INSURANCE FOR CLIMATE CHANGE:

Opportunities for Public-Private Partnership Initiatives

To Share Losses and Promote Adaptation.

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Losses from climate variability and extreme weather events related to climate have been rising rapidly over the past three decades, and these losses are set to increase even more rapidly with the acceleration of long-term climate change. Efforts to prevent climate change by reducing the emission of greenhouse gasses are underway, of course, but technical, economic and political obstacles mean that we are unlikely to see stable atmospheric concentrations any time soon. In the meantime, more extreme weather can be expected [IPCC (2001)]. The United Nations Framework Convention on Climate Change (UNFCCC) also encourages adaptation designed to reduce losses attributable to climate change, and it provides for assistance to the most vulnerable countries in meeting the costs of adaptation. Available funds are subject to some severe restrictions, though, and the adaptation capacity of the most vulnerable countries is low and can only improve slowly. In some instances, adaptive capacity to climate change and variability continues to deteriorate over time as non-climatic stresses take their toll. Losses will therefore continue to grow in the absence of some new initiatives, and they will constitute an increasing threat to economic development. The costs of emergency humanitarian assistance to the global community will increase, and so will borrowing by developing countries to pay for the costs of reconstruction.

This paper describes a framework for a hypothetical, public-private climate insurance program (CIP) designed to complement and even supplement existing efforts in climate change mitigation and adaptation. We begin in Section 1 with the simple observation that the availability of insurance for climate-related disasters is currently severely restricted even though risks are growing in developed as well as developing countries. Section 2 places this observation into the context of the existing language of the UNFCCCC before we turn to a brief description of a few experiments and pilot projects for disaster insurance in Section 3. These early sections make two fundamental points. On the one hand, we note that the private insurance industry is withdrawing from many markets because of the high uncertainty and ambiguity of the risks and the low capacity among potential clients to pay the necessary premiums. Without some form of public intervention, the potential markets are likely to remain small and financially unattractive. It seems obvious to us, as a result, that there is scope for a new approach through the development of public-private partnerships. On the other, we argue that the creation of a CIP could assist in breaking the negotiating impasse between developed and developing countries. Developed countries want developing countries to commit to mitigation targets before they will talk seriously about substantial adaptation assistance, but developing countries want to see supplemental adaptation assistance before they even begin to think about emission reductions. We think that a carefully constructed CIP could provide incentive for both sides to move toward accommodating the other *because it would be in their own best interest.*

Any new scheme of insurance for climate-related weather events should build upon the knowledge from existing pilot projects in disaster insurance described in Section 3 and Annex 1 and give consideration to ways of incorporating them into a wider, more unified program. Reference in Section 5 and Annex 2 to the first principles of economically efficiency insurance coverage makes it clear that care must also be taken to avoid the moral hazard of encouraging increased risk-taking. We think that the development of appropriate and verifiable eligibility requirements can achieve this goal even as they promote effective adaptation and the enhancement of existing adaptive capacity. No quantitative estimate of these benefits will be offered, however; that they exist is clear from the economic theory. Nor will cost estimates be reported, because they will depend in large measure on the way any new CIP is designed. Indeed, the implementation of a new CIP would have to overcome many technical obstacles – the devil would surely be in the details. We nonetheless conclude that the prospects for new initiatives involving public-private partnerships are sufficiently encouraging to warrant a more detailed study. We therefore propose that an

independent task force or commission conduct this analysis, working in close cooperation with interested stakeholders as well as representatives from the private insurance industry. The purpose of its work would be to formulate one or more alternative proposals for consideration by national governments, the financial services sector, and Conference of the Parties (the COP) to the Framework Convention.

1. Climate Change and Natural Disaster Losses.

The world suffered nearly one trillion US dollars in economic losses (and some 560,000 fatalities) due to 8,000 natural disasters in the last 15 years of the 20th Century. Three-quarters of the losses were weather-related, and one fifth were insured [Mills, Lecomte, and Peara (2001)]; and they are part of a trend that has seen global losses from extreme weather events such as floods, droughts, and tropical cyclones rise for more than three decades (Munich Re). Many contend that this increase is largely the expected result of the growth of population and material wealth. That losses have been rising at an even faster rate can, though, be explained only in terms patterns of development that involve the disproportionate expansion of poorly designed and/or constructed human settlements, infrastructure and operational activities in high-risk zones. While insured and uninsured losses have been growing in both developed and developing countries, an overwhelming proportion of insured losses are suffered in developed countries. Indeed, a large but unknown proportion of the uninsured losses is believed to occur in the developing countries where national, community and individual capacities to cope are much lower.

