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Insurance against Losses from Natural Disasters in Developing Countries

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Introduction

The impact of natural hazards—weather variability, climate extremes, and geophysical events—on economic well-being and human sufferings has increased alarmingly. More than three-quarters of recent losses from natural hazards can be attributed to windstorms, floods, droughts, and other climate-related hazards (UNISDR 2007). This trend can be attributed largely to changes in land use and increasing concentration of people and capital in vulnerable areas, for example, in coastal regions exposed to windstorms, in fertile river basins exposed to floods, and in urban areas exposed to earthquakes (Mileti 1999). Climate change is aggravating the situation (Schönwiese et al. 2003; IPCC 2007; Emanuel 2005). The Intergovernmental Panel on Climate Change (IPCC 2007) has predicted that climate change will increase weather variability as well as the intensity and frequency of extreme weather events.

Low- and middle-income countries, and especially the vulnerable within these countries, suffer the most from natural hazards. During the last quarter century (1980–2004), over 95 percent of natural disaster deaths occurred in developing countries and their direct economic losses averaged US\$54 billion per annum (Munich Re 2005). As illustrated in Figure 8.1, a sample of large natural disasters over this period showed that fatalities per event were higher by several orders of magnitude in low- and middle-income countries compared with those in high-income countries; and losses as a percentage of gross national income (GNI) across countries were also highly negatively correlated with per capita income.

Figure 8.1 Differential burden of natural disasters.

Notes: Graphs depicting (i) fatalities per event and (ii) insured and uninsured losses according to country income groups.

Data source: Munich Re (2005).¹

Developed and developing countries differ not only in human and economic burden of natural disasters, but also in insurance cover. In rich countries about 30 percent of losses (totaling about 3.7% of GNP) in this period were insured; by contrast, in low-income countries only about 1 percent of total losses (amounting to 12.9% of GNP) were insured.² It should be kept in mind that these losses generally do not include long-term indirect losses, which can be very significant, particularly in countries with low capacity to cope. Due to lack of insurance, combined with exhausted tax bases, high levels of indebtedness, and limited donor assistance, many highly exposed developing countries cannot raise sufficient capital to replace or repair damaged assets and restore livelihoods following major disasters, thus exacerbating the impacts of disaster shocks on poverty and development (Gurenko 2004).

The seriousness of the post-disaster capital gap and the emergence of novel insurance instruments for pricing and transferring catastrophe risks to global financial markets have motivated many developing country governments, as well as development institutions, nongovernmental organizations (NGOs), and other donor organizations, to consider pre-disaster financial instruments as a component of disaster risk management (Linnerooth-Bayer et al. 2005). Donor-supported pilot insurance programs are already demonstrating their potential to pool economic losses and smooth incomes of the poor facing weather variability, climate extremes, and geophysical disasters. These schemes provide insurance to farmers, property owners, and small businesses, as well as transfer risks facing governments to global capital markets.

Since many of these and other recent insurance programs are still in the pilot stage, and none have experienced a major and widespread catastrophic event,

it is too early to fully assess their effectiveness in reducing economic insecurity. However, the need for careful examination of their effectiveness and sustainability, even if based on a short operating history, is underscored by the recent experience with disaster insurance systems in developed countries, especially the widespread inefficiencies of agricultural insurance systems and the insurance controversies following Hurricane Katrina's devastation to poor communities in New Orleans. The question arises whether developing countries should follow the path of the developed world in forming public-private partnerships to insure against catastrophic events, and which insurance instruments and modifications may be appropriate for better tackling the developmental dimensions of natural disasters.

The intent of this chapter is to examine recent experience with insurance and other risk-financing instruments in developing countries, informed by that of developed countries, to provide insights into the effectiveness of insurance for reducing economic insecurity.³ Insurance and other risk-financing strategies should be viewed in the overall context of risk management, including prevention of losses as well as financing the recovery process through risk pooling and transfer strategies. The next section thus briefly reviews the respective cases for risk prevention and risk financing. We then turn to examining insurance and other risk-sharing mechanisms in developing countries: household/business insurance instruments in "Insurance for households and businesses"; agricultural insurance instruments in "Insurance for farmers and herders"; and government risk pooling and transfer mechanisms in "Insurance for governments." Throughout these sections, we discuss relevant experience in industrialized countries. In the final section, we discuss the effectiveness of insurance for providing economic security to vulnerable communities by examining the costs, benefits, and risks, and the appropriate role for donors. Finally, we conclude with general observations about the future role of insurance instruments in developing countries.

Disaster risk management

Insurance instruments are only one of many options in managing risks of natural hazards. The first, and arguably the highest priority in risk management, is to invest in preventing or mitigating human and economic losses. Disaster prevention can take many forms: reducing exposure to risks (e.g. land-use planning); reducing vulnerability (e.g. retrofitting high-risk buildings); or

creating institutions for better response (e.g. emergency planning). The residual risk can then be managed with insurance and other risk-financing strategies for the purpose of providing timely relief and assuring an effective recovery. Disaster risk management thus consists of risk reduction and risk coping.

Disaster risk reduction

While anecdotal evidence shows large benefits to disaster risk reduction in many contexts, there have been only a few systematic cost-benefit analysis (CBA) and other appraisal of prospective investments in disaster risk reduction (Penning-Rowsell et al. 1992; Benson and Twigg 2004; Mechler 2005; Benson et al. 2007; Moench et al. 2007). According to Mechler (2005), available evidence suggests that in many contexts every Euro invested in risk prevention returns roughly 2 to 4 Euros in terms of avoided or reduced disaster impacts on life, property, economy, and environment. In a retrospective analysis of 4,000 mitigation programs, the United States Federal Emergency Management Agency (FEMA) found an average benefit–cost ratio of 4 (Multihazard Mitigation Council [MMC] 2005).

Despite high returns, disasters are very much under-prevented. In the United States, several studies show that only about 10 percent of earthquake- and flood-prone households have adopted loss-reduction measures (Kunreuther 2006). Kunreuther attributes this shortfall mainly to social myopia, which appears hard to influence through public policies. Even with extensive public awareness campaigns in earthquake-prone California, there has been little change in risk perception. Policy makers, faced with myopic voters, also appear reluctant to allocate public resources to reducing disaster risks.⁴ This may be especially the case for development and donor organizations. According to some estimates, bilateral and multilateral donors currently allocate 98 percent of their disaster management funds for relief and reconstruction and only 2 percent for proactive disaster risk management (Mechler 2005).⁵

Studies of risk reduction projects generally demonstrate high benefit–cost ratios (see Linnerooth-Bayer and Mechler 2004 for details). However, assessing costs and benefits of disaster risk reduction is complicated especially because of two difficult tasks: (i) evaluating and expressing risk and (ii) monetizing benefits. Since it is misleading to assess benefits of prevention by deterministic means or by average expected gains (avoid loss), CBAs have to express avoided losses in probabilistic terms. Similarly, monetizing key relevant impacts, such as indirect

economic consequences on income and livelihoods, health effects, loss of life, and ecological effects, is also quite challenging.

