Climate Change — Risk Management Solutions for Developing Economies A Portfolio Approach

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While many explanations for why the world will regretfully fail to meet the Millennium Development Goals exist, two threats existentially challenge economic, social, and political progress in those very countries and economies of concern for decades to come. First, anthropogenic climate change[2] will increase the frequency and severity of extreme climate events (e.g., storms, drought, extreme rainfall events, flooding, etc., IPCC 2007a). Second, population dynamics will increase the concentration of the poor in areas and regions that are most vulnerable to natural disasters. As a result, future disasters will have increasingly detrimental effects on developing economies.[3] And while progress is being made in many developing economies, it is still the case that the poor live in the most vulnerable areas; public infrastructure is not suited for even the *current climate risk*; and extreme climate events constrain access to banking services, hinder development of other market opportunities, and fundamentally slow economic growth and poverty alleviation.

This paper begins by framing the problem in a social context. How do extreme climate anomalies affect developing economies? Where do we expect climate change to have the largest affect? What are the implications? How should society respond? Within this context, the key issue for this paper turns to the role of insurance against extreme climate events. At the outset, a point of clarification is needed in addressing the confusion that has emerged around the notion that it may be possible to develop 'climate insurance'. Climate has two important dimensions (temporal and spatial). *Anthropogenic climate change* has a longer term (temporal) influence on global, regional, and local climate conditions (spatial). Developing products to insure against something that is going to happen decades into the future has remote relevance to the emerging, detrimental consequences of climate change. Investment and adaptation, not insurance, are the appropriate response to highly probable future events such as rising sea levels. *Regional climate anomalies*, however, are insurable and there are a number of developments underway that merit serious consideration.

Despite the clear costs associated with extreme climate events, market and institutional arrangements to manage these events are largely missing in developing economies. The creation of a portfolio of financial instruments for catastrophes that are created by extreme climate events in developing economies is in its infant stages. Two overarching themes dominate the framework of this paper. First, if insurance markets for natural disasters are to be one of a portfolio of tools used to address climate change, the *threat* of climate change only serves to intensify the need to develop these markets given the *current climate risk* as a first step. Second, only when the need for insurance markets for natural disasters in developing economies is properly assessed can market development strategies and institutional responses be effectively implemented. Climate insurance products must first focus on *regional climate anomalies.* And while it may be possible to design multi-year insurance products that cover these anomalies, products covering short to medium time horizons (e.g., less than five years) have the greatest opportunities for success.

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[2]In this paper, climate change refers to the anthropogenic or the human impact on the environment. While most of the focus is on the buildup of green house gases, land use changes can also change regional climates (e.g., the dust bowl of the 1930s in the United States).

[3] Unless otherwise specified, we intend to use the term 'developing economies' to apply to all economies except developed economies — that is, developing economies include transition and emerging economies. While a precise list of developed economies is not required for this paper, we refer readers to the IMF Advanced Economies as an illustrative list of developed economies (IMF, 2011).

This paper introduces the idea of insurance based on scientific forecasts of extreme *regional climate anomalies*, and describes our experience developing the first regulated insurance market for 'forecast insurance' in the world in Peru. By converting these contracts to multi-year contracts, a foundation may be developed for climate insurance that is more relevant to the challenges of adapting to climate change. To be sure, innovations of this type are desperately needed as the foundation for addressing the future risks that will come with anthropogenic influences. The dynamics of these processes over time fit very well with the idea that climate insurance can contribute to greater resilience as society faces the perils of climate change.

In sequence, the postulated dynamics can work as follows:

- Stakeholders use regional climate forecast insurance payments before the disaster to respond to the forecast so as to change production systems, adjust management systems, implement real-time improvements in infrastructure, etc. These changes would not be possible without the insurance payment;
- Simply having a way to transfer this risk should also give stakeholders more courage to invest in higher-return activities to improve incomes and resilience to risks;
- As climate change causes the cost of the regional forecast insurance to increase over time, at some point investments in adaptation systems must dominate spending on the climate insurance.

