster, as no one was affected. The leak of poisonous methyl isocyanate gas from the Union Carbide pesticide plant on the outskirts of Bhopal, India in December 1984, which immediately killed more than 3 000 people, was by contrast a genuine disaster, but it was certainly not natural in origin. What this paper calls natural disasters are understood to lie somewhere in between the Siberian meteorite and the Bhopal tragedy, combining features of both. While the Bhopal disaster was clearly “man-made” in origin, many natural disasters are arguably man-made as well, at least in part. For example, earthquakes have far more disastrous consequences where building codes are not rigorously enforced (as in Turkey in 1999 or Mexico City in 1985) than they do in other circumstances. In this example and many others, there are proximate or underlying causes that are socially produced. [Brookfield (1999) offers a dissenting view to this emerging consensus, arguing that certain calamitous events could be expected to wreak havoc whatever the social context in which they occur.]

Alcántara Ayala (2002) makes the useful distinction (echoed in many other studies) between *natural hazards*, which are geophysical events such as volcanic eruptions, floods, earthquakes or tsunamis, and *natural disasters* which involve the interaction of natural hazards and social systems. In this conception, two societies might face a similar *exposure* to natural hazards, but they may have different vulnerabilities to the damages that ensue from the hazard. These hazards are essentially exogenous, from an economic standpoint<sup>3</sup>. *Disasters* occur when

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3. Of course, hazards are not exogenous from a geophysical standpoint. Nevertheless, though there is concern that human activity may be increasing the frequency of disasters, decision-makers can nevertheless treat El Niño-induced events (notably drought) or hurricanes as exogenous to the economic system. The physical process that produce these hazards can still be profitably studied to better monitor and predict the occurrence of such hazards (see, for example, Alcántara Ayala, forthcoming; Wood, 2002).

societies or segments therein are vulnerable to such hazards. If natural disasters are indeed increasing in frequency, this likely arises not only because of global-warming-induced increases in the frequency of hazards, but rather because of increased vulnerability to them when they occur.

## Data on Disasters

The US Office of Foreign Disaster Assistance/Centre for Research on the Epidemiology of Disasters International Disaster Database (EM-DAT, 2004) contains information on nearly 9 000 natural disasters during the period 1900-2002 (The OFDA/CRED data set is described in greater detail, and assessed comparatively relative to two other disasters data sets, by Guha-Sapir and Below, 2002). The deadliest natural disaster of the twentieth century was the influenza pandemic of 1917, which claimed some 20 million lives worldwide. This was followed, in terms of lethality, by the 1932 famine in the Soviet Union (5 million dead), and flooding of the Yangtze, followed by famine, in China in July 1931 (3.7 million dead). Table 1 presents a basic frequency count of the various types of natural disasters included in the OFDA/CRED data set. One might quibble with the inclusion of epidemics, or at least acknowledge that they are different from the largely geophysical hazards that account for the remaining disasters. [Indeed, Baylies's (2002) study of HIV/AIDS policy in Zambia leads her to conclude that the epidemic ought not be considered "a shock like any other". Her recommendations, nevertheless — regarding careful *ex ante* and *ex post* interventions — could be profitably applied to other disaster types.] Rather than attempt to draw a circle around what are disasters and what are not, this table is presented to give a general idea of the types and general frequency of natural disasters.

Table 2 summarises, for the four most common disaster types — wind storms, floods, earthquakes, and droughts — the reported number of deaths associated with each disaster, and the monetary cost of damages. Given that the disasters in the data set span more than a century and monetary values are reported in current dollars, I have restricted the table to disasters over the period 1990-2002, when these dollar values would at least be plausibly comparable. For the sake of consistency, the information in the table is likewise restricted to the 1990-2002 period for the purpose of reporting the number of people killed. A perusal of Table 2 suggests a number of points. First, information on deaths is available for many more disasters than information on monetary damages. The prevalence of empty cells calls into question the representativeness of the reported data for both series. Second, earthquakes are by far the costliest disasters in terms both of deaths and monetary damages. Third, the human cost and the monetary cost of disasters diverge for disasters other than earthquakes. In particular, wind storms, on average, kill many more people than droughts or floods (by one or two orders of magnitude), but wind storms are the least costly of the four disaster types in monetary terms. This may be due to the spatial distribution of the disaster types: a greater frequency of wind storms in lower income regions (like the Caribbean or Southeast Asia), together with a greater number of floods and droughts in higher-income countries like the United States would produce the observed pattern<sup>4</sup>.

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4. Kron (2000) arrives at similar conclusions based on a more systematic analysis of comparable data on the incidence of disasters.

Table 2. Fatalities and Monetary Damages for Four Disaster Types, 1990-2002

<i>Number of people killed</i>					
Disaster type	number	mean	standard deviation	minimum	maximum
Wind storm	985	218	4 466	0	138 866
Flood	1 207	89	892	0	30 000
Earthquake	288	434	2 907	0	40 000
Drought	201	9	52	0	500
<i>Money damages (thousands of current dollars)</i>					
Disaster type	number	mean	standard deviation	minimum	maximum
Wind storm	484	401 905.7	1 651 756	35	30 000 000
Flood	431	530 668.5	2 003 022	32	20 000 000
Earthquake	101	2 192 848	13 400 000	786	132 000 000
Drought	65	524 200.2	933 180.9	453	4 500 000

Source: EM-DAT (2004).

Data sets such as the OFDA/CRED data are subject to legitimate concerns about coverage, consistency and completeness, the same concerns that bedevil most cross-country development data sets (Srinivasan, 1994). It is, for example, reasonable to wonder whether the frequency or the severity of disasters are as accurately recorded in a high-income environment as they are in a low-income one, both in the cross section and over time. It is furthermore questionable whether the reporting standards — e.g. what constitutes an “affected” person? — are consistent across countries and over time. If the analyst decided she can live with these concerns, these data are suitable for asking questions like whether damages (in terms of lives lost or money spent) are larger for earthquakes or tsunamis, for example, or which countries or regions have the highest incidence of disasters. The five countries with the highest number of disasters during the period 1900-2002 are the United States (655), India (459), China (420), the Philippines (355) and Indonesia (276); this suggests that more meaningful frequencies would be derived by normalising annual disaster numbers by land mass or population (reducing the prominence of the United States, India, China and Indonesia, but not the Philippines). Such international data could also be used in somewhat naïve cross-country regressions to detect, for example, the size of the contraction in GDP per capita in the year of or the year following a certain type of shock<sup>5</sup>.

