

Impact of Behavioral Issues on Green Growth Policies and Weather-Related Disaster Reduction in Developing Countries

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Abstract

This paper focuses on how developing countries can change the way they prepare for disasters so they are better equipped to sustain economic growth. It discusses the importance of considering the goals of key decision makers and the need to understand the perceptions, systematic biases, and heuristics used by the relevant interested parties (the affected public, private and public sector organizations, and nongovernmental organizations) in choosing between alternatives. The paper highlights the importance of undertaking benefit-cost analysis to evaluate disaster risk reduction measures, recognizing that decision makers might not make meaningful use of this

policy tool given their behavioral biases and simplified heuristics. To address these issues, the authors propose green growth strategies that involve multi-year contracts coupled with short-term incentives that have a chance of being implemented. The strategies focus on the role of multi-year micro-insurance, long-term loans, and multi-year catastrophe bonds that reflect the institutional arrangements in the developing country. The paper illustrates this proposal in the case of farmers' agricultural practices and investment decisions that reduce losses to property from catastrophic disasters such as drought.

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1. Introduction

Consider the following examples:

Example 1: A farmer has to determine whether to invest in new equipment to grow a high yield crop (HY Crop) that has a much higher yield than his current low-yield crop (LY Crop) if the area has less than the average amount of rainfall (i.e., a drought).

Example 2: A community has to determine whether it wants to invest in irrigation systems to reduce the consequences of low rainfall amounts on agricultural yields of farmers in its area.

Example 3: A government has to determine what investment strategies it needs to pursue to protect farmers against severe losses from a disaster during the growing season.

Each of these examples require the individual farmer, the community and the country to determine how to protect themselves against climate related disasters that have potentially severe consequences with respect to agricultural production. More generally, they raise the question as to the appropriate strategies by the private and public sector to encourage individuals and communities to undertake measures that improve human well-being and social equity---the definition of a Green Economy according to the United Nations (UNEP, 2010).

Billions of people reside in hazard-prone areas around the world today, but many of them do not undertake proper risk reduction measures nor do they purchase adequate insurance to protect themselves against the economic consequences of future catastrophes. When disasters occur in emerging economies, the countries themselves may have a difficult time achieving sustainable economic development if those disasters repetitively destroy crops, infrastructure and services. As a result, the reconstruction process will be slow, and during that time financial and human capital are allocated to rebuilding the country, rather than be used for development. In highly hazard prone areas, another disaster is likely to occur before the region has even had the time to fully recover from the previous one.

Disasters are indeed known to have enduring negative effects on less-developed countries because of the magnitude of the damage relative to their gross domestic product (GDP) (Gurenko, 2004; Linnerooth-Bayer et al., 2005). A recent study compared the economic impact of recent catastrophes on national economies (as measured as a percentage of their GDP). It revealed that

Hurricane Katrina cost nearly \$150 billion, but that amount represented only 1.2 percent of the U.S. GDP in 2005, the year that the disaster occurred. Similarly, the major 1995 Kobe earthquake in Japan cost nearly \$100 billion, which represented about 3 percent of the country's GDP for that year. At the other end of the spectrum, Hurricane Ivan in 2004 inflicted \$900 million in direct economic losses to the island of Grenada, 200 percent of its GDP. An extreme example is Hurricane Gilbert that devastated the island of St. Lucia in 1988 causing \$1 billion in damages – equivalent to 365 percent of its GDP (Cummins and Mahul, 2008). The local macro-economic status has also been shown to be an important factor in how developing countries can respond to disasters (Hallegate and Dumas 2009; Hallegate and Ghil, 2008).

One of the major challenges of disaster in developing countries is that they not only destroy physical infrastructure on a large scale, but also affect a disproportionately high number of individuals, compared to OECD countries. The major earthquake in Haiti in January 2010 caused 300,000 deaths, directly and during in the weeks following the catastrophe because of lack of proper medical treatment in the post-disaster period. The historical flooding in Pakistan that same year, which affected over 20 million people and required massive donations from the international community to start the reconstruction process, is another recent illustration of the devastating impact that natural catastrophes can have on developing countries where there is a lack of preparedness.

We address the following question in this paper: How can one change the way developing countries prepare for disasters so they are better equipped to sustain economic growth? While financial constraints are a fundamental barrier, we argue that other factors also contribute to the lack of preparedness. To address these catastrophe risk management issues, **Section 2** of the paper discusses the importance of considering goals of key decision makers and the need to understand the perceptions of the relevant interested parties (e.g., the affected public, private and public sector organizations, NGOs). These perceptions are affected by systematic biases and simplified decision rules such as a focus on short-term returns (i.e., myopic behavior) and the failure to consider the consequences of events whose likelihood of occurrence is below the decision makers' threshold level of concern. **Section 3** examines the role that risk perception and behavioral biases play in how decision makers choose between alternatives using the above three examples of farmer, community and government, to illustrate these points. **Section 4** discusses the importance of undertaking benefit-cost analysis to evaluate disaster risk reduction measures, recognizing that

decision makers might not make meaningful use of them given their behavioral biases and simplified heuristics.

To overcome these challenges, **Section 5** proposes green growth strategies that involve multi-year contracts coupled with short-term incentives that have a chance of being implemented. The strategies will focus on the importance of risk transfer instruments such as multi-year micro-insurance, long-term loans, and multi-year catastrophe bonds that are consistent with the institutional arrangements in the developing country for which it is being proposed. We will illustrate how these proposed green growth programs can be applied to farmers’ agricultural practices and investment in measures that reduce losses to property from catastrophic disasters such as drought.

2. Understanding the Goals of Key Decision Makers

The risk management process begins by having the region or community decide on its goals and objectives in the short-term and long-term. Figure 1 delineates a set of goals that should be considered when allocating limited resources to developing a hazard management program.

