Insurance-Related Actions and Risk Assessment in the Context of the UNFCCC

Background paper for UNFCCC workshops – commissioned by the UNFCCC Secretariat

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Decision 5/CP.7 calls for the implementation of two insurance-related workshops. This paper focuses on the needs of developing countries arising from the impacts of climate change, in particular extreme weather events. It is intended to provide background material for participants attending the workshops and for work on insurance-related activities in the UNFCCC context. This paper contains information on the legal context of insurance-related actions within the UNFCCC and Kyoto Protocol (Section I), describes the challenge of risk assessment and sharing of the risks of extreme weather events in developing countries (Section II), and presents an overview of risk assessment methodology and the difficulties arising when climate change concerns are incorporated in risk assessment and modeling (Section III). Section IV then presents examples of catastrophe insurance and other risk hedging instruments that have developed, as national and international institutions have increasingly sought out private-public partnerships to assist in the transfer of risk related to natural disasters. Section V presents further examples of how insurance concepts have been utilized by the international community in the establishment of sophisticated legal mechanisms for risk-transfer for transboundary environmental damage, noting the ways in which compulsory private insurance and collective loss sharing arrangements have emerged as preferred risk transfer strategies within those mechanisms. Finally, Section VI presents some issues for discussion as well as options for cooperation of the climate regime with other existing institutions engaged in related substantive work.

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I. Background for Insurance-Related Actions in the UNFCCC and Kyoto Protocol

This section provides an overview of the history of the UNFCCC and Kyoto Protocol treaty provisions pertinent to the issue of insurance-related actions, as well as the current status of negotiations/decisions on this issue.

1. Negotiation History: the AOSIS proposal

During the negotiations of the UNFCCC, developing country parties repeatedly stressed the need for instruments to meet the challenge of damage resulting from the impacts of climate change. Although it was agreed early on that implementation costs of developing country parties would be met (to some extent) through a financial mechanism, the issue of who would bear the risk of impacts was left unresolved (Tol/Verheyen, 2003). Introducing the term “insurance” for the first time, the Alliance of Small Island States (AOSIS) suggested at the third session of the Intergovernmental Negotiation Committee (INC3) in 1991 that a fund should be established to “*compensate developing countries (i) in situations where selecting the least climate sensitive development option involves incurring additional expense and (ii) where insurance is not available for damage resulting from climate change*” (A/AC.237/Misc.1/Add.3). AOSIS specified this demand at INC 4 with a proposal on the creation of an "International Insurance Pool" (A/AC.237/15).

AOSIS’s proposal sought to establish an international scheme under the control of the COP, funded by industrialised parties, which would compensate small island and low-lying developing nations for loss and damage resulting from sea level rise. Mandatory contributions to the pool were to be administered by an administrating authority (Authority), which would also be responsible for handling claims made against the resources of the pool. (The composition and role of the proposed Authority is comparable to today’s CDM Executive Board and comparable to the IOPC Fund’s Executive Committee, described in Section V.5.b below).

The proposal contemplated that before an insurance situation arose, areas in developing countries potentially affected by sea level rise would be valued, with the insured values and coverage negotiated between each country and the Authority. (This negotiation differs from a traditional risk assessment approach, see Section III.) All assets and interests would then be registered with the Authority to determine the scope of application of the insurance scheme. Both economic and human losses as well as ecological damage were to be covered, including option and existence value.

Contributions to the fund were to be calculated using a formula similar to that agreed by the Parties to the 1963 Brussels Convention on Third Party Liability in the Field of Nuclear Energy (see Section V.5.c below). Contributions would be calculated based on (i) the ratio between the GNP of each industrialised country contributor and the total of the GNPs of the group of contributors, and (ii) the ratio of individual country CO_2 emissions to the CO_2 emissions of the group of contributing countries. Historic contributions of countries to CO_2 emissions would be disregarded; the base year for determining emissions would be the year before contributions were to commence under the scheme.

Ten years after the entry into force of the Convention (i.e. in 2004, had the insurance scheme been adopted together with the UNFCCC), if the rate of global sea level rise had reached an agreed figure, industrialised nations would contribute an agreed percentage of their total GNP to the fund. The ten year time period was chosen because at the time the proposal was made (1991), the IPCC had predicted that within this period, more detailed information would be available for assessing the impacts of climate change (mitigated and unmitigated).

No right to claim against the pool would arise until the rate of global mean sea level rise and the absolute level of global mean sea level rise had reached previously-agreed figures, and the relative mean sea level rise for an insured area in a vulnerable country had reached an agreed level above base levels. Trigger levels were to have been subject to negotiation between individual countries and the Authority. Funds would then be paid out of the pool to meet claims. Commercially-insured property and assets would be excluded from the scheme.

From the possible responses to sea level rise (categorised by the IPCC as (i) retreat, (ii) accommodation, and (iii) protection), only retreat and accommodation (continued use of the land at risk, without protecting the land but providing protection for the people, i.e. emergency shelters etc.) would fall within the scope of the insurance scheme. Protection would be a matter of adaptation and therefore one for financial mechanism of the UNFCCC. However, in assessing claims the Authority was to determine whether and to what extent the loss or damage could have been avoided by "measures which might reasonably have been taken at an earlier stage." For this assessment, availability of funds and availability of commercial insurance would have been key criteria.

In sum, the insurance mechanism proposed by AOSIS was not aimed at establishing private sector insurance, or liability, but a compensation fund to address direct damage from sea level rise (compare generally Section V). Private sector insurance was not discussed in depth during the negotiations.

2. *UNFCCC and Kyoto Protocol provisions and decisions*

What remains from the insurance discussions prior to 1992 is reflected in Article 4.8 of the UNFCCC, which calls upon Parties to “consider” actions, including those related to insurance, to meet the specific needs and concerns of developing countries with respect to both the adverse impacts of climate change and the impact of the implementation of response measures. Article 3.14 of the Kyoto Protocol calls for the implementation of Articles 4.8 and 4.9 of the UNFCCC in fulfilling obligations of the Kyoto Protocol, and explicitly calls for the consideration of the “establishment” of insurance. The term “insurance” is not defined in either treaty or in COP decisions and thus the term does not refer to any specific kind of risk transfer or collective loss sharing instrument (for a definition of these terms, see Section II below).

The following relevant decisions and actions have been taken by the Parties:

- Decision 3/CP.3 requests the SBI to launch a process to identify actions needed to meet the needs of developing countries specified under Articles 4.8/4.9 and 3.14 – including insurance.
- Decision 5/CP.4 establishes a framework for further analysis for the implementation of Articles 4.8/4.9 of the UNFCCC and 2.3/3.14 of the Kyoto Protocol: (a) identification of the adverse effects of climate change; (b) identification of the impacts of the implementation of response measures; (c) identification of the specific needs and concerns of developing country Parties; and (d) identification and consideration of actions, including actions related to funding, insurance and the transfer of technology. Following Decision 1/CP.4 these issues became part of the Buenos Aires Plan of Action. An expert workshop was also to be conducted (Annex to decision 5/CP.4). That workshop was held from 21-24 September 1999 (Report in FCCC/SB/1999/9).
- Decision 12/CP.5 calls for a workshop on initial actions (including insurance) with regard to impacts of climate change and a workshop on methodological issues with regard to impacts of response measures. These were held 9-15 March 2000 (Report in FCCC/SB/2000/2).
- Decision 5/CP.7 mandated the UNFCCC Secretariat to organize a workshop on insurance and risk assessment in the context of climate change and extreme weather events (para.34) as well as a workshop on insurance-related actions to address the specific needs and concerns of

developing country Parties arising from the adverse effects of climate change and from the impact of the implementation of response measures (para. 35). The decisions called upon the SBSTA and SBI to review the progress of these activities and make recommendations thereon to the Conference of the Parties at its eighth session (para. 9). The workshops were not held prior to COP8 due to financial constraints.

- The SBI decided at its 17th session to consider the reports of the workshops on insurance at its 18th session, “with a view to providing input into the consideration, by the COP at its ninth session, of the implementation of insurance-related actions to meet the specific needs and concerns of developing country Parties arising from the adverse effects of climate change and the impact of the implementation of response measures” (FCCC/SBI/2002/17).

3. *Views of Parties*

In response to solicitations for the views of the Parties on the terms of reference for the two insurance-related workshops, submissions have been made and compiled in UNFCCC/SBI/2002/MISC.4 and Add.1–2. These views were considered in the design of the workshop agenda.

One group submission explicitly referred to the AOSIS proposal for an International Insurance Fund. (described above). Other submissions focused on risk assessment as a tool for coping with the adverse impacts of climate change. Many stressed the limitations of existing risk assessment models for estimating the future scale of risk from climate-change related weather events. The need for technical cooperation was also emphasised, including cooperation between insurance companies and climate scientists. In this context, Parties questioned whether climate-related stresses and risks could effectively be distinguished from other socio-economic stresses. Uncertainties in climate science were also emphasised.

Parties suggested that scope for cooperation might exist between the climate regime and the disaster relief community. It was further suggested that synergies between the various UN bodies should be explored to ensure more effective disaster relief and prevention, as well as more effective use of existing funds.

Some Parties stressed that insurance is only one possible instrument to cope with climate change risks. Some noted that publicly-funded mechanisms might encourage mal-adaptation. It was felt that particular attention should be given to adaptation and prevention of losses, in addition to risk spreading. At the same time, public-private partnerships were suggested as a means to support insurance schemes in developing countries.

II. The Challenge: Risks and Insurance for Weather Extremes in Developing Countries

The IPCC Third Assessment Report (IPCC, 2001a; IPCC, 2001b) has concluded that, during the 20th century, the frequency of extreme precipitation events has increased in areas which experienced increased precipitation, e.g. at mid- and high northern latitudes (with 66-90% confidence) (see Schönwiese et.al, 2003), and that the occurrence of extreme weather events has increased in temperate and tropical Asia, including floods, droughts, forest fires and tropical cyclones (with 67-95% confidence). The IPCC has noted some indication of increases in extra-tropical cyclone activity during the latter half of the 20th century in the northern hemisphere. At the same time, more pronounced severe dry events have occurred in the past decades over Sahel, eastern Asia and southern Africa (IPCC, 2001a).

For the 21st century, and based on emission scenarios estimating the human component of climate change, the IPCC predicts, *inter alia*:

- higher maximum temperatures and more hot days over nearly all land areas (90-99% confidence), leading to increased risk of damage to a number of crops, increased heat stress in livestock and wildlife, reduced energy supply reliability and a shift in tourist destinations (67-95% confidence);
- more intense precipitation events over many areas (90-99% confidence), resulting in increased damage from floods, landslides, avalanches and mudslides, and increased soil erosion, leading to increased pressure on insurance systems and disaster relief (67-95% confidence);
- increases in tropical cyclone peak wind intensities over some areas and tropical cyclone mean and peak precipitation intensities over some areas (67-90% confidence), resulting in increased risk to human life and of infectious disease epidemics, increased coastal erosion and damage to coastal buildings and infrastructure and increased damage to coral reefs and mangroves (67-95% confidence).

Confidence in observed changes (latter half of 20th century)	Changes in Phenomenon	Confidence in projected change (during 21st century)
Likely	Higher maximum temperatures and more hot days over nearly all land areas	Very likely
Very likely	Higher minimum temperatures, fewer cold days and frost days over nearly all land areas	Very likely
Very likely	Reduced diurnal temperature range over most land areas	Very likely
Likely, over many areas	Increase of heat index over land areas	Very likely over most areas
Likely, over many Northern Hemisphere mid- to high latitude land areas	More intense precipitation events (for other areas, insufficient data or conflicting analyses)	Very likely, over most areas
Likely in a few areas	Increased summer continental drying and associated risk of drought	Likely, over most mid-latitude continental interiors. (Lack of consistent projections in other areas)
Not observed in the few analyses available	Increase in tropical cyclone peak wind intensities	Likely, over some areas
Insufficient data for assessment	Increase in tropical cyclone mean and peak precipitation intensities	Likely, over some areas

Table II.1: Estimates of confidence in observed and projected changes in extreme weather and climate events. Likely indicates 66-90% confidence, *Very likely* indicates 90-99% confidence. (Source: IPCC, 2001a).

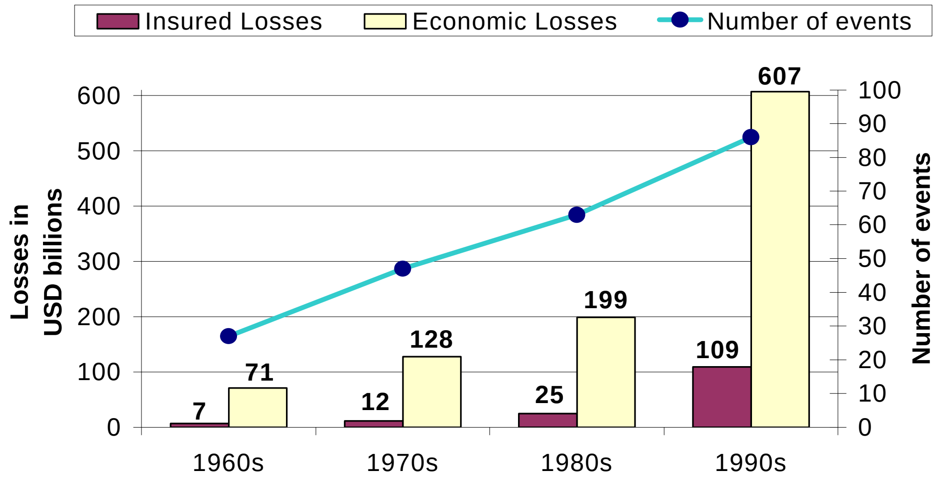
In sum, the IPCC concludes with a high degree of confidence that the risk of extreme weather events will increase as the climate changes. Yet, the problem of uncertainty remains: climate scientists are currently unable to quantify the extent to which this risk is increasing, let alone provide more specific guidance as to when and how a disaster will strike. What seems clear though is that adaptation measures as envisaged in the UNFCCC and Kyoto Protocol might not be able to prevent substantial damage in developing countries in all cases (Verheyen, 2002).

Great/Large Weather Disasters: events that exceed the self-help capacity of the regions concerned and require interregional or international assistance.

Natural Catastrophes: events caused by natural forces (such as earthquakes, and storms), and/or the impacts of an extreme natural event on an exposed, vulnerable society (Mechler 2003). Note that the IPCC's definition of "climate extremes" is not similar to "natural catastrophes."

Disasters cause humanitarian, economic, and ecological impacts. There is no question that the economic losses from disasters of all kinds are rising dramatically. As illustrated in Figure II.1, economic losses from all disasters have increased almost nine-fold in real terms from the decade of the 1960's to the 1990's, and insured losses more than 15-fold. Of these, losses due to extreme precipitation events and floods and storms have increased most (Munich Re, 2003).

Figure II.1 Losses from Extreme Weather Events (Adapted from Munich Re, 2000)



The IPCC has concluded that at least part of the increase in economic losses is due to changes in climatic conditions (IPCCb, 2001, Chapter 8) but the dominant factors behind this increase are changes in land-use and the 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) (Miletti, 1999).