Paralleling their differential advantage in acquiring insurance, developed countries have much greater general capacity to cope with climate hazards than the poorer and more vulnerable countries. Events such as Hurricane Mitch, and the floods and droughts associated with the 1997-98 El Nino have repeatedly demonstrated the extreme vulnerability of many developing countries. Losses from climate hazards over recent years in Ecuador, Honduras, India, Mozambique, Peru, and elsewhere have sometime had an economic impact equivalent of up to a decade's worth of economic growth. Large-scale losses have also occurred in China, (floods), Germany (floods), Canada (drought), Poland, Hungary and Rumania (floods), but their long-term burdens have been much smaller. Crichton (2002) attributes this asymmetry to the fact that most of the losses in developing countries were uninsured. As a result, the citizens and governments of developing countries were forced to borrow funds to replace infrastructure and essential services and thereby add to their already significant burden of international debt.

The conventional response of the international community to uninsured disaster losses has been to provide emergency disaster relief and temporary rehabilitation assistance as quickly as possible. Once the immediate needs for disaster relief have passed and the new media have gone on to the next story, however, impacted countries, communities, families, and individuals are left largely to their own devices to pick up the pieces of their lives. At the national level, these devices usually involve further borrowing by governments from international financial institutions. At the local level, reconstruction and replacement of lost or damaged infrastructure is usually undertaken in haste in order to get back to business as soon as possible. As a result, urgent reconstruction often takes place in the same hazardous location as before with the same or sometimes lower building standards and design criteria.

The recently confirmed relationship of extreme weather events to the El Nino phenomenon can be expected to make matters worse for several reasons. Inter-annual phenomena like El Nino might increase the frequency of extreme events might change; but even if they don't tracing a series of extreme events to a common cause will mean that the incidence of extreme events over widely disparate areas may not be independently distributed. The resulting simultaneous occurrence of climate-related disasters across widely scattered locations around the world would add significantly to demands for humanitarian relief and generally add to the stress faced by economic development and global financial institutions.

IPCC (2001) stopped short of attributing any specific extreme event unequivocally and entirely to climate change. IPCC (2001) did report, however, that a growing general agreement among the experts sees climate change increasing climate variability and the magnitude and frequency of climate extremes, and may already be doing so to an undetermined (and perhaps undeterminable) degree. Saunders (1998) made a convincing case that the disaster experiences of recent years are consistent with what might be

expected as climatic regimes change. In the absence of much stronger efforts in both mitigation and adaptation, he argued that the rising trend in losses may be expected to continue, probably at an accelerating rate.

One might expect that the private sector insurance industry would respond proactively to these trends and conditions by promoting insurance as a risk-spreading mechanism, especially in developing countries, but this has not been the case. Labatt and While (2002) report that the private insurance industry has, in fact, been moving in the opposite direction. The industry has been withdrawing from these markets because of the high uncertainty and ambiguity of the risks to be insured and the low capacity among many of the potential clients to meet the necessary cost of the premiums. At a time when risks are increasing, therefore, the availability and accessibility of insurance is diminishing and especially for those whose need is evidently greatest.

2. The Climate Convention Context.

The United Nations Framework Convention on Climate Change (UNFCCC) recognized that the developed countries should take the lead in reducing net greenhouse gas emissions. Developed countries responded by negotiating the Kyoto Protocol (1997) as a vehicle for the setting of targets and schedules for the reduction of emissions, but the ratification process has stalled and the Protocol is not in force. Perhaps more importantly in the short run, the Convention further recognized that developed countries should provide assistance to the most vulnerable countries in meeting the costs of adaptation. Many developed responded by insisting that developing countries assume some responsibility for their own emissions beginning in the next commitment period. Developing countries are resistant to this proposal – some because developed country members of the Conference of the Parties have yet to demonstrate good faith in reducing their own emissions and others because they have thus far declined to ratify the Kyoto Protocol.

The management of financial assistance for adaptation under the UNFCCC process has meanwhile been ceded to the Global Environment Facility (GEF). Three funds are now being established in the framework of a three-stage adaptation process with emphasis to date focusing attention on planning and preparing for adaptation. Developed countries have been slow to provide significant funds for actual adaptation measures because it is difficult to define adaptation to climate change (as distinct from normal development assistance) and because the number of activities that might be described as adaptation to climate change and climate variability is potentially very large. As a result, negotiations are placing emphasis on the "mainstreaming" adaptation into national sustainable development activities and planning. In addition, two limiting criteria have curtailed the potential cost of adaptation under the Framework Convention. One holds that funds should be available only for the incremental costs of adaptation to climate change, and not full adaptation costs, (except in the case of enabling activities such as National Communications). The second mandates that GEF funded activities demonstrate global environmental benefits because the GEF, designed explicitly to protect the *global environment*, should not duplicate normal development assistance.