Despite the earlier methodological difficulties, transparent CBAs of disaster risk reduction can be useful in guiding public policies. An example is provided by Smyth et al. (2004) who estimated (in probabilistic terms) the economic efficiency of different seismic retrofitting measures for a representative apartment building in Istanbul. Based on estimates of the expected direct damages and the costs of selected retrofitting measures, the authors estimated the expected net present value of such measures. The analysis was conducted for different time horizons, with and without including the monetary value of saving lives. Interestingly, as shown in Figure 8.2, the net present value of bracing apartment buildings and other retrofitting measures *without considering the value of saving lives* was negative for all time horizons considered. Only when including fatalities and a value of US\$1 million for the life of a person did the projects become cost effective for time horizons longer than 10 years. Such findings are of huge policy interest since most retrofitting decisions are made by absentee landlords, who may consider only the economic value of the retrofitting investment without considering the human losses. The analysis shows the large difference between private and social benefits of retrofitting programs, justifying public intervention and funding for such programs.

Increasing evidence of high returns on investments in prevention throughout highly exposed developing countries makes a clear case for giving priority to

Figure 8.2 Net present value for bracing an apartment house in Istanbul over time.

Source: Smyth et al. (2004).

disaster risk reduction. The major hurdle in this regard appears to lie in the absence of requisite political will, as was eloquently expressed by Kofi Annan and United Nations (1999):

Building a culture of prevention is not easy. While the costs of prevention have to be paid in the present, its benefits lie in a distant future. Moreover, the benefits are not tangible; they are the disasters that did NOT happen.

Disaster risk coping

Risk coping through insurance and other hedging instruments spreads and pools risks, thus lessening the *variability* of losses, but not directly reducing them. By providing indemnification in exchange for a premium payment, insured victims benefit from the contributions of the many others who are not affected, and thus in the case of a disaster they receive a contribution greater than their premium payment. However, over the long run, insured persons or governments can expect to pay significantly more than their losses. This is due to the costs of insurance transactions and the capital reserved by insurance companies for potential losses (or reinsurance), as well as the financial return required for absorbing the risks. The “load” can be significant, as much as 500 percent of the pure risk (expected losses). Still, people buy insurance, and justifiably so, because of their aversion to large losses. Insurance and other risk-transfer instruments are thus justified by the concept of risk aversion.

While insurance does not directly prevent losses, well-structured contracts can provide incentives for loss reduction. For example, in Istanbul apartment owners pay less for their insurance if they retrofit their buildings. By providing timely post-disaster liquidity, insurance also reduces the long-term indirect losses, which can be as devastating to lives and livelihoods as the direct damages. In addition to reducing direct and indirect losses, insurance provides economic security. For businesses, insurance removes risks from balance sheets, meaning that higher-profit and higher-risk activities can be pursued. For governments, insurance assures timely assistance and recovery, which can attract more investment to the country.

Globally, insurance penetration for disaster risks is varied. As shown in Figure 8.3, in the United States, parts of Europe, and Australia, the average person pays over US\$500 annually in premium for nonlife disaster coverage as compared to Africa and parts of Asia where the analogous figure is less than US\$5. The averages, however, hide large differences within the regions. In Africa, for instance, there is virtually no coverage at all in a number of countries,

Figure 8.3 Global distribution of nonlife insurance premiums per capita.

Source: Munich Re (2003).

whereas the earlier described per capita premium in South Africa is US\$160 (Munich Re 2003; Swiss Re 2007).

The insured share of economic losses has increased globally from approximately 10 percent in the 1970s to about 25 percent in 2004; yet the overall insurance penetration for many hazards remains relatively low (see Figure 8.4). Globally, storm risk (since it is often bundled with property insurance) has the greatest penetration with about 50 percent of losses currently absorbed by insurance, followed distantly by flood, at less than 10 percent. Other hazards, such as earthquake, wildfire, lighting, and so on, have even less penetration.

As recent major disasters show, even in high-income countries, households and businesses rely extensively on public assistance (see Figure 8.5). After the 1995 Kobe earthquake, where only about 4 percent of damaged or destroyed homes were insured despite a national public–private seismic insurance system, the government provided extensive assistance. Taking another example, in the United States, about 30 percent of total direct private and public losses from the 1994 Northridge earthquake were absorbed by private insurance companies, and the federal government provided extensive assistance to private victims, as well as to state governments for repairing public infrastructure. In stark contrast, in the United Kingdom, which claims 75 percent flood insurance penetration,

Figure 8.4 Global disaster insurance density for different hazards.

Source: Mills (2005).

Figure 8.5 Insurance and government assistance for selected disasters as a percentage of direct losses.

Source: Linnerooth-Bayer and Mechler (2007).

the government gave practically no assistance to the private victims after the 1998 Easter floods.

Insurance is practically nonexistent in least developed countries, like Sudan, where the victims absorbed over 80 percent of the losses from the severe flooding in

1998, and the state covered the rest with outside assistance (Linnerooth-Bayer and Mechler 2007). Outside donor aid and financial assistance are volatile, and with the exception of highly publicized disasters (e.g. the 2004 Indian Ocean Tsunami), aid is usually only a small fraction of what is needed. Humanitarian assistance reported by the Organization for Economic Cooperation and Development (OECD) Development Aid Committee in the 1990s was less than 10 percent of disaster losses in recipient countries (Freeman et al. 2002). Post-disaster arrangements not only are often insufficient for meeting needs for relief and reconstruction, but also tend to be ad hoc and inefficient (Cardenas et al. 2007).

In the absence of government assistance and international aid, poor victims rely on an array of (often innovative) pre- and post-disaster arrangements for financing their recovery. As shown in Table 8.1, insurance is only one of many different modalities for this purpose. The most usual financial course is to raise needed capital after a disaster strikes: Individuals take out emergency loans from family, microcredit institutions, or money lenders; sell or mortgage assets and land; or rely on public and international aid. Likewise, governments raise post-disaster capital by diverting funds from other budgeted programs, borrowing money domestically, or taking loans from international financial institutions.

Table 8.1 Examples of pre- and post-disaster risk financing arrangements

	Security for loss of assets (households/ businesses)	Food security for crops/livestock loss (farms)	Security for relief and reconstruction (governments)
Post-disaster (<i>ex post</i>)	Emergency loans; money lenders; public assistance	Sale of productive assets, food aid	Diversions; loans from World Bank and other IFIs
Pre-disaster (<i>ex ante</i>)			
Nonmarket	Kinship arrangements	Voluntary mutual arrangements	International aid
Inter-temporal	Microsavings	Food storage	Catastrophe reserve funds, regional pools, contingent credit
Market-based risk transfer	Property and life insurance	Crop and livestock insurance (also index based)	Insurance or catastrophe bonds (also index based)

While many locally based funding sources, for example, borrowing from neighbors or family, appear to work reasonably well for small localized events (Cohen and Sebstad 2003), they are problematic for catastrophes that affect large regions or many persons at the same time (so-called covariant or systemic risks). To hedge against covariant risks, households may purposely locate family members outside of harms way or diversify their livelihoods. They may also arrange contingent savings or food supplies, activities that spread risks temporally. Alternatively, households/businesses and farms can purchase property or crop insurance, which spreads risk both temporally and spatially. Insurance can be provided by microinsurance programs, which are distinguished from other types of insurance by their provision of affordable coverage to low-income clients. Like individuals, governments can also spread risks temporarily and spatially by setting up reserve funds or regional pools and by purchasing insurance or hedging instruments (e.g. catastrophe bonds or contingent credit), respectively.