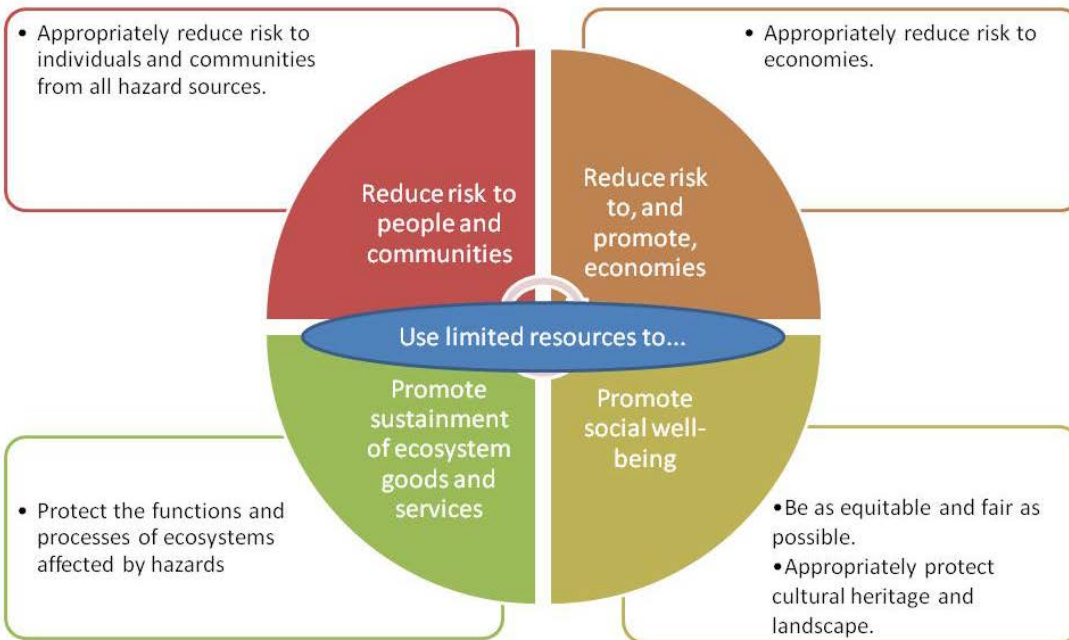


FIGURE 1. THE GOALS OF RISK MANAGEMENT

(Modified from Sayers, et al. 2012)

The goals and objectives of the region or community will be influenced by the values of the key interested parties concerned with managing risk, the current laws and public sector institutional arrangements at the local, state and federal level, and current programs and policies already in place (e.g., national insurance programs or homeowners' insurance offered by the private sector).

A key element of this aspect of risk management is determining what level of risk is *acceptable* to the community and the resources that can be available to carry out the proposed activities to reduce the current risk to this acceptable level. As indicated in subsequent sections of this paper, these decisions will be highly influenced by the behavioral norms and culture of the region or community and the risk perceptions of the key decision makers. The reconfirmation of acceptable levels of residual risk for the community after mitigation measures have been implemented needs to be carefully examined as part of this process.

To illustrate the role that goals and plans play in the decision-making process, consider each of the interested parties in the three examples in the Introduction.

Example 1: A farmer may not want to incur the cost of equipment to grow the HY Crop because of budget constraints, so he will continue to plant his fields with the LY Crop. His principal goal is *having enough income to meet his family's needs*. He might not be concerned with the consequences of a drought year because it is below his threshold level of concern.

Example 2: A community may have as a key goal *investing in projects that yield a positive short-term return*. They will thus be reluctant to incur the high upfront costs of an irrigation project where the net long-term benefits justify the investment, but the return over the next couple of years is somewhat less than the project cost.

Example 3: The government will have as its principal goal *meeting the needs of its constituents*. It is highly unlikely that they will pay attention to the consequences of a drought during the growing season because the disaster is perceived to have a low likelihood of occurrence that is below the threshold level of concern of farmers in the area.¹ Those farmers thus do not put pressure on the elected officials and state legislators to allocate money or pay attention to this extreme event.

¹ This would be different if the country suffers recurrent droughts in a given region, as is the case in many countries on the African continent.

3. Perceptions and Choice Rules²

We now explore in more detail why farmers, communities and governments are reluctant to protect themselves against weather-related events, such as a drought year or severe flooding. It is useful to begin by reviewing how protective decisions should ideally be made in a world where all decision makers follow the economic rationality of utility maximization. We can then examine how biases, constraints and simplified decision rules foster actions that depart from economic rationality.

Suppose that the decision maker is considering incurring an investment that has potential payoffs for the next T years and that there is an annual probability p of a drought in any given year t . Should such an event occur, the annual benefit of investing in a measure that reduces the consequences of drought will be denoted as B .³ In this case, the decision to protect against this event could be made by observing whether the upfront cost (C) of the investment is less than the discounted stream of expected benefits (pB) i.e., if

$$C < \sum_{t=1}^T (pB) \beta^t \quad (1)$$

where β is the decision-maker's annual discount rate.⁴

Implicit in (1) are three strong assumptions about how the decision maker estimates and values costs and benefits over time. Specifically:

- 1) all future benefits are discounted exponentially
- 2) individuals can estimate future probabilities of a drought
- 3) individuals can estimate the costs and benefits of the risk reduction measure

In practice, decision makers are likely to utilize simplified choice rules, focus on constraints as well as short-run benefits and costs rather than discounting the future exponentially and may not consider probabilities in their decision on whether or not to invest in the risk-reduction measure.

² This section is based on Kunreuther, Meyer and Michel-Kerjan (in press).

³ For simplicity, we are assuming only a single drought event that occurs any year t with a well-specified probability. The qualitative conclusions will not change if there are a number of possible events and probabilities vary over time. One could also make probabilities of drought in future years $t+n$ conditional on what happens in year t to address issues of long-term drought and/or climate change.

⁴ We assume here that the decision is made solely choosing alternatives where the costs are less than the net expected discounted benefits.