These two criteria, when strictly applied, severely limit funding that is available for adaptation to climate change within the UNFCCC process. From the perspective of a donor concerned with development assistance, adding adaptation to climate change to a process promoting sustainable economic development makes good sense; this is the practical definition of mainstreaming. From a developing country perspective however, the idea of mainstreaming threatens to blur and perhaps eliminate the special status of adaptation (and other) assistance under the Convention. To developing countries, the costs of adaptation to climate change (but not "normal" climate variability) are supposed *to supplement* "normal" development assistance – a view drawn from the Rio de Janeiro UN Conference on Environment and Development (1992). There, of course, participants recognized a new class of global environmental problems that will require new international agreements and new funding mechanisms.

These differences of opinion produce the specter of an impending impasse the climate negotiations under the UNFCCC. Developed countries are asking for developing country participation in the reduction of emissions, and they are reluctant to commit large funds for adaptation without assurance of

"mainstreaming". Developing countries are resisting the demand to assume some commitments to control the level of their own emissions and, they are asking for adaptation assistance that will supplement regular development assistance. We believe that carefully designed public partnerships for the enhanced and accelerated provision of insurance could help to achieve a number of objectives and at the same time might facilitate negotiations under the UNFCCC. More importantly, we believe that these partnerships can offer a way of breaking this impasse by offering both sides something about which to bargain.

3. Existing Insurance Availability and Innovations.

We have already made the point that the availability of insurance against damage caused by natural disasters is problematic even in developed countries; and we have emphasized that the news is worse in the developing countries where availability and coverage is even smaller. Explanations for this relative lack of coverage are easy to construct, but they all look like adverse selection from the perspective of the insurance industry. Extreme weather events, for example, tend to be concentrated in more or less definable zones. Tropical cyclones inflict their greatest harm on coastal areas in certain well-know low latitude regions. Flood plains define the topographic boundaries of flooding risks. Even the more widespread phenomena like droughts have distinct geographical distributions. In short, well-defined regions prone to natural disasters exist, and spreading risk over broad populations that include these regions is a significant obstacle. Only those most at risk are interested in insurance, but even those at risk have been slow to purchase insurance when available (Kunreuther 1996). Premiums may be judged to be too high, perhaps because perceptions of the likelihood of future disasters in that one locality may not be inaccurately low.

Given the paucity of reliable data, actuarial calculations of risk are highly uncertain (or ambiguous, at best). Prospective insurers must confront records of past events that are relatively short (in relation to the probability of extreme events), and translating an extreme event into economic loss is a highly inexact science. Insurance and reinsurance companies have been developing improved models for developing country contexts, but the rate of progress is difficult to judge because much of their information as proprietary. Moreover, problems of risk identification and estimation are becoming much more difficult with the advent of climate change. Past records of climate variability are losing whatever predictive value they might have once held, and climate projections based on scenarios derived from Global Climate Models (GCMs) are on too broad a scale to catch local scale variability and extremes. As a result, there is no immediate prospect that probability estimates will emerge in which the insurance industry can have sufficient confidence to expand their coverage under conventional arrangements.

Some have tried recently to respond creatively to situations of high uncertainty and profound ambiguity in the actuarial calculations. A few examples are listed and described briefly in Annex 1. Taken together, they are encouraging, but their scale is too small for a global problem like climate change. Moreover, nobody has been able to assess their relative success. To count on them to solve the climate risk problem would be premature, at best.

Others have tried to create instruments designed explicitly to transferring the financial risk of weather events – "weather derivatives" in the vernacular. Usually based on some agreed weather indices measured by some objective third party, weather markets are expanding in the United States where participants are drawn from a number of economic sectors such as energy, insurance, banking, agriculture, leisure, construction, and entertainment. According to a survey conducted by PricewaterhouseCoopers, more than $US7.5 billion of weather risk has been transferred in weather risk markets since 1997 (Varangis, Skees, and Barnett 2003, Lancaster, 2001); but is there a connection to the real economy? Not to a great degree, because the agricultural sector has so far made little use of weather risks markets even though they have a number of advantages over traditional crop insurance and could be more widely used in both developed and developing countries. In Ontario and Alberta, Canada, for example, weather risk instruments have been used to hedge against production risk, but examples of this sort are scarce. Considerable opportunities for expansion exist for this market, but only if the necessary policy and regulatory environments are put in place *and* only if networks of sufficiently reliable weather observation stations can be established – challenges in developed countries, but obstacles in developing countries.