An alternative type of data set available is household survey data, sometimes extraordinarily rich; in these data sets, the unit of analysis is the household. Such is the case of

5. Even with these modifications to the data set, many problems regarding the inference of causality would remain. An example is provided by the study by Mills *et al.* (2003) of commune-level data from Madagascar, which is conceptually similar to cross-country data in this context. They find, for example that cyclones have a positive and significant effect on per-capita expenditure: that is, it appears that cyclones raise household well-being. While it could be that post-cyclone relief efforts overcompensate for damages, actually raising households’ spending, it is more reasonable to conclude that these associations arise because cyclones, as it happens, are more likely to hit relatively prosperous communes (as the authors themselves hypothesise). The point is that this kind of data set makes it difficult to determine the direction of causation.

data used for disaster impact studies by Datt and Hoogeveen (2003), Del Ninno *et al.*, Morris and Wodon (2003), Owens *et al.* (2003), studies which will be considered in greater detail later in this report. In the best of cases, survey data were collected before and after the disaster, usually quite coincidentally<sup>6</sup>. In some cases, post-disaster surveys might rely on respondents' recall information about conditions before the shock. These data are suitable for exploring issues like the immediate losses to affected households of assets, consumption or income. In some cases, they allow analysis of the impact of policy measures or food aid. It is rare that data sets are sufficiently rich to address adequately the impact of post-disaster policy by comparing the fortunes of households benefited by policy with that of those not benefited (that is, to use difference-in-difference estimators). One can readily imagine that a good experimental design would compare households affected by the disaster to those not directly affected (in order to identify the effect of the disaster and isolate it from other macroeconomic trends); within the first group, one would also want to compare those benefited by some policy intervention with those not benefited (in order to identify the effectiveness of the policy). For all three categories of households (not affected, affected and benefited, affected but not benefited), good information on consumption, income, asset stocks, health indicators, labour-market activity, etc., would be needed both before and after the disaster. Few household data sets would be sufficiently rich to permit such an analysis. Even further requirements would be imposed to trace out the longer-term impacts by tracking respondents over many years. This is why the study by Hoddinott and Kinsey (2001) on the long-term effects of early-1980s drought in Zimbabwe on the health status of children is so useful; the researchers can compare anthropometric data on children in the 1980s to data on the very same individuals, now grown, in the late 1990s. They find, in fact, significant long-term deficits in terms of lower heights, which are robustly linked in the larger health literature to a host of poor human-capital outcomes.

In light of the shortcomings of both types of data sets, the best immediate strategy is to assess intelligently as many case studies as possible. The "case" might be a particular disaster (like the Mexico City earthquake of 1985), a disaster type (like earthquakes generally), a policy (like food aid following a particular disaster, or food aid generally), or a country (like disasters in China over many years), making systematic comparison difficult. The strategy that followed in this paper is to glean lessons from two recent, illustrative, and especially well-studied cases: Hurricane Mitch in 1998, the Turkish earthquakes of 1999.

### Are Disasters All Bad?

For now, note two aspects of these hazards: they are difficult to predict, and they have negative effects ranging from mild to truly catastrophic. In principle, of course, shocks can be positive or negative. Many macroeconomists, for example, study the consequences of positive productivity shocks; farmers, too, know well the symmetric phenomena of positive and negative rainfall shocks. But there is good reason to restrict attention to negative shocks in the context of natural disasters that concerns us here. The kinds of natural phenomena that concern us — landslides, for example, or earthquakes — do not have symmetric good and bad instances the

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6. An especially good example of this kind of serendipity is the Indonesian Family Life Survey, which straddled the Asian financial crisis of 1997-98 (Strauss *et al.*, 2002).

way that rainfall shocks do. Nevertheless, there are some researchers who have emphasised positive *consequences* of natural disasters. In the field of disturbance ecology, for example, Reice (2001) points out the critical biological role of periodic fires in Jack pine boreal forests, long-leaf pine savannas, eucalyptus forests and chaparral, a role that is counteracted by policy measures to suppress fires (a similar story can be told about flood cycles in flood plains). It should be pointed out, nevertheless, that in terms of our conceptual framework, Reice and other ecologists are concerned not with natural disasters *per se*, but rather with natural *hazards*. There is no sense in which natural disasters are ecologically necessary, and indeed Reice recommends that people be dissuaded from settling fire-prone habitats, or cultivating flood plains, policy measures that would reduce vulnerability to natural hazards. Thus we ignore potential positive ecosystem effects of such disasters here.

It could also be argued that natural disasters induce economically productive behaviour. Thus, for example, Skidmore (2001) explores the hypothesis that Japan's high savings rate is a consequence of its higher exposure to earthquakes, volcanic eruptions, landslides and typhoons than other OECD economies. As a result, precautionary saving is higher than elsewhere, with beneficial effects on the rate of physical-capital accumulation. While potentially interesting, the applicability of such a result to the cross section of developing countries exposed to natural hazards is limited in two important ways. First, even if Japan's saving is higher than it would be in the absence of natural hazards, it is not at all clear that its intertemporal welfare is higher. When households save for precautionary motives, they are self-insuring; equal or better rates of insurance could in principle be achieved with a genuine insurance scheme that pools risk across households. The second limitation on the generalisation of this Japanese result is that the means available to many poor developing-country households to save are severely constrained. There is mixed evidence that households might accumulate livestock (see, for example, Fafchamps *et al.*, 1998, and Rosenzweig and Wolpin, 1993, for conflicting accounts), for example, and that they draw down such stocks in time of natural disasters. But for many such households, low initial asset endowments and periodic negative shocks preclude effective precautionary saving, a phenomenon that is exacerbated by imperfect or non-existent capital markets.

Finally, there is an untested (so far as we know) hypothesis that disasters might have net effects that are positive for small, vulnerable island countries (see Briguglio, 1995, for an overview of the special problems of such economies). Such countries typically lead the lists of aid recipients (when ranked by aid flows relative to national income), and often this aid is tied to natural disasters. Chand's (2000) analysis of Fijian data provides some insight for this question. Chand suggests that while disasters (quite frequent in Fiji) depress per capita income in the following year, the effect is smaller by an order of magnitude than that of coups (also fairly frequent in Fiji). Moreover, while coups tend to depress investment, disasters tend to promote investment relative to trend levels. Unlike the Japanese example, wherein disasters promote investment via their effect on saving behaviour, in the small-island model, the investment is largely fuelled by post-disaster aid. There is clearly a partial-equilibrium sense in which disasters are "good" for such economies, but relative to an alternative growth path featuring higher domestic saving, the aid-dependent strategy is not a good one. Disasters, in a larger sense, are bad even for economies like Fiji in that they contribute to trapping the economy in a lower-growth steady state.

On balance, then, it seems eminently reasonable to analyse disasters as events with negative economic consequences. Indeed, Auffret's (2003b) study of sixteen disaster-prone Latin American and Caribbean economies over the period 1970-99 reveals that disasters are followed by a substantial decline in the growth rates of output and investment, a moderate decline in the rate of growth of consumption, and a worsening of the current account of the balance of payments.

### Social Risk Management and Natural Disasters

Holzmann and Jørgensen (2000, 2001; see also World Bank, 2001, ch. 09) have developed an eminently useful framework for policy analysis that they call *social risk management*. They categorise risks as idiosyncratic (affecting a single household) or covariant (affecting several households at once, and thus limiting the extent to which neighbouring households can pool such risks). They consider the strengths and weaknesses of the various actors that can address these risks: households, communities, non-governmental organisations, governments, and international organisations. Finally, they propose a typology of the responses those actors can deploy to manage risk. Risk-management strategies include: *risk prevention*, actions intended to reduce the likelihood of adverse risks occurring at all; *risk mitigation*, actions intended to reduce the damages associated with risks should they occur; and *risk coping*, actions taken after the fact.

Natural disasters are covariant risks *par excellence*, striking entire regions or countries at once; consequently governments or indeed international organisations (or both) are the appropriate actors to undertake risk management. Here, the characteristics of the country matter in a purely physical sense. Flooding of the Yangtze River in China (as occurred to disastrous effect in 1998) might affect as many households as a hurricane that strikes St. Kitts and Nevis; the larger size of the Chinese economy, however, means that the national government might be able to respond (by pooling risk across regions, for example) in ways not available to St. Kitts and Nevis, given that the whole of the Caribbean nation will be affected by the hurricane. Informal, community-based strategies will be limited in their capacity to manage disaster risks. Nevertheless, national or international efforts might be more effective in communities with larger stocks of social capital (see, for example, Wisner 2003).