Many of these risk financing modalities are conventional; yet, some, most notably index insurance and catastrophe bonds, are rather novel and have been made possible by new developments in modeling risks and financial transactions. Whereas conventional insurance is written against actual losses, index-based (parametric) insurance is written against physical or economic triggers. Index-based insurance is against *events* that cause loss, not against the *loss* itself. For example, crop insurance may be based on measures of insufficient rainfall at key points in the growing season or a loss index determined by the correlation between historical weather events and crop yields in a region. The insurer will pay out if rainfall measured by a rain gauge falls below a specified level regardless of crop damage. The major advantage of index-based insurance is the substantial decrease in transaction costs, which, particularly for developing countries, have impeded the development of insurance mechanisms. The major disadvantage is *basis risk*, which is the lack of correlation of the trigger with the loss incurred. If the rainfall measured at the weather station is sufficient, but for isolated farmers insufficient, they will not receive compensation for crop losses.

As another novel insurance mechanism, a catastrophe bond is an instrument whereby disaster risks are packaged (*securitized*) in the financial markets (they can be parametric or indemnity based). The investor receives an above-market return when a specific catastrophe does not occur in a specified time but sacrifices interest or part of the principal following the event. Disaster risk is thus transferred to international financial markets that have many times the capacity of the reinsurance market. Another advantage accrues to investors. By

adding catastrophic risk to their investment portfolios, needed diversification is increased since natural catastrophes are not correlated with stocks and other investments tied to economic performance. There are also risks to this and other novel financial instruments, especially if they are not subject to national or international regulation and oversight.

Prevention and coping

How much should be invested in the prevention of disaster losses, and how much in insurance? This is a complex question, which ultimately depends on the costs and benefits of both types of activities, as well as on their interaction (e.g. through incentives, financial instruments influence prevention activities). Cost and benefits, in turn, depend on the nature of the hazard and losses (e.g. the occurrence probability and exposure).

One way to think about prevention and insurance is illustrated by the layering approach shown in Figure 8.6. Generally, costs of prevention increase disproportionately with the severity of the consequences. Therefore, for low- to medium-loss events that happen relatively frequently, prevention is likely to be more cost effective in reducing burdens than insurance. Moreover, individuals and governments are generally better able to finance lower consequence events (disasters) using their own means, such as savings or calamity reserve funds; including international assistance.

Figure 8.6 The layering approach for risk reduction and risk coping.

The opposite is generally the case for costly risk-coping instruments, including insurance, catastrophe bonds, and contingent credit arrangements. Catastrophe insurance premiums fluctuate widely and are often substantially higher than the pure risk premium (average expected loss), mainly because the insurer's cost of backup capital is reflected in the premium. For this reason, it may be advisable to use those instruments mainly for lower probability hazards that have debilitating consequences (catastrophes). Finally, as shown in the uppermost layer of Figure 8.6, most individuals and governments find it too costly to insure against very extreme risks occurring less frequently than, say, every 500 years.

In what follows, we discuss the effectiveness of insurance and other *ex ante* risk-coping schemes that offer security to low-income (i) households and businesses; (ii) farms; and (iii) governments.

Insurance for households and businesses

Microinsurance schemes

Households and businesses in poor countries cannot easily afford commercial insurance to cover their risks, even in the unlikely case that providers exist. Without an insurance culture, or support from family or the government, disasters can lead to a worsening of poverty as victims take out high-interest loans (or default on existing loans), sell assets and livestock, or engage in low-risk, low-yield farming to lessen exposure to extreme events (Varangis et al. 2002).

The intent of microinsurance is to service low-income markets by offering limited coverage and greatly reducing transaction costs (Mechler et al. 2006). Until recently, natural hazards have not been explicitly considered as a niche for microinsurance because they impact large regions with multiple and simultaneous losses, and thus are both more uncertain and have higher potential losses than other types of insurance. The covariant or systemic nature of the risks—and the large capital reserves necessary to avoid insolvency—distinguishes catastrophe coverage from health, accident, and other forms of microinsurance. Given the challenges of providing microinsurance-type coverage for natural disasters, various innovative programs are emerging with the support of governments, NGOs, and international donors.

As identified by Cohen and McCord (2003), there are four institutional models for providing microinsurance-type coverage for catastrophic, covariant risks:

- *Community-based model*: Local communities, MFIs, NGOs, and/or cooperatives develop and distribute the product, manage the risk pool, and absorb the risk, with no involvement on the part of commercial insurers.
- *Full service model*: Commercial or public insurers provide the full range of insurance services.
- *Provider model*: Banks and other providers of microfinance can directly offer or require insurance contracts. These are usually coupled with credit, for example, to insure against default risk.
- *Partner-agent model*: Commercial or public insurers together with microfinance institutions (MFIs) or NGOs collaboratively develop the product. The insurer absorbs the risk, and the MFI/NGO markets the product through its established distribution network. This lowers the cost of distribution and thus promotes affordability.

The microinsurance program offered by *Proshika* in Bangladesh illustrates the community-based model scale. With more than 2 million clients in 20,000 villages and 2,000 slums in 57 districts of the country, Proshika's insurance fund has wide geographic coverage. In 1990 it introduced Participatory Livestock Compensation Fund (PLCF), under which each group of borrowers contributes 3 percent of the purchase value of the animals to this fund and in case of death of the animals the whole purchase value is compensated. However, the scheme experienced wide-scale defaults in years of serious flooding when large part of the country was inundated.

Proshika's experience shows that if insurers with limited capital reserves choose to indemnify large covariant and recurring risks, they must guard against insolvency by diversifying their portfolios geographically, limiting exposure, and/or transferring their risks to the global reinsurance and financial markets. In Bangladesh, large areas of the country can be affected by disasters. For example, normal flooding can affect about 25 percent of the land area whereas extreme events can submerge more than 50 percent of Bangladesh (FAO 2005). Since Proshika's scheme operates without reinsurance or donor support, and without stringent Bangladesh regulations for insurer reserves, its financial viability is questionable. The Proshika scheme is not alone in this respect (Mechler et al. 2006).