Disaster fund models that are not dependant upon the existence of a strong and well-entrenched insurance sector have also been explored. Gurenko and Lester (2003) report that these models typically base their approach on government-sponsored pools that are supplemented by various reinsurance and capital market instruments. One scheme, the Turkish Catastrophe Insurance Pool (TCIP) under which Turkish registered private residential property owners are obliged to buy a basic level of coverage against earthquake loss, has attracted some interest, but few have explored seriously the creation of similar insurance pools for weather-related disasters.

Examples of weather derivatives and catastrophic loss insurance demonstrate the existence of new market opportunities that are likely to expand considerably as the impacts of climate change become more evident. At the same time, however, it is apparent that the insurance and financial services industries are unlikely to move rapidly into this area without a favorable policy and regulatory environment and without some public sector interventions.

4. A Framework for Climate Insurance.

Experience with natural hazard and disaster insurance provides some useful lessons and identifies some of the ways in which climate insurance might improve global welfare. There are some important differences, however, which suggest that the provision of insurance for climate-related weather events should be considered in a category all its own. Perhaps most importantly, an international convention (the UNFCCC) anticipates and proposes the use of insurance as a risk-sharing mechanism for dealing with the unequal impacts of a global environmental problem. In addition, the global atmosphere is a common property resource to be used for the benefit of humanity so that all can claim the right to a basic level of protection. Experience suggests that insurance can be a useful mechanism to achieve sound risk management and, if properly designed, international equity; but we have seen that climate insurance is not likely to be made widely available without some sort of public intervention. At the same time, we have recognized that moral hazard involved in making insurance available at sufficiently attractive rates can be a significant problem. Taking all of these insights into account, therefore, it seems reasonable that any proposed scheme involve public intervention that would be contingent on with certain eligibility criteria even as it provided incentives for risk mitigation. Specifying these criteria, at least broadly, and describing these incentives are the focal points of our proposal.

To that end, we try to imagine what a global climate insurance program (CIP) might look like. Its purpose would be to create a pool of financial resources that would compensate victims for climate-related losses. Losses could be reported at the national level, and they could be subject to international (management) verification. Certain exceptions might be created, especially in cases in which specific weather criteria have been established (as, for example, in the case of weather derivatives). The financial pool could draw its initial funding from Annex 1 countries, and developing countries might subscribe to the program only by agreeing to certain programmatic criteria. These eligibility criteria could be designed to ensure that the CIP could operate effectively within a subscribing nation-state. If the program were established under an appropriate international authority, such as the UNFCCC, itself, or one or more of the international financial institutions such as the World Bank or the IMF, then the precise formulation of the ownership and management structure of the CIP would have a home.

What might the qualifying criteria look like? One might envision criteria at the national level countries that required specific climate risk management practices – the details of which are not, at this point, important. We need only recognize that they are likely to vary according to the nature of the climate hazard and the level of vulnerability. They might include building codes, land-use planning and regulation, forecasting and warning systems, and other climate adaptation measures that reduce vulnerability. They could rely on existing measures and risk criteria like some generic definitions such as the 100 year flood. They could even include the necessity that participating countries agree to (modest) emission reductions for greenhouse gases. In any case, national participants in the CIP could specify the level of insurance that they would prefer and negotiate the types of climate risk coverage that they could achieve and the premiums that they would have to pay.

Having subscribed to the CIP, national governments would turn to adopting legislation and policies designed to make the program available to citizens and institutions within their jurisdiction. Potential clients would include individual property owners, public and private enterprises, and possibly the national government itself. Marketing could be handled by local private insurance industries; and the policies, themselves, could still be written by an administering government agency or by the insurance companies themselves under a Write Your Own (WYO) arrangement.