These losses seriously affect both the developing and developed world. Yet, the per capita cost of natural disasters in relation to GDP is at least 20 times higher in the developing than in the developed world (as reported in Freeman, 1999). Moreover, up to 95% of recent disaster deaths have occurred in poor countries (Mitchell/Ericksen, 1997). Although the majority of economic losses occur in developed countries, most of the human suffering (death toll, injuries, loss of income) occurs in developing countries (Müller, 2003). Not only developing countries, but the poor in those countries are already the most vulnerable to weather related disasters (POVCC 2003, UNDP 2001).

Total number of people killed	1982 - 1991	1992 – 2001	2002
Africa	575 160	40 076	661
Americas	60 147	79 293	825
Asia	328 886	463 681	8570
Europe	40 577	35 994	459
Oceania	1 130	3 319	61

Table II.2.: Disaster related fatalities (source: Red Cross 2002) and Munich Re (2003)

Insured losses in developing countries, however, are negligible. In low income countries only about 1% of disaster losses are insured (Hoff et al., 2003). Asia (excluding Japan) and Africa only represent 6.3% of the world insurance market. Of all natural catastrophes in 2002, only 4.8% were insured in Asia and 1.1% in Africa (Swiss Re 2003), and only 3.8% of all damages from natural disasters between 1985-1999 were insured in Latin America and the Caribbean (Aufrett, 2003). It is therefore affected people and governments in developing countries are therefore left to tackle the aftermath of weather disasters.

To increase private sector coverage, both insurers and public institutions have called for public-private partnerships (Swiss Re 2003, Munich Re 2003, Hoff et al. 2003) which could indeed help to start-up insurance schemes for the previously “uninsurable.” Some have also argued that market arrangements (both domestic and international) can better channel and fund weather related risks, with governments and multilateral institutions, such as development banks, supporting the development of self-sustaining structures (see Pollner 2001). It should be noted that the penetration of any risk transfer instrument will require capital “up front” – for example to pay insurance premiums. With one billion people – two thirds of them women – living in utter poverty, and a further two billion living on less than $2 a day, any discussion on the how to spread the risks from extreme weather events in developing countries must take into account the capacity to engage in such efforts by those most at risk. This discussion must also take into account the relative costs of alternative ways to transfer risks or share losses.

Section IV discusses various approaches as well as the potential for collective loss sharing mechanisms, which may be a more cost effective way of sharing the disaster loss burden in many countries. Whether such instruments can be put in place in developing countries depends on the availability of risk analysis tools, which are discussed in Section III.

Risk Transfer refers to instruments that share/hedge risks before losses occur.

Collective Loss Sharing refers to instruments that allow losses to be shared among various national or international actors after they occur.

It should be noted, however, that for some of the possible impacts of climate change insurance-related activities might not constitute the optimal, and certainly not a comprehensive, approach. To address these impacts, it might prove wiser for governments to invest in disaster reduction and preparedness measures – i.e. to engage in loss-reduction/adaptation activities. For example heat waves with temperatures of up to 49°C killed 1037 people in India in 2002 (Swiss Re, 2003). Such human losses can only be prevented by proactively preparing for heat waves. Neither risk transfer nor collective loss sharing instruments can ever bring back the human victims of weather extremes.

III. Risk Analysis for Insuring Extreme Weather Events

In this section, we discuss the methodological issues that arise in developing a framework for the implementation of insurance-related activities in poor countries facing weather extremes. Since insurance is an integral part of a risk-management strategy, we begin by briefly discussing risk management and the role of insurance and other types of risk transfer. We then turn to examining the insurability of weather-related catastrophes. This leads to a discussion of the quantitative assessment of natural disaster risks, and we describe the evolution from actuarial methods of risk assessment to the current development of catastrophe models for the purpose of estimating dependent, low probability risks with extreme consequences. We also examine the important question of the role climate change is playing with regard to weather-related risks, and the degree to which this role can be quantified. Finally, we ask if these risk-assessment methods and models are accessible to developing countries, and we discuss their role in developing a framework for the implementation of insurance-related activities.

1. Risk and risk management

Risk is generally defined as the probability and magnitude of an adverse outcome, which includes the uncertainty over its occurrence, timing, and consequences (Covello/Merkhofer, 1993). (The financial community, however, sometimes uses the term risk to refer to measurable (typically statistical) volatility and speaks of "upside" and "downside" risks to refer to the possibility that an outcome may be respectively better or worse than the expected outcome.) The estimate of the risks of extreme events is characterized thus by the frequency, magnitude and location of the human, economic, ecological and other losses. In the natural disaster community, risk is a combination of the natural <u>hazard</u> and <u>vulnerability</u> of people and structures.

A ***hazard*** is a specific situation that increases the probability of the occurrence of loss arising from a peril, e.g., a flood or earthquake (Kunreuther /Roth, 1998). ***Hazard*** may also be used specifically within the context of modeling to identify the particular parameter that causes damage (e.g., peak ground acceleration for earthquakes, water level or water velocity for floods, peak wind speed for hurricanes, etc.).

Vulnerability can be defined as "{t}he degree to which an exposure unit is susceptible to harm due to exposure to a perturbation or stress, and the ability (or lack thereof) of the exposure unit to cope, recover, or fundamentally adapt (become a new system or become extinct)" (Kasperson /Kasperson, 2001). The IPCC (2001b) defines vulnerability to climate change as "{t}he extent to which a natural or social system is susceptible to sustaining damage from climate change."

Risk estimation is an important part of managing natural disaster risks, and involves three types of activities: (1) the reduction of the risks by preventing losses and preparing for crises before disasters; (2) emergency response during the disaster; and (3) providing relief and reconstruction after disasters. Because of the concern in many developing countries that far more resources are spent on post-disaster activities at the expense of proactive preventive measures (Kreimer/Arnold, 2000), the concept of integrated disaster risk management has become increasingly popular. This concept calls for a holistic approach to disaster management activities, across different functions, across different hazards, and taking into account the social, psychological and consequences of disasters (Okada /Amendola, 2003). An important extension of this concept has become known as financial risk management, which examines the ways in which insurance and other financial instruments can be put into place to assure that countries and citizens can quickly and effectively recover from disasters, and to link these instruments with preventive measures (see Kreimer/Arnold, 1999).

2. Insurability of disaster risks

According to Kunreuther (1998), a risk is insurable if it meets two conditions: (1) insurers must be able to identify and quantify the risk, that is, to estimate the chances of the event occurring and the extent of losses likely to be incurred, and (2) insurers must be unrestricted (unregulated) in setting premiums. Insurers do not offer coverage for all insurable risks, since it may not be possible to specify a rate for which there is sufficient demand and incoming revenue to cover the development, marketing, and claims costs of the insurance and still yield a net positive profit. This is especially the case in poor regions or countries, but even in developed countries full insurance cover is not available for many types of disasters.

As a case in point, the U.S. government introduced the National Flood Insurance Program in 1968 because private insurers were not offering comprehensive cover in many regions. Not only was there a lack of risk data and flood maps, but the frequently recurring nature of the hazard, combined with problems of adverse selection and moral hazard, would have required insurers to set prohibitively high premiums. Moreover, households and businesses are notoriously myopic and often do not purchase insurance nor take cost-effective measures to protect themselves (Kunreuther, 1998).

Adverse selection arises from a situation of asymmetric information between insurers and those seeking insurance, which can result in more high-risk persons purchasing insurance than those with lower risks.

Moral hazard describes the situation in which persons holding insurance may take fewer precautions to reduce their risks than if they did not have insurance.

In many respects, catastrophic risks are becoming more insurable as developments in computer technologies provide improved methods for estimating the risks and as better knowledge reduces the problem of adverse selection. Despite these developments, insurers are pulling out of many catastrophic risk markets. In the U.S., Hurricane Andrew in 1992, followed by the Mississippi floods in 1993 and the Northridge earthquake in 1994, and finally the events of Sept. 11, 2002, were unprecedented in the extent of insured losses. These mega-loss events threatened the solvency of a number of insurers and raised alarms that insurers may be over exposed in many regions and states. This has led to an increase in premiums on catastrophe insurance with a corresponding reduction in demand (in some states, insurers have stopped offering cover since they are constrained by regulators in raising premiums). This is not only a problem in the U.S., but insurance is unavailable for many types of disasters throughout emerging-economy and developing countries

3. Catastrophic risk estimation

Within the private-sector insurance community, actuarial methods were long the preferred technique for estimating risks and setting premiums (Walker, 1997). In many areas of insurance coverage, such as car accidents, insurance policies are typically underwritten on the basis of historical loss data. In these areas, many financial losses are inherently predictable due to a statistical concept known as the law of large numbers, also known as the insurance principle.

The ***law of large numbers*** states that for a series of independent and identically distributed variables the sample mean over the variables converges to the theoretical population mean of the probability distribution and thus the variance around the mean decreases for large numbers. For insurance, this means that the variance of average claim payments to the insured decreases as the number of policies increases (see Mechler, 2002).

The critical assumption behind this principle is independence, which means that the probability of payment of a claim on one policy must be independent of claim payments on other policies. To illustrate, consider the case of single-home fires, each occurring with probability of one percent. Under normal conditions, the occurrence of a fire in one home does not affect the probability of a fire in other homes. If an insurance company has sold 500 policies widely dispersed across the city, it can expect to pay approximately five claims (0.01*500) per year. The law of large numbers ensures that the company would not expect to pay significantly more or fewer claims, and the company can therefore charge annual premiums sufficient to cover those five claims plus its administrative costs. Furthermore, the company can actually reduce this variation by selling more policies.

This is not the case with dependent risks, and this example illustrates the dangers to insurers of writing claims for natural disasters. Consider the situation in which an insurer's policies are concentrated in one neighborhood with connected (row) houses without fire protection systems. If a fire were to start in one house, it could quickly spread to the other houses, in which case the insurance company is faced with payment on all claims at once. Because of the dependent (or covariant) nature of the risk, insurers have historically been careful to spread their catastrophe exposure widely through diversification and reinsurance.

This distinction between a fire in a single house and a catastrophic fire affecting many houses also has implications for the estimation of risks. The single-house fire is much higher in probability and lower in consequence than the multi-house fire, and (as with automobile accidents) insurers may have access to a large historical data base for actuarially calculating the probabilistic distribution of losses. This is not the case for rare, catastrophic losses, where there may be little recorded history of the very extreme events. Lacking historical information on losses, insurers have traditionally estimated and managed catastrophic risk using the concept of the probable maximum loss (PML), which was typically the historically worst loss adjusted for current conditions. For risk management purposes the PML concept was combined with the notion of capacity, which is the maximum amount of aggregate loss that an insurer is willing to accept from a disaster event (Kunreuther/Roth, 1998). Capacity is typically determined on a regional basis, and many insurers (and reinsurers) did not always consider the possibility that the same disaster might result in the PML in more than one zone (Covello/Merkhofer, 1993). The cascade of disasters in the 1990's made clear that even reinsurers can be affected by multiple extreme events. Many insurers, finding themselves over exposed in these vulnerable areas, recognized the need to more systematically examine the dependent nature of the risks of their book of business. This has led to a greater appreciation for alternative methods for quantifying risks.

4. Modeling the risks from natural disasters

Risk assessment models go beyond deterministic estimates of losses, e.g. the probable maximum loss, to yield probability distributions of losses over their full range by making use of a representative ensemble of scenarios. These models rely on historical data to the extent that it exists, but then add information to the risk estimation process based on an understanding of the physical processes that lead to these losses. Similar to the various climate models, risk assessment models are a representation of the real world, here of the chances of human, economic and other losses due to natural disasters. Modeling of risks from natural hazards has a long pedigree (Petak/Atkisson, 1982), particularly within the public policy community. Walker (1997) provides a succinct summary of the evolution of public-policy oriented computer based models into catastrophe models for the insurance industry.

A ***catastrophe model*** is a risk-analytic technique with the following characteristics:

- The technique: It uses simulation modeling to supplement (or replace, if necessary) purely historical actuarial data for purposes of estimating probabilities and outcomes.

- The structure: Catastrophe models are typically comprised of relatively independent sub-models reflecting the input from different disciplines (meteorology, hydrology, structural engineering, cartography, etc).

- The output: The results are distributional, including both probabilities and consequences.

- The use: originally used in insurance settings, but great potential for public policy decisions on loss reduction, preparedness and risk transfer.

Essentially catastrophe models are distinguished from traditional disaster risk-assessment procedures in their use by the insurance industry, their methodology of simulation and their focus on insured losses. Because appropriately designed simulation models can explicitly account for dependencies between losses, their use in the insurance industry expanded greatly after the events of the early 1990's (Kozlowski, et al., 1997; Clark, 2002; Boyle, 2002). These simulation models – which essentially generate a "history" of rare events - were made possible by advances in fast computer technology. The current evolution of these efforts is reflected by rather sophisticated integrated models for flood damage assessment (U.S. Army Corps of Engineers, 1998) and for seismic risk assessment (Federal Emergency Management Agency, 1999).

Catastrophe models and more traditional risk assessment models provide answers to the following four questions:

1. What is the probability of a selected hazard of a particular intensity at a particular location?
2. How vulnerable are different types of structures to the selected hazard, i.e., how much damage would be incurred to a particular type of structure in the event of a given hazard?
3. What is the distribution of exposures, e.g., what is the distribution of different types of structures over the affected area?
4. What is the probability distribution of losses from the selected hazard? Catastrophe models, in contrast to more traditional risk assessments, use Monte Carlo simulation techniques to generate this probability distribution.

To arrive at a probability distribution over losses, catastrophe models are typically modular and employ simulation techniques. For example, a recent flood catastrophe model developed for the Upper Tisza region in Hungary (Ekenberg, et al., 2001) made use of historical data of precipitation in the upper reaches of the river, where a runoff module translated this precipitation to inflows into the river. A hydrology module, in turn, translated these inflows into a distribution of the water level of the river. With information on the height and failure of the levees, this information could generate scenarios of releases. Combined with a module of the topology of the region, and with further information on crops and structures, the model ultimately translated precipitation into a probability of damages with the use of Monte Carlo simulations. Many authors define this procedure in terms of three modules: (1) a scientific or hazard module comprising an event generator and a local intensity calculation, (2) an engineering module for damage estimation, and (3) a damage coverage for (insured) loss calculation. These modules can be carried out in great detail for a small area, for example, a stretch of a river through an urban area, or in much less detail for a region or a country.

Until recently, versions of risk-assessment models were used within a public-policy framework that was oriented towards loss prevention or reduction rather than risk spreading or transfer. However, applications of these models were often limited because of the lack of the requisite data (public authorities often do not have these data bases, nor even reliable information on the losses from natural disasters). The insurance community recognized that methods used in the public policy arena could also be applied to the analysis of insured losses, and these techniques were taken into the insurance community under the name of catastrophe modeling, and, especially in the U.S., consulting firms invested large sums into collecting the requisite data. This data along with the emergence of very fast computers allowed these firms to develop complex and data-intensive simulation models of earthquake and windstorm risks along the west and east coasts of the country, respectively, and the results were sold to insurance companies. Many insurance companies and brokerage firms are now developing their own capacity to build catastrophe models. In the public sector, there is a great deal of interest in collecting the relevant data, although in some cases there are issues of confidentiality.