### Natural Disasters and Poverty

It is well-established that there is a tight link between natural disasters and poverty. This is true in at least two senses: first, that natural disasters are more frequent in developing countries, and second, that the poor in any society exposed to natural hazards are more likely to suffer damages.



Alcántara Ayala's (2002) analysis of the OFDA/CRED data set shows that most disasters occur in developing countries, and that the death toll is even more concentrated in developing countries<sup>7</sup>. In many cases, this is an unhappy consequence of the non-uniform distribution of exposure to hazards over the planet's surface. Four-fifths of the planet's volcanic activity occurs in the so-called Circum-Pacific Volcanic Belt, within which are located many Asian and Latin American countries. The droughts that regularly follow the onset of El Niño years are concentrated in Southern Africa and South Asia. The El Niño-related "malarial fringe" is located along coastal regions of South America and South Asia. [Malaria epidemics tend to occur in regions where the illness had, until the time of the outbreak, been rare, so that people have poorly developed protective immunity. Even small year-to-year changes in temperature or rainfall, such as those caused by El Niño, can suddenly make conditions more favourable for the mosquitos and other vectors that transmit the disease, leading to an epidemic. See Kovats *et al.* (2003).]

Anderson (2000) argues that the poor are more vulnerable to natural hazards. In this sense, poor countries are not only more exposed, but they are more vulnerable than rich countries; and the poorest people within them are the most vulnerable. Poor people live in housing of poorer quality, and often on marginal land (like the *favelas* surrounding Rio de Janeiro); they face liquidity constraints that limit their access to saving or insurance in the face of risk; they cannot as readily escape disaster zones; their human capital is lower and more vulnerable to shocks, as when poor households decide to withdraw children from school so that they may earn labour income.

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7. A controversial book by social historian Mike Davis (2001) constructs an alarming thesis based on this association; Davis argues in essence that the developing world is poor precisely because it is disaster-prone. More precisely, Davis suggests that the three major El Niño-related droughts of the late nineteenth century, and the horrific famines that ensued, particularly in India, China and Brazil, were exploited by the colonial powers to subjugate, and in a sense to create, the "third world". Part of Davis's argument relies on the noxious effects of international markets for foodstuffs, which were promoted by the British colonial authorities in India in particular. The observation that food is sometimes exported from starving regions is not new to Davis, of course; Amartya Sen has documented this phenomenon in more recent famines (1981). Nevertheless, as Del Ninno *et al.* (2003) argue for the case of the 1998 floods in Bangladesh, it was precisely trade liberalisation prior to the disaster that allowed rice imports, which prevented a speculative increase in rice prices (of the kind described by Davis in India in the late 1870s, where British soldiers guarding grain stores literally watched starving peasants die before their eyes). Clearly, the interaction of market forces and disasters is a complex one.

### III. LEARNING FROM CASE STUDIES

The prospect of disaster policy as development policy is considered at length in Section IV. First, though, it is instructive to look in greater detail at a pair of recent, and calamitous, disasters: the Kocaeli and Düzce earthquakes in Turkey in August and November 1999; and Hurricane Mitch in Central America in October 1998<sup>8</sup>.

#### The Turkish Earthquakes of 1999

Turkey has been struck by a number of devastating natural disasters, particularly earthquakes. In the last century, according to the OFDA/CRED data set, Turkey has lost nearly 90 000 lives to natural disasters; this is substantially more than some other large countries in the data set that have suffered a greater *number* of disasters, such as Indonesia and the Philippines. In more recent years, Turkey has suffered several moderate to large earthquakes: Erzincan (which was also the centre of the December 1939 earthquake that killed almost 33 000 people), in 1992, which killed 547 people; Dinar, 1995, which killed 101; Adana-Ceyhan, 1998, which killed 145. These events paled in comparison to the 1999 quakes, however.

#### *The Immediate Human Cost*

On 17 August 1999, an earthquake with a moment magnitude of 7.4 on the Richter scale struck the north-western Kocaeli and Sakaraya provinces, densely-populated and heavily industrialised regions. Indeed, the August Kocaeli earthquake is considered the largest event to have damaged an industrialised area since the 1906 San Francisco and 1923 Tokyo earthquakes. The Kocaeli earthquake killed an astonishing 17 127 people. On 12 November 1999, another earthquake with a magnitude of 7.2 on the Richter scale struck Düzce, killing a further 845 people<sup>9</sup>. The earthquakes led to considerable international financial assistance: the World Bank granted loans totalling more than \$750 million, and the European Investment Bank provided a 450-million-euro facility.

The earthquakes took a very high human toll. As they struck highly urbanised areas, the collapse of buildings led to many of the casualties. In addition to the approximately 18 000 deaths, nearly 50 000 people were hospitalised for injuries; some 40 per cent of them were permanently disabled.

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8. The impacts of a large number of similarly large-scale disasters are summarised in OECD (2004).

9. The principal sources consulted for this review of the Turkish earthquakes were Bibbee *et al.* (2000), Brauch (2003), Erdik and Durukal (2003), and Selçuk and Yeldan (2001); data on losses and other indicators are generally taken from EM-DAT (2004).

### *Economic Impacts*

In addition, the economic impact of the earthquakes arose in part because they hit a key industrial centre. The earthquake region (the seven districts affected<sup>10</sup>) accounts for more than a third of Turkish GDP, and nearly half of the nation's industrial output. Substantial capital losses (\$2.5 billion for the August earthquake, according to the Kocaeli Chamber of Industry) were reported. Payments of insurance claims totalled some \$600 to \$800 million for the August earthquake; the 19 state-owned enterprises in the region reported losses of \$880 million. On the basis of a general-equilibrium model, Selçuk and Yeldan (2001) estimated the initial impact of the Kocaeli earthquake anywhere between -4.5 per cent and 0.8 per cent of GDP, depending on policy makers' response. The best-case scenario would result if key sectors were subsidised with foreign-aid receipts to recover their capital losses; the worst-case scenario would result if indirect taxes were raised to finance fiscal spending.

### *Buildings*

A much-commented element of the Turkish earthquakes was their effect on the built capital of the region, both because of their urban epicentre, and because of the role that building collapses played in contributing to elevated mortality. Some 23 400 buildings were condemned following the earthquake. Heavy damage (including collapse) befell 93 000 housing units and 15 000 small-business units; lesser damage struck a further 220 000 housing units and 21 000 small-business units (Erdik and Durukal, 2003). Among commercial and industrial buildings, observers noted that newer facilities performed better; older heavy-industrial facilities, especially those with taller structures, were more likely to partially or entirely collapse. In addition, as was observed following the 1998 Adana-Ceyhan earthquake, buildings constructed with pre-cast concrete were far more vulnerable to damage.