The experience of the Proshika scheme and similar other programs have led many observers to recommend the partner-agent model, where commercial insurers play an important role (Linnerooth-Bayer and Mechler 2007). The *Afat Vimo* all-hazard insurance program sponsored by the All India Disaster Mitigation Institute (AIDMI) illustrates this model.⁶ This partner-agent scheme appears to be both affordable to poor clients and, with backup capital from public insurers and donors, resilient to large catastrophes. Important features contributing to its expanding client base, according to its sponsors, are the long-standing relationship that AIDMI has with the communities it serves and the trust established through the administration of the Livelihood Relief Fund (LRF) (Linnerooth-Bayer and Mechler 2007). Effectively utilizing such relationships has, however, proven administratively costly. The enlisting of new clients apparently costs about the same as the premium, and the cost of processing claims about three times this amount.

Diversification and reinsurance can add significantly to the costs of providing microinsurance, which raises the challenge of assuring the financial sustainability of microinsurance providers and at the same time providing affordable premiums to poor and high-risk communities. Many support subsidies (in the broadest sense) to meet this challenge and caution against shifting full responsibility to the poor, while others warn against the negative incentives promoted by subsidies and favor limiting support. It is notable that the *Afat Vimo* program does not adjust premiums to award risk-reducing behavior, which introduces moral hazard in the sense that clients may not take cost-effective preventive measures. Despite the advantages of donor-supported public-private partnerships in providing sustainable and affordable insurance, there are thus concerns that excessive public and international support will distort market prices and greatly jeopardize the incentive effects of insurance.

National insurance programs

Microinsurance programs like *Afat Vimo* usually serve only very few clients. Scaling up across regions with uncorrelated risks adds valuable diversification to these schemes (the scaled-up Proshika scheme appears to include covariant risks), but at the same time diminishes the institutional familiarity and trust that both contributes to their success and reduces expense. This raises the question of how insurance can effectively serve large regions or countries exposed to high systemic risks.

Even in industrialized countries, private insurers have been reluctant to offer region- or nation-wide policies covering flood and other hazards because of the systemic nature of the risks, as well as problems of moral hazard and adverse selection (Kunreuther 1998). Especially for large-scale systems, purchasers often have information that is not known to insurers, or costly to obtain. This asymmetric knowledge jeopardizes the insurance pool.

Because private insurers are often not prepared to fully underwrite the risks, many countries, including Japan, France, the United States, Norway, and New Zealand, have legislated public–private national insurance systems for natural perils with mandatory or voluntary participation of the insured as well as single hazard and comprehensive insurance. The United States National Flood Insurance Program (NFIP), created in 1968, is one such program in which the federal government serves as the primary insurer, offering voluntary policies to residential and commercial buildings (mandatory in the case of a mortgage).

However, the aftermath of Hurricanes Katrina, Wilma, and Rita in 2005 revealed large debts in the NFIP and its continuing dependence on taxpayer support. Insurance brokers estimated that these hurricanes could cost global insurance and reinsurance sectors up to US\$80 billion. A recent government study claimed that the NFIP is not actuarially sound. It does not collect sufficient premium income to build reserves to meet long-term expected future flood losses, partly because the United States Congress authorized subsidized insurance rates for some properties.

Another example is the French system under which private insurers are required to offer catastrophe insurance in an all hazards policy that is bundled with property insurance. The program is reinsured through a public administered fund, the Caisse Centrale de Réassurance (CCR). If this fund proves insufficient, taxpayers will be called upon to contribute.

In an attempt to exploit the advantages of a national pool for disaster risks, and to avoid the problems that plague systems in high-income countries, World Bank and Turkish experts designed the Turkish Catastrophe Insurance Pool (TCIP). The purposes of this pool were to reduce the government's fiscal exposure (large post-disaster liabilities) by gradually building up capital in an insurance pool funded by affordable private contributions, and to create incentives for retrofitting apartment buildings and reducing risk.

The TCIP would not have been possible without recent advances in catastrophe modeling. In the absence of large sets of historical data, advanced risk modeling simulation techniques have increased the confidence insurers place in risk estimates and greatly enhanced the insurability of catastrophic

risks (Kozlowski and Mathewson 1997; Bier et al. 1999; Clark 2002; Boyle 2002). Although risk assessments can be very resource intensive, by drawing attention to risk and prevention measures they can be useful beyond the pricing of insurance contracts. This is the case in Turkey, where local universities have worked together with government in assessing risks and drawing up a blueprint for prevention.

By making policies mandatory and risk based, and by providing for commercial and donor backup capital, TCIP designers attempted to avoid the problems of insufficient penetration and moral hazard experienced by the US flood and French all-hazards systems, respectively. The ambitions of the designers, however, have not been fully realized. Enforcement of compulsory policies has been weak, and penetration at about 20 percent is far from universal. Even full penetration would not include the large number of illegal dwellings in Istanbul. Nor are premiums fully risk based, and some critics argue that the system should have been more closely linked with public spending for retrofitting high-risk apartments (Smyth et al. 2004). Because of increasing vulnerability and lack of widespread penetration, there is a concern that reinsurance capacity will not be sufficient to cover claims in the event of a major earthquake, creating a risk for the government and the insurance industry, and raising the specter of a post-Katrina-type debacle. Despite these serious issues, the TCIP sets an important precedent as the first nation-wide disaster insurance system in a middle-income developing country.

Insurance for farmers and herders

In 2001, global annual agricultural and forestry insurance premiums amounted to some US\$6.5 billion compared with the estimated total value of agricultural production of US\$1,400 billion, implying a global coverage rate of 0.5 percent only. This coverage is concentrated in developed countries, with only a minor percentage of global premiums paid in the developing world (Roberts 2005). Still, agricultural insurance programs exist throughout Asia (e.g. India, Malaysia, and the Philippines), Latin America (e.g. Argentina and Brazil), and Africa (e.g. Mauritius). For the most part, they are heavily subsidized, as illustrated by the Philippines's crop insurance program, which is operated by a para-governmental entity, the Philippines Crop Insurance Corporation (PCIC).

There is a great deal of controversy surrounding subsidized agricultural insurance. Subsidized programs in North America and Europe are viewed

by many economists as failed policy. Commenting on the US farm insurance program, Jerry Skees (2001) remarks:

What was once a good idea—using crop insurance to share risk in agriculture—has become bad public policy in America. What was touted as a “market-based solution” is now very costly, inefficient, and inequitable . . .

Subsidies are a concern for agricultural insurance programs in developing countries, not only because of inefficiencies caused by market distortions, but also because governments cannot afford income transfers given the large segments of the population engaged in farming in these countries.

Index-based crop insurance

Traditionally, insurers have paid claims based on actual losses (indemnity-based insurance), which requires extensive networks of claims adjusters who assess individual losses following an event. It also means investing in controlling moral hazard. Moreover, insurers in low-income countries have far less access to global crop reinsurance markets than do those in developed countries. The low volume of business and large fixed transactions costs means that reinsurers can service these markets only at high cost. Traditional indemnity-based crop insurance programs are thus costly, which is a reason why many such programs have failed in developing countries (World Bank 2005).

To avoid the high transaction costs of indemnity-based insurance systems, index-based or parametric schemes make payouts contingent on a physical trigger, such as rainfall measured at a regional weather station, thus circumventing expensive claims settling. In the case of weather derivatives, farmers collect an insurance payment if the index reaches a certain measure or “trigger” regardless of actual losses. These schemes may offer a less costly and thus more viable alternative to traditional indemnity-based crop insurance.