Finally, it is important to note that a catastrophe model, or complete characterization of the loss-risk profile, is not always necessary for insurance purposes. Reinsurance contracts are sometimes written on the basis of a physical trigger, like the intensity of a windstorm or precipitation in a defined area and time, instead of on losses or excess losses. This contract only requires historical data on the weather phenomenon, but a problem is that the trigger may not be perfectly correlated with losses, for example, a mild windstorm might cause unexpected severe losses. Insurers refer to this as basis risk.

5. Assessing the effects of climate change on the risks from weather extremes

The IPCC has concluded that, while there are uncertainties, some extreme events, such as droughts, floods, heat waves, avalanches and windstorms, are projected to increase in frequency and/or severity due to changes in the mean and/or variability of climate (IPCCa, 2001). To date, there is little understanding of what this forecast means for weather-related disasters happening today and in the near future, and a discussion on incorporating the effects of a changed climate into risk-assessment models is only beginning. A topical question is to what extent, if any, recent weather losses can be attributed to climate change?

For the past decades, there is little evidence of a linkage between weather losses and climate change, but convincing evidence linking losses to other anthropogenic causes: the movements of population and capital into harm’s way and human-driven transformations of physical systems. Normalizing the trend in losses from major natural disasters across the globe over the last decade to account for population and wealth increases, Miletti (1999) concludes that increased disaster losses can almost be fully explained by increasing population and capital. But does this conclusion apply to current and near-future losses? This question has recently been examined in the context of flood disasters with mixed and uncertain results. Climate change can affect the frequency and intensity of floods in different and sometimes subtle ways. A warmer climate will likely increase precipitation (MacDonald, 1998; Changnon, et al., 1997), where the distribution of rainfall in addition to the average plays an important role with regard to flood risks, and climate change can also alter vegetation and affect water absorption.

The main difficulty in investigating these phenomena on flood losses is separating them from the many other human-induced factors influencing flood frequency and intensity: changes in land use and land cover, modifications to the river morphology and the channel system and the increase in human settlements and capital in flood-risk areas. Recent investigations reflect these difficulties. In a review of research on climate change and European flood risks, Bronstert (forthcoming) concludes that there is some evidence of a correlation between climate warming and more intensive and frequent flooding in some European regions and no correlation in other regions. He is not surprised by the conflicting evidence and cautions about the uncertainties and unknowns inherent in the scientific investigations. The knowledge of climate change and its effects on systems and cycles of the earth is still very limited. Much of the research relies on the results of large global climate models, but the spatial scale of these models is too large for simulating anthropogenic climate change on a regional level. Moreover, most of the investigations of changing flood risks do not adequately take into account the full range of human influences. The conclusion that Bronstert draws for Europe has been reaffirmed by recent research investigating the relationship between global warming and riverine flooding elsewhere (Schnur, 2002; Palmer/Rälsänen, 2002; Milly, et al., 2002). These authors present results indicating that global warming may have increased the risk of flooding in selected, very large river basins; however, they also point to the limitations of available climate models and to the large and inherent uncertainties. Despite these uncertainties, some scientists think that with continued research, it might be possible to establish a relationship between climate change and increasing frequency and intensity of weather extremes with some degree of confidence, stressing that uncertainties will always remain (Schönwiese, 2003).

Adapting risk analysis techniques used in insurance settings to incorporate the uncertain potential effects of climate change is a challenging task, whether an actuarial approach or a simulation modeling approach is used. Actuarial methods, which rely on analysis of historical data, are of limited applicability when confronted with scenarios, e.g. from land-use practices or climate change, that are not reflected in past experience. There are two potential ways in which climate change may affect estimates of risk based on actuarial methods. First, increases in the base rates of occurrence of losses may result in steadily increasing claims, but, as noted above, other non-stationary processes appear to dominate climate-related effects, and sorting these out from climate change is difficult. Second, and potentially more significant, dependent losses from more frequent climate-induced extreme events may be an increasing share of the insurers overall loss portfolio.

Incorporating climate change into catastrophe modeling is also challenging (Jones/Mearns, 2003). A first step is gaining information on predictions of changes in the regional climate, e.g., changes in rainfalls, windspeeds, or other climatic phenomenon, which can serve as input into the physically based catastrophe models. Existing global circulation models provide this information only for very large grids, and the challenge is to downscale this information to the relevant spatio-temporal scales (e.g., from global scale to scales on the order of square kilometers and from annual scales to hourly scales) necessary for accurate risk analyses (Minnery/Smith, 1996). Some attempts are underway for this downscaling, but these estimates will remain highly uncertain. When the potential for non-steady state climactic conditions is taken into account, the uncertainties increase dramatically.

Uncertainty in the results of risk analyses, especially for very rare events, has long been recognized. In the early 1980's, Petak and Atkisson emphasized that "the results derived from the risk analysis models are not to be considered 'fact'. Much uncertainty is associated with the findings generated by the models" (p. 186). Pervasive uncertainties in the underlying science remain. A common perception is that modeling can reduce uncertainty, but this is not always the case. Models do not necessarily reveal anything new about the world, but they usefully structure available information and bring additional relevant information to bear on a problem. Rather than reducing uncertainty, models may reveal just how uncertain a situation is.

Dealing with uncertainty is critical for the use of these models, and considerable progress has been made in methods for model verification and validation for the explicit analysis of uncertainty (cf Morgan/Henrion, 1990; National Research Council, 2000; Bier et al., 1999). Furthermore, multiple assessments can be carried out. According to Gary Venter of Guy Carpenter, a "...key to effective catastrophe modeling is understanding the uncertainties involved...it is critical to look at the results from a number of catastrophe models so that we can see what range of results would be and how different approaches to a problem could lead to different outcomes" (Guy Carpenter Views, 2003). This uncertainty is not unique to catastrophe modeling. The scientific uncertainties in other types of risk assessments, for example, the probabilistic safety assessments carried out by the nuclear power industry, have led such bodies as the US National Research Council to recognize the inherently uncertain (even subjective) nature of risk assessment and suggest that for many purposes risk characterization might be a more relevant concept than risk estimation (Stern/Fineberg, 1996).

6. Risk-assessment for a climate-change insurance regime

In the face of large uncertainties in assessing the risks of weather-related disasters in poor countries, and the uncertain effects of climate change on these risks, can a framework for the implementation of insurance-related activities in these countries be developed? To answer this question, it is important to return to the issue of uncertainty for the insurability of catastrophic risks. Uncertainty is an inherent and essential condition for an insurance contract, but for insurance purposes it is important to distinguish between two types of uncertainty. The first is temporal and spatial: when and where (or to whom) will an event occur? Without this uncertainty, insurance is not possible. For example, slowly developing catastrophes, such as sea level rise, are uninsurable, although a fund can be created to compensate victims (Tol, 1998). The second type of uncertainty, which we have discussed in this section, concerns the confidence one has in the risk estimates. Without knowing the time or place of losses, it is still necessary to have information on the expected losses, and in the case of rare events, the chances of very large losses (the tails of the risk distribution). The more uncertain or ambiguous the risk estimates, the more cautious insurers will be in offering policies. In the extreme case, with little on no information, insurers may consider the risk to be uninsurable. If insurers do offer catastrophe cover on the basis of very ambiguous risk estimates, they will spread this risk by diversification and/or reinsurance. Both of these strategies will result in costs to the insurers and ultimately in increased premiums, and the remaining uncertainty will be an additional factor in the premium load. Therefore, ambiguity of the risk estimates will generally lead to higher premiums (we show the current range of premiums for catastrophe cover in the following section).

While advanced risk modeling techniques will continue to result in uncertain estimates, they can deliver much improved risk estimates and therefore improve the insurability of many types of disaster risks. Expressing risks as a distribution allows a much better characterization of loss possibilities than that embodied in the annual expected loss or the probable maximum loss concept. While more types of catastrophic events may be insurable, the residual uncertainty in the estimates means that premiums may remain ill affordable to the majority of households and businesses in the developing world.

Yet, there are many other advantages to assessing the risks of disasters in developing countries. Walker (1997) suggests that the true advantage of catastrophe modeling: “...lies in the step change in the information it provides, not the marginal improvement in a single point calculation...the benefits lie in the overall savings arising from an integrated approach to risk management”. The development of a flood risk model, for example, can provide valuable information on the ways in which deforestation and other types of land use are affecting the flood peril, as well as on the risks due to increased settlements in high-risk areas. Potentially these models can also add insights on the effects of climate change. The product of the modeling exercise can be enhanced with stakeholder involvement. The population can bring a great deal of local knowledge and expertise, and stakeholders can also learn from the modeling process. A major advantage of these types of integrated models is that they can produce outputs tailored towards different stakeholders and multiple hazards simultaneously. "The primary output ... may be the loss experienced by a single property or facility (single-site analysis), the aggregate portfolio loss in a particular catastrophe zone (zone analysis), or the aggregate portfolio loss for a whole state or country, or worldwide, from a particular hazard (specific hazard analysis) or all hazards (multi-hazard analysis)" (Walker, 1997). The outputs from an integrated model of windstorm risk, for example, can show the distribution of economic losses and other impacts to farmers (both the distribution and across the whole sector), to urban dwellers, to insurers, and to governmental treasuries. For insurers, catastrophe modeling can aid decision making on cover of losses, profits, stability, and survival through diversification and reinsurance in an environment of spatial and temporal dependencies (Ermoliev, et al., 2000).

Developing countries can, therefore, greatly benefit from the development of risk assessments for weather-related and other disasters, both for improving the insurability of the risks and for improving their management. However, risk assessments can be very resource intensive. Catastrophe models developed for insurers can cost hundreds of thousands, if not millions, of dollars. For example, a river flood catastrophe model developed for insurers by a consulting firm took two years to develop and more than 12 man-years of effort (Risk Management Solutions, 2001). This was in addition to the costs of collecting the relevant data, which can be a main expense of these models. For the physical modeling, it may be possible to either adapt existing models or purchase consulting services for much less than the cost of developing a model. In the U.S, for example, physical models for the flood peril for all major flood-risk areas are available on the internet through HAZUS, which is a program sponsored by the Federal Emergency Management Agency (FEMA). Local policy makers can make use of these models by putting in their estimates of the value of property and infrastructure at risk (if available) within their jurisdictions. In developing countries, however, there may be little data on infrastructure lifelines, property values and vulnerability (e.g., the vulnerability of wooden footbridges versus reinforced concrete span bridges, the effect of building codes and their implementation on vulnerability, etc).

While many uncertainties will remain, catastrophe modeling can improve the insurability of risks in developing countries and, therefore, can aid in the development of a framework for the implementation of insurance-related activities. However, a quantifiable link between climate change and weather-related risks is and might remain tenuous. Notwithstanding the tenuous influence of climate change on disaster risk, the benefits of reducing and transferring risks in the developed world may be significant. Since the implementation of insurance-related activities is valuable independent of climate change, building a framework for this purpose can be considered a no-regret strategy. In developing this framework, however, it is important to examine the conditions under which insurance and other insurance-related instruments are a cost-effective way of transferring and spreading the risks of natural disasters in poor countries. This is the subject of the next section.

IV. Risk Transfer, Collective Loss Sharing, and Public-Private Partnerships

This section examines the experience and potential of insurance and alternative risk-transfer instruments for spreading the risks and sharing the losses from sudden-onset weather-related catastrophes. The focus is on developing and transition countries, and we ask how the international community can contribute to risk transfer and loss sharing at the local, national and global levels. We conclude that insurance and other pre-disaster risk-transfer instruments have a great deal of potential for assisting countries in their adaptation to weather catastrophes and for contributing to incentives for loss reduction; however, we point out that the cost of these instruments can substantially exceed that of traditional state-supported, loss-sharing financing mechanisms. These traditional mechanisms, however, may not be available for very poor countries experiencing severe disasters, in which case risk-transfer instruments that are put into place before the disaster can be an important, but costly, addition to the portfolio of measures available to the national and local authorities. One of the more promising possibilities may be in supporting public-sector risk-transfer for highly exposed and vulnerable countries. We also discuss emerging *public-private* partnerships as a way of providing insurance to households and businesses, and the possibilities for the international community to support these partnerships.

Risk transfer spreads risks before a catastrophe occurs and requires the use of *hedging instruments*, which are pre-disaster arrangements in which the purchaser incurs a cost in return for the right to receive a much larger amount of money after a disaster occurs. The important distinction between risk transfer and *collective loss sharing* is that the former is purchased by the persons or community at risk, whereas the latter is provided by the state and thus (usually) funded by current and future taxpayers. Risk-transfer instruments, however, can also serve as important re-distributive instruments if the premiums for insurance or the interest for capital market securities are cross subsidized by persons within the victim community or subsidized by persons outside.

Risk transfer through insurance or insurance-linked securities is not the only way to provide relief to disaster victims or repair damaged public infrastructure. In fact, only about 20 percent of global disaster losses are insured (Swiss Re, 1998). Relief to victims and repair of public infrastructure can also be provided through taxes and charitable donations, what we refer to as *collective loss sharing*. The ways in which catastrophe risks are transferred or losses are shared are not value neutral, but they differentially transfer the risk and the loss burden to family members, contributors to an insurance pool (e.g., property owners), taxpayers, future generations, and citizens/investors in other countries. Importantly, they also have differential incentives and implications for loss reduction.

1. *Collective loss sharing and solidarity*

National and local governments are heavily involved in reducing and absorbing the losses from catastrophic events by funding prevention measures, emergency response, repairing public infrastructure and compensating disaster victims. In addition, governments can act, either separately or in combination, as primary insurers or as reinsurers, e.g., by administering or supporting insurance pools. With 95% of deaths from disasters occurring in the developing countries, the importance of improved warning systems, the retrofitting of structures to withstand weather hazards and many other loss reduction measures are high on the agenda of the disaster community. This community is intent upon reallocating resources from disaster response to the prevention of the human and economic losses. Since all, or even most, losses cannot be prevented given the scarce resources of poor countries, governments must also be prepared to provide relief to victims and repair public infrastructure after a disaster occurs. In what follows we discuss the financing needs of governments in fulfilling their collective role in disaster relief and rehabilitation, as well as the relationship between providing relief and preventing losses.

Relief to victims: Throughout the developing *and* developed world the private victims of natural disasters – households and businesses – bear most of their financial burden themselves, or they share it with family and neighbors (Linnerooth-Bayer/Amendola, 2000). Additional relief to private victims, with only a few exceptions, comes mainly from taxpayers, who also provide the funds for reconstruction. This collective loss-sharing institution is substantial throughout the world. For example, in the U.S. the average annual expenditure by the federal government for disaster assistance from 1977 to 1993 was more than $7 billion in 1993 dollars. This is significantly greater than the average annual loss borne by reinsurers on U.S. catastrophe coverage (Froot/O'Connell, 1999). As a case in point, the US federal government covered 30% of the losses from the 1993 Midwest floods, whereas insurance only absorbed 12% of these losses. In Europe, Italy is perhaps extreme in that the government is statutorily obligated to compensate earthquake victims 100 percent of their losses (Linnerooth-Bayer et al., 1999). The developed countries in Asia appear to be no exception. For example, after the 1995 Great Hashin earthquake, the Japanese government absorbed close to 50% of the direct losses, whereas private insurers absorbed only 2½%. The resource-constrained governments in the developing world also play a relatively large role in providing aid to victims and repairing infrastructure. For example, Colombia spent US$ 800 million to rebuild Armenia and Perei after the 1999 earthquakes. This was more than 50% of the direct damages (Freeman, et al., 2003).