### *Megacities and Governance*

Given the role of collapsing buildings in the human and economic cost of the Turkish earthquakes, it is not perhaps surprising that a United Nations agency report would identify the following three factors underlying Turkey's vulnerability: urbanisation, inconsistent application of building regulations, and haphazard siting of industrial facilities, in contravention of environmental-protection rules (UNISDR, 2002). The second and third of these proximate causes have to do with monitoring and enforcement of formal rules; these rules existed before the earthquakes, and they were designed, at least in part, to reduce the country's vulnerability to such disasters. In practice, the problem is a mixture of insufficient monitoring and enforcement, and inadequate rules (whatever the quality of their enforcement). Indeed, observers of the 1999 earthquakes pointed to problems of technical and professional standards in the Turkish construction industry; there is little legal liability, regulation or supervision of standards. Building codes have failed to keep pace with improvements in earthquake technology. Finally,

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10. The districts of Kocaeli, Sakarya, Bolu, and Yalova were directly affected by the earthquake, while three neighbouring districts (Bursa, Eskisehir, and Istanbul) were chiefly affected indirectly, through commercial and industrial linkages.

there is evidence of abuse in public procurement; public buildings such as schools and clinics exhibited many of the same structural defects as private buildings. More broadly, these causes have to do with the quality of governance, which is surely a relevant concern in other regions vulnerable to disasters.

The first of the causes identified by the UN can likewise be readily generalised beyond the Turkish example: the risks posed by emerging “megacities” (cf. Brauch, 2003; Wisner, 2003). Rapid rates of growth of urban centres in developing countries, almost synonymous with high population density and the spread of informal housing, increases vulnerability to natural disasters. Wisner (2003, 182) notes four features of megacities that accentuate their vulnerability to natural disasters: their scale and complexity (which complicate monitoring of and rapid response to emergencies); their considerable ecological impacts, among them, large energy and water use, as well as large amounts of waste; their proximity to natural hazards, especially given their coastal or riverine locations; and the widespread “irregularity” of many settlements. Wisner enumerates some of the developing-country cities at risk of major disasters, among them Mexico City, Lagos, São Paulo, Mumbai, Shanghai, Calcutta, Jakarta, Beijing, Manila and Johannesburg. The risk continues to be great for Turkey. While it may seem that many factors came together to make the 1999 earthquakes as bad as they possibly could have been, in fact an earthquake centred in the larger cities of Izmir, Istanbul or Ankara would almost certainly be more lethal, and these cities are indeed located in seismically-active areas.

## Hurricane Mitch, 1998

### *The Immediate Human Cost*

Natural disasters are not unusual in Central America; in 1974, Hurricane Fifi killed 8 000 people in Honduras and caused significant economic devastation throughout the region (EM-DAT, 2004). The region is particularly beset by natural disasters that occur cyclically, including windstorms, earthquakes and volcanic eruptions. Even against this backdrop, however, Hurricane Mitch, the last and most powerful storm of the 1998 season, had unusually severe effects. The storm formed off of Jamaica in late October 1998, and began moving slowly towards the west, intensifying until it was classified a tropical storm. Then, Mitch began to move northwest toward Nicaragua. By 26 October, Hurricane Mitch was classified a category-5 hurricane on the Saffir-Simpson scale<sup>11</sup>, making it one of the most intense hurricanes in the Caribbean in the last two centuries. Winds registered sustained velocities of 288 kilometres per hour, gusting to 340 kilometres per hour. From a point north of the Honduran coast, the hurricane changed trajectory and began to move slowly in a south-easterly direction, crossing through Honduras on its way to El Salvador. For five days following its landfall, Mitch

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11. The Saffir-Simpson scale combines information on wind speeds and storm surges (the difference in ocean-water level between the predicted astronomical tide and the actual observed water level). Level 5 — “catastrophic” — is the highest value taken by the scale, and is characterised by major damage to vegetation, complete building failure, and massive evacuation.

generated torrential downpours, causing rivers to overflow and leading to huge floods. The country-by-country impacts of Hurricane Mitch are summarised in Table 3; some 18 799 people lost their lives, with the casualties concentrated in Honduras and Nicaragua<sup>12</sup>.

Table 3. Hurricane Mitch: Summary of Damages

Country	Killed	Affected	Damage (\$000)	GNP per capita (1998 PPP \$)
Belize	0	60 000	-	3 940
Costa Rica	8	16 700	-	6 620
El Salvador	475	84 000	-	2 850
Guatemala	384	105 700	-	4 070
Honduras	14 600	2 112 000	2 000 000	2 140
Nicaragua	3 332	868 228	1 000 000	1 790
Panama	0	7 500	-	6 940

Sources: EM-DAT (2004) and World Bank (2000, Table 1) for GNP per capita.

Note: PPP = "purchasing-power parity"

### *Economic Losses*

Initial reports estimated massive losses in agriculture: 30 per cent of coffee production and 80 per cent of the maize crop in El Salvador; 50 per cent of the export crop of bananas in Guatemala; 70 per cent of all agricultural production in Honduras, 50 per cent of all agricultural production in Nicaragua (EM-DAT, 2004). There was massive destruction of infrastructure: half of the roads in Honduras, 2 500 kilometres of highway in Nicaragua. The United Nations Economic Commission for Latin America and the Caribbean would estimate direct and indirect material losses at about \$6.0 billion, of which two thirds occurred in the primary sector (CEPAL, 1999, Table 1).

### *Heterogeneity of Impacts*

Despite the generalised loss of life, injury, and economic damages of Hurricane Mitch, one of its most interesting features is its uneven impact across the affected countries. Table 3 demonstrates that, leaving aside Belize, Costa Rica, and Panama, which lay more or less in the periphery of the storm's impact, the effect of Mitch on the remaining four countries was quite varied. Of course the reasons for this heterogeneity in the impact of an essentially identical shock are two: different countries were exposed to the hurricane in slightly different ways (depending on its path, essentially), and different countries had differing underlying vulnerability to a hurricane. As a very crude indicator of such vulnerability, Table 3 includes income per capita for 1998, corrected for purchasing-power parity, for the seven countries in the path of Mitch. It is striking that a ranking of the countries in terms of the severity of the hurricane and a ranking in terms of the poverty of the country would be almost identical. The association is not perfect: Honduras is marginally less poor than Nicaragua, but suffered more, largely because the

12. The principal sources of information on Hurricane Mitch are CEPAL (1999), FAO (2001), IDB (2000), Morris and Wodon (2003) and UNDP (2003); figures are generally taken from EM-DAT (2004).

hurricane made landfall in the former country, and ripped across its length on its way to El Salvador. Nevertheless, there is a suggestive pattern: poorer countries fare worse when exposed to a similar shock.

One of the characteristics that separated Honduras and Nicaragua from their neighbours, in addition to their deeper poverty, is the extent of environmental degradation there, which predated the hurricane. Much of Mitch's impact in Honduras and Nicaragua was not attributable to wind damage, but to the large number of floods, flash floods, landslides and debris flows triggered by the hurricane. These derived, in turn, from the effects of environmental degradation that occurred over several decades. Environmental degradation was likely catalyzed by the 1997 El Niño event, which caused drought and fires. This complex interaction of poverty, climate-induced environmental damage, and a hurricane shock, was further complicated by weaknesses in early warning and disaster preparedness that led to large losses of life.