Budgeting Heuristics

The simplest explanation as to why farmers may fail to invest in equipment to grow a drought-resistant crop is affordability. If the farmer has limited disposable income after purchasing necessities, there would be little point in their undertaking a benefit-cost analysis of whether to incur the upfront cost of the new equipment. If the farmer is only focusing on next period (i.e., $T=1$), he may not be able to afford the cost of drought-resistant seeds and other required inputs even if they do not have to invest in new equipment to plant the seeds. We will discuss this case in more detail in Section 5.

Budget constraints may extend to higher income individuals if they set up separate mental accounts for different expenditures (Thaler, 1999). Empirical evidence for this budgeting heuristic comes from a study where many renters indicated no change in their willingness to pay for a dead-bolt lock when the lease for the apartment was extended from 1 to 5 years. When asked why, one individual responded by saying:

\$20 is all the dollars I have in the short-run to spend on a lock. If I had more, I would spend more—maybe up to \$50. (Kunreuther, Onculer and Slovic, 1998, p. 284).

Safety-first Behavior

Individuals may utilize a simplified decision rule that determines whether to invest in protective measures only if the probability of the event (p) is above their threshold level of concern (p^*). If the decision makers perceives $p < p^*$, then they will not undertake any protection. If, on the other hand, $p > p^*$ then they will want to invest in protection.

Should there be an opportunity to determine how much to invest in mitigating the consequences of the event (e.g., reducing the negative consequences of drought to a farmer) then the decision maker may utilize a safety first rule by determining the optimal amount of protection so that $p \leq p^*$. This “safety first” rule initially proposed by Roy (1952) is utilized by insurers today in determining how much coverage to offer and what premium to charge against extreme events such as wind damage from hurricanes in hazard-prone areas (Kunreuther and Pauly, in press).

Under-weighing the Future

There is extensive experimental evidence, revealing that human temporal discounting tends to be *hyperbolic*: temporally distant events are disproportionately discounted relative to immediate ones. As an example, people are willing to pay more to have the timing of the receipt of a cash prize accelerated from tomorrow to today, than from the day after tomorrow to tomorrow (in both cases a one-day difference) (Loewenstein and Prelec, 1992).

The implication of hyperbolic discounting for protective decisions is that farmers might be asked to invest a tangible fixed sum now to achieve a benefit later that they instinctively undervalue. The effect of placing too much weight on immediate considerations is that the upfront costs of protection will loom disproportionately large relative to the delayed expected benefits in losses over time.

A farmer might recognize the need for investing in equipment to plant the High Yield Crop and see it as a worthwhile investment when it is framed as something to be undertaken a few years from now when both upfront costs and delayed benefits are equally discounted. However, when the time arrives to actually make the investment might get cold feet due to hyperbolic discounting.

Myopic Behavior

An extreme form of hyperbolic discounting is when the decision maker considers only the expected benefits from the protective measure over the next year or two rather than over the life of the equipment. Elected officials are likely to view the decision by reflecting on how their specific decisions are likely to affect their chances of re-election. If the perceived expected benefits from the measure before they start campaigning again are less than the costs of protection they will very likely oppose the expenditure. They will prefer to allocate funds where they can see an immediate return. The fact that protective measures only yield positive returns when a disaster occurs makes it even more difficult to justify these measures. This reluctance to incur upfront costs that do not yield immediate benefits highlights a NIMTOF (Not in My Term of Office) behavior.

Procrastination

The tendency to shy away from undertaking investments that abstractly seem worthwhile is exacerbated if individuals have the ability to *postpone* investments—something that is almost always the case with respect to protection. A community might recognize the need to invest in irrigation measures to reduce the consequences of drought but may still fail to act.

A case in point with respect to lack of preparedness is demonstrated by the city of New Orleans and FEMA in advance of Hurricane Katrina in 2005. While emergency planners and the New Orleans Mayor's office were fully aware of the risks the city faced and understood the need for investments in preparedness, there was inherent ambiguity about just what these investments should be and when they should be undertaken. Faced with this uncertainty, planners did what decision makers tend to do when faced with a complex discretionary choice: they opted to defer it to the future, in the (usually false) hope that the correct choices would become clearer and/or more resources would then be available (Tversky and Shafir, 1992).

Underestimation of Risk

Another critical factor that has been shown to suppress investments in protection is underestimation of the likelihood of a hazard—formally, under-estimation of p in (1). For one thing, decisions about protection are rarely based on formal beliefs about probabilities. Magat, Viscusi and Huber (1987) and Camerer and Kunreuther (1989), for example, provide considerable empirical evidence that individuals do not seek out information on probabilities in making their decisions. In a study by Huber, Wider and Huber (1997), only 22 percent of subjects sought out probability information when evaluating risk managerial decisions. When asked to justify their decisions on purchasing warranties for products that may need repair, consumers rarely use probability as a rationale for purchasing this protection (Hogarth and Kunreuther, 1995).

There is also evidence that people tend to simply ignore risks when the likelihood is small enough. In laboratory experiments on financially protecting themselves against a loss by purchasing insurance or a warranty, many individuals bid zero for coverage, apparently viewing the probability of a loss as sufficiently small that they were not interested in protecting themselves against it (McClelland et al., 1993; Schade et al., 2011). Many homeowners residing in communities that are potential sites for nuclear waste facilities have a tendency to dismiss the

risk as negligible (Oberholzer-Gee, 1998). It is also not clear how much knowledge farmers or communities have regarding the likelihood and consequences of an untoward event.

Even experts in risk disregard some hazards. After the first terrorist attack against the World Trade Center in 1993, terrorism risk continued to be included as an unnamed peril in most commercial insurance policies in the United States. Insurers were thus liable for losses from a terrorist attack without their ever receiving a penny for this coverage. (Kunreuther and Michel-Kerjan, 2004). Following the attacks of September 11, 2001, insurers and their reinsurers had to pay over \$35 billion in claims due to losses from the terrorist attacks, at that time the most costly event in the history of insurance worldwide, now second only to Hurricane Katrina.