Such a CIP would offer many potential benefits. First of all, it would provide a mechanism for risk spreading and sharing open to the whole global community – an appropriate response mechanism for a global environmental issue like climate change. Second, it could be designed to promote, and to some extent require, clients and beneficiaries to put adaptation measures in place. It would thereby contribute in a real and verifiable way to the long-term reduction of vulnerability; and it would counteract social forces that currently encourage mal-adaptation and otherwise enlarge overall vulnerability through non-sustainable development practices. By reducing vulnerability, the CIP would simultaneously slow and perhaps eventually reverse the growing spiral of costs for emergency disaster relief and humanitarian assistance. If successful, the CIP would slow the growth in disaster and other climate-related losses, improve the balance of payments of developing countries, and thus diminish their need for debt-financed reconstruction. Reduced borrowing would, of course, mean reduced debt burdens and reduced likelihoods of destabilizing debt crises. At the same time, the CIP would remove some of the most important obstacles in the path of achieving the Millennium Development Goals by consolidating development aid for the planet's poorest people and poorest countries. Finally, it would provide a mechanism by which developing countries would see some benefit to committing themselves to emissions targets and timetables.

While the prospect of making progress in all these directions has some obvious appeal, a number of questions would need to be addressed if the goal of a global CIP is to be realized. The list of issues is long, of course, but some of the most important are the most obvious:

- How should climate-related hazard events be defined?
- How could premiums be determined in the face of high uncertainty and ambiguity in calculating risk?
- How much coverage should be available, and how should losses be measured?
- Could a CIP be launched on a sound actuarial basis so that all costs would be covered (in expected value over the long term) by income?
- In view of the longer-term adaptation benefits (reduced vulnerability), should the program be at least partially subsidized by adaptation funds?
- How should the CIP be managed?
- Who should be the designated "owner" of the CIP?
- How could we define the various roles of international financial mechanisms, national governments, private financial services, and the end-users?
- What should the criteria for national-level eligibility look like?
- Could templates for national level legislation be drafted so that that eligibility requirements are clearly understood?
- Should there be minimum and maximum levels of coverage?
- Should deductibles be part of the structure and, if so, how should they be determined?
- Could standard definitions of risk be defined, or should they be subject to negotiation so that they could vary by country or by risk?
- How could monitoring and verification be managed, and should penalties for non-compliance be established?
- What data, techniques and models would be required to support the definition of risk the management of the program?
- How should the operation of a CIP be divided between governments and the private sector?
- How could management assure that a globally conceived and organized program reaches "grass roots" levels, especially the poor in remote areas?

Clearly these and many other questions would have to be answered before agreement to launch any such scheme could be achieved; and surely, the devil is in the details. Nonetheless, we do not have to work through all of the details immediately. The notion of a global climate insurance scheme could easily be tested on an experimental or pilot basis. Indeed, we have reported that some of the weather derivative and catastrophic loss products are already moving in this direction on a limited basis. It is our expectation that the private insurers who are creating these products could find an expanding market within the context of an evolving global CIP.

5. The Economics of the CIP.

First principles of economic theory can easily demonstrate how a CIP could improve global welfare. Annex 2 records some of the analytical details, but the basic rationale is easily described without resorting to cumbersome mathematical model. The availability of insurance generally improves welfare by allowing risk-averse individuals and/or nations to spread risk across a risk-neutral institution. To see why, we simply note that individuals who try to maximize their expected utility will fully insure themselves against possible loss when faced with unpredictable states of nature as long as the premiums that they have to pay for coverage is actuarially fair. In other words, these individuals will purchase just enough coverage to guarantee that they will achieve the same level of utility *regardless of which state of nature (and therefore which loss situation) actually occurs* if the premium that they pay for each dollar of coverage against any particular loss *equal the probability that they will suffer that loss.* As an aside, it is important to note that actuarially fair premiums mean that the insurer expects to make zero economic profit by providing coverage. So how do they make money? By investing the money during the time between when they collect in premiums and compensate the insured for their losses.

Given this result, it is clear that any program that could reduce either the probability of a loss or its magnitude by lowering exposure or sensitivity to a stochastic and external event would improve welfare by directly increasing expected utility. It is equally important to note, however, that this result does not mean that insurance mechanisms will always emerge whenever risks provide an opportunity to improve welfare and make some money. The key to seeing why is to understand that the insured will likely know more about his or her risk circumstance and behavior than the insurer. As a result, moral hazard and adverse selection can both arise – issues that can, in extreme cases, cause the institution of insurance to collapse.