### *Relief Efforts*

Morris and Wodon (2003) analyse the impact of disaster aid following Hurricane Mitch in Honduras. In broad brush strokes, they find that aid was reasonably well targeted to victims of the hurricane, but tiny (on the order of \$10 per household) compared to asset losses. Poorer households and those who suffered larger losses were more likely to receive aid. Looking more closely at the targeting, they find that relief amounts appeared to be linked more closely to losses incurred than to pre-disaster asset levels. In part this reflects that the in-kind transfers that predominated (food, clothing and medicine) were needed in similar quantities by all households, even though their proportional losses might have differed substantially. In particular, among the poorest households that received aid, the value of mean relief was larger than the mean asset loss. Nevertheless, among the poorest households, including those that did not receive aid, the mean relief received was only about one-fifth of the asset loss.

### **Policy Lessons from the Turkish Earthquakes and Hurricane Mitch**

Both natural disasters considered here involved natural hazards that, while not at all unexpected, would strain the capacity of most societies. Nevertheless, in the days and months following the tragedies, analysts would argue that some pre-existing conditions in Turkey and Central America led to an outcome that was worse than it need have been. That is, the human and economic consequences of the disasters were not solely a function of natural phenomena. The review of the events provided above furnishes evidence of this. Environmental degradation associated with human settlement patterns led to widespread flooding in Central America, and floods caused greater devastation than the high winds of the hurricane itself. The failure to monitor and enforce adequately building codes and other regulation in Turkey meant that buildings (and the people inside them) were far more vulnerable.

The immediate conclusion is that human actions, whether taken by households, firms, communities or governments, have a substantial effect on the consequences of physical events like windstorms or earthquakes; that is, human actions can make societies more vulnerable (as was argued at length in Section II). The corollary of this statement, of course, is that judicious human action, including public policy, can reduce the negative consequences of disasters. Thus,

intelligent development policy that avoids environmentally precarious siting of farms (as in Honduras) or factories (as in Turkey) will reduce society's vulnerability. Intelligent standards (effectively enforced) for buildings, or assistance for housing construction for the poorest members of society will likewise reduce vulnerability.

Section IV will consider policies that reduce the negative consequences of natural disasters, both before and after the fact. It will be seen that actions can be taken at the domestic and international levels, and that there are furthermore ample opportunities for the public and private sectors.

## IV. ADAPTIVE CAPACITY AND POLICY ISSUES

### Adaptive Capacity

A lesson of the Mitch experience is that roughly similar natural hazards might have vastly different social effects, depending at least in part on the capability of different societies to weather (literally) such shocks. The same lesson could be gleaned from the Turkish earthquakes. Erdik and Durukal (2003) contrast these with the roughly contemporaneous September 1999 earthquake in Ming-Chin (Nantou City), Chinese Taipei. The earthquake in Chinese Taipei had a physical force (measuring 7.2 on the Richter scale) and economic losses (between nine and fourteen billion dollars) similar to those of the Turkish earthquakes. The principal difference between the two earthquakes lay in the number of casualties. According to the OFDA/CRED data base (other accounts give slightly different but qualitatively similar figures), the Chinese Taipei earthquake killed 2 264 (compared to the combined Turkish toll of 17 972) and injured 8 664 (versus 18 901 in Turkey) (EM-DAT, 2004). These comparisons illustrate that societies may well differ in their “adaptive capacity.” Adaptive capacity, in turn, can be best understood with reference to vulnerability and resilience.

Following somewhat loosely the work of Sinha and Lipton (1999) on *damaging fluctuations*, we can distinguish three characteristics of a society related to shocks: exposure, vulnerability, and resilience. *Exposure* is the *ex ante* probability that the shock will occur within a given time frame. Thus, geologists predicted that a major earthquake (with an intensity of 7 to 7.9 on the Richter scale) will strike in the next 30 years in the area of Turkey that comprises Izmir, Istanbul and Ankara with probability equal to 62 per cent (Brauch, 2003). Similar judgements might be made regarding the exposure of Tokyo to an earthquake. *Vulnerability* is the expected value of the damage that would occur conditional on the realisation of the shock. In this dimension, urban Turkey and Tokyo differ significantly<sup>13</sup>. *Resilience* is the capacity of the economy to respond to the shock. This may embody notions of the cost of response and clean-up, or of social assistance; it might likewise embody a longer-term notion of “snap-back”: how quickly does GDP per capita return to its pre-shock trend level? How quickly do child health indicators return to pre-shock levels?

Adaptive capacity, then, can be understood as a combination of vulnerability and resilience. While all shocks may be costly and difficult to predict, historical episodes of shocks

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13. A related research literature on measuring vulnerability has grown in recent years: see the papers by Chaudhuri *et al.* (2002) and Ligon (2003), or the summary provided by Hoddinott and Quisumbing (2003 *a, b*).



demonstrate that qualitatively similar shocks have different impacts in different environments, as in the varied country experiences with Hurricane Mitch in Central America. The differences in such cases can be traced to the adaptive capacities of the two economies hit by similar shocks. For countries with a reasonably high exposure to natural disasters of some type, adaptive capacity can therefore range from low (high vulnerability and low resilience) to high (low vulnerability and high resilience). Interesting cases include those economies “off the main diagonal”: with high vulnerability but high resilience, or with low vulnerability but low resilience.

What might be called the “Sen hypothesis”, if there weren’t too many other well-known hypotheses associated with that economist, holds that India suffered fewer famines than China in the latter half of the twentieth century because the former country had a democratic government and a free press, while the latter did not (see, for example, Drèze and Sen, 1989, ch. 11). These concerns were echoed more recently in international criticism of Chinese lassitude in responding to the SARS epidemic. Surely, adaptive capacity in the face of natural disasters is in part a function of such institutional features of a society such as press freedoms or democratic government. In principle, adaptive capacity is a function of two classes of variables: policy-determined variables including the social assistance infrastructure, disaster policy, levels of aid inflows, access to capital markets, and such institutional variables; and structural factors such as the size of the economy, average income, rates of poverty and inequality, geography.

## Policy Issues

Policies can be grouped according to the typology proposed by Holzmann and Jørgensen (2000, 2001): *prevention*, *mitigation*, and *coping*. It should be noted immediately that natural hazards, at least the major geophysical ones, cannot reasonably be *prevented* given the technological and scientific constraints of the age; we simply cannot at the moment stop tectonic plates from moving around. Therefore, unlike other forms of damaging fluctuations (e.g. harvest failures, commodity prices, violence), policy has not and will not in the foreseeable future be aimed at risk prevention.

Nevertheless, policies can and do seek to reduce vulnerability and raise resilience; that is, to strengthen adaptive capacity. A striking feature of the catalogue of disaster-relief measures tallied by Skoufias (2003) is that it includes most of the classic poverty-alleviation policies; there is nothing especially disaster-specific about any of them. Skoufias lists cash transfers, public works, unemployment assistance, wage and commodity-price subsidies, targeted human-development transfers such as those conditional on school attendance, service fee waivers, food and nutrition supplements, microfinance, and social funds.

## Mitigating Vulnerability to Natural Hazards

While risk-prevention strategies seek to reduce the probability of a risk occurring, risk-mitigation strategies attempt to reduce the damages associated with the risk should it occur. These are *ex ante* actions; in the natural-disaster context, this corresponds to reducing *vulnerability* to natural hazards. Risk-mitigation comes in three forms. *Diversification* of risk reduces the variability of income by using a greater variety of assets to generate that income. *Insurance*

involves the pooling of risk across agents, by means of formal insurance contracts or informal arrangements among households. *Hedging*, finally, as is witnessed in financial markets, is effected when one agent pays a second agent a sum to assume a risk borne by the first agent.