The World Bank has provided the impetus and technical assistance for implementation of innovative index-based crop insurance schemes, making use of MFIs for promoting and distributing the product in developing countries. As a recent example, in Malawi, where the economy and livelihoods are severely affected by rainfall risk resulting in drought and food insecurity, groundnut farmers can now receive loans that are insured against default with an index-based weather derivative (Hess and Syroka 2005).

Under this scheme, there is no need for expensive individual claims settling, and expedient payments will reduce the need for farmers to sell their assets and

livestock to survive the aftermath of a disaster. Because of the physical trigger, there is no moral hazard; to the contrary, farmers will have an incentive to reduce potential losses, for instance, by diversifying their crops. Because they can access higher yield and higher risk crops, the insurance will promote cost-effective higher-risk activities, thus reducing the chances for moral hazard. In the words of one of the designers of the Malawi program:

We want farmers to adopt high return technologies that allow them finally to make the leap and accumulate earnings over time. Systemic risk is the factor impeding this and so far banks cannot handle the risk and the high transaction costs in rural areas. This Malawi transaction shows that there is a sustainable way to take the big rocks out of the way—drought risk—and clear the path to development! (Hess 2005)

Although direct premium subsidies are not necessary, the program received assistance from the World Bank for starting up operations. It should be kept in mind, however, that the Malawi program provides only very limited coverage. By reducing loan repayments in the case of drought, the insurance only indirectly protects farmers from loss of livelihood and food insecurity. This is not the case with a similar pilot scheme, BASIX, launched by a rural microfinance organization in the Indian state of Andhra Pradesh, which provides cash payouts—albeit to middle-income farmers—who insure their cash crops (Hess and Syroka 2005; Mechler et al. 2006).

Comparing the two schemes in Malawi and India, neither of which has public assistance from taxpayers, the question arises whether more extensive outside assistance for microinsurance schemes of this type is necessary. Can the private market fulfill the insurance needs of the poor? The answer depends on the ability of clients to afford the requisite coverage. Middle-income farmers in Andhra Pradesh can afford the premiums for insurance that significantly reduces their insecurity; this would not be the case for very low-income farmers in Malawi, who cannot afford such extensive coverage. Unless supported by technical assistance, national subsidies, or international donors, these schemes are out of reach for very low-income smallholder farmers facing high risks.

This explains why international insurers have been reluctant to commit significant capital and underwriting expertise to developing market-based microinsurance programs. Support from international donors can change this situation. As a recent case in point, Swiss Re has insured about 150,000 smallholder farmers in Kenya, Mali, and Ethiopia against drought through

a parametric product. The insurance is purchased by the internationally backed NGO, and other partners are being solicited to provide further financial support.

Enthusiasts point out that the Malawi, BASIX, and Swiss Re programs, if scaled up, could provide the blueprint for insuring more than 40 percent of farmers in developing countries, who face threats to their livelihoods from adverse weather (World Bank 2005). A survey of 168 farmers participating in the 2005–2006 Malawi pilot program provides both optimism and caution for this scenario (Suárez et al. 2007).

The survey results are optimistic in that most stakeholders remain strong supporters of the program. However, low trust in key institutions and lack of understanding of the system raise the question whether the institutional context is sufficiently mature for such schemes to operate on a large scale.

Index-based livestock insurance⁷

In Mongolia, where domestic animals provide sustenance, income, and wealth to protect nearly half the residents, a harsh winter (*dzud*) can have devastating effects even for experienced herders. To protect herders against livelihood losses from extreme weather, an innovative livestock insurance program has recently been developed by the World Bank. It stands in contrast to Mongolia's traditional indemnity-based livestock insurance, which was ineffective for several reasons, such as high costs of settling claims across vast areas, disincentives to reduce losses, and incentives to falsely report animal deaths. The goal of the new public–private system according to its founders (see Mahul and Skees 2006) is to (i) offer insurance coverage that is attractive to herders, (ii) involve the domestic insurance market while protecting it against catastrophic losses, and (iii) limit the fiscal exposure of the government. Under the Index-Based Livestock Insurance (IBLI) system, compensation is based on the overall mortality rate of adult animals in a given county determined by a (long-standing) yearly census. The insurance system is made affordable to herders and viable to insurers by a layered system of responsibility and payment. Herders retain small losses that do not affect the viability of their business. The next layer of losses is transferred to the private insurance industry through risk-based premium payments on the part of herders. A third layer of risk is absorbed by taxpayers, in what Mahul and Skees (2006) refer to as the “social product.” Herders who purchase the first layer of protection are automatically registered for the social layer at no additional cost. The financing of the Government's potential losses during the pilot phase

relies on a combination of reserves and—as a fourth layer—a contingent credit provided by the World Bank.

As with other index-based systems, the Mongolian scheme minimizes moral hazard, but since the claim payment is triggered by the event (the *dzud*) rather than individual losses, basis risk is a concern. Since insurance claims depend on overall mortality, IBLI provides strong incentives to individual herders to manage their herds so as to minimize the impact of major *dzud* events. But, the imperfect match between index payouts and individual livestock losses can be a significant issue for extreme winters with large losses, in which case the designers hope that other informal risk sharing measures will be enhanced. Like in Malawi, lack of understanding of the index system may present a problem, and focus groups with herders have already been conducted to help shape educational material. Finally, the potential for fraud in the distribution of the product, and elsewhere in the system, is not negligible despite certification of sales persons, the use of unique identification numbers, and strict accounting systems.

Insurance for governments

Governments usually have responsibility for a large portfolio of public infrastructure assets that are at risk to natural disasters. Moreover, most governments are obligated to provide post-disaster emergency relief and assistance to vulnerable households and businesses. Governments of developing countries typically finance their post-disaster expenses by diverting from their budgets or from already disbursed development loans, as well as by relying on new loans and donations from the international community. In the past, these post-disaster sources of finance have often proven inadequate to assure timely relief and reconstruction in developing countries. For example, 2 years following the 2001 earthquake in Gujarat, India, assistance from a government reserve fund and international sources had reached only 20 percent of original commitments (World Bank 2003). Post-disaster assistance not only is often inadequate, but can also discourage governments and individuals from taking advantage of the high returns to preventive actions.

Insuring governments

In wealthy countries government insurance hardly exists at the national level, although states in the United States, Canada, and Australia often carry

coverage for their public assets. In theory, there is little rationale for insuring public infrastructure risks in large developed countries. It was noted earlier that people buy insurance because of their aversion to large losses. In contrast to individuals, governments are not, in theory, risk averse, and thus in most circumstances should not purchase insurance (in Sweden, insurance for public assets is illegal). This is the result of a well-known theorem by Arrow and Lind (1970), who give two reasons for the risk neutrality of the public sector: If the government spreads its risk over its citizens (most usually by means of taxation), the expected and actual loss to each individual taxpayer is minimal due to the sheer size of the population. Moreover, a government's relative losses from disasters in comparison with its assets may be small if the government possesses a large and diversified portfolio of independent assets.