4. The Importance of *Undertaking Benefit-Cost Analyses of Risk Reducing Measures*

As discussed in the previous section, decision makers may not understand the risk their country faces and actions that should be taken to reduce it. To evaluate the relative merits of alternative measures, key decision makers can undertake a systematic benefit-cost analysis. In this section we describe the elements of this evaluation process in the context of investing in measures to reduce the impact of flood losses to property in Jakarta, Indonesia as part of a study undertaken for the World Bank by our research team at the Wharton Risk Center, in collaboration with the International Institute for Applied Systems Analysis (IIASA) and Risk Management Solutions (RMS) (Hochrainer-Stigler et al., 2010). A similar process could be utilized to evaluate the cost-effectiveness of measures to increase agricultural productivity.

Jakarta is the capital of Indonesia with around 8.5 million inhabitants. Severe flooding is frequent and closely linked to extreme rainfall events. This case study focuses on the region around the Ciliwung River in Central East Jakarta, a densely populated and economically important area of the city where flooding occurs most frequently. Jakarta has a wide variety of buildings, from very modern skyscrapers to informal settlements erected on wooden stilts. We focus our study on residential properties in East Jakarta, which make up about 60 percent of the city's structures. Research using Google Earth suggests that the vast majority of the buildings located outside the commercial center are two- or three-story masonry residential homes typically occupied by persons of high and medium wealth.

We selected two representative housing types: a high-value two-story home constructed with brick walls, concrete floor and clay roof (referred to as “Masonry”) and a middle-income two- to-three story home constructed with mixed wall, concrete floor and asbestos roof (referred to as “Mixed Wall”). The replacement value of the representative high-value building is assumed to be 19,200 USD and 7,000 USD for the middle-income one (based on estimates from Silver, 2007).

Exceedance Probability Curve and Selected Disaster Risk Reduction Measures

Given flood hazard data available for Jakarta, our analysis is based on approximate flood extent maps and limited depth estimates for two past floods in January/February 2002 and February 2007 (Dartmouth Flood Observatory, 2008). Our hazard analysis also uses a 30-year monthly rainfall time series, observed at the Jakarta Observatory (NOAA global database) within the catchment of the Ciliwung and an elevation map based on data from the NASA Shuttle Radar Topography Mission. Based on these inputs, two probabilistic flood depth curves are generated, representing a higher (‘max hazard’) and lower (‘min hazard’) hazard location. Using two curves also allows us to test the sensitivity of findings to the hazard approximation.

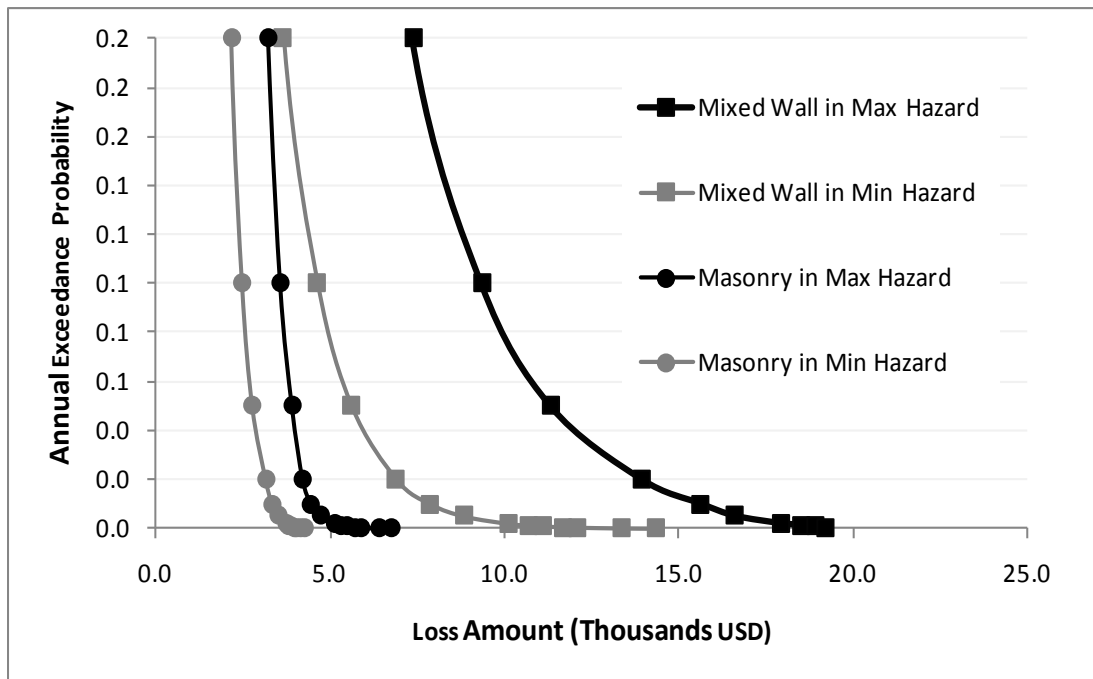


FIGURE 2: FLOOD RISK IN JAKARTA - EP CURVES FOR TWO BASE LINE STRUCTURES IN TWO DIFFERENT HAZARD LOCATIONS WITH NO DISASTER RISK REDUCTION

Two adaptation measures are selected for reducing flood risks to the Masonry and Mixed Wall dwellings. The cost estimates are based on FEMA adapted to account for labor cost differences in the United States (Teicholz, 1998; Davis, 2002):

- Measure 1: Improve flood resilience and resistance of the property. Approximate cost is 3,100 USD
- Measure 2: Elevate the house by 1 meter. Costs are estimated to be 9,345 USD.

Benefit/Cost Calculations

Using data on expected average annual loss (AAL) and estimates of AAL reductions resulting from the application of each aforementioned measure, Table 1 shows the results of the benefit-cost- calculations for the two options. The results are highly sensitive to the choice of the discount rate, the assumed length of life of the residential structure and the hazard level. We show the results for discount rates of 5 percent and 12 percent and for an expected lifetime of the structures of 10 and 25 years.