### *Diversification of Hazard Risk*

Diversification of assets with risky returns involves accumulating assets with uncorrelated returns. Poor agricultural households might “scatter plots”, hold parcels of land in two or more different places; they might rely on income from family members who have migrated elsewhere; they might undertake non-agricultural pursuits in addition to their farming. When faced with a shock, assets are valuable because they can be drawn down to smooth consumption; *diversified* assets are furthermore valuable because it is possible that not all asset types have suffered damage.

Arguably, human-capital transfers, broadly construed, serve the role of diversifying disaster risk. Households with higher levels of education and better health status are better able to weather shocks. They are better prepared to heed warnings from governments, to seek alternative means of generating income; their superior health means they are better able to withstand short-term shocks to consumption.

Such aims are served by so-called “social funds”, the most-studied of which is probably Mexico’s PROGRESA program<sup>14</sup>. Skoufias (2003) and others argue that if programs like the social fund are in place before a disaster strikes, it dramatically reduces the start-up cost of disaster relief, given that the pre-existing programs can be used to channel aid. What is more immediately relevant to the current discussion is that such targeted human-development transfers effectively diversify poor households’ human-capital portfolio away from a dependence on unskilled labour. Datt and Hoogeveen’s (2003) study of the impact of the Philippine drought of 1997 suggests that diverse sources of labour income helped to protect living standards. It should be noted nevertheless that greater education did not seem to matter to how households fared, and the adverse impact of the shock *increased* with land ownership (this last result is not inconsistent with the beneficial effects of diversification; holding all else constant, raising a household’s land ownership is tantamount to reducing its diversification). Similarly, Reardon and Taylor’s (1996) study of agroclimatic shocks in Burkina Faso showed that rural households with less diversified sources of income fared worse.

Asset redistribution policies (of which many human-development transfers are a subset) can be thought of as diversifying risk in a more global sense. A simple example will illustrate the point. Suppose that a hurricane strikes two communities, each with ten households. In one community, seven houses are built of concrete block, and three are built of straw; in the second, the proportions are reversed. Suppose that all concrete houses can withstand a hurricane and no straw houses can. After the hurricane, there are seven houses standing in the first community and three standing in the second. If more households in the latter community had the means to

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14. See also, for example, the 2002 (16:2) symposium issue of the World Bank Economic Review on “Impact Evaluation of Social Funds”, with cases from Armenia, Bolivia, Nicaragua and Perú. For a more general discussion, see Dercon (2002).

construct more durable housing, their losses from the hurricane would have been less significant. Indeed, Morris and Wodon's (2003) study of the impact of Hurricane Mitch in Honduras finds that households with more assets fared better. Certainly, the prominence of disaster damages in middle-income countries like Brazil and the Philippines is at least in part a function of the inequality with which resources are distributed there, and not solely the mean level of resources per household. A form of asset redistribution targeted toward diversifying the risk of natural hazards is neighbourhood improvement. Thus, a local NGO in Peru facilitated rebuilding of houses destroyed by an earthquake with more earthquake-proof materials (called *quincha*); these houses resisted a subsequent earthquake (World Bank, 2001, 173-174). This is a case of raising the proportion of disaster-proof housing in the example given above. In this context, then, establishing, monitoring and enforcing building standards — a key vulnerability in the Turkish earthquakes — is in fact a policy that diversifies risk and genuinely redistributes wealth.

Resettlement of populations out of hazard-prone areas (e.g. flood plains or the slopes of volcanoes) is another variant of diversification, although problematic because it is likely to face stiff opposition from those to be resettled. Further, most examples of resettlement have been for reasons other than diversifying disaster risk.

Del Ninno *et al.* (2003) consider two major diversification strategies that helped Bangladesh stave off a starvation crisis in the wake of flooding in 1998. The first was long-term agricultural and investment policies that had fostered expansion of winter rice, reducing dependence on flood-susceptible monsoon rice. Thus, though the monsoon harvest was devastated, the impact on consumption was less drastic than would have been the case in the absence of the winter-rice policy. Second, and perhaps more startling in its impact, substantial liberalisation of trade in the years preceding the flooding allowed massive rice imports, which prevented a surge in the rice price. This is contrasted with the 1974 famine in Bangladesh in which speculative behaviour by rice traders and the shortage of foreign exchange with which to purchase foreign rice led to 50-percent increases in rice prices; as many as 100 000 starved to death during the earlier episode. Trade liberalisation can legitimately be seen as diversifying the risk of a natural hazard to food supplies.

### *Insuring against Hazard Risk*

Despite their ingenuity, many community-level risk-pooling schemes are ill-suited to insure their participants against covariant risks like natural hazards (see Bardhan and Udry, 1999, ch. 8). For similar reasons, private insurance companies are unlikely to provide risk-pooling services, given that they may not be able to pool risks with consumers not subject to the risk of natural hazard. Given the thinness of formal insurance markets in many developing countries, it is unlikely that purely private insurance would be a viable means of insuring against disaster risk in any case, even if such risks were geographically limited relative to the size of the market. As with other covariant risks (such as the risk of macroeconomic recession), it is natural to think of the state — or international aid — as the risk manager.

In the late 1990s, the Mexican disaster-relief authority (FONDEN) underwent major changes, some of which look very much like an insurance scheme in which state governments are the contributors and beneficiaries. Institutional reforms to increase the transparency and

accountability of FONDEN decision-making could well increase the authority's ability to behave as a provider of social insurance. Similarly, reforms to disaster relief in Turkey following the 1999 earthquakes (and financed by international donors) include earthquake insurance for property owners (World Bank, 2001, 175, 173). A key emerging theme in discussions of disaster insurance is that hybrid public-private schemes might be most attractive; this will be discussed in Section V below.

### Resilience: Coping with Disasters

The post-Mitch relief effort in Honduras (see Section III) was probably a reasonably successful one; the quality of the effort is thus an upper bound on the efficacy of this kind of *ex post* coping measure. Two lessons emerge from the Mitch experience in Honduras. First, relief aid can potentially avoid "type-I error", or targeting aid to people who suffered no loss (in Honduras, there was strong evidence that aid was channelled to households with housing damage); but aid easily makes type-II error, or failing to reach many victims. Second, in-kind aid is not well-scaled, by its nature, to the *magnitude* of an individual household's losses. Thus poorer victims were, if anything, "overcompensated", and wealthier victims were drastically undercompensated. Such imbalance between losses and compensation would not, presumably, be a feature of well-functioning insurance contracts, for instance.

Del Ninno *et al.* (2003) consider the policy response to massive flooding in Bangladesh in 1998. Two government programs channelled food aid to flood-affected households. The programs exhibited somewhat larger leakage than in Honduras to poor-but-not-flooded households. Like the Honduran case, the volume of food aid was small relative to the needs of households (only one-sixth to one-eighth of the size of household borrowing following the floods). The analysis of Owens *et al.* (2003) of government response to the drought in Zimbabwe in 1994-95 finds even weaker targeting of victims.