Neither of these reasons applies to small, low-income and highly exposed countries that have overstretched tax bases and highly correlated infrastructure risks (Linnerooth-Bayer and Mechler 2004). Realizing the shortcomings of after-the-event approaches for coping with disaster losses, sovereign insurance may become an important cornerstone for tackling the substantial and increasing effects of natural disasters (Gurenko 2004). This message became clear to the Mexican authorities after experiencing the 1985 earthquake in Mexico City. Colossal expenses on rehabilitation and reconstruction resulted in an increase in the fiscal deficit of US\$1.9 billion over the next 4 years (Cardenas et al. 2007). In 1996, the authorities created a financial risk management program (FONDEN) including a catastrophe reserve fund. In 2005, after the severe hurricane season, the FONDEN fund was exhausted, leading the Finance Ministry to consider hedging against natural disaster shocks. As a result, the authorities recently engaged in an international risk-transfer transaction to provide financial protection to the fund. Mexico has thus become the first transition country to transfer its public sector catastrophe risk to the international reinsurance and capital markets.

This transaction is likely to set an important precedent for protecting highly exposed developing and transition country governments against the financial risks of natural catastrophes. To date, catastrophe bonds have been issued mainly by primary insurance companies as an alternative to reinsurance, and this market has been growing at a considerable pace. Total coverage is currently US\$5 billion, up from approximately US\$3.5 billion in 2003 (Guy Carpenter 2006).

Since it is held by an independent authority, one major advantage of a catastrophe bond issued by a sovereign state is the avoidance of political risk, or

the risk that the funds will be allocated to other government programs, which plagued FONDEN. There is no guarantee, however, that the post-disaster bond payments reach those most in need after a disaster. Moreover, the catastrophe bond transaction proved to be of very high cost. Specifically, expenses amounted to about 2 percent of the coverage, which is far greater than traditional reinsurance, which normally approximates 1 percent (Lane 2004). The costs included payments to outside consultants for modeling risks, a myriad of legal fees, costs of the rating agency, and other administrative expenses (Cardenas et al. 2007). While it is difficult to standardize the placement of catastrophe bonds in the financial markets and thus reduce legal and other fees, the cost of estimating risks may be reduced by improving public domain data bases and developing internal capacity for risk assessments. For example, the World Bank is currently sponsoring work on creating an openly accessible and verifiable database for Central America, which can potentially provide the basis for risk financing transactions in that region. It should also be possible to substitute outside consultancy firms with internal expertise in estimating risks. In Istanbul, for example, the universities are developing their capacity to carry out sophisticated catastrophe modeling as a basis for risk assessments. Participants at a recent workshop on this topic emphasized the potential contribution of donor organizations to the development of data bases and capacity building (Linnerooth-Bayer et al. 2007).

Pooling small states' sovereign risks

As discussed earlier, larger countries can generally absorb the impact of adverse natural events since the affected region can be subsidized by revenues from unaffected regions. This type of geographic distribution of risk is not possible for many small states, and for this reason they can benefit from pooling arrangements stretching beyond their borders. Only few such vulnerable developing countries, however, have insurance. Exceptions include Colombia, Madagascar, Honduras, and Barbados. A limitation facing small states intent upon transferring their risk is that they pay international prices subject to wide fluctuations. For example, Barbados experienced a ten-fold increase in insurance premiums after Hurricane Andrew in 1992, despite the fact that the island does not lie in a major hurricane path.

Partly to avoid this limitation, the Caribbean Catastrophe Risk Insurance Facility (CCRIF) was recently established to provide the Caribbean Community (CARICOM) governments with limited, but immediate, liquidity in the event of

a major hurricane or earthquake at a significantly lower cost than if they were to purchase insurance separately in the financial markets. Early cash claim payment received after an event will help to overcome the typical post-disaster liquidity crunch. The facility appears well protected against insolvency with reinsurance and pro-rated contracts. Once again, a major concern about the long-term acceptance and viability of the pool is basis risk. For instance, Hurricane Dean (2007) imposed damages on Jamaica, but not sufficient to trigger compensation from the pool.

Concluding remarks

The questions motivating this discussion were whether developing countries should follow the path of the developed world in building public-private partnerships to insure against catastrophic events, and which insurance instruments and modifications may be appropriate for better tackling the developmental dimensions of natural disasters.

While most would agree that private and social insurance systems have provided security against old age and disability, unemployment, and other risks in the developed world, the record of insurance for providing security against floods, earthquakes, and other hazards is more tenuous. Due to the specific nature of covariant risks, insurance penetration is weaker and uneven. Private insurers have been reluctant to commit capital to many types of hazards; adverse selection and moral hazard continue to plague indemnity-based systems; subsidies have proven disruptive to markets; private and national programs alike are often undercapitalized; and climate change appears to be contributing to increased insurance losses and, in some cases, un-insurability. These are problems that will limit the effectiveness of insurance in developing countries as well.

At the same time, recent and innovative insurance programs in developing countries may potentially offer a preferred alternative to reliance on post-disaster donor aid. With this in mind, it is important to closely examine the development of nascent insurance systems throughout Asia, Africa, and Latin America.

A review of the innovative schemes shows that there is a large potential for insurance in the developing world for changing the way development organizations provide disaster assistance, engaging the private sector in vast markets, providing reliable and dignified post-disaster relief, supporting adaptation to climate change and, not least, spurring economic development. There are also many challenges: assuring sustainability and affordability in

light of covariate risks and adverse selection; defining an appropriate role of donors in light of the inefficiencies of subsidies; and assuring that systems avoid moral hazard and contribute to “good” investments. Pilot programs are offering a testing ground that should be carefully monitored and built upon by governments, international development organizations, NGOs, private insurers, and the climate-adaptation community.

Notes

- 1 Country income groups are according to World Bank classification using GNI per capita. Low income: less than US\$760 per year, middle income: US\$760–US\$9,360 per year, high income: larger than US\$9,360 per year in 2005.
- 2 These losses are mostly direct losses of productive assets and property (*stocks*). Only to a minor extent are *indirect* losses of value added (*flows*), such as business interruption losses, accounted for and insured.
- 3 For more detailed discussion of the issues, see Linnerooth-Bayer and Mechler (2009).
- 4 “In the absence of concrete information on net economic and social benefits and faced with limited budgetary resources, many policy *makers* have been reluctant to commit significant funds for risk reduction, although happy to continue pumping considerable funds into high profile, post-disaster response” (Benson and Twigg 2004: 4).
- 5 This is the topic of an ongoing study sponsored by World Bank and UN-ISDR on “The economics of disaster risk reduction.”
- 6 See Linnerooth-Bayer and Mechler (2009) for description of various concrete cases.
- 7 This section is based on Mahul and Skees (2006).