In the first instance, moral hazard becomes a problem when the insured takes the certainty of full coverage as an incentive to reduce his or her vigilance in protecting against the loss. More specifically, this sort of behavior can increase the probability of loss; and if the insurer cannot observe the change in the behavior of these "high-risk" clients, then he or she will loose money. When that happens, the insurer must raise the premium for everyone, including "low-risk" clients who do not change their behavior, in the hope that they can return to a position of zero pure economic profit. The new premium is now higher than the probability of loss for low-risk clients but still lower than the probability of loss for the high-risk clients. In this situation, a corollary of the basic result shows that high-risk clients will begin to over-insure (taking out even more coverage so they are better off suffering a loss and making a claim than they are in states of nature where no loss occurs). The same corollary shows that low-risk clients will begin to under-insure and, as a result, the insurer's profit picture deteriorates even future. Taken to its logical extreme, this story can lead to one of three types of market collapse: insurers servicing only high-risk clients, insurers charging premiums that are so high that nobody wants to purchase coverage, or insurers simply refusing to offer coverage to anyone.

Adverse selection can also cause the collapse of an insurance market. Adverse selection is possible when various possible clients confront the insurer with different probabilities of suffering a loss. If the insurer could differentiate accurately between these people on the basis of these probabilities, of course, then he or she would charge premiums that reflected individual probabilities and the previous full-insurance result would stand. This is why young male drivers in the United States pay more for automobile insurance than more careful and more experienced older drives (or more careful female drivers). Absent any ability to differentiate across these potential customers, however, the insurer must offer coverage at a

common premium that would be too high for low risk people and too low for high risk people. In this case, high-risk clients would again over-insure against their potential losses while low-risk clients would underinsure; and, as a result, the same story starts all over again.

It is now a simple matter to provide some theoretical justification for a CIP with well-defined eligibility requirements. The imposition of various eligibility criteria would, first of all, improve expected welfare directly by lowering both the probability of climate related losses and their magnitude. We now see an immediate role for international governmental institutions, because only those institutions could assure compliance with the criteria. In addition, imposing the eligibility requirements would reduce problems of moral hazard because participating communities would have to adopt prudent development strategies that expand neither the likelihood of suffering a loss nor the associated damage. Finally, internationally imposed eligibility criteria would reduce problems of adverse selection because they would improve the risk information available to insurance carriers and reduce the variance of potential losses across various locations.

6. Conclusions and Recommendations.

We have identified a significant need and an equally significant opportunity for public initiatives designed to create public/private partnerships that expand insurance coverage for climate-related losses, especially in developing countries. We have also outlined a broad framework within which a global climate insurance program could be created – a program whose will increase with time as the impacts of climate change are increasingly felt. Such a program could also encourage and facilitate improved adaptation to climate change and expanded efforts to mitigate future disaster risk. We are certain that one or more of the existing international financial institutions could manage an appropriately designed program, but there are a number of technical, economic and management issues that would have to be addressed. Nonetheless, the initial development of a CIP would not depend upon the full resolution of all these issues. A program could begin (and is to some extent already underway) on an experimental and pilot project basis. Current activities are still small in relation to anticipated needs and are concentrated in the area of disaster management without specific reference to climate change, but the UN Framework Convention on Climate Change provides an international context within which a global climate insurance program could grow and flourish.

While the difficulties involved should not be underestimated, we argue that the prospects are sufficiently encouraging to warrant further exploration of how, exactly, a climate insurance program might be structured. A series of linked technical papers and studies are in order, but they will not be persuasive unless the are managed and guided by an independent task force or commission that could bring the major stakeholders to the table. Ultimately, such a body could be expected to formulate one or more alternative proposals for consideration by national governments, the financial services sector and the Conference of the Parties to the United Nations Framework Convention on Climate Change.

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Annex 1. Some Current Insurance Initiatives.

Caribbean Disaster Pool, (proposed)

Catastrophic Bonds.

France-Caisse Centrale de Reassurance (flood insurance)

OECS and Barbados. Catastrophe Risk Management and Insurance Reform Project. This proposed project is to put in place comprehensive country and sub-regional risk management ex ante funding strategies to reduce fiscal, economic and financial instability in the wake of natural disasters, which occur due to resource dislocations and budgetary outlays traditionally required for reconstruction of un insured and uninsurable public and private assets. It also serves to strengthen the domestic insurance industries and their arrangements with the international reinsurance and credit markets. These objectives incorporate more optimal use of risk management strategies coupled with vulnerability reduction measures.