Conceptually, the distinction between *ex ante* mitigation policies and *ex post* coping policies is that the former must be conceived before disaster strikes. On the ground, both policies may look similar: delivering food or medicine to households affected by the disaster, for example. But as Skoufias (2003) notes, where poverty-alleviation or social safety net policies exist before a disaster, they can be called upon to provide post-disaster relief without first incurring prohibitive fixed costs. In the context of a different kind of shock, Maluccio (2003) argues that the Nicaraguan social safety net provided surprisingly effective relief for coffee farmers and others hit by the precipitous decline in world coffee prices, even though the policy was not intended to mitigate terms of trade shocks. In the case of natural disasters, mitigation policies might include the formation of medical networks that could be rapidly mobilised, or the establishment of food-storage facilities.

## V. KEY THEMES FOR PUBLIC ACTION

This report has sought to situate the economic discussion of natural disasters by drawing upon two related conceptual frameworks that have gained currency in development economics. First, the paper has drawn upon work on damaging fluctuations (Sinha and Lipton, 1999) to characterise the various features of the risk of natural disasters. Societies may differ in terms of their exposure to natural hazards such as windstorms or seismic activity, but even societies with similar exposure might differ in terms of their *ex ante* vulnerability — the damage that could be expected in the event the hazard occurs — and in terms of their *ex post* resilience — the ability to “snap back” following the occurrence of a natural hazard. Because of cross-country variation in vulnerability and resilience (which together can be thought of as a society’s adaptive capacity), one can readily appreciate that natural disasters are as much socially-produced as they are naturally-produced events. Second, the paper has used the framework of social risk management (Holzmann and Jørgensen, 2001) to understand the kinds of policies that address the risk of natural hazards: both *ex ante* diversification and insurance, and *ex post* coping. These concepts were illustrated with a consideration of two recent disasters: the Turkish earthquakes of 1999, and Hurricane Mitch in 1998.

As a way of concluding this report, it is perhaps useful to underscore three key dimensions of public action: domestic versus international policies; *ex ante* versus *ex post* measures; and public versus private actions. These are not just trade-offs, but balances that must be struck by disaster-related policies. This section concludes with a consideration of how innovative financial instruments for disaster relief might balance these tensions (policy lessons are distilled from a range of recent disasters in OECD, 2004).

### Domestic and International Policies

The first balance is that between domestic and international policy makers, especially bilateral and multilateral aid donors. In this connection, Freeman (2003, 41) calculates “resource gaps” for disaster-prone countries, as a function of per capita income, geographic variation in risk, and frequency of hazard events. For some countries he considers, like El Salvador and the Dominican Republic, the probability is non-trivial that a disaster will occur that will outstrip their ability to raise post-disaster reconstruction funds. Similarly, the Inter-American Development Bank estimates that additional resources of approximately \$2 billion will be needed in each Central American country to safeguard against another hurricane of Mitch-like proportions (IDB, 2000). In such cases, additional international aid will be necessary. As a general rule, for a given degree of exposure to natural hazards, more international assistance will be required the lower is per capita income and the lower is the within-country variation in disaster risk.

The gross magnitude of foreign and domestic resources required to address disaster risk, however, is only one dimension; another is the qualitative nature of foreign and domestic resources. In many settings, these will not be perfect substitutes. Locally-specific human capital might be highly valuable in terms of emergency preparedness and *ex post* coping efforts: that is, local community networks might be able to provide these services at a lower average cost than international agents. Conversely, some kinds of technical expertise [like those involved in establishing early-warning systems or internet-based information-sharing networks like the Regional Centre for Disaster Information in Costa Rica ([www.crid.or.cr](http://www.crid.or.cr))] might be more ably provided, at least initially, by international donors.

The Turkish and Central American case studies (Section III) provide several examples of domestic policies that can reduce vulnerability and increase resilience. Regulations that govern urban development should seek to avoid construction of homes and industrial sites in areas subject to risk of earthquake or flooding; failing that, such regulations should encourage (with subsidies and other incentives, if necessary) buildings and settlements more likely to withstand such hazards. Rural-development policies should provide incentives for households to engage in farming and settlement behaviour that does not increase the rural sector's vulnerability to hazards (e.g. flooding following a windstorm). Furthermore, these policies should encourage urban and rural development that will permit the timely delivery of post-disaster aid (by avoiding entirely unregulated and chaotic "irregular" urban settlement, for example). Finally, such regulations must be effectively monitored and enforced. Whether the resources necessitated by such policies are generated domestically or are financed by foreign aid, their effective implementation will require location-specific knowledge that can only be provided by domestic policy-makers in concert with their constituents.

Finally, recent research on foreign aid cautions that the same aid flows might differ widely in their effectiveness depending on the policy environment in the country to which they are channelled (Burnside and Dollar, 2000). Certainly, disaster-prone countries differ in terms of the quality of governance, and this will have an effect on the efficacy of international disaster-related aid.

### *Ex ante versus Ex post Policies*

It is arguably the case that most developing-country disaster policy takes the form of *ex post* coping. Indeed, *ex ante* policies, to the extent that they exist, are not specifically targeted to disasters -- although this is a feature of some *ex post* measures as well. In any case, many authors argue that a greater emphasis on *ex ante* measures is called for. The US Federal Emergency Management Agency (FEMA), it is reported, calculates that a dollar spent on mitigation saves two in coping (World Bank, 2001, 173). The case studies considered in Section III lend support to this view. In the Turkish cities struck by earthquakes in 1999, it seems reasonable to assume that fewer resources would have been required to build once to code rather than building and then rebuilding earthquake-damaged structures. In the case of the Caribbean (relevant to the example of Hurricane Mitch), the UN estimates that it is less costly to design and build a structure to standards that would withstand maximum expected wind or seismic forces in a given location, rather than build to lower standards and suffer the damages (UNISDR, 2002). Naturally, the

balance struck between *ex ante* and *ex post* policies will have implications for the quantity of domestic and foreign resources that will be needed.

The study by Owens *et al.* (2003) is especially useful in this regard, as it compares the post-drought impact of relief aid in Zimbabwe (1994/95) with counterfactual projections of the impact of *ex ante* policies. Their analysis is based on an unusually good panel data set that allows such questions to be asked. What, they ask, would be the difference if Z\$100 of drought relief post-disaster were instead disbursed as a pre-disaster capital-stock transfer? They answer the question in terms of agricultural income. They develop a number of different scenarios and conduct various sensitivity checks. Their results indicate that under all counterfactuals, income poverty drops dramatically in non-drought years but remains largely unchanged in the drought year. This must be interpreted with caution. It means that *ex ante* transfers have limited power to reduce *income* shocks in disaster years; given that income is substantially higher in non-drought years, however, households are better able to accumulate buffer stocks that can better smooth consumption during drought years.

It would be premature to claim decisive scientific evidence in favour of the cost-effective superiority of *ex ante* measures relative to *ex post* ones, but given the preponderance of *ex post* measures in practice, and the suggestive evidence cited here, an increased focus on *ex ante* measures is certainly appropriate.

### Public versus Private Initiatives

Given that natural hazards are largely covariant risks, households and communities will be ill-suited on their own to insure against such risks. And it is a commonplace to observe in most developing countries that few households, certainly few poor households, can access the formal financial system to smooth their consumption in the face of risks like natural hazards: markets for insurance or credit are thin or non-existent for many people. From this it usually follows that the appropriate agent to manage such risks is the public sector, either in the form of developing-country governments, or international donors, or both. But is this the appropriate conclusion?