There are both pros and cons of state disaster relief to households and businesses. On the negative side, if disaster victims are guaranteed state aid in the form of grants and low-interest loans that enable them to continue to locate their property in hazard-prone areas, and more people build in those areas, losses will increase and taxpayers will be subject to increasingly larger expenditures for bailing out victims of future disasters. For this reason, many economists argue for making private responsibility (and insurance) a cornerstone of catastrophic risk management (Kunreuther/Roth, 1998). On the positive side, national solidarity for disaster victims can reinforce social values of sharing and helping in times of distress, and evidence in Europe suggests widespread public support for taxpayer solidarity. A public survey in Hungary showed that more than 70% of the public, and more than 50% of persons living in no-risk areas, support unconditional government compensation to flood victims even taking into account the associated negative incentives for personal risk reduction. There was a great deal of mistrust of private insurers (Linnerooth-Bayer/Vari, 2003).

Public and individual solidarity in poor countries is usually supplemented by domestic and international donations. Yet despite the comparatively large burdens imposed by natural disasters on developing and emerging-economy countries, reported figures on direct donations from the developed world are small. In 1996, the total amount of humanitarian aid reported by the Development Aid Committee (DAC), which also includes donations to cover losses from military conflicts, was around US$ 2.9 billion or about four per cent of reported natural disaster losses of that year. It also appears that international donor aid for disasters is decreasing (Mechler, 2003).

Reconstruction: National and local governments are also liable for the damages of disasters to public infrastructure. If critical infrastructure is not repaired in a timely manner, there can be serious effects on the economy – and foreign investment also depends on the disaster response capability of governments. The repair of public infrastructure can be a significant drain on public budgets especially in developing and transition countries. In Poland and eastern Germany, for example, public infrastructure damage from the 1997 floods amounted to 41% and 85% of the reported direct losses, respectively. The Polish government absorbed close to half of these losses, which increased its budget deficit substantially. This is not a problem in large, wealthy countries like the U.S., where the federal government absorbs up to 90 per cent of state and local government infrastructure losses from major disasters, thus spreading these losses across the entire U.S. population.

Unlike the US and countries in Europe, governments of poor and disaster-prone countries, for example, Honduras, the Philippines, Mexico and regions in China, face such enormous liabilities in repairing their critical infrastructure and providing subsistence to disaster victims that without international assistance they can be set back years in their development. After Hurricane Mitch devastated Honduras in 1998, the GDP growth in the following year (despite the growth impetus from reconstruction) dropped from an estimated 3.3% to -1.9% (Mechler, 2003: 114). The earthquake that struck Taiwan in 1999 reportedly resulted in a loss of GDP of NT$ 43.64 billion, and a net growth rate reduction of 0.3% (Shaw, 2000). Typically disasters affect government budgets by reducing tax revenue, increasing fiscal deficits and worsening trade balances (Otero and Marti, 1995).

Financing public relief and reconstruction: Public authorities have a number of alternatives for financing disaster response and rehabilitation. After a disaster occurs, they can issue bonds or other debt instruments, raise taxes, divert funds from their current budgets or accept international bank loans. Debt instruments, which pass the burden on to future generations, are the most common post-disaster financing option, particularly for countries with a high credit standing or bond rating. The country can borrow either domestically or on the foreign market. For instance, after the 1997 floods Poland raised all its needed capital domestically; alternatively, Honduras relies fully on foreign borrowing after disasters.

To reduce their dependency on debt financing, many countries have put into place a catastrophe or calamity fund. For example, the Mexican catastrophe reserve fund, FONDEM, was set up to smooth the volatility of economic activity after natural disasters (World Bank, 2000). Costa Rica, Nicaragua and Honduras also have or intend to create national funds (Charveriat, 2000). This financing option differs importantly from a post-disaster tax, which has the added disadvantage of high administrative costs. A catastrophe fund has a cost equal to the foregone return from maintaining liquid capital and an additional benefit in having the resources immediately available with less transaction costs. A major problem with a fund, however, is that it may not be able to supply sufficient capital, especially if the disaster occurs shortly after its creation. In principle, insurance companies also operate with a reserve to cover large outlays; however, private insurers are more concerned than the government that their reserves are sufficient to avoid insolvency, and for this reason they diversify their insurance portfolio. A second problem with a catastrophe fund is the political risk that it is diverted for other purposes in years with no disasters.

International donations are also important for bolstering government relief and reconstruction budget, but as noted above they are relatively small and declining. Still, the donor community is concerned that international donations and loans for post-disaster reconstruction are taking an increasing portion of declining official development assistance (Mechler, 2003). Most international assistance appears to come from international financial institutions. For example, the World Bank estimates that it has loaned US$ 14 billion to developing countries over the last two decades for disaster relief and recovery (Gilbert/ Kreimer, 1999), and the Asian Development Bank also reports large loans for this purpose (Arriens/ Benson, 1999).

Finally, governments throughout the world resort to diverting funds from other budgeted items to cover their post-disaster liabilities. This is a rational alternative if the return on the diverted funds is less than the interest on the debt, and some governments have even legislated this response as priority. In the developing countries, these diversions are often from international loans for infrastructure projects. Based on anecdotal evidence, Lester (1999) cites a figure of 30% of infrastructure loans from the World Bank diverted for this purpose. Whereas this response may be the least costly one for the government, it can be disruptive both economically and politically. Clearly, the World Bank and other lending organizations are keenly interested in reducing the post-disaster liabilities of poor governments by promoting more risk transfer at the public level.

A problem with these traditional pre- and post-disaster financing instruments is they are seldom sufficient for very poor countries whose governments may experience difficulties and constraints in issuing more debt, in raising taxes after a major disaster and in diverting funds. Following the devastation of a disaster, the country’s credit rating may worsen, and its citizens may be at the limits of taxation. In sum, poor countries may experience a substantial “resource gap” between the funds needed to repair infrastructure and provide relief and the funds available through traditional disaster financing.

Example: Honduras

Over the last decade Honduras has experienced a number of devastating hurricanes and other weather disasters. With over half of its 6.5 million people living in poverty, Honduras is socially and economically highly vulnerable to these extremes in weather. Since the 1980s, the economy has been subject to a combination of adverse internal and external influences causing stagnation, inflation and a large increase of external debt. Hurricane Mitch, which struck Central America in 1998, resulted in 5,700 deaths in Honduras, countless homeless, and losses totaling approximating 80% of the country's GDP . The extent of the devastation overwhelmed the government's capacity to provide relief and repair critical infrastructure. In other words, Honduras experienced a serious resource gap, and by some estimates, the economic development of Honduras was set back significantly.

Given Honduras' exposure to weather extremes and its financial vulnerability, a recent study examined the conditions under which the government can expect to experience a similar resource gap (Mechler/ Pflug, 2003). This information can be useful for developing a financial management strategy. With historical data and a simulation model, the study gained insights on the overall risks of flood and storm events in the country, and the ensuing liabilities for the government (note that this was not a full catastrophe model as described in the previous section, but a very rough picture of flood and storm risks based on historical losses). The analysts then looked closely at the capacity for the government to raise funds through borrowing, raising taxes and diverting from other budgeted items. In addition, they examined the likely availability of external aid and assistance.

As shown in Figure 4.1, the model showed that if the event occurred in 2003, the government could "withstand" the losses from moderate flood and storm disasters. But for very rare, high-consequence events – one-in-500 years or worse – there is a sizeable resource gap

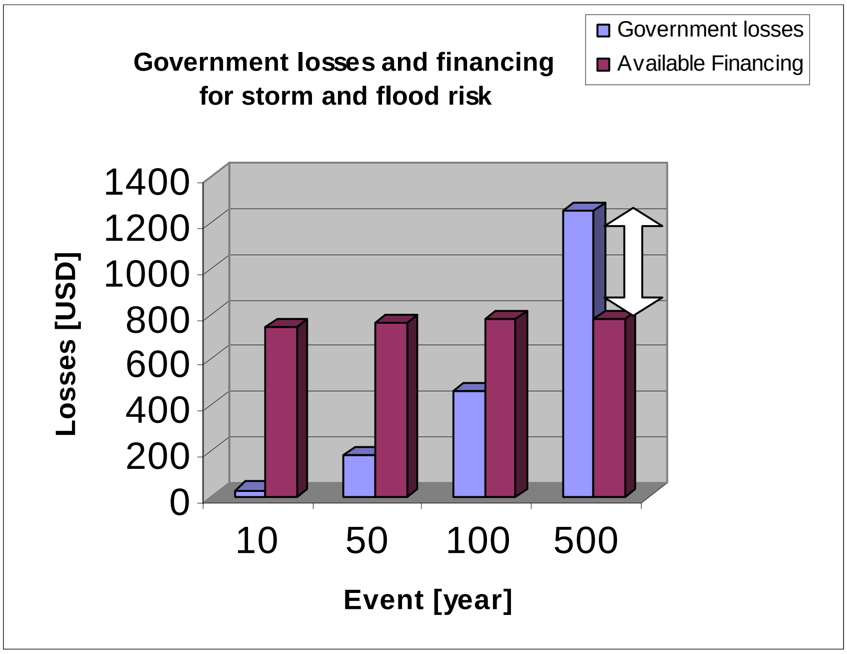


Figure 4.1. The Resource Gap for Honduras (Source: Mechler and Pflug, 2003)

In what follows, we examine whether Honduras and other governments of poor countries facing extreme weather events might consider pre-disaster hedging options, including insurance and insurance-related risk-transfer instruments to fill their resource gaps.

2. Insurance and other risk-transfer instruments

Insurance is an important pre-disaster, risk-transfer institution in that it distributes the losses (transfers the risks) among a pool of at-risk households, businesses and/or governments and to the reinsurance markets. As primary and re-insurance markets become more international – attracting capital from investors throughout the world - insurance becomes an instrument for transferring disaster risks over the globe. Recently, another risk-transfer instrument, commonly called a catastrophe or cat bond, has emerged, which can be used to replace traditional reinsurance. Cat bonds make use of different formulas to trigger compensation based on losses or on a physical phenomenon such as wind speed or precipitation. These bonds are purchased by investors and thus transfer the risk to the global capital markets.

A catastrophe bond (cat bond) is an instrument whereby the investor receives an above-market return when a specific catastrophe does not occur (e.g. an earthquake of magnitude 7.0 or greater in the vicinity of Tokyo, Japan), but shares the insurer's or government's losses by sacrificing interest or principal following the event.

Catastrophe bonds emerged as instruments primarily for insurers. As pointed out in the last section, insurers cannot diversify dependent risks by writing a large number of similar policies, and therefore locally operating insurance companies diversify through reinsurance. Reinsurance companies, in turn, manage their risk by an even wider and more global diversification, but in the early 1990s large losses from U.S. catastrophes strained the capacity of the reinsurance markets and raised the price of reinsurance. This insurance crisis led to the development of new financial instruments to transfer catastrophe risk exposures, including catastrophe bonds, but also to other types of index-based securities that are traded on the equity markets. For instance, the risk transfer characteristics of cat bonds can be replicated through a mechanism called catastrophe risk swaps, where the cedant (e.g., the government) makes fixed payments equal to the premiums paid in a cat bond structure against receipt of claims compensation in case losses occur.

These relatively new instruments have been made possible mainly because of recent advancements in catastrophe modeling that allow analysts to estimate the risks and potential losses of future disasters more accurately than in the past (see Section 3). They are potentially attractive to investors since they are not correlated with other equities. However, index-based bonds and securities have an associated "basis" risk since they may be poorly correlated with losses.

The potential of insurance and these alternative instruments for transferring the risks of disasters to investors across the globe is enormous. The size of the US capital market alone is in the order of US$ 26 trillion (Insurance Services Office, 1999), which could easily absorb the annual bill of global weather disaster losses averaging about US$ 40 billion. In other words, the *worldwide* losses from extreme disasters are only a small percentage of the world capital market, which deviates everyday by several billion dollars. This highlights the scope and potential of trans-border risk transfer, especially for governments of poor countries that cannot form a viable insurance pool of taxpayers within their borders.

As shown in Figure 4.2, however, few citizens or governments of poor countries hold insurance policies or take advantage of other hedging instruments to transfer their risks.

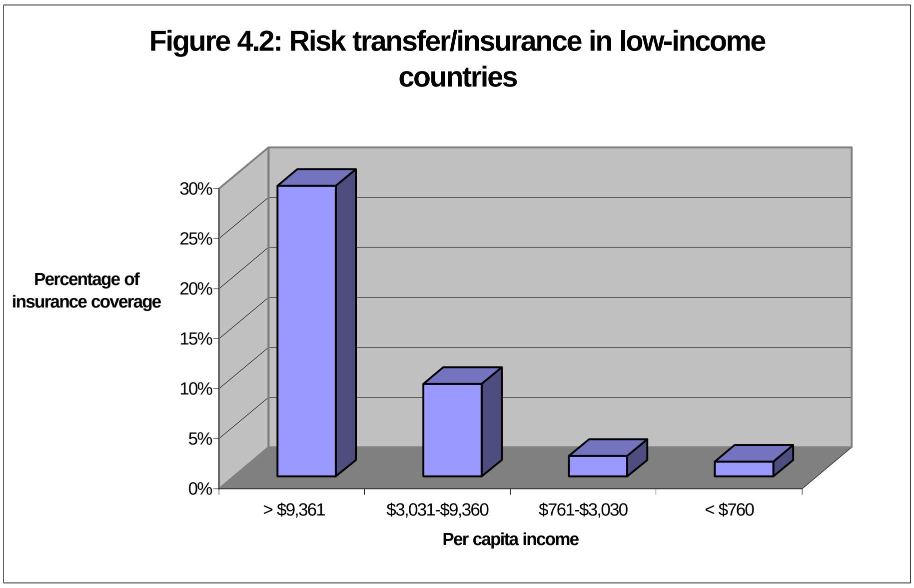


Figure 4.2 – Risk Transfer in Low-Income Countries. Source: Mechler, 2003

Low catastrophe insurance uptake in the developing world is neither surprising nor perhaps disturbing. Although there is great scope for and appeal of transferring risks out of national borders into the capital markets, risk transfer comes at a price. As noted above, governments may have access to less costly means to finance their disaster liabilities, and the premiums for insurance are hardly affordable for most of the citizens at risk in the developing world. Most private insurance arrangements incur an expected net financial loss to the purchaser since insurance companies are profit seeking and averse to risks that threaten their solvency. Several years ago Froot and O´Connell (1999) contended that the premium for catastrophe protection was considerably above its actuarially fair price or pure premium. They attributed this differential to a number of factors, including insufficient capital reserves, imperfect competition in insurance and reinsurance markets, ambiguity or uncertainty aversion by the insurer, adverse selection and moral hazard.

Indeed, over the past decade the premium for catastrophe insurance has been high and cyclical, ranging from double to 18-times the actuarial fair premium, although there have been periods where the price actually fell below pure premium. Despite expectations, alternative insurance instruments appear to be as costly as traditional insurance; however, this may change as investors gain more experience with these instruments (Andersen, 2000). Commenting on the high price of risk transfer, Auffret (2003) points out that in the Caribbean region, catastrophe insurance premiums are estimated to represent about 1.5% of GDP during the period 1970-1999 while average losses per annum (insured and uninsured) accounted for only about 0.5% of GDP. Following the terrorist attacks of September 11th there has been an increasing concern by the investment community in providing coverage for catastrophic events, and the price for this protection has risen (Kunreuther, 2002). Based on recent market data, the average XL (excess of loss) rates for different levels of catastrophe coverage based on probability of occurrence, are shown below. The Index shows the “risk load” added to the pure probability premium (Pollner, et al, 2001).