References

- Annan, K. A. and United Nations (1999) *Facing the Humanitarian Challenge: Towards a Culture of Prevention*. New York: United Nations Department of Public Information.
- Arrow, K. J. and R. C. Lind (1970) “Uncertainty and the Evaluation of Public Investment Decisions,” *The American Economic Review*, 60, 364–378.
- Association of British Insurers (ABI) (2007) *Renewing the Partnership—How the Insurance Industry Will Work with Others to Improve Protection Against Floods*. London: Association of British Insurers.
- Auffret, P. (2003) “Catastrophe Insurance Market in the Caribbean Region,” World Bank Policy Research Working Paper No. 2963. Washington, DC.

- Benson, C. (1998) "The Cost of Disasters," in J. Twigg (ed.), *Development at Risk? Natural Disasters and the Third World*, pp. 8–13. Oxford: Oxford Centre for Disaster Studies.
- Benson, C. and J. Twigg (2004) "Measuring Mitigation: Methodologies for Assessing Natural Hazard Risks and the Net benefits of Mitigation—A Scoping Study." International Federation of the Red Cross and Red Crescent Societies, ProVention Consortium, Geneva.
- Benson, C., J. Twigg, and T. Rossetto (2007) *Tools for Mainstreaming Disaster Risk Reduction: Guidance Notes for Development Organizations*. Geneva: ProVention Consortium.
- Bier, V., M. Yacov, Y. Haimes, J. H. Lambert, N. C. Matalas, and R. Zimmerman (1999) "A Survey of Approaches for Assessing and Managing the Risk of Extremes," *Risk Analysis*, 19(1), 83–94.
- Boyle, C. (2002) "Catastrophe Modeling: Feeding the Risk Transfer Food Chain," *Insurance Journal*, February 25. Available at <http://www.insurancejournal.com/magazines/west/2002/02/25/features/18828.htm>
- Cardenas, V., S. Hochrainer, R. Mechler, G. Pflug, and J. Linnerooth-Bayer (2007) "Sovereign Financial Disaster Risk Management: The Case of Mexico," *Environmental Hazards*, 7, 40–53.
- Clark, K. M. (2002) "The Use of Computer Modeling in Estimating and Managing Future Catastrophe Losses," *The Geneva Papers on Risk and Insurance*, 27, 181–195.
- Cohen, M. and M. McCord (2003) "Financial Risk Management Tools for the Poor," in ADA, Microinsurance Centre Briefing Note #6. MicroinsuranceCentre.
- Cohen, M. and J. Sebstad (2003) *Reducing Vulnerability: The Demand for Microinsurance*. MicroSave-Africa.
- CRED (2007) *EM-DAT: International Disaster Database*. Belgium: Centre for Research on the Epidemiology of Disasters, Université Catholique de Louvain.
- Emanuel, K. (2005) "Increasing Destructiveness of Tropical Cyclones Over the Past 30 Years," *Nature*, 436, 686–688.
- Food and Agriculture Organization (FAO) (2005) *The State of Food Insecurity in the World, 2004*. Rome: Food and Agriculture Organization of the United Nations.
- Freeman, P. K., L. A. Martin, J. Linnerooth-Bayer, R. Mechler, S. Saldana, K. Warner, and G. Pflug (2002) *Financing Reconstruction. Phase II Background Study for the Inter-American Development Bank Regional Policy Dialogue on National Systems for Comprehensive Disaster Management*. Washington, DC: Inter-American Development Bank.
- Fuchs, S., M. Thöni, M. McAlpin, U. Gruber, and M. Bründl (2006) "Avalanche hazard mitigation strategies assessed by cost effectiveness analysis and cost benefit analyses—evidence from Davos, Switzerland," *Natural Hazards*, 41(1), 113–129.
- Ghesquiere, F., O. Mahul, M. Forni, and R. Gartley (2006) "Caribbean Catastrophe Risk Insurance Facility: A Solution to the Short-Term Liquidity Needs of Small Island States in the Aftermath of Natural Disasters." Available at www.aidandtrade.org, IAT03–13/3

- Griffin, D. L. (2007) "Testimony before the US Senate Banking, Housing and Urban Affairs Committee Concerning the National Flood Insurance Program on behalf of the Property Casualty Insurers Association of America," October 2, Congressional Record, Washington, DC.
- Gurenko, E. (2004) "Introduction," in E. Gurenko (ed.), *Catastrophe Risk and Reinsurance: A Country Risk Management Perspective*, pp. 3–16. Risk Books, London.
- Guy Carpenter (2006) *The Catastrophe Bond Market at Year-End 2005. Ripple Effects from Record Storms*. Guy Carpenter, New York.
- Hess, U. (2005) Personal communication.
- Hess, U. and J. Syroka (2005) "Risk, Vulnerability and Development," Presentation at BASIX Quarterly Review & Insurance Meeting, Hyderabad, October 21.
- Insurance Journal* (2005) "National News, Fitch: Hurricane Wilma Further Strains a Delicate Florida Insurance Market," October 26. Available at <http://www.insurancejournal.com/news/national/2005/10/26/61318.htm>
- Intergovernmental Panel on Climate Change (IPCC) (2007) "Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability Summary for Policymakers." Cambridge: Cambridge University Press.
- Kozlowski, R. T. and S. Mathewson (1997) "A Primer on Catastrophe Modeling," *Journal of Insurance Regulation*, Spring, 322–341.
- Kramer, R. A. (1995) "Advantages and Limitations of Benefit-Cost Analysis for Evaluating Investments in Natural Disaster Mitigation," in M. Munasinge and C. Clarke (eds), *Disaster Prevention for Sustainable Development: Economic and Policy Issues*, pp. 61–76. Washington, DC: World Bank.
- Krugman, P. (2007) "Innovating Our Way to Financial Crisis," *The New York Times*, December 4. Available at www.nytimes.com/2007/12/03/opinion/03krugman.html
- Kunreuther, H. (1998) "Insurability Conditions and the Supply of Coverage," in H. Kunreuther and R. J. Roth (eds), *Paying the Price: The Status and Role of Insurance Against Natural Disasters in the United States*, pp. 17–50. Washington, DC: Joseph Henry Press.
- (2006) "Disaster Mitigation and Insurance: Learning from Katrina," AAPSS, 604(March), 206–227.
- Lane, M. (2004) "The Viability and Likely Pricing of "Cat Bonds" for Developing Countries," in E. Gurenko (ed.), *Catastrophe Risk and Reinsurance: A Country Risk Management Perspective*, pp. 239–268. Risk Books, London.
- Liedtke, P. (2007) "What's Insurance to a Modern Economy," *The Geneva Papers*, 32, 211–221.
- Linnerooth-Bayer, J., P. Hoeppe, L. Petersen, and E. Gurenko (2007) *Summary: Expert Workshop on Insurance Instruments for Adaptation to Climate Risks: Linking Policy Agendas*, IIASA, Laxenburg, Austria, September 24–25. Available at <http://www.iiasa.ac.at/Research/RAV/conf/ICR-07/icr-agenda.pdf>