Table 1: Flood Risk in Jakarta - Summary of Selected B/C Ratios

Adaptation Measure	Time Horizon (years)	Masonry				Mixed Wall			
		Min Hazard		Max Hazard		Min Hazard		Max Hazard	
		Discount Rate		Discount Rate		Discount Rate		Discount Rate	
		5%	12%	5%	12%	5%	12%	5%	12%
1. Improve flood resilience	10	0.49	0.36	0.63	0.46	0.10	0.07	0.11	0.08
	25	0.90	0.50	1.16	0.64	0.18	0.10	0.21	0.11
2. 1 m elevation	10	0.83	0.61	1.18	0.86	2.06	1.51	3.69	2.70
	25	1.51	0.84	2.15	1.20	3.77	2.10	6.73	3.75

Note: numbers above 1 are in bold and indicate that the benefit is higher than the cost of these measures

The results show benefit-cost ratios to homeowners that are substantially higher among mixed wall structures than among masonry structures, due to a greater hazard level. Elevating the property by 1 meter also has mostly favorable results, with benefit/cost ratios ranging from 0.61 to 6.73. Note however, that this is only the direct economic benefit to the homeowner. This does not include the indirect private benefit s/he can derive from a more resilient house (i.e., reducing the need for temporary housing, need for health care, evacuation cost), nor the broader benefits to society if all houses in a disaster prone area are resilient.

5. The Role of Insurance and Loans in Promoting Green Growth Strategies

We now turn to the importance of establishing ex ante risk financing mechanisms which can provide some financial safety net to those living in hazard-prone areas. For centuries, insurance has played a critical role in allowing people to get back on their feet, firms to innovate, and countries to grow economically with the knowledge that they are financially protected against some of their risks. If the decision maker is held fully responsible for the losses should a disaster occur she is not likely to change the way she does business. But this assurance of being protected for taking what is perceived as a potential risk (i.e., changing crops) may make farmers more likely to adopt more effective crops when communities or governments are unlikely to expend resources on irrigation systems.

Insurance provides assurance of financial protection. When coupled with loans for adaptation measures, these two financial products can play a key role in promoting green growth strategies. We first show how insurance and loans can incentivize subsistence farmers to invest in drought-resistant seeds for the next growing season when they face budget constraints, providing examples of successful programs in Malawi and Andhra Pradesh, India. We then propose that both insurance and loans be multi-year contracts so they encourage communities and governments to invest in irrigation equipment⁵. We will also explain how risk transfer instruments can supplement insurance when losses are catastrophic.

Insurance and Loans for Farmers

The World Bank has provided the impetus for implementing innovative *index-based* insurance schemes coupled with loans that overcome the financial constraints that prevent subsistence farmers from investing in seeds and other purchases that significantly increase agricultural productivity. Index-based insurance makes payouts to the insured party contingent on a physical trigger such as rainfall measured at a regional weather station.⁶

⁵ Providing subsidies to the farmers may make them more likely to plant high yield crops. The challenges with subsidies is that they do not provide a clear signal as to what the risk of a major drought is nor do they provide a long-term self-sustainable solution to the farmers. The farmer is likely to plant low yield crops as soon as international donors stop providing the subsidy.

⁶ Note that this requires that a network of properly operating weather stations exist in the area of study.

The pre-specified trigger avoids moral hazard since the farmers will receive a fixed payment independent of their own behavior. This type of insurance thus incentivizes farmers to invest in higher yield and higher risk crops knowing that they are protected against low amounts of rainfall. An index-based insurance reduces administrative costs by eliminating expensive claims settling processes associated with traditional insurance products. An immediate payment should rainfall be below the trigger reduces the need for farmers to sell their assets and livestock should they suffer severe losses from a drought (Linnerooth-Bayer and Mechler, 2007).

Initiative in Malawi. The most successful example of index-based insurance for droughts to date is the case of Malawi, where low-income farmers are offered protection against insufficient rainfall and a loan package to purchase better groundnut seeds. First implemented in 2005 when approximately 900 smallholder farmers participated in a pilot project, the features of the system have two interrelated components:

- Index-based insurance in which the premium is calculated based on the probability that rainfall amounts in a particular area will be below certain amounts. Should rainfall be below the trigger, pre-specified payouts are given to the affected farmers.
- Loans by banks to the farmer so they can purchase rainfall insurance⁷ as well as seeds and other expenditures necessary for high yielding crops.

If the rains during the season as measured by the weather station are always above the relevant triggers then the insurance company keeps the premium and farmers pay back the loan with proceeds from their harvest, which will normally be much greater than that of their current low-yielding seeds. If measured rains are below the triggers at critical stages in the groundnut growing season, the insurance company pays part or all of the loan to the bank as a function of the amount of rain experienced. The Malawi insurance scheme improves farmers' creditworthiness knowing they are protected against drought. Banks thus are willing to provide loans for seeds and other agricultural inputs (Suarez et al., 2007).

⁷ The bank pays the premium directly to the insurer.

The success of this pilot can be measured by comparing the net gains from the farmer investing in hybrid high-yielding seeds rather than traditional seeds. The loans are easily repayable given the increased productivity of the hybrid seeds, estimated to be 500 percent (Suarez and Linnerooth-Bayer, 2011).

This project also contributed to help increase gains for farmers who decided to participate. However, even though 86 percent of these farmers indicated willingness to participate again, multiple issues have still stunted overall demand. A main problem is the difficulty farmers had in understanding low-probability events and the terms of insurance when making their choices. Survey results indicated that only 55 percent of respondents reported understanding the insurance scheme before joining it. Another key issue is the inherent lack of trust in insurance providers and in the weather station measurements in this region. Rainfall varies by farm, and so some farmers are inherently winners or losers depending on their proximity to the weather reporting station (Suarez and Linnerooth-Bayer, 2011).

The study was expanded in 2007 to include cash crops, and by 2008 the number of participating farmers increased to 2,600. However, many farmers today still do not understand the insurance policy. This indicates the need for improved outreach and educational programs about the benefits of insurance, as well as the need to improve the communities' trust of private and public organizations (GFDRR, 2011).