XL Rates by Event Probability

Probability	XL Rate	Index Rate/Prob.
15.0%	17.0%	1.1
5.3%	8.3%	1.6
3.5%	6.6%	1.9
2.5%	5.8%	2.3
1.5%	4.9%	3.3
1.2%	4.2%	3.5
0.8%	3.9%	5.2
0.7%	3.8%	5.4
0.4%	3.5%	10.0
0.2%	3.4%	18.9

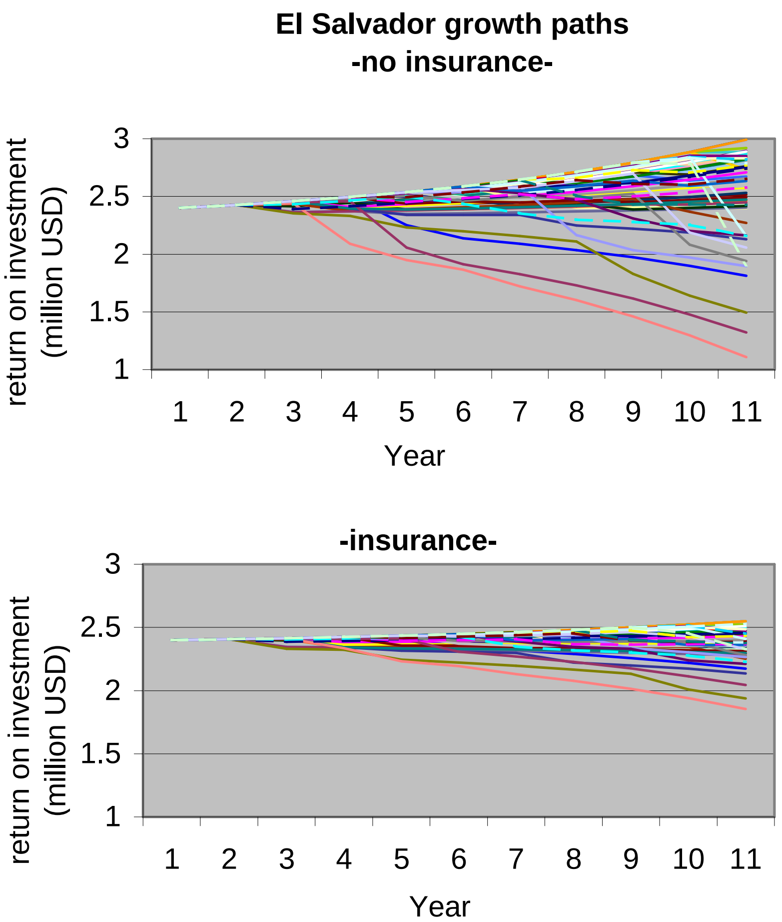
Risk transfer for public infrastructure

Despite the costs, there has been a great deal of excitement about the potential of insurance and other forms of risk transfer for hedging the risks of extreme weather-related and other disasters facing developing countries. Governments carry a large and highly dependent portfolio of infrastructure assets, some of which are critical for restoring economic growth, and for the same reason as firms they may wish to reduce the variance of their disaster losses by diversifying with insurance and other risk-transfer instruments (Freeman/Pflug, 1999). This strategy may have the added value of enhancing foreign investor confidence. A country, however, is importantly different from a firm since most governments can pass their infrastructure losses on to taxpayers. In theory, governments are thus less risk averse than firms, and risk aversion is the main justification for paying the additional costs for insurance (Arrow/ Lind, 1970).

Yet, as illustrated in the above example, a poor and highly exposed country like Honduras may not be able to pass its budget losses on to taxpayers, and risk transfer may be the only available option for covering extreme-event losses. Many governments of developing countries do carry some limited insurance, e.g., Honduras carries some limited insurance on its quasi-private capital stock, such as airports, telecom energy facilities and state-owned enterprises, whereas roads, bridges, hospitals, government buildings remain without protection (Pollner, et al., 2001). There is little experience, however, with other insurance instruments. To date catastrophe bonds have mainly been marketed by the private insurance sector, although the California Earthquake Authority proposed, but never implemented, a large catastrophe bond (US$ 1.5 billion) to cover state expenses in the aftermath of a major earthquake. In some cases, private insurers are offering novel types of hedges for natural disasters. For example, the private Small States Insurance Scheme provides relief from debt servicing obligations in the case of a natural disaster in order to free up capital for recovery efforts. The amount of coverage is linked to meteorological and/or geological event triggers (see CDMA).

Lacking more attractive financing alternatives, the government benefits from risk transfer since it reduces the variability of its disaster losses, but risk transfer requires resources that could otherwise be invested in the economy. In terms of economic growth there is thus an inherent tradeoff: a reduction in funds spent on current growth permits a government to protect itself against extreme future losses. This tradeoff was illustrated for El Salvador by a simulation model of economic growth with and without

public-infrastructure insurance (Freeman, et al. 2003). Looking at Figure 4.3, the model shows that the return on investment in El Salvador, or economic growth, is higher on average if the government does not allocate its resources to catastrophe insurance (top graph), but the economy has fewer extremes, that is, it is more stable with public sector insurance (bottom graph).



This growth-stability tradeoff is a difficult one for a developing country like El Salvador, where a large percentage of the population lives in poverty. Ideally, El Salvador could continue on a strong growth path *and* reduce the possibility of extreme shocks to its economy. This ideal raises opportunities for international assistance. The international donor community could consider aiding vulnerable country governments to hedge their disaster liabilities as a partial substitute for post-disaster relief. This pre-disaster strategy would have the added benefit of providing an incentive for governments and the donor community to plan for disasters, and this plan could be linked with loss-reducing measures. As a novel idea, this aid could also come from private citizens, who might add catastrophe bonds to their portfolios at lower cost to the developing country government than insurance. This charitable investing might also be a strategy of large investors, such as pension fund managers. National governments could provide tax incentives for charitable investment in developing country cat bonds.

Private Sector Insurance and risk transfer

Turning to the private sector, the extent of private disaster insurance in the developing countries is very low; mainly it is purchased by businesses, hotels and other types of enterprises. Yet, even in developed and transition countries insurance cover differs greatly across countries and hazards. In the UK and Hungary, where flood cover is bundled with property insurance, private insurance uptake is as high as 70% and 40% respectively, compared with only about 10% in Germany where flood cover is purchased separately. Also, the share of private insurance versus public relief for private disaster losses differs significantly in the developed world. The UK government hardly gives any assistance to disaster victims, whereas in Austria and Hungary assistance can be up to 100% of private victim losses. There is mounting pressure, however, especially on the emerging-economy countries of Europe, to reduce public assistance and to promote more private insurance to meet the fiscal constraints imposed by the European Union. In fact, throughout the world governments are under increasing pressure to reduce their post-disaster spending.

Another argument for shifting more responsibility for disaster losses to the private sector through insurance concerns incentives for loss reduction. If insurance premiums are set to reflect the risk, this will create incentives for homeowners and businesses to take loss-reducing measures and to relocate out of high-risk areas. While this is true in theory, the practice looks somewhat different. Insurers generally do not charge premiums that encourage loss prevention measures since they feel that few people would voluntarily adopt these measures based on the small annual premium reduction (Kunreuther, 1996). Another possible explanation is that insurers have not promoted loss control measures since these measures could negatively affect their profits (Hunter, 1994). The role of insurers in preventing losses, however, may be changing as insurers become more concerned about huge or mega losses. Kunreuther and Linnerooth-Bayer (forthcoming) show how the premium for an insurance contract to cover the flood risks to a sewer treatment plant in Poland can be set to reflect the measures the government can take to protect the plant.

Risk-averse individuals benefit from insurance, but as discussed above the premiums for catastrophe cover can be quite high. Shifting the burden from national governments to private individuals in poor countries, critics argue, will result in profits for the insurance industry. Moreover, there is also an associated moral hazard with private insurance, although it can be lessened with deductibles. Finally, many private structures in developing countries are considered uninsurable. In the Caribbean region, for example, the vast majority of buildings with catastrophe insurance are hotels and businesses. A large segment of the population in Barbados, Jamaica and Trinidad and Tobago lives in vulnerable, uninsurable properties that could be easily dislodged in the event of flooding or strong winds (Auffret, 2003). Insurance premiums on these vulnerable buildings, if offered at all, would be prohibitively expensive.

To bypass formal catastrophe insurance arrangements for poor households and businesses, micro-insurance has become topical. Micro-insurance involves voluntary and contributory schemes for the community and is oriented to small-scale cash flows. These schemes are sometimes subsidized by the government; however, they address mainly health and funeral expenses. The more than 40 micro-health insurance schemes in Bangladesh, India, Nepal, the Philippines and Thailand do not provide insurance against disaster-related losses. The problem for small-scale insurers is the dependent nature of the risk and the difficulties in achieving sufficient scale, maintaining affordable premiums and controlling moral hazard (Brown/Churchill, 2000). The schemes could diversify through swaps, but the transaction costs might render them then unaffordable. Other traditional risk-transfer schemes based on social capital, such as asset pooling and kinship networks, are not fully viable for the same reason since geographically concentrated disasters affect all households and family members at the same time (POVCC, 2003).

It should not be overlooked that banks and other financial institutions indirectly act as insurers. For instance, the Grameen Bank expects a large number of defaults on its small-scale loans after a major disaster, and it can pool these risks over the country. To absorb these risks it will have to charge higher interest on its loans, but the low transaction costs may make this form of insurance attractive. Of course, loan arrangements only pools the risks of borrowers.

Another interesting alternative to traditional insurance is a so-called weather hedge, which can protect farmers against droughts, storms and other extremes. Accordingly, insurance contracts are written against, say, severe rainfall shortages measured at a regional weather station. The insurance is sold in standard units by banks, farm cooperatives or micro-finance organizations, and all buyers pay the same premium and receive the same indemnity payment per unit of insurance – a kind of lottery against the weather. By keeping it simple, the transaction costs are reduced. However, again a major constraint to this and any micro scheme for providing disaster insurance is the dependent nature of the insured risks within a single region. When an event occurs, the insurance provider may not have the capital to cover the dependent claims.

For this problem, micro or other insurers could make use of reinsurance, or of catastrophe bonds that spread the risks internationally. Many consider the use of alternative instruments as an exciting new opportunity to pool large volumes of dependent risks at the global level, and they point out that these instruments have already been successful to spread insurers' risks. However, as pointed out above, there is a substantial cost associated with these instruments that may make these schemes unaffordable without assistance from international donors.

3. *Public-private partnerships and national insurance systems*

Thus far we have examined the case for government and private responsibility for financing disaster losses, noting that neither can stand on its own. Public-sector insurance is more costly than many government financing measures, and households and businesses in poor countries can ill afford insurance premiums. At the same time, governments are increasingly implored to meet fiscal constraints and will have grave difficulties in bearing the increasing financial burdens from disasters. This is especially the case in transition and developing countries. Finally, insurers are, themselves, increasingly reluctant to expand cover in areas with skyrocketing losses, and some are even pulling out of high-risk areas.

Recognizing that neither private insurance nor public assistance can stand on its own, some countries have legislated national insurance programs that combine private and public responsibility. Of course, public-private partnerships do not solve the fundamental problem that the citizens of poor and highly exposed countries, like Honduras, cannot afford to be paying members of a risk or solidarity pool for extreme losses. Their vulnerability explains why these programs, with the important exception of Turkey, exist only in the developed countries, including the US, France, Norway, New Zealand and Japan. Yet, some developing countries have formed elements of public-private partnerships. For example, in 1994, Puerto Rico created a Reserve for Catastrophe Losses under which a portion of tax-deductible property insurance premiums is passed to a trust for reinsuring Puerto Rican insurers. These pools need not be national, but can also be regional in scope as suggested for the Caribbean region (Pollner, 2000). These regional or national public/private programs for flood, earthquake and other hazards differ significantly with respect to how the losses are shared, the role of the government and private insurers and the incentives they provide for loss-reducing measures. In what follows we briefly describe the main characteristics of three programs: the US National Flood Insurance Program (NFIP), the French all-hazards system and the recent Turkish Catastrophe Insurance Pool (TCIP). The tiered responsibility of the public and private sectors in these programs is illustrated in Figure 4.4 .

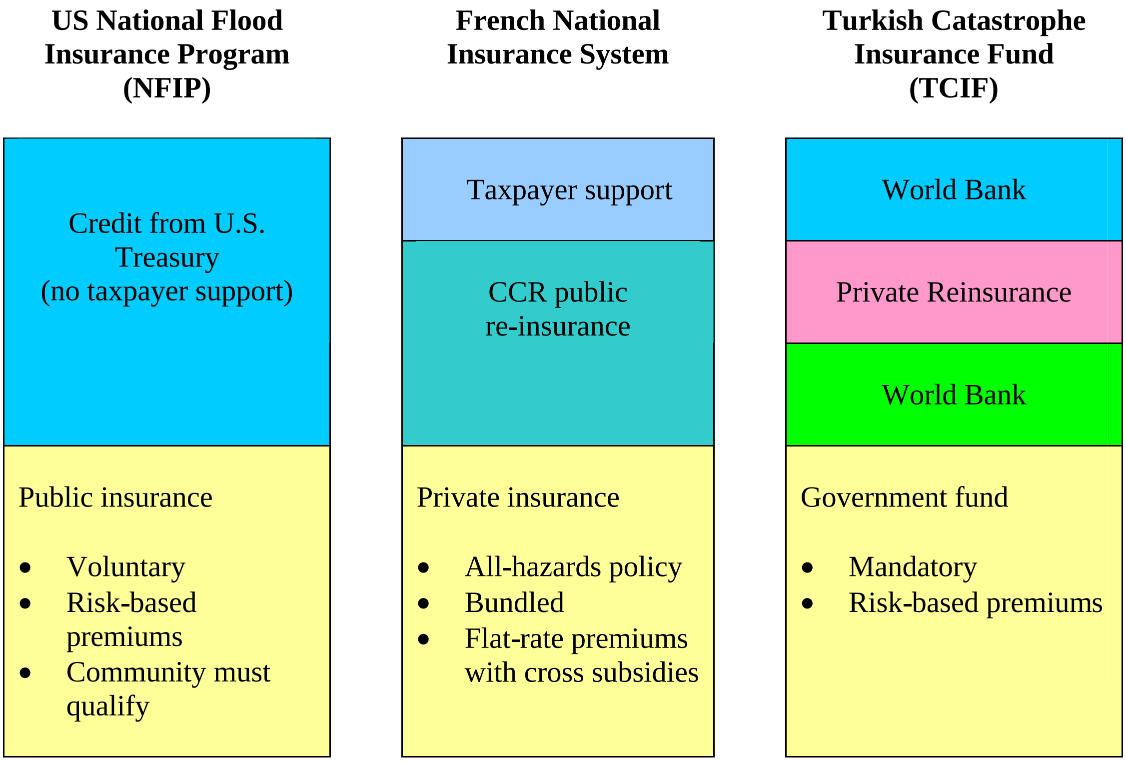
The US National Flood Insurance Program is unique in that the federal government serves as the primary insurer for floods, offering voluntary policies to residential and commercial buildings. Because the flood peril was considered uninsurable, the NFIP was designed to increase the role of the insurance industry in writing the flood insurance policies (where the government bears all the risks) and ultimately to have the industry take over a risk-bearing role. A notable feature of the NFIP is that communities must take prescribed loss reduction measures if their residents are to be eligible for cover. Premium rates are increasingly risk-based, but about 30% of policies cover properties built before flood-risk maps were available. Since risks are pooled across the entire country, there is little need for reinsurance. In the unlikely case that multiple floods occur that exceed NFIP reserves, the Federal Emergency Management Administration (FEMA), which administers the program, will borrow from the treasury. In this way, taxpayers are not called upon to share the risks. Minus taxpayer support and with risk-based premiums, the philosophy of the NFIP (and also the earthquake insurance program recently put into place in California) is that persons living in exposed areas should bear their full risks.