- Linnerooth-Bayer, J. and R. Mechler (2004) "Financing Disaster Risks in Developing and Emerging-Economy Countries," Paper presented at the OECD conference, "Catastrophic Risks and Insurance," Paris, November 22.
- (2007) "Disaster Safety Nets for Developing Countries: Extending Public–Private Partnerships," *Environmental Hazards*, 7, 54–61.
- (2009) "Insurance against Losses from Natural Disasters in Developing Countries," DESA Working Paper No. 85, ST/ESA/2009/DWP/85. New York: United Nations.
- Linnerooth-Bayer, J., R. Mechler, and G. Pflug (2005) "Refocusing Disaster Aid," *Science*, 309, 1044–1046.
- Mahul, O. and J. Skees (2006) "Piloting Index-Based Livestock Insurance in Mongolia," *AccessFinance*, World Bank, Issue no. 10.
- Mechler, R. (2004a) *Natural Disaster Risk Management and Financing Disaster Losses in Developing Countries*. Karlsruhe: Verlag für Versicherungswirtschaft.
- (2004b) "Piura Case Study," Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ), Eschborn.
- (2004c) "Semarang Case Study," Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ), Eschborn.
- (2005) "Cost-Benefit Analysis of Natural Disaster Risk Management in Developing Countries," Working Paper. Deutsche Gesellschaft fuer Technische Zusammenarbeit (GTZ), Eschborn.
- Mechler, R., J. Linnerooth-Bayer, and D. Peppiatt (2006) *Microinsurance for Natural Disasters in Developing Countries: Benefits, Limitations and Viability*. Geneva: ProVention Consortium. Available at http://www.proventionconsortium.org/themes/default/pdfs/Microinsurance_study_July06.pdf
- Mileti, D. S. (ed.) (1999) *Disasters by Design: A Reassessment of Natural Hazards in the United States*. Washington, DC: Joseph Henry Press.
- Mills, E. (2005) "Insurance in a Climate of Change," *Science*, 309, 1040–1044.
- (2007) *From Risk to Opportunity: Insurer Responses to Climate Change*. Boston, MA: Ceres.
- Mizina, S. V., J. B. Smith, E. Gossen, K. F. Spiecker, and S. L. Witkowski (1999) "An Evaluation of Adaptation Options for Climate Change Impacts on Agriculture in Kazakhstan," *Mitigation and Adaptation Strategies for Global Change*, 4, 25–41.
- Moench, M., R. Mechler, and S. Stapleton (2007) "Guidance note on the Costs and Benefits of Disaster Risk Reduction," Paper for ISDR High level Platform on Disaster Risk Reduction, June 4–7, Geneva.
- Multihazard Mitigation Council (MMC) (2005) *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities: Volume 2—Study Documentation*. Washington, DC: Multihazard Mitigation Council.
- Munich Re (2003) "NatCatSERVICE," Global Distribution of Insurance Premiums Per Capita Munich Re, Munich.
- (2005) "NatCatSERVICE," Natural Disasters According to Country Income Groups 1980–2004. Munich Re, Munich.

- Nagarajan, G. (1998) *Microfinance in the Wake of Disasters: Challenges and Opportunities*. Bethesda, MD: Microenterprise Best Practices Project.
- Penning-Rowsell, E., C. Green, P. Thompson, A. Coker, S. Tunstall, C. Richards, and D. Parker (1992) *The Economics of Coastal Management—A Manual of Benefit Assessment Techniques (The Yellow Manual)*. London.
- ProVention Consortium (2005) *Successful Disaster Prevention in Latin America: The Argentina Flood Rehabilitation and the Rio Flood Reconstruction and Prevention Project*. Geneva: ProVention Consortium.
- Roberts, R. A. J. (2005) *Insurance of Crops in Developing Countries*, FAO Corporate Document Repository. Available at <http://www.fao.org/docrep/008/y5996e/y5996e02.htm>
- Schönwiese, C. D., J. Grieser, and S. Tromel (2003) "Secular Change of Extreme Monthly Precipitation in Europe," *Theoretical and Applied Climatology*, 75(3–4), 245–250.
- Skees, J. R. (2001) "The Bad Harvest: More Crop Insurance Reform: A Good Idea Gone Awry," *Regulation: The CATO Review of Business and Government*, 24, 16–21.
- Smyth, A. W., G. Altay, G. Deodatis, M. Erdik, G. Franco, P. Gülkan, H. Kunreuther, H. Luş, E. Mete, N. Seeber, and Ö. Yüzügülü (2004) "Benefit-Cost Analysis for Mitigating Seismic Losses: Probabilistic Evaluation of Retrofit Measures for Residential Buildings in Turkey," *Earthquake Spectra*, 20(1), 171–203.
- StormingMad.com (2006) *News: The Truth Hurts*, Florida Pushing Aside Troubled Insurer, May 19. Available at <http://www.stormingmad.com/2006/05/florida-pushing-aside-troubled-insurer.html>
- Suárez, P., J. Linnerooth-Bayer, and R. Mechler (2007) "Feasibility of Risk Financing Schemes for Climate Adaptation: The Case of Malawi," DEC-Research Group, Infrastructure and Environment Unit. Washington, DC: The World Bank.
- Swiss Re (2007) *World Insurance in 2006. Premiums Came Back to "Life."* Sigma 4, Swiss Re, Zurich.
- United Nations International Strategy for Disaster Reduction (UNISDR) (2007) Available at <http://www.unisdr.org/disaster-statistics/impact-economic.htm>
- US Government Accounting Office (GAO) (2005) *Federal Emergency Management Agency, Challenges Facing the National Flood Insurance Program*, GAO Highlights, Washington, DC, October.
- Varangis, P., J. R. Skees, and B. J. Barnett (2002) "Weather Indexes for Developing Countries," in B. Dischel (ed.), *Climate Risk and the Weather Market*, pp. 279–294. London: Risk Books.
- Vaux, T. (2007) "Risk Transfer for Human Security: A Review of the Regional Risk Transfer Initiative," Report for AIDMI, Ahmedabad, India.
- Venton, C. C. and P. Venton (2004) *Disaster Preparedness Programmes in India: A Cost Benefit Analysis*. London: Humanitarian Practice Network, Overseas Development Institute.

- Vermeiren, J. C. and S. Stichter (1998) "Costs and Benefits of Hazard Mitigation for Building and Infrastructure Development: A Case Study in Small Island Developing States," Paper before Conference of The International Emergency Management Society.
- Wiseman, W. and U. Hess (2007) "Reforming Humanitarian Finance in Ethiopia: A Model for Integrated Risk Financing," Draft manuscript submitted to Elsevier Publishers.
- World Bank (1996) "Argentina Flood Protection Project," Staff Appraisal Report 15354. Washington, DC: World Bank.
- (2003) "Financing Rapid Onset Natural Disaster Losses in India: A Risk Management Approach," Report No. 26844. Washington, DC: World Bank.
- (2005) *Managing Agricultural Production Risk*. Washington, DC: World Bank.
- (2007) "The Caribbean Catastrophe Risk Insurance Initiative," Results of Preparation Work on the Design of a Caribbean Catastrophe Risk Insurance Facility. Washington, DC: World Bank.