After completing a review and developing some conceptual foundation of the issues associated with climate anomalies, climate change and the effects in developing economies, the paper turns to some of the progress that has been made in ex ante financing of natural disaster risk for sovereign countries which includes individual country action (MultiCat in Mexico) and multi-country pooling arrangements (the Caribbean Catastrophe Risk Insurance Facility – CCRIF). Importantly, these core examples are being replicated in other countries and regions. While some measure of success can be marked for the public-private partnerships underway in managing sovereign risks, efforts to introduce innovative insurance products for climate risks for the private sector in developing economies have been more challenging. A number of experiments are underway to target new weather index insurance products to households (mostly to agriculture). Currently, the record is quite mixed. Another paper in this volume covers these innovations for agriculture. The innovations in weather index insurance are demonstrating that it will require significant public sector investments to get these programs on a solid foundation. Most practitioners who have worked on micro level weather index insurance products have concluded that these products are better targeted at the firms and financial institutions that serve these households (World Bank, 2011; GlobalAgRisk, 2011).

In classifying ex ante financing interventions for natural disasters, the World Bank develops four basic categories:

1. Sovereign disaster risk transfer programs that protect governments, providing the fiscal resources to cope with natural disasters;
2. Property catastrophe risk insurance designed to protect property losses for homeowners, private firms and public infrastructure;
3. Agricultural insurance programs that are sold to farmers, herders, agricultural firms in the value chain, and, in some limited cases, financial institutions making loans in the agricultural sector; and
4. Disaster micro-insurance programs that are attempting to create insurance products for livelihood protection of the poor.

This paper will not review all four of these categories as there is a separate paper that addresses agricultural insurance and due to the fact that traditional property catastrophe risk insurance products are largely missing in developing economies for some good reasons — weak legal and regulatory frameworks, limited enforcement of suitable building codes, transaction costs of working with small-value policies, and the classic problems of moral hazard and adverse selection that plague most forms of insurance. Rather, this paper will focus on innovations in developing markets that use parametric or index insurance products. We frame the case of El Niño insurance in Peru to suggest that, in some circumstances, the same product can potentially be used for all four categories identified by the World Bank. Additionally, we explore the potential value of 'forecast insurance' as a mechanism to help stakeholders address the many consequences of current climate risks. This may lay a foundation for using ex ante financing solutions to facilitate adaptation to climate change.

Global Climate Risk and Vulnerability

NOAA makes an important distinction between climate and weather. Weather describes atmospheric conditions over a short period of time in specific locations. Climate generally describes how the atmosphere 'behaves' over a longer time period and is relevant at a broader geographic scale. The frame for anthropogenic climate change is a long time horizon (for example, the IPCC, 2007a, divides findings into effects in the 21st century and effects beyond this century) and a broad geographic scale (global and regional). However, some of the regional climate anomalies that we experience today may already be the result of certain anthropogenic influences. To be clear, several 'drivers' may be responsible for certain regional climate anomalies: 1) teleconnections (e.g., El Niño Southern Oscillation, North Atlantic Oscillation, Indian Ocean Dipole, Arctic Oscillations, etc.); 2) natural phenomena like volcanic eruptions; 3) regional land use practices such as the U.S. dust bowl of the 1930s; and 4) the buildup of greenhouse gases. And while it is not easy to separate the influences, a consensus within the scientific community is emerging that anthropogenic climate change will create more frequent and more severe regional climate anomalies (IPCC, 2007a; Morton, 2007; Corbera et al., 2006, Samson et al., 2011).