A different philosophy underlies the French system, which deliberately incorporates national solidarity through taxpayer involvement and cross subsidies from low-risk to high-risk areas and across hazards. In France, private insurers are required to offer non-mandatory catastrophe insurance in an all-hazards policy (including fire) that is bundled with property insurance. The program is reinsured through a public administered fund, the Caisse Centrale de Réassurance (CCR). If this fund is insufficient, taxpayers will be called upon to contribute (in contrast, the Japanese earthquake program is also backed by government reinsurance and taxpayers, but only to a certain level at which claims will be pro-rated (meaning that claimants will receive less)). The French have rejected risk-based premiums in favor of a flat rate as a percentage of the property value. In this way, those living in low-risk areas subsidize high-risk households and businesses – solidarity through insurance. The French recognize that the system provides disincentives for individuals and local communities to take risk reduction measures. A recent and imaginative decree to counter this problem sets a deductible that increases with the number of disasters in the same area. This means that the compensation a household or business receives will continually decrease in high-risk areas, leading to incentives to relocate or take other loss-reduction measures.

The Turkish Catastrophe Insurance Pool (TCIP) legislated in 1999 is the first of its kind for a developing country (see Balamir, 2002; Andersen, 2001). Designers of this system have attempted to solve the fundamental problem of the un-affordability of earthquake insurance in poor countries by offering limited cover and by transferring some of the risk out of the country with World Bank support. The TCIP combines international reinsurance contracts and capital market transactions with a national insurance pool. (In many ways this resembles national catastrophe funds, such as FONDEM in Mexico, except that the TCIP is not funded by taxpayers and not at the discretion of the public authorities.). Recent legislation makes earthquake insurance policies obligatory for all property owners, who pay a fee based on their risk zone, the construction of their property and risk reducing measures, to a privately administered, public fund. The TCIP provides coverage for earthquake losses up to US$600 million, and only persons holding insurance policies will be eligible for additional government assistance after a disaster. As shown on Figure X, the World Bank funds the next risk layer, that is, it will finance 100% of claims up to $82.5 million if the losses during the initial years are greater than the funds built up in the pool, together with any reinsurance of excess of loss reinsurance cover. A large part of the next higher risk layer was ceded in the global reinsurance market, whereas the highest risk layer up to a certain limit is again funded by the World Bank. In total, the World Bank will provide up to $100 million in an uncommitted contingent loan facility. The facility is a standby (contingent) line of credit, with an option to be drawn (given to the Pool) in case of a disaster and against specific claims. The TCIP pays a standby contingent fee for this option every year in lieu of reinsurance premium.

The disbursement of this facility will be contingent upon progress in regulatory reform and prevention measures. In turn, the World Bank can cover part of its risk exposure by engaging in risk transfer arrangements in the international financial markets in its own name. In this way, the Bank has substituted the unpredictable granting of post-disaster loans for a calculable annual commitment to the insurance system. The fund, however, has been criticized in that it makes no allowance for directly financing loss reduction measures (Balamir, 2002).

Figure 4.4: The Tiers of Three National Insurance Programs



Democratic process

The complexities and technical details of financing catastrophic risk can easily conceal that any institutional insurance arrangement is embedded in a social/political system and entails value judgments about who bears the risks and benefits, and who decides. A recent pilot study in Hungary developed and tested a citizen-participatory procedure for designing a public-private insurance and compensation program for flood losses (Linnerooth-Bayer/Vari, 2003). Renn et al. (1995) define public participation as the "…forums of exchange that are organised for the purpose of facilitating communication between government, citizens, stakeholders and interest groups, and businesses regarding a specific issue or problem" (p.2). The challenge for the Hungarian participatory process was to identify the contending perspectives and preferred policy directions held by the stakeholders (the public, the local and national government authorities, insurance companies, environment groups and other NGOs), and more importantly to identify a consensus policy path for a nationwide, public-private insurance/compensation system. To meet this challenge, a five-round, participatory stakeholder process was developed and tested, combining stakeholder interviews, a nation-wide questionnaire and a deliberative stakeholder workshop where participants chose and argued for their preferred policy option. The process was aided by a simulation (flood catastrophe) model that demonstrated the incidence of the policy options for a pilot (and very poor) area on the Upper Tisza river. As a result of this process, a consensus was reached on a nation-wide system that was both similar and importantly different from the three systems discussed here. The Hungarian stakeholders rejected mandatory insurance, but like in Turkey they agreed that only households and businesses with limited insurance would be eligible for post-disaster aid. Like in France, there would be a flat-rate premium with resulting cross subsidies, and in addition the government would subsidize insurance premiums for poor households. However, the government would not take the role of re-insurer. More important than the outcome, however, is the citizen participatory process that will likely help legitimize upcoming legislation on this issue.

4. Concluding remarks

This brief discussion shows that insurance and risk-transfer instruments are not a panacea for resolving the needs of developing countries to finance their recovery from natural disasters, but in combination with risk reduction they can be a useful, but costly, addition to the portfolios of poor countries facing high exposures to weather extremes. Despite its high costs, countries without access to other financing instruments will find pre-disaster risk-transfer particularly attractive from an economic view. These countries will require donor aid in the form of pre-disaster financing. Other benefits of risk transfer also enter the financing decision, especially the potential relationship of risk transfer with incentives for loss reduction. The equity aspects of these instruments are also important since they differentially allocate losses to taxpayers and insurance pools. Perhaps most importantly, risk-transfer instruments necessarily require planning before disasters, and their use will force attention to prevention along with post-disaster financing needs.

V. International Legal Responses to Risk and Approaches to Insurance

Earlier sections of this paper have addressed how a variety of public and private insurance tools may be used to transfer risk resulting from extreme weather events associated with climate change. This section is intended to provoke thought on how insurance-related actions might be used to transfer and redistribute risks associated with the adverse effects of climate change, *within the legal framework* of the climate change regime.

This section will consider how combinations of risk transfer and collective loss-sharing tools are used both in and through existing international civil liability and compensation regimes, to address transboundary environmental harm from ultra-hazardous, hazardous and dangerous activities. The most prominent of these regimes have developed in connection with risks from nuclear damage, oil spills, transportation of dangerous and hazardous goods, and the pollution of watercourses through industrial accidents. The central objective of each regime is to attribute responsibility for transboundary harm pre-disaster (regardless of fault), in order to assure prompt and adequate compensation to private and public victims post-disaster. In each case this is facilitated through use of insurance mechanisms, backstopped by private, governmental or intergovernmental collective loss sharing arrangements.

1. Introduction

A quick look at the impetus behind the development of the liability and compensation regimes to be discussed below, readily illustrates their common themes and challenges: massive pollution with expensive transboundary impacts; numerous victims; an absence of readily-identifiable and/or legally-responsible parties; an absence of a ready and adequate source of compensation; and an absence of a harmonized system for addressing claims.

- In 1967, the *Torrey Canyon*, a Liberian-registered vessel carrying bunker fuel, ran aground off the coast of England, releasing 120,000 tonnes of oil into the English Channel. The spill caused unprecedented damage along the British coastline and reached as far as the French coast. It was realized that, under many national systems, it was not clear who compensates for losses when an incident involves a foreign ship in international waters. The international community created the current oil spill regime in response, to provide a harmonized system for addressing claims and providing compensation. Further legal initiatives have commenced following the 1999 oil spill from the *Erika* off the coast of Brittany, and the sinking of the oil tanker *Prestige* off the coast of Spain in November 2002. These disasters pointed to the need for increasing levels of available compensation.
- In April 1986, explosions occurred at a commercial nuclear power plant in Chernobyl, Ukraine, resulting in a prolonged release of radioactive materials to the environment. Effects were noted across Europe and detected as far away as Canada, Japan and the United States (OECD NEA). Existing liability regimes were found inadequate to address resulting economic losses from crop and agricultural contamination, evacuation, and business disruption, because the former Soviet Union, owner of the nuclear power plant, had not acceded to nuclear conventions and had no national nuclear liability law. No compensation was paid out to any of the neighboring countries. In response, the international community amended and linked existing nuclear conventions.
- In the early 1990s, shipments of hazardous and illegal waste from developed countries increased to and through developing countries, as a result of the high cost of domestic disposal. Developing countries became increasingly concerned about their lack of funds and technologies for coping with illegal dumping and accidental spills of hazardous and illegal waste in their territories, when responsible parties could not be easily identified. The international community developed the 1999 Basel Protocol to address these concerns.
- In January 2000 an accident at a tailings dam in Romania spilled 100,000 tonnes of cyanide-contaminated waste water. This led to massive pollution of the Tisza and the Danube Rivers, which killed tonnes of fish and poisoned the drinking water of more than 2 million people in Hungary (UNECE 2003, WISE 2002). Countries negotiated and agreed the 2003 Watercourse and Industrial Accidents Protocol in response.

The tools and concepts that have been developed to address the need for funds to allow for post-disaster recovery include: strict operator liability regardless of fault, tied to compulsory insurance coverage (in all cases); supplemental layers of compensation funded by levies imposed on private parties and administered by intergovernmental organisations (in the oil pollution and hazardous and noxious substances schemes); state collective loss sharing pools (in the nuclear schemes); and international collective loss sharing pools (in the oil spill and nuclear schemes). These different mechanisms will be described in greater detail below.

The sections that follow will: (1) address general principles of international law, and their relationship to the creation of liability regimes; (2) discuss how international liability and compensation regimes operate as insurance mechanisms for governments and their constituencies; (3) introduce how insurance tools are used within these existing regimes to transfer and share risk and losses; (4) present the tiered compensation systems currently used in these regimes to redistribute risk; and (5) identify the common insurance and collective loss sharing tools in use within these regimes. This is done to allow consideration of how similar concepts might be used to address transboundary damage resulting from climate change.

2. General Principles of International Law

It is a general rule of international law that States have the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or to areas beyond the limits of their national jurisdiction. This rule is reaffirmed in Principle 21 of the Stockholm Declaration, and Principle 2 of the Rio Declaration. It is also repeated in the preamble to the UNFCCC.

It is a further principle of international law that every international wrongful act entails international responsibility. In the context of transboundary environmental damage, this principle has two parts: first, a State has a responsibility to take measures to prevent the occurrence of transboundary environmental harm; and second, a State has a responsibility to redress damage if transboundary harm occurs. To this end, Principle 13 of the Rio Declaration provides that

"States shall . . . cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction."

International liability and compensation regimes typically impose civil liability on third party private and public actors responsible for the damage caused by environmental disasters. In so doing, these civil liability regimes, which are negotiated among States, and address State-regulated industries, further Rio principles. They deter transboundary environmental harm from domestic industries, by creating cross-border financial repercussions for economic activities that may have significant cross-border impacts. They also serve a reparative function, by identifying or creating funding sources to compensate for transboundary damage caused by domestic industries. In this way, civil liability and compensation regimes implement the polluter-pays principle by shifting the costs of transboundary environmental harm that might otherwise be borne by society at large, through government disaster relief and collective loss sharing mechanisms at the first instance, directly to the person or entity most responsible for the activity causing damage. If operator liability proves insufficient to ensure redress, these regimes fall back upon agreed state and global collective loss sharing arrangements to address uncompensated damage.

These civil liability regimes are instructive for addressing the role of insurance in combating climate change-related risks, because each has considered how to allocate the risk of transboundary damage among individuals, the private sector and governments, and each has employed insurance and collective loss sharing strategies to minimize the financial impact of man-made disasters, and assist in prompt response.

3. Liability and compensation schemes as insurance

Liability and compensation regimes commonly channel liability for damage resulting from a dangerous activity to the entity undertaking that activity. Liability is strict – meaning that liability is tied to the conduct of the dangerous activity giving rise to damage, rather than to the actual fault of the operator. (See CBD 2001) Liability is also generally limited to a fixed amount, based on the risk posed by an operator's specific activities. In exchange for the benefit of limited liability, operators are required to secure and maintain insurance, or other forms of financial guarantees, corresponding to their liability. The existence of agreed financial limitations on what could otherwise be unlimited liability, as well as limitations on the time within which claims may be brought, and upon the types of damage for which recovery may be had, all serve to render the economic risk from undertaking dangerous activities estimable, and therefore *insurable.* Mandatory insurance requirements then make certain that these risks are in fact insured by the operator. Above these limits, the structure of supplemental layers of compensation are agreed to address excess loss.

International liability and compensation regimes are themselves a form of pre-disaster risk hedging instrument, purchased by participating State governments (and their taxpayers) through international negotiations. The State's cost is the expense of negotiating a civil liability text with other State Parties, and the expense of constructing a domestic legal and institutional framework to implement the agreed international framework. In developing countries, this cost is often subsidized through financial assistance for negotiation and implementation.

With a third party liability regime in place, governments that might otherwise have been compelled to tap their own disaster funds (or resort to donor funds) to address response costs and damage for the transboundary impacts of a major oil spill, a major nuclear disaster, or the toxic contamination of a major water supply, can shift post-disaster response costs directly to a strictly liable private or public entity (or its insurer), eliminating the transactions costs involved in proving fault and collecting damages. In some situations, governments may also be able to shift a portion of their response costs to other governments, through collective loss sharing arrangements. Where regimes create mechanisms for the handling of individual claims for compensation, resource-constrained states are relieved of a portion of this burden as well.

Participation in these regimes reduces uncertainty (risk) for States, who might otherwise be cast in the role of unwilling insurers of their own and their citizens' losses. This can occur when adequate compensation cannot be obtained from responsible parties, either because operator liabilities have caused bankruptcy, causation cannot be determined, the responsible party cannot be located, or domestic laws are inadequate to guarantee recovery. These regimes also reduce uncertainty (risk) for potential victims, by ensuring the availability of a certain minimum level of compensation, and elaborating procedures for the presentation of a defined category of claims. Finally, these regimes reduce risk for investors in business operations engaged in high-risk activities, by defining limits of liability. This in turn helps to ensure that exposure to liability does not deter economic activities that are viewed as in the public interest, despite their associated risks.

Potential victims and States do nonetheless retain certain risks: the cost of pursuing compensation or reimbursement claims under the scheme (in effect, payment of a deductible); and the risk that damage will exceed limits of liability and not be recoverable (in effect, exceed policy coverage). However, liability and compensation regimes may further reduce these risks through the provision of supplemental cover.