Initiatives in India. Another program, BASIX index-based crop insurance, covers non-irrigated farmers in Andhra Pradesh, India against the risk of insufficient rainfall during critical phases of the growing season. The policies are marketed to growers through micro-finance banks which are linked to the micro-finance entity known as BASIX (Bhartiya Samruddhi Finance Ltd). The BASIX system was initially support by international technical assistance provided by the World Bank. During the first three years of its operation its penetration increased from 230 farmers to over 250,000. Similar programs have been implemented or underway in Mongolia, Ukraine, Peru, Thailand and Ethiopia (Mechler et al., 2006; Gine, 2009).

While the Andhra Pradesh program has been successful in increasing the number of insured farmers, there are several design issues that have restricted its reach. Demand for the insurance is price elastic, however the price of the insurance is not actuarially fair for reasons

that have not been documented. This has significantly limited potential demand, as the high price of insurance was a principal reason given by 64 percent of non-participating farmers for not purchasing the insurance – they faced liquidity constraints.

Households purchase the insurance at the beginning of the growing season, a time when many uses compete for available cash. Similar to the Malawi case, there is a lack of trust in the insurance process and limited education and financial literacy in the region. Formal legal protections are also viewed as relatively weak, further deteriorating the trust necessary for the success of the program. Limited salience of the insurance product can be improved by using different selling techniques, including door-to-door sales. The continued success of the program and its ability to scale, expand, and become self-sufficient is dependent on overcoming these barriers (Cole et al., 2010).

In Gujarat, India, the Self-Employed Women's Association (SEWA) has pioneered index weather insurance distribution, beginning in 2006 (Cole et al., 2011). Leveraging their longstanding, trusted presence as a trade union, SEWA's insurance sales operation has grown by an order of magnitude over this time, initially targeting 15 households in each of about 30 villages and in 2011 targeting about 70 households in each of 60 villages. Each year SEWA has used village meetings to introduce the insurance sales, followed by door-to-door marketing visits.

Between 20 percent and 40 percent of visited households have purchased the insurance, and the trend line is upward-sloping, but for research purposes the marketing outreach and the policy prices have been subsidized. A long-term randomized impact evaluation is ongoing, and will shed light on the dynamics of demand, the opportunities for greater production efficiencies, and the implications for consumption-smoothing. Consistent with the view that ambiguity aversion may influence adoption of index insurance (Bryan, 2010), in the Gujarati data the partial correlation of insurance demand with risk aversion is negative initially, but positive in the more recent data. This suggests that ambiguity about index insurance can fall over time, with salutary consequences for risk management.

Initiative in Peru to reduce losses associated with El Niño. In a new collaboration between GlobalAgRisk, with the support of the Bill and Melinda Gates Foundation, and the United Nations Development Programme, Peru has initiated a new insurance model to mitigate losses

associated with natural events. However, unlike the initiatives in India or Malawi that use insurance to compensate for losses *after* an event has occurred, Peru has a program that provides payments *before* the event occurs.

This program is intended to reduce losses associated with El Niño, an event characterized by the warming of the tropical Pacific Ocean that brings devastating rainfall and flooding to Northern Peru normally occurring with a frequency of once in every fifteen years. This event destroys crops, and the risk associated with such a disaster limits available credit for farmers. Fortunately, this warming can be predicted months in advance by measuring changes in sea temperatures off of the coast of Northern Peru.

The financial program that has been developed triggers a payment based on the amount the farmer has chosen to insure whenever an El Niño event is predicted, allowing for the insured to use the payment to mitigate against any losses that would normally occur without the insurance.

There are multiple contract options. To illustrate, purchasers of the insurance make a relatively small initial payment and receive a payout when sea temperatures are in excess of 24 degrees Celsius between November and December. The payout is a percentage of the total percentage insured and increases in a linear fashion as sea temperatures increase, with 100 percent of the sum insured being paid when the temperature reaches 27 degrees Celsius. This provides a cash infusion to the insured in January, before the serious flooding occurs in February through April. Currently, the insurance is available for purchase by banks and other businesses through La Positiva, a local insurer with the backing of PartnerRe, a global reinsurance company. For banks and large businesses, the insurance allows them to be more prepared for the inevitable increased default rate after the event to prevent insolvency and transfer the portfolio risks.

The next step is to roll out the insurance to individual households and small businesses, as well as to public institutions. Households could use the payout to engage in protective measures including cleaning drainage systems, changing planting plans to minimize risk, and installing irrigation systems. It could also be used during the flooding when access to credit is limited, and after the flooding to assist in any clean up and rebuilding. This expansion to

households allows La Positiva to utilize local microcredit institutions (known as *cajas*) to offer the insurance tied to loans, particularly focusing on multi-year loans.

This program has led to a change in thinking regarding potential opportunities for “forecast index insurance.” In terms of El Niño events, there are opportunities to expand coverage to parts of Africa, Asia/Pacific, and the Americas where it affects seasonal patterns of rainfall and temperature. However, concerns still remain as to how this initiative will address issues related to moral hazard and potential adverse selection, as there is little information about what form the payments are to be made in and little explicit regulation of how the insured will be monitored in the use of their payouts. Either way, this program offers a unique solution to disaster mitigation (Cavanaugh, Collier and Skees, 2010).

Initiative on protecting against flooding in Vietnam. Flooding is clearly a major agricultural concern in developing countries. However, flooding does not uniformly affect agricultural productivity in a region (some farms may be flooded while others unaffected). Crops are also impacted at different levels of severity based on when the flood occurs in relation to the crop’s lifecycle, with crops being more vulnerable during certain stages, such as flowering. This leads to challenges when constructing index based flood insurance programs for developing countries.