Samson et al. (2011) develop a climate-demography vulnerability index to map the predicted climate change to human populations. One sample of their mapping appears in Figure 1. In effect, this mapping attempts to incorporate the relationship between vulnerable populations and climate. It is designed to capture both the direction and magnitude of changing climate and changing demographic trends. As the authors conclude

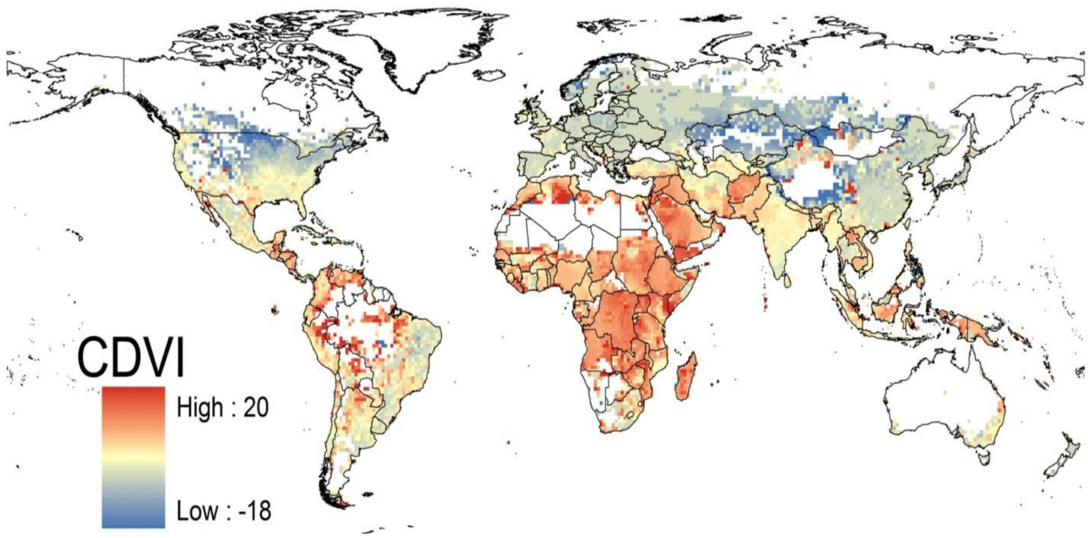
'we believe that the capacity of our simple human ecological models to explain broad density distribution patterns provides a coarse but important way to formulate initial predictions of the impact of climate change on human societies'

Admittedly, this 'coarse' snapshot is of considerable concern. The vulnerable regions are concentrated in developing economies.

Many developing economies operate with fewer protections against regional climate anomalies. Public and private infrastructure and personal dwellings are less equipped to withstand disasters. The poorer segments of society are more likely to work on marginalized land including in flood plains or land with less robust soils. Public safety nets may also be less equipped.

Financial service penetration, especially for insurance, also limits the capacity of the poor to manage regional climate anomalies. For example, the rate of penetration of insurance in developed economies is over two times that of emerging economies (3.57 percent of GDP versus 1.32 percent of GDP). The dichotomy between need versus access is obvious and there is not much more to add in this paper.

Figure 1 Climate-Demography Vulnerability Index (CDVI)



Source: Samson J. et al. (2011)

Are Regional Climate Anomalies Insurable?

The brief discussion above raises questions about how to introduce insurance that will pay for strong regional climate anomalies. At the core it is important to develop an understanding of how insurance underwriters may price the uncertainty associated with climate change. For the moment, it is more likely that insurance underwriters will use historic data rather than climate models. In other words, time series analysis provides more information about the underlying risks in a region than do climate change models. Climate change models are not reliable for pin-pointing what is going to happen within a region. Insurers already develop and price insurance against regional climate anomalies such as drought, flood, sustained, extreme temperatures, and cyclone risks using historic data. Thus, underwriting these and other climate anomalies in new regions including for longer time horizons is possible. A second consideration is the feasibility of these new potential markets. Here we organize three challenges to climate insurance and provide anecdotes to illustrate each.

Theme One — Management Decisions Affect Climate Vulnerability

Vulnerability to regional climate anomalies is not only a function of climate risk, but of the management choices of decision makers. The policy agenda to