4. Role of insurance and collective loss approaches within compensation and liability regimes

International civil liability and compensation regimes typically require the private or public operator of a dangerous or hazardous activity to maintain sufficient insurance or financial security to cover claims up to an established liability limit. This compulsory insurance requirement ensures that a reliable amount of funding will be readily available to compensate victims in the event of a disaster.

Over the years, tiered compensation systems have evolved to provide supplemental coverage for those situations in which claims exceed the limits of the operator's limited liability and therefore the operator's compulsory insurance coverage. These tiered systems have many similarities with commercial reinsurance. They have been created where: (1) the potential damage from a particular risk is so great that it cannot be insured by the private market alone; (2) the limits of liability established in international treaties have proven to be too low (potential economic losses from accidents involving hazardous activities have risen) and the relevant convention that limits operator liability cannot be easily amended; (3) a public policy decision has been made to share uncompensated losses collectively, at the state or global level; or (4) a public policy decision has been made to direct “overflow” losses to a class of actors other than operators, who are nonetheless causally linked to the creation of the regulated risk.

Not surprisingly, the most elaborate tiering systems have developed around the activities that pose the greatest threat of massive transboundary damage and consequently the spectre of the greatest potential liability and costs of redress. In these situations, tiering has served to spread the risks of damage beyond individual operators, to operator industries as a whole, to public funds and/or to international solidarity funds, much in the way that reinsurance is used to backstop insurance and in the way that governments or the World Bank backstop national insurance systems. This evolution is most readily seen in the oil spill regime, which presently uses a two-tiered system of compensation, and the nuclear damage regime, which uses a three-tiered compensation system.

5. *Tiered systems of compensation*

a) *Single-tiered systems*

The polluter-pays principle is implemented most directly in the international liability schemes that use a single tier of compensation for disaster losses. In these systems, strict liability is imposed on operators involved in hazardous activities or in the transportation or handling of dangerous or hazardous substances. Operators are then required to maintain insurance or other financial guarantees to satisfy claims for damages resulting from their activities up to an established limit of liability. Each regime has a different way of establishing limitations on liability. These limitations reflect different ways of measuring potential risk from a dangerous activity *ex-ante*, (volume handled, toxicity, activity, characteristics of operators). They also reflect value judgments about appropriate burden sharing in each context, since primary limits of liability directly affect the amount of risk to be retained by victims and/or their governments as insurers of last resort.

For example, under the ***1972 Convention on International Liability for Damage Caused by Space Objects,*** any State that launches a space object is strictly liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft in flight. There is no limit on liability and States self-insure against these losses.

Like the Space Convention, the ***Basel Protocol on Liability and Compensation for Damage Resulting from Transboundary Movements of Hazardous Wastes and their Disposal*** (Basel Protocol) clarifies who will be responsible for compensation in the event of an accident. The Protocol channels liability to notifiers, importers, exporters, re-importers and disposers of hazardous and illegal waste, at each phase of transboundary transport, and requires potentially liable persons to establish insurance, bonds, or other financial guarantees during their period of potential liability. *Minimum* limits of liability are established based on tonnes of waste shipped, ranging from 1 million SDR (Special Drawing Rights) (approx. US$1.37 million or €1.25 million as of April 22, 2003) for a shipment of up to 5 tonnes of waste, to 30 million SDR for a single incident involving a shipment of 30,000 or more tonnes. Limitations also vary based on the role of the responsible party as notifier, exporter, importer or disposer. The Basel Protocol is not yet in force.

Under the ***1989 Convention on Civil Liability for Damage Caused During Carriage of Dangerous Goods by Road, Rail and Inland Navigation Vessels*** (CRTD Convention), carriers of dangerous goods are held strictly liable for damage occurring during transport, and must obtain insurance or financial security to provide cover for losses. The CRTD Convention limits liability by type of carrier (road, rail, vessel) and type of injury potentially suffered (loss of life, personal injury, other). The liability of the road or rail carrier is limited for claims arising from any one incident to 30 million SDR: 18 million for loss of life or personal injury; and 12 million SDR with respect to any other claim. The liability of the carrier by inland navigation vessel is limited to 15 million SDR: 8 million for loss of life or personal injury; and 7 million with respect to any other claim. The CRTD Convention is not yet in force.

Under the new ***Protocol on Civil Liability and Compensation for Damage Caused by the Transboundary Effects of Industrial Accidents on Transboundary Waters*** (Watercourses and Industrial Accidents Protocol), operators of industrial installations will be held strictly liable for damage caused by the impacts of their activities on international watercourses, and must establish financial security, such as insurance or other guarantees to provide cover for these losses. The Protocol limits liability by reference to the quantity of hazardous substances present at an industrial facility, and the type or toxicity of those substances. Limits of liability range from 10 million SDRs up to 40 million SDRs. In a variation on the standard arrangement, in which the financial security required is equal to liability limits, minimum levels of financial security range from 2.5 to 10 million SDRs -- only a portion of the limits of liability imposed by the Protocol. The Protocol is due to be signed in May 2003, and is not yet in force.

Claims under these systems generally may be brought directly against the operator, or directly against the insurer or financial security. None of these regimes provides for a supplementary tier of compensation if the damage caused exceeds the operator's limited liability, in effect leaving the risk in excess of these limits with victims and their governments. Future adjustments are possible though. (Article 15 of the Basel Protocol contemplates that future mechanisms may be established to provide supplementary compensation and the Watercourses Protocol provides that limits of liability will be kept under review.)

b) Two–tiered systems

Two-tiered systems have developed for risks and damage relating to the marine transport of persistent oils, and the marine transport of hazardous and noxious substances. These systems take the polluter-pays principle beyond simple operator liability to recognize that demand for transported products also plays a direct role in increasing risk to the environment from spills. Accordingly, these regimes transfer a portion of the economic consequences of spills to the owner of the shipped cargo, by requiring that persons receiving oil or hazardous and noxious substances (HNS) over certain threshold amounts contribute to compensation funds to address losses not covered by the operators' (tanker owners') limits of liability.

Oil spills are addressed under the inter-related ***1992 Civil Liability Convention*** (CLC 92) and the ***1992 Fund Convention***. The oil spill regime has very broad coverage. The 92 Parties to the CLC 92 represent over 91% of the world's oil shipping tonnage, and the 85 Parties to the 1992 Fund Convention represent over 87% of that tonnage (IMO-1).

At the first level, the CLC 92 places strict liability for oil spills on tanker owners, and requires that each owner maintain insurance or financial guarantees sufficient to cover a prescribed limit of liability. Limits of liability are graduated, based on the gross weight of the individual tanker measured in tonnes, from a minimum of 3 million SDRs per incident for a vessel of up to 5,000 gross tonnes, to a maximum limit of 59.7 million SDRs per incident (approx. US$82 million) for a vessel up to 140,000 gross tonnes. If oil escapes from a tanker, claims for damage may be brought directly against the insurer or against the financial guarantees up to that limit of liability (***operator insurance***).

At the second level, the 1992 Fund Convention creates a supplementary layer of compensation. If damage claims exceed the owner's fixed limit of liability under CLC 92, remaining claims may be asserted against the International Oil Pollution Compensation Fund (IOPC Fund) established under 1992

Fund Convention, up to a second, higher limit of 135 million SDRs per incident (approx. US$175 million), which includes the amount paid under the CLC 92 by the owner or its insurer. If the amount of established claims then exceeds even the maximum amount of compensation available under the second higher limit, claims are settled equitably among claimants within the ceiling. The IOPC Fund is constituted through a levy imposed on any person in a Contracting State who receives more than 150,000 tonnes of crude or heavy oil in a calendar year (whether a private company, State-owned company or government authority), based on the actual total tonnage received in that year (***oil receiver contributions***). Contributors to the IOPC Fund are generally oil companies.

The specific amount of the levy is decided each year by the Fund Assembly (comprised of all Contracting States)**,** based on anticipated payments of compensation and administrative expenses. States are not responsible for these payments unless they have accepted responsibility on behalf of their oil receivers, or unless they themselves receive oil in excess of reportable amounts. Each Contracting State is required to communicate to the Fund the name and address of any person who is liable to contribute, as well as the quantity of oil received by such persons. Each State is also required to certify reports from its shipping companies. (Similarly detailed reporting requirements exist already within the UNFCCC framework, e.g. for the operation of the Kyoto Protocol's flexible mechanisms). The Fund uses a deferred invoicing system, which permits the Fund to collect from oil receivers only what it will need to cover claims in any given year, and minimizes the collection of reserves. The Fund Assembly meets and fixes a specific amount to be assessed for a given calendar year, then invoices each contributor in March of the following year, based on the number of tonnes received, for a lower amount. The remaining amount, or a portion of the remaining amount, is invoiced still later in the year if necessary to satisfy claims (IOPC 2001).

The risk of oil pollution damage from a major spill is thus shared among those who benefit most from the use of the seas for the shipping of oil: (1) tanker owners, who receive the primary financial benefit from use of the seas and who are theoretically in the best position to take measures to avert spills (up to 59.7 million SDR); and (2) entities that receive oil in bulk and whose use of the seas for shipping entails risk (up to 135 million SDR). Oil pollution damage in excess of these limits from any one incident is presently borne by pollution victims (state and private individuals) and the environment. The Fund Protocol of 2003 is scheduled to go into effect on November 1, 2003, and will increase the overall limits of liability to 203 million SDR.

The European Commission has proposed the creation of a ***third tier*** of compensation, following the breaking apart of the Maltese oil tanker *Erika* off the coast of Brittany in 1999. That proposal, which is now pending, would complement the existing international two-tier regime for oil pollution damage by tankers by creating a European supplementary fund, the ***COPE Fund***, to compensate victims of oil spills in European waters whose claims have been considered justified, but who have been unable to obtain full compensation due to insufficient compensation limits under the IOPC Fund (see EU Proposal 2000). Compensation from the COPE Fund would be based on the same principles and rules as the current international fund system, but subject to a ceiling deemed sufficient by the EU to fully cover any foreseeable disaster, e.g., € 1,000 million. The Fund would be financed by European oil receivers, and only be activated once an accident that exceeds, or threatens to exceed, the maximum limit provided by the IOPC Fund ***(EU oil receiver contributions).***

CLC 92 and 1992 Fund Convention example.
Example. A 25,000 gross tonne tanker spills oil in the Mediterranean, off a developed coastline. The oil spreads and causes 230 million SDR in damages and response measures in Countries X and Y. Both countries have realized that the spill is likely to cause significant damage, and have contacted the IOPC Fund, which has sent experts to ensure that the response measures undertaken are reasonable. The owner's limit of liability under the CLC 92 Convention for a tanker of 25,000 tonnes is 11.4 million SDRs. The owner's insurance or financial guarantee satisfies the first 11.4 million of the 230 million in claims, leaving 218.6 million unpaid. The IOPC Fund satisfies the next 123.6 million ratably (135 - 11.4 already paid), leaving 95 million remaining unpaid (230 - 135). After November 2003, when increased limits of liability for the IOPC Fund go into effect, claims up to 203 million SDR could be compensated (leaving 27 million uncompensated). If the accident occurred in EU waters, with the proposed COPE Fund in effect, the COPE Fund would satisfy remaining claims.

The oil spill regime described effectively creates layers of insurance pools. Tanker owners cover their risk generally through mutual protection and indemnity associations or clubs (P&I Clubs), which function as mutual insurance companies, sharing profits and losses, and insure the liabilities of almost 95% of the world's ocean going tonnage. Cargo interests then pool funds through the IOPC Fund, to retrospectively address damage for spills up to the limit established by the Fund Convention. Under the proposed COPE Fund, a third insurance pool would be created to provide a third retrospective layer of cover for victims of spills in certain geographic areas.

Since its establishment, the original 1971 Fund has addressed 108 incidents and paid out over US$500 million in compensation. The 1992 Fund has handled claims arising out of 16 incidents and paid out approximately US$120 million in compensation (Hasebe 2003).

The ***HNS Convention***, which has not yet entered into force, is similar in structure to the CLC 92 and Fund Conventions. Shipowner limits of liability are linked to vessel tonnage. When an incident occurs for which compensation is payable under the HNS Convention, compensation is first sought from the shipowner, up to the maximum limit of 100 million SDRs. Once this limit is reached, compensation is paid from the second tier (the HNS Fund) up to a maximum of 250 million SDRs, which sum includes compensation paid under the first tier. Contributions to ***HNS Fund*** are levied on persons or entities in the Contracting States who receive a certain minimum quantity of HNS cargo during a calendar year. A significant difference from the IOPC Fund is that the HNS Fund will consist of one general account and three separate accounts for oil, liquefied natural gas (LNG) and liquefied petroleum gas (LPG). This separation of accounts is done to avoid cross-subsidization between different HNS substances, when compensation is occasioned by transport.

c) Three-tiered systems

The nuclear conventions create a three-tiered system of compensation. The 1960 Paris Convention, as amended by the 1963 Brussels Supplementary Convention, and the 1963 Vienna Convention, which are linked by a 1988 Joint Protocol, together address risks from the peaceful use of nuclear energy. These regimes combine operator liability and insurance obligations in a first tier, backstopped with installation state public funds in a second tier,further backstopped by a global collective loss sharing mechanism in a third tier. This tiering recognizes that given the almost incalculable extent of possible damage from nuclear incidents, it is not possible to internalize the costs of potential damage as a risk management strategy.

At the first level, these conventions hold operators of "nuclear installations" (primarily facilities used to generate nuclear energy) strictly liable for damage resulting from nuclear incidents. State Parties are required to establish by national legislation a *minimum* operator liability of US$5 million SDRs for damage resulting from any one nuclear incident under the Vienna Convention, though States may allow for higher limits. The Paris Convention establishes a maximum limit of 15 million SDRs, though States may agree to greater or lesser amounts, though no less than US$5 million. The operator's minimum liability is to be guaranteed by insurance or another form of financial security (***operator insurance***).

At the second level, if the operator's financial security is insufficient to cover the limit of liability established by the State, under the Vienna Convention the State must make up the difference, up to the operator's limit of liability. Above the established operator's limit of liability, supplementary public funds are required to be made available up to a total of *175 million SDRs* by the State Party in whose territory the nuclear installation that caused damage is located (***installation State public funds)***.

At the third level, if damage exceeds the 175 million SDRs provided through the second level, *a further sum of 125 million SDRs* (bringing the total available from all sources up to 300 million SDRs*)* is to be provided from public funds contributed jointly by all Convention Parties, on the basis of a predetermined formula, based on each Party's installed nuclear capacity and UN rate of assessment ***(international collective loss sharing).*** Under the 1963 Brussels Supplementary Covention, contributions are based 50% on the ratio between the GNP of each Party and the total of the GNPs of all Parties for the year preceding the nuclear incident, and 50% on the basis of the ratio between the thermal power of the reactors situated in the territory of each Party and the total thermal power of the reactors sited in all Parties (again emphasizing the polluter-pays principle).