Risk Prevention Initiative, (RPI) is a business/science community partnership designed to help business better understand, assess, and manage climate change-related risks. "The RPI insurance initiative was formed by a partnership of insurance and reinsurance companies with the objective of helping to make climate change prediction understandable, usable, and relevant to the global insurance and reinsurance industry. The RPI is a very good example of cooperation between the insurance industry and the climate change scientists that is needed to improve and expand the sector's response to climate change risks and opportunities. The RPI research is conducted by the Bermuda Biological Station for Research and government and private sector funded NGO's." (GCSI 2002)

Turkish Catastrophe Management System (TCMS) and Insurance Pool (TCIP) were developed in 1999 with the assistance of the World Bank. Under the TCMS property owners are required to carry catastrophe insurance. A risk pool has been created and liability has been transferred to the private sector. Since the official launch of TCIP in September 2000 almost 2.3 million earthquake insurance policies have been issued, making the TCIP the second largest catastrophe pool in the world. The TCIP operates primarily as a catastrophe risk transfer and risk financing facility, and also has a mandate to promote mitigation measures and educate the public about earthquake risk. The TCIP has served to raise the financial preparedness of Turkey for future disasters, reduced government fiscal exposure to major catastrophic events and made liquidity readily available to insured homeowners affected by such events. (Gurenko and Lester 2003). The extension of this model of catastrophe insurance to weather events influenced by climate change warrant further exploration.

UNEP Insurance Industry Initiative. The project is currently engaged in the development of methods for standardized environmental reporting in association with the World Business Council for Sustainable Development.

UNEP Finance Initiatives (UNEPFI), "is a public-private sector partnership that promotes better risk assessment practices through the development of non-proprietary information on climate change and investment in risk management initiatives. The UNEPFI has a total of 179 banks and 84 insurers who have committed to integrating environmental considerations into all aspects of their operations." (GCSI 2002). The UNEPFI has a Climate Change Working Group, which conducts research on the impacts of climate change and engages in adaptation and adaptation capacity building initiatives.

US. National Flood Insurance Program. http://www.fema.gov/nfip/intnfip.htm#1

Weather hedging, weather indexed securities. These are relatively new financial products used for hedging against the risk of weather-related losses for commercial activities. They have so far met with limited success in developed countries with the best examples in the US and the UK.

Annex 2. The Theoretical Basis for Climate Insurance.

Insurance allows people or communities who are risk-averse to spread the risk that they face across a social institution that is essentially risk-neutral. This opportunity comes at a price, of course, but it is easy to show that welfare can nonetheless be improved unambiguously. The prospect of a welfare increase from insurance markets does not, however, mean that governmental intervention is required. It does not mean, more specifically, that the prospect of efficiency gains from insurance necessarily calls for governmental intervention with its incumbent expenditure of public monies. Governments should dedicate funds to insurance programs only if their intervention will increase public welfare above and beyond levels that would otherwise be achieved by private companies. This section will make the case that climate insurance would satisfy this requirement. It begins with a brief analytic description of why insurance is such a good idea. A second subsection offers some general caveats to this optimistic conclusion.

A.2.1. The Welfare Value of Insurance.

We begin the discussion with a simple model designed to illuminate the value of insurance when individuals act to maximize their expected utility in the face of well-defined risks. To be more specific, let π represent the probability that some individual will sustain some loss L against initial wealth denoted by W. Let P be the price per dollar of insurance coverage, let C denote amount of coverage actually purchased, and let the individual's utility function be concave in net wealth (so that he or she is risk-averse).[1] If C* = 0 maximizes expected utility for this individual, then we would conclude that insurance would make no contribution to welfare. We will, though, show that C* = L solves the optimization problem if the insurance offering is actuarily fair; i.e., risk-averse people will fully insure against losses that they face if the institution offering insurance is, in fact, risk-neutral.

Our problem is to maximize expected utility,

$$E\{U(--)\} = \pi\, U(W - L - C\,P + C) + [1 - \pi]\, U\{W - C\,P)$$

with respect to C. The appropriate first order condition is

$$\pi\,(1 - P)\,U'(W - L - C^*P + C^*) - (1 - \pi)\,P\,U'(W - C^*P) = 0$$

where

> U'(W – L – C*P + C*) simply denotes marginal utility [dU/dW] evaluated in the bad state of nature in which net wealth is {W – L – C*P + C*} and C* represents the optimal coverage and
>
> U'(W – C*P) similarly denotes marginal utility evaluated in the good state of nature in which net wealth is {W – C*P}.

It follows that the efficient level of coverage, C*, solves:

$$\{U'(W - L - C^*P + C^*)\} / \{U'(W - C^*P)\} = \{(1 - \pi)\,P\} / \{\pi\,(1 - P)\}. \qquad (1)$$

Meanwhile, actuarily fair insurance guarantees that the expected value of income in the good state of nature for the (risk-neutral) insurance institution equals the expected value of outflow in the bad state of nature for any level of coverage; i.e.,

$$\{(1 - \pi)\,P\,C\} = \{\pi\,(C - CP)\} = \{\pi\,C\,(1 - P)\}.$$

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[1] To be analytically precise, we assume that utility depends on net wealth according to U = U(W). The assumption of concavity means that the individual is averse to risk, that marginal utility is positive (i.e., that dU/dw > 0), but that marginal utility declines as wealth increases (i.e., d^2U/dW^2).