In Vietnam, GlobalAgRisk has developed rice production insurance that has been structured similarly to business interruption insurance. The contract is intended to be purchased by the Vietnam Bank for Agriculture and Rural Development (VBARD). This bank lends to rice farmers against a pre-defined early-season flooding event. This contract would help VBARD protect its portfolio from different business interruption costs such as when client farmers seek loan restructuring after early flooding. The contract would be underwritten against recorded water levels at a main river gauge station, using this data as a proxy for flood damage. This assumes the existence of a reliable and consistent river gauge system in the different regions, a potential issue moving forward. This project represents a significant step forward in mitigating against agricultural flood losses by increasing the market for early season flooding insurance (Manuamorn, 2009).

Multi-Year Insurance and Loan Programs for Communities and Government

The above index-based insurance programs are designed to cover a one-year period so as to enable farmers to purchase high yield seeds and other inputs to increase their productivity. With respect to investments that have a relatively long life such as new equipment or irrigation systems, we believe there is an opportunity to develop new instruments such as multi-year insurance coupled with multi-year adaptation loans to encourage these investments.

Multi-year insurance (MYI) programs have been proposed to overcome the tendency for individuals to cancel their insurance policies after several years. Even in the United States, where knowledge about flood risk is available to any resident who seeks this information and flood insurance is available at reasonable cost, many residents in hazard-prone areas purchase flood insurance and then cancel their coverage after several years (Michel-Kerjan and Kunreuther, 2011). An MYI contract would increase the likelihood that individuals are protected over time. They will thus be less exposed to severe disaster losses while at the same time benefiting from their investment in risk-reduction measures by paying lower insurance premiums each year. Long-term loans would further encourage investments in cost-effective mitigation by spreading the upfront costs over time. If insurance rates are actuarially-based, then the premium reduction from adopting a risk-reduction measure will be greater than the annual loan cost.

An MYI policy combined with multi-year loans may encourage communities and national governments in low-income countries to invest in risk reducing measures such as irrigation systems for reducing the impacts of drought. Here is how the combined insurance-loan system would work:

- The community or government would purchase index-based insurance to protect itself against losses from a disaster. The policy would pay a fixed amount based on certain triggers (e.g., rainfall below a certain amount during a given time period).
- The MYI premium would be based on risk to be reviewed every five years so it can reflect structural changes such as climate may change. The revised premium would be based on a credible index regarding the structural change.

- Farmers would be covered for five consecutive years, making the chances of receiving a claim during this period more likely than if they focused on the annual probability of a disaster occurring.
- The multi-year loan would spread the upfront cost of the investment over a number of years. Local authorities, banks or institutions such as the World Bank could provide the loan.
- The amount of protection against a disaster (for example, drought) required by the community or government would be much lower if they invested in a risk reducing measure such as an irrigation system.
- The annual premium reduction of the MYI policy when one invested in a risk reducing measure (for example, an irrigation system) should be greater than the cost of the loan if the measure is a cost-effective one.

Multi-year insurance policies have been examined by very few pilot studies, with the Peruvian initiative discussed in the previous section being a notable exception. Since this initiative is so recent there has been little time to examine the effects of tying multiyear loans and insurance policies. With the program's planned expansion into multiyear loans for households, small businesses, and the public sector we hope to see an increase in demand, as well as, increases in investments in long term mitigation strategies including irrigation systems (Cavanaugh, Collier and Skees, 2010).

The Role of Risk Transfer Instruments for Covering Catastrophic Losses⁸

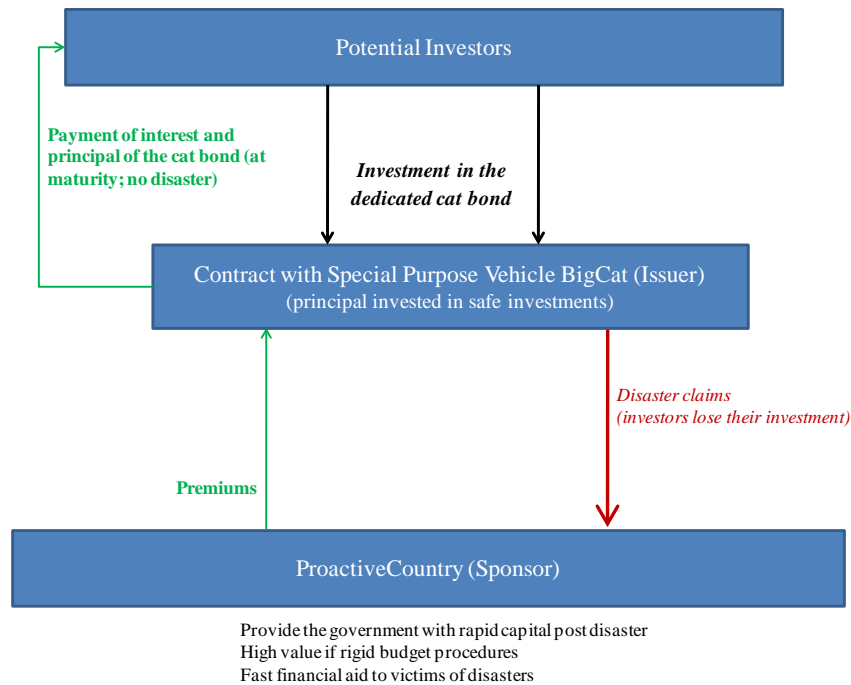
A multi-year insurance and loan program should be a win-win for all interested parties. The farmers would be safer and could generate higher revenue, which in turn will help economic growth and further investment in innovative technologies. There would be less need for the government and international charities to provide financial assistance and aid to victims of future disasters since the exposure will be reduced by physical investment in risk reduction measures and by financial protection through insurance.

⁸ This section is based on Michel-Kerjan et al. (2011).

Still, there is the possibility that a truly devastating disaster could adversely affect a large number of individuals simultaneously even if risk reduction measures are in place. To deal with a catastrophic loss, governments can use dedicated financial products to supplement traditional insurance and reinsurance products. The development of alternative risk transfer (ART) instruments grew out of a series of insurance capacity crises in the 1970s through the 1990s that led purchasers of traditional reinsurance coverage to seek more robust ways to buy protection. Although ART instruments comprise a wide range of products, we focus here on catastrophe bonds that transfer part of the risk exposure directly to investors in the financial markets.⁹ This financial instrument has increased in volume in recent years and is likely to continue to grow as the world experiences more costly catastrophes in the coming years.