As with the oil spill regime, the liability imposed under the nuclear conventions has effectively resulted in layers of insurance pools. Because the capacity for individual insurers to cover nuclear risk is limited, national insurance pools have been organised to allow a number of insurance companies to each contribute to cover a small part of the third party liability of an operator. (Vanden Borre, 2002). As a result, Dutch operators are restricted to buying third party liability insurance with the Dutch pool, Belgian operators restricted to the Belgian pool. Vanden Borre explains that pool members (i.e. insurance companies) declare each year how much coverage they are willing or able to provide, so that the capacity of the pool is equal to the contributions of its members. This allows insurers to insure a greater nuclear risk, because the amount of exposure is known. Reinsurance of nuclear risk occurs also directly among national pools, without the intervention of third parties, which minimizes the cost of reinsurance, as only a portion of costs are charged, rather than reinsurance commissions (7.5% on average, versus 30%, according to Vanden Borre). Above the operator insurance limit, excess claims are covered by installation state public funds, and then by another insurance pool, assembled with joint State funds.

Paris/Brussels Convention example.

Example. A nuclear incident occurs in a Contracting State to the Paris Convention. The Contracting State has limited operator liability to 15 million SDR under its domestic legislation. The incident causes 230 SDR in damage to the installation state and its neighbouring States. Under the 1963 Brussels Supplementary Convention, the operator's insurance covers the first 15 million SDR in damage. The installation state is responsible for the next 160 million SDR in damage (up to the ceiling of 175 SDR). The remaining 55 million SDR in compensation (230-175) is provided to victims by contributions of public funds contributed jointly by all Convention parties, in a ratio that reflects each Contracting State's GDP, and each Contracting State's installed nuclear capacity.

It should be noted that a ***1997 Protocol to Amend the Vienna Convention***, which has been adopted but not yet ratified, sets a new possible limit of the operator's liability at not less than 300 million SDRs (approx. US$400 million). The ***1997 Convention on Supplementary Compensation***, which has yet to enter into force, offers the possibility of a global nuclear regime, because it could be ratified by countries that are not presently parties to existing nuclear treaties, including the United States. The Convention presents a new formula for contingent retrospective joint state contributions that builds upon the 1963

Brussels Supplementary Convention formula. Parties to the 1960 Paris Convention and 1963 Brussels Supplementary Convention have also negotiated new limits on liability. It is expected that when they come into force they will be the following: Operator, up to €700 million; Installation State (public funds), up to €500 million; and Joint State contributions up to 300 million, for a total of €1500 million (OECD NEA 2003). New shares have also been negotiated for the basis of joint State contributions: 65% upon installed nuclear generating capacity and 35% upon an "economy factor" based on GDP. The negotiated Protocol with new limits is expected to be ratified after parties have enacted relevant legislation (OECD NEA 2003).

6. *Insurance and collective loss sharing tools offered by existing Conventions*

As seen above, existing civil liability and compensation schemes use both pre-disaster and post-disaster insurance-related tools to redistribute risk from disasters and ensure a means for adequate compensation:

- strict operator liability (regardless of fault), with compulsory private insurance or financial security
- strict State liability with self-insurance (1972 Space Convention)
- collective loss sharing among operators, through privately-managed mutual insurance pools (P&I Clubs)
- collective loss sharing among beneficiaries, through government-managed mutual insurance pools (IOPC Fund, HNS Fund, EU Cope Fund)
- Installation State public funds
- Joint State Funds (International solidarity funds)

Tier	**Source of compensation funds**		
III		*EU Cope Fund (EU cargo interests)*	Joint State Funds (int'l solidarity pool)
II		IOPC/HNS Fund (int'l cargo interests)	Installation State (public funds top-up)
I	Operator Insurance	Operator Insurance (P&I Clubs)	Operator Insurance (nat'l ins. pools)
Regime	**Basel/CRTD/ WIA**	**Marine transport CLC/HNS**	**Nuclear**

Figure V.1. Tiered Systems

Given the present uncertainty in estimating risks related to climate change, and the potential for massive adverse impacts on governments and individuals, a combination of tools is likely to be required to transfer, redistribute and manage these risks.

Lessons learned from the development of civil liability and compensation regimes include the benefits of clearly allocating the burden of compensation for transboundary environmental damage among private and governmental sectors pre-disaster, and the benefits of specifying and circumscribing these burdens so that risks are known and therefore insurable. Tiered systems, and collective loss sharing arrangements, may assist in providing a way forward through least-cost solutions.

VI. Insurance Mechanisms and Extreme Weather Events – Opportunities, Challenges and Possible Partners for the UNFCCC

As this paper has shown, weather extremes can have impacts on developing countries' economies and people, and the frequency and severity of such events are predicted to increase due to anthropogenic climate change. Based on Art 4.8 of the UNFCCC, the international climate regime can provide a framework for insurance-related activities, which might help countries to cope better with the risks and impacts of weather extremes. Some measures taken in this context could also be beneficial for many countries from the perspective of sustainable development now. Yet, this paper has also stressed the limitations of private insurance and risk transfer mechanisms in general.

1. Possible Items for Discussion

Under Art. 4.3 and 4.4 of the UNFCCC and Art. 12.8 of the Kyoto Protocol, developed country parties are required to provide assistance to vulnerable developing countries in adapting to the impacts of climate change. Where adaptation measures cannot cost-effectively prevent damage from extreme weather events, risk hedging and collective loss sharing mechanisms may nevertheless assist developing countries in adapting to the impacts of extreme events. These mechanisms could be used to supplement the efforts of the disaster community, which already provides many kinds of post-disaster aid, by providing increased access to capital for recovery efforts, and is a means to link support for risk transfer to capacity building and prevention measures.

There are many specific ways in which the international community and climate regime can assist developing countries to transfer their risks from weather extremes, and UNFCCC workshop participants may wish to discuss the following (by no means exhaustive) possibilities:

- *Supporting public private partnerships*: Building on experience from the Turkish insurance program, the climate regime could transfer (or arrange for the transfer of) the risks of national or regional public-private insurance systems in the capacity of re-insurer or consider subsidizing the costs of alternative hedging instruments.
- *Supporting relief and reconstruction:* The international community could assist governments in transferring their risks of public infrastructure damage either through private insurers or directly to the capital markets through alternative risk-transfer instruments.
- *Supporting micro insurers*: The international community could also play a role in supporting and transferring the risks of micro insurers, for example those offering weather hedges, possibly by acting as reinsurer or assuming the interest payments of catastrophe bonds.
- *Supporting data collection and analytical capacity building:* Since any insurance or insurance-related system requires knowledge of the risks, the international community could provide support to developing countries in collecting the requisite data and in building analytical capacity. The process of national communications could be explored as a source of data and information. As methodological options are explored, it is important to note that even in the absence of data for a full risk analysis of potential losses, it is possible to construct hedging instruments based on physical triggers.
- *Supporting new risk hedging instruments:* Parties may also wish to discuss options to create national-level market incentives, for example tax reductions to individuals or institutions for purchasing developing country catastrophe bonds at lower interest. There might be possibilities for enhancing the participation of voluntary contributions and NGOs in these schemes. One imaginative idea could be to link investments in developing country disaster hedges to emerging sustainable-development investment portfolios.

There are also ways in which the international community and climate regime could assist developing countries respond to disasters through insurance-related activities and collective loss sharing mechanisms:

- *Fund:* Recognising that risk transfer mechanisms are not always the most effective means to complement the national risk-bearing ability of a country, and understanding the term insurance in a broad manner, the climate regime may also wish to reconsider suggestions for setting up a climate damage compensatory fund as a loss sharing instrument. Just as the Turkish system makes public post-disaster aid dependent on insurance cover, the international community could use such a fund to aid countries that have taken prescribed precautionary measure or have put into place a national insurance program. Moreover, for slowly developing climate impacts such as sea-level rise, insurance is not an option, and loss sharing mechanisms could be usefully explored (e.g. along the lines of the AOSIS proposal).
- *Institutional Issues:* If Parties wish to consider an international fund to subsidize insurance and insurance-related activities in developing countries, they might wish to discuss the institutional set-up of such a fund. For example, a fund could be managed by an intergovernmental organisation composed of Member State governments under the guidance of the COP (for example an institution similar to the CDM Executive Board or to the IOPC Fund's Executive Committee). It could also be operated through existing financial institutions such as the World Bank, the Inter-American Development Bank, etc. These institutions already play a role in implementing insurance and insurance-related schemes.

Learning from the legal regimes described in Section V of this paper, the role of private operators/emitters could be considered by workshop participants. While climate change as a phenomenon is very different from oil pollution or nuclear accidents, some parallels can be discerned. For example, in the oil pollution regime it is acknowledged that private interests benefit from the ocean transport of oil**.** Similarly, in the climate change context, private interests derive benefits from the emissions of greenhouse gases. In fact, the private sector has already been drawn into the climate regime through the Kyoto Protocol's flexible mechanisms.

- *Contributions to risk sharing* (e.g., through the payment of fees to an international authority) could be discussed. Perhaps related to the emission levels of major emitters relative to a baseline (attributed share of base-year emissions, for example). Such an approach might create incentives for major operators to decrease emissions and support domestically-set emission reduction targets in many countries. Consideration might be given to contribution thresholds so that large numbers of small private emitters do not complicate such a scheme.
- *Timeframes for initiating action* might also be considered, i.e. the question of when private parties would actually need to contribute to a scheme. This timeframe could be made contingent upon observed *effects*, such as measured rates of sea level rise, actual sea level rise, or increased storm frequency or frequency of El Niño events. (See Section I above, discussing AOSIS proposal).
- *The Role of the Public:* As is the case in selected liability regimes (oil pollution, nuclear installations) the public can also play a role in sharing risks and the burden of extreme weather events. A second tier of contributions to support either pre-disaster insurance or post-disaster recovery could be established through taxpayer contributions or from those who benefit most from greenhouse gas emissions. This could be based on GDP, per-capita GDP, historical emissions or other indicators of benefit, in the light of Art. 3.1 of the UNFCCC. Institutional considerations might also be warranted here.

2. Possible Cooperation and Partners

To complement the options and possibilities listed above, this section names some possible avenues for cooperation. This is by no means an exhaustive list, but only an indication of the great number of positive multi-stakeholder efforts now being undertaken to facilitate links between the disaster reduction communities, financial institutions, and climate change communities. Many of these also discuss or focus on insurance mechanisms.

International Financial Institutions

International Financial Institutions are already involved in discussions on how to better share risks from natural disasters in developing countries. These include

- the World Bank with its Disaster Risk Management Facility, which has enabled the Turkish earth quake insurance scheme discussed in Section IV (www.worldbank.org)
- the Inter-American Development Bank, has examined a range of risk transfer alternatives (see Keipi/Tyson, 2002) and has suggested the creation of an insurance pool for the Caribbean region (Pollner, 2001)

UNEP Finance Initiatives (www.unepfi.net)

The UNEP Finance Initiatives (FI) Climate Change working group (CCWG) is one of four key working groups which drive the substantive work programme for UNEP FI, a ten-year-old public-private partnership between the United Nations Environment Programme (UNEP) and some 300 financial institutions worldwide. The working group is comprised of a UNEP representative and executives from major banking, insurance and re-insurance institutions. 80% of UNEP FI’s funding comes from the private sector. In 2001-2002, UNEP FI conceived, undertook and published a landmark study entitled: “Climate Change and the Financial Services Industry.” Taking the results of this study further, in 2003, the CCWG will implement an awareness raising campaign in the financial services sector, and create a project team to develop a quantitative methodology for asset managers that will capture the implications of climate change regulations. The CCWG also collaborates with the Carbon Disclosure Project (CDP) and will engage in follow-up CDP activities in the coming months, contributing to the effort to seek disclosure of investment-relevant Greenhouse Gas Emissions data among FT500 companies. The CCWG will additionally seek to ensure that UNEP FI work is integrated in an appropriate manner as part of the insurance sector contribution to the IPCC Fourth Assessment Report process, which is due to be published in 2007 and which will contain a chapter on climate change and the insurance industry. The CCGW could play an important role in exploring the role of insurers to transfer the risks from extreme weather events in developing countries.

International Strategy for Disaster Reduction (ISDR) (www.unisdr.org)

The International Strategy for Disaster Reduction (ISDR) is the successor arrangement to the International Decade for Natural Disaster Reduction (IDNDR), which was launched by the international community to increase awareness of the importance of disaster reduction. The UN General Assembly has mandated the ISDR Secretariat to continue international cooperation to reduce the impacts of El Nino and other climate variability, and to strengthen disaster reduction through early warning. The ISDR works inside the ProVention Consortium (see below) and has four Working Groups: (1) El Nino; (2) Early Warning; (3) Risk, Vulnerability & Disaster Impact; and 4) Wildland Fires. The risk vulnerability & disaster impact group is working to improve the consistency, coverage and accuracy of disaster impacts data, and undertaking a systemic comparison of national and global disaster databases. The El Nino and risk, vulnerability & disaster impacts groups together are working to expand hydrometerorological information on disasters catalogued in disaster databases, to generate hazard databases from climate databases for specific event types and their intensities. These efforts could be tapped into to provide the necessary data for risk assessment methodologies (see Section III). The ISDR is working on a proposal linking natural disaster reduction and adaptation to climate change that would establish a collaborative process between the climate change and disaster reduction communities. The ProVention Consortium and its member organizations would be involved in the implementation. The project would gather practical experience from natural disaster management (risk reduction in particular) and then link those strategies for adaptation to climate change.

ProVention Consortium (http://www.proventionconsortium.org)

The ProVention Consortium (PVC) is a global coalition of UN programs and institutions, governments, international organizations, academic institutions, the private sector, and civil society organizations dedicated to increasing the safety of vulnerable communities and to reducing disaster impacts in developing countries. Member organizations include WMO, Red Cross, insurerers, reinsurers, development banks and finance institutions. The PVC was set up by the World Bank and is now based at the International Federation of Red Cross and Red Crescent Societies in Geneva. The PVC functions as a network to share knowledge and to connect and leverage resources to reduce disaster risk. The PVC seeks to develop links between the scientific community and policy makers, the private and public sectors, and donors and victims to facilitate the promotion of risk assessment, risk reduction and risk education activities in developing countries. PVC projects focus on the links between disasters, poverty and the environment. These projects fall into three general categories: (i) hazard and risk identification, (ii) risk reduction, (iii) risk sharing/transfer, and (iv) information sharing. Outputs include research projects, pilot and demonstration projects, education and training activities, and workshops and conferences.

International Federation of Red Cross and Red Crescent Societies (www.ifrc.org)

The International Federation of Red Cross and Red Crescent Societies is the world's largest humanitarian organization. The expected changes in temperature and increase of weather extremes will have major consequences for the operations and programs of the organization worldwide. The *Red Cross/Red Crescent Climate Centre* (established June 2002) hopes to address the threat millions of people face from climate change related disasters every year by seeking to bridge the gap between meteorological science and relief aid. The Climate Centre will strengthen Red Cross and Red Crescent relief aid programmes by making better use of scientific data on climate change and extreme weather to enable National Societies to eventually reduce the loss of life and the damage done to the economy by extreme weather conditions. It will focus on adaptation to climate change and the improvement of disaster preparedness. The Red Coss international network could prove helpful for testing and discussing any potential insurance-related activities.

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Transport and Watercourses Conventions	http://www.basel.int/COP5/docs/prot-e.pdf http://www.unece.org/trans/danger/publi/crtd/crtd_e.html http://www.unece.org/env/documents/2003/wat/mp.wat.2003.1.pdf