Certainly the study by Del Ninno *et al.* (2003) on the role of international rice markets to smooth consumption in the wake of flooding in Bangladesh in 1998 illustrates that markets can be harnessed to manage risks. [This is so even if others have pointed out that international food markets can, under different circumstances, allow foreign consumers to out-bid disaster-struck, and sometimes starving, local consumers (Sen, 1981).] In the context of epidemics, the appropriate analogue is liberalisation of international trade in generic medications. To the extent that market forces can reduce the costs of disaster risk-management policies, decision-makers will have a lively interest in such market-oriented alternatives. As is so often the case in debates about the appropriate roles of the market and the state, it is not helpful to pose the question in terms of a dichotomy. Instead, intelligent public action will seek to complement rather than supplant market forces.

## Innovative Aid Instruments

In the spirit of seeking innovative ways to finance ambitious development objectives such as the Millennium Development Goals (see, for example, Reisen, 2004), can aid donors distil these lessons into novel strategies to manage the risk of natural disasters?<sup>15</sup>

First, if new strategies are to focus on mitigation rather than coping, they will do so by providing diversification of natural hazard risk, or insurance against such risks. As I have argued in Section IV, the establishment and (perhaps more important) enforcement of standards is akin to diversification. Donors can provide technical guidance regarding building standards, but the harder task may prove to be the encouragement of monitoring and enforcement of such standards.

Insurance against disaster risk raises different issues. Such schemes might, at one extreme, be social-insurance systems that are entirely publicly-provided; alternatively, firms and households could purchase private insurance contracts. There exist proposals that seek a third way: using public resources to foster and promote private insurance markets for natural disaster risk.

There are certainly formidable obstacles to be overcome. In the Caribbean context, Auffret (2003a) outlines problems that have prevented the emergence of private insurance markets. There is little to no local forecasting capacity (for predicting location, frequency, duration and magnitude of catastrophes) on which premiums could be based; in their absence, international reinsurers have set premiums at levels observed in the United States. There are the usual asymmetric information problems that beset insurance in most contexts: households and firms who live in high-risk areas are likely to buy more insurance than those in low-risk areas (adverse selection), and those who buy insurance are less likely to engage in risk-reduction activities that would reduce the negative effects of potential natural disasters (moral hazard). As economists have argued for decades, such problems reduce the willingness of private insurers to offer contracts in the first place. Catastrophic events, though frequently cyclical, are sufficiently irregular that people do not adequately prepare for them even when they can. Domestic insurers may face restrictions on investing in international financial markets: this prevents them from buffering their assets against a possible fallout from catastrophic occurrences. This in turn leads insurance companies to set premiums above those that would prevail if they could diversify their investments; and high premiums exacerbate the asymmetric information problems, driving relatively less risky consumers out of the pool. Finally, the availability of *ex post* international assistance is itself a disincentive for risk-reduction policies: why undertake costly measures before the fact when foreign aid is certain to come after the fact?

Several of these problems — notably, the tendency of high-risk buyers to be overrepresented among consumers (i.e. adverse selection) and firms' lack of access to international financial markets — lead to what Skees *et al.* (2002) call the "prohibitive pricing" problem that besets catastrophic or disaster-related insurance. To these might be added the

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15. This section is based primarily on a reading of Auffret (2003a), Batabyal and Beladi (2001), Skees (2000), Skees *et al.* (1999), Skees *et al.* (2002).



tendency of reinsurers to simply drop out of developing-country markets following a disaster, or the problem of insufficient capitalisation of firms.

While economists have long advocated prudent government intervention to address such market failures, Skees and his co-authors remind us that government intervention, at least in the sphere of crop-insurance schemes, has not always been prudent. Government-sponsored schemes have tended to founder on high administrative costs and poorly-designed payout arrangements (farmers often withdrew far more than they put in).

Nevertheless, Auffret correctly argues the public sector (supported by international aid) can address many of these obstacles, at least in principle. Governments can provide the necessary infrastructure for the emergence of private insurance markets, incurring the fixed cost of scientific research to enable local forecasting. Moral hazard could be reduced through enforcement of building standards and other measures; these measures would reduce the supply of "uninsurable properties". Governments can provide tax credits and other incentives to firms and households that make risk-reduction investments or purchase disaster insurance. Removal of restrictions on domestic firms' foreign investments (and on foreign insurance firms' participation in the domestic market) would allow insurers to spread more adequately the risk of disasters they insure. International donors could counter the disincentive effects of *ex post* relief by switching their role from providers of disaster-related assistance to initiators of the implementation of risk-reduction measures, or provide disaster-related lines of credit contingent upon the implementation of some preliminary risk-reduction measures.

This is a long list of policies, not all of which will be everywhere politically feasible. Opening up the domestic market to foreign insurance companies is likely to be politically sensitive, for example. It will be difficult for foreign donors to signal credibly that they are "switching roles", providing less *ex post* assistance in favour of contingent *ex ante* aid. It is furthermore hard to envision how it is that governments that have failed to enforce building standards will suddenly begin to do so. Nevertheless, the key lesson to be drawn from this discussion of catastrophic insurance in the Caribbean is that it poses a very fruitful role for governments to enhance and foster the emergence of markets. This involves a quite traditional rationale for public action, as the provider of infrastructure that lowers the costs of private agents in a host of markets.

A concrete example of this kind of promotion of insurance markets is provided by Skees and his co-authors in a series of studies of the feasibility of crop insurance in some Latin American contexts. The simplest and lowest-cost variant is a rainfall-index insurance scheme that pays farmers when rainfall in their region is below some kind of average<sup>16</sup>. This kind of arrangement especially focuses on the asymmetric-information problems mentioned above, given that farmers cannot manipulate the level of rainfall<sup>17</sup>. Concretely, this may work as follows. A multilateral agency like the World Bank makes a contingency loan to a developing-

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16. Their preferred scheme is based on an index of crop yields, rather than rainfall, at the local level, but this poses more demanding data requirements.

17. Of course, farmers can presumably tamper with rain gauges, which might be a real problem in some instances.

country government. The government offers option contracts payable if rainfall in a region is extremely low by historical standards. Insurance firms and reinsurers can buy whatever quantity and mix of such contracts they like, and use them to hedge their payout risk to farmers themselves, who buy crop insurance from the firms. Reinsurance may be attractive for financial firms, as the risks involved (linked to local rainfall patterns) may be uncorrelated with other global financial returns. In the case of massive rainfall failure, the government draws upon its international contingency loan. (In another variant, international aid could capitalise domestic insurance firms in order to cushion against the probability of a major rain shortfall early in the emergence of the market, the risk of which would otherwise tend to push up premiums and force a return of the prohibitive pricing problem.)

The rainfall-index insurance scheme is targeted not at disasters *per se*, but rather at one of the consequences (crop failure) of a type of disaster (drought). Different disaster types (e.g. urban earthquakes) may be insurable along these lines, but will require suitably-modified schemes. Insurance schemes for disasters whose principal consequences are health-related would not be targeted at households, like the crop-insurance scheme, but at health authorities themselves. Working out the various versions of such public-private hybrid insurance schemes is an eminently worthwhile research task.

The principal point to emphasise here is that such schemes promise to provide substantially more cost-effective disaster relief than many current practices. The choice here for international donors is between financing the World Bank contingency loan and providing *ex post* consumption and other forms of relief. More important, improving *ex ante* security raises the well-being of risk-averse farmers. An added benefit is that this kind of promotion of private insurance will thicken domestic financial markets more generally; this in turn provides greater opportunities to more households and firms to mitigate risks of all kinds.

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