How do catastrophe bonds work? Catastrophe bonds (“cat bonds”) can enable a country, a company or any organization to access funds from investors if a severe disaster produces large-scale damage. Consider a country, Proactive, which would like to cover part of its exposure against catastrophes. To do so, it creates a company, BigCat, whose only purpose is to finance the disaster costs of Proactive. Notably, BigCat is not a government-run company but an independent company. In that sense, BigCat is a single purpose insurer (also called a special-purpose vehicle, or SPV) for Proactive. When the insurance contract is signed, the sponsor (Proactive) pays premiums to BigCat. SPV BigCat raises the capital to support its insurance policy by issuing a bond to investors. Premiums collected from Proactive will be used to provide the investors with a high enough interest rate to compensate for a possible loss of their principal should a disaster occur. Figure 3 provides the structure of a typical government cat bond.

⁹ See Anderson et al. (2000) and Cummins and Weiss (2009) for comprehensive journal articles, Lane (2002) and Barriau and Albertini (2009) for edited volumes, and WEF (2008), Michel-Kerjan (2010) and OECD (2010) for a more general analysis.



Source: Michel-Kerjan et al. (2011)

FIGURE 3. SIMPLIFIED STRUCTURE OF A GOVERNMENT CAT BOND

How a government benefits from a cat bond. There are several widely used ways the payment of a cat bond can be triggered. First, all the stakeholders can agree at the execution of the contract on an external trigger for the insurance payment, independent of the actual level of losses the country has suffered, but easily verifiable, similar to the rainfall trigger on index-based insurance. This is called a *parametric* trigger. The data for this parameter can be collected at multiple reporting stations across a given geographical area. It is also possible to agree on a certain level of the actual economic losses incurred by Proactive from a disaster or series of disasters over the maturity of the cat bond. This is an *indemnity* trigger.¹⁰ The main advantage of an indemnity trigger is that the payment received by Proactive will be much closer to its actual loss but it could create moral hazard problem by having the country overstate the loss it has incurred. Parametric

¹⁰ This form of cat bond trigger is more analogous to a traditional insurance policy with its loss settlement process. Other triggers are on *modeled losses* or *industry losses*. For *modeled losses*, instead of dealing with Proactive's actual losses, an exposure portfolio is constructed for use with catastrophe modeling software. When there is a disaster, the event parameters are run against the exposure database in the cat model. If the modeled losses are above a specified threshold, the bond is triggered. For *industry losses*, the cat bond is triggered when an entire industry loss from a certain peril for the insurance industry doing business in this country reaches a specified threshold.

cat bonds are more transparent and simpler to use and hence have been the preferred type in lesser developed countries.

Advantages of using a cat bond. There are several advantages of using a cat bond to provide protection against a catastrophic disaster. They are:

(1) *Multi-year coverage and price stability.* Insurance and reinsurance contracts are typically issued for one year and are subject to price increases particularly after a large-scale disaster.¹¹ Cat bonds offer an important element of stability for their users by guaranteeing a predefined price over several years. As of 2008, more than 170 cat bonds had been issued since 1996, and their average maturity has been three years with a few bonds being as long as five or ten years. Longer bonds reduce upfront costs by allowing fees to be amortized over a longer period of time (Michel-Kerjan and Morlaye, 2008).

(2) *Guaranteed expedited payment.* Another key advantage of a parametric cat bond is that the money can flow to the government in just a few weeks. By design, the capital of the bond is commonly invested in risk-free assets, such as U.S. Treasury money market funds, so there is limited credit risk.¹²

(3) *An alternative to a government reserve.* A typical financial policy tool for governments is to build up a reserve of money over time to be used in the case of a catastrophe. However, a catastrophe could occur in the very first years so that the fund simply does not have enough money to pay for the losses. If the country does not suffer major losses for a long period, attention fades and the reserves may be transferred to other programs particularly when budgets are tight.¹³ It is difficult to have a long-term perspective on these issues for reasons discussed

¹¹ The Guy Carpenter Rate-on-Line index shows a 30 percent annual volatility over the past ten years. Premiums also differ markedly among perils that increase the concentration of risk to the reinsurers and perils which provide diversification. And it is not unusual to see reinsurance prices in a region increase by 20 to 50 percent after a major disaster. Catastrophe reinsurance prices in Florida increased by nearly 100 percent the year after Hurricane Katrina (Kunreuther and Michel-Kerjan, 2009, chapter 7).

¹² Note that some reinsurers now provide collateralized reinsurance treaties as well, but those are more expensive than traditional reinsurance treaties.

¹³ This was suggested in the United States for the Hurricane Relief Fund in Hawaii in 2009. Another example relates to the U.S. Pension Benefit Guaranty Corporation. In the 1990s there were interest groups lobbying the PBGC to reduce premiums because they were “too high,” as evidenced by the fact that the PBGC was running a surplus.

above (Michel-Kerjan and Slovic, 2010). Cat bonds overcome these challenges, since the catastrophe portion of the risk is transferred to financial investors who serve as third parties.

Note also that as with any insurance mechanism, the use of cat bond requires the payment of a premium. This might present a political challenge: if an administration pays for a cat bond for several years and that no disaster occurs that is covered by the instrument, some might argue that the cost of the insurance was lost (“we pay for nothing”).

This is why the use of a cat bond, or any other disaster risk financing instrument, has to be regarded as part of an overall national strategy for disaster risk management to support green growth. Such a strategy must combine better knowledge of the risk and exposure, a program of risk reduction measures and some risk transfer mechanisms for the residual risk a country does not want to—or cannot— support alone. Surprisingly, the international donor community has focused on providing ex post disaster relief to those in need, rather than also advocating an ex ante risk reduction strategy. There are important opportunities here for the World Bank and other international organizations to support a more comprehensive approach.

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