After some algebra, therefore,

$$\{(1 - \pi)\, P\} / \{\pi\, (1 - P)\} = 1.$$

It follows immediately that

$$U'(W - L - C^*P + C^*) = U'(W - C^*P).$$

It must be true, as a result, that the outcome in the good state of nature matches the outcome in the bad state of nature. Mathematically, therefore

$$W - L - C^*P + C^* = W - C^*P. \qquad (2)$$

This could only happen if C* = L, of course; i.e., expected utility is maximized if the individual were fully-insured so that his or her net wealth would be the same regardless of whether or not the loss actually materialized. Note, finally, that the insurer makes money, even when expected payments equal expected receipts, by investing the receipts between the time at which the premium is collected and the time at which the loss is covered.

A.2.2. Extensions and Caveats.

It is important to understand that this result does not mean that the risk of loss is without cost. Indeed, we now know that, in the optimum defined by equation (2),

$$E\{U(--)\} = U(W - C^*P) = U(W - L\pi).$$

It follows immediately that

$$\partial E\{U(--)\}/\partial\pi = -U'(W - C^*P)\pi < 0 \text{ and} \qquad (3a)$$

$$\partial E\{U(--)\}/\partial C = -U'(W - C^*P)C < 0. \qquad (3b)$$

In words, expected utility climb fall if the probability of loss were to increase and/or if the size of the loss were to climb. Any program that could reduce either π or C by lowering exposure or sensitivity to a stochastic and external event would therefore improve welfare by directly increasing expected utility.

It is equally important to understand that this result does not mean that insurance mechanisms will always emerge whenever risks provide an opportunity to improve welfare and make some money. The key to seeing why is to understand that the insured will likely know more about his or her risk circumstance and behavior than the insurer. As a result, moral hazard and adverse selection can both arise – issues that can, in extreme cases, cause the institution of insurance to collapse. In the first instance, moral hazard becomes a problem when the insured takes the certainty of full coverage as an incentive to reduce his or her vigilance in protecting against the loss. More specifically, diminished care can cause π to increase to (π') without notice, and the insurer can loose money. Deductible provisions (i.e., requiring the insured to cover the first $X of a loss) are frequently sufficient to handle moral hazard problems (if the expected cost $($\pi$')X were greater than the cost involved in maintain vigilance). In some cases, however, deductible provisions are insufficient. When that happens, the insurer must raise the premium P or, in the extreme, refuse to offer coverage.

Adverse selection can also cause the collapse of an insurance market. Adverse selection is possible when various individuals confront the insurer with different probabilities of suffering a loss. If the insurer could differentiate accurately between these people on the basis of these probabilities, of course, then he or she would charge premiums that reflected individual probabilities and the previous full-insurance result would stand. This is why young male drivers in the United States pay more for automobile

insurance than more careful and more experienced older drives (or more careful female drivers). Absent any ability to differentiate across these potential customers, however, the insurer must offer coverage at a common premium that would be too high for low risk people and too low for high risk people. In this case, high-risk people would over-insure against their potential losses while low-risk people would underinsure; and, as a result, the insurer would again loose money (especially if the probability of suffering losses were positively correlated with size of those losses).[2] The insurer would respond by raising premiums to cover the associated increase in expected payment, but that would only amplify the inefficiency. In the extreme, only high-risk individuals would buy coverage; i.e., all but the worst risks could be driven from the market.

[2] To see why, suppose that the probability π were lower than the premium P. In that case, $\{(1-\pi)/(1-P)\} > 1$ and $\{P/\pi\} > 1$ so that, from equation (1), we know that

$$\{U'(W - L - C^*P + C^*)\} / \{U'(W - C^*P)\} > 1.$$

As a result,

$$U'(W - L - C^*P + C^*) > \{U'(W - C^*P)$$

so that net wealth in the bad state of nature (when the loss is suffered) must be lower than net wealth in the good state (recall that marginal utility is positive but decreasing in net wealth). Clearly, therefore, the individual is no longer fully insuring against his or her potential loss. The same logic shows that opposite conclusion would hold if the probability π were higher than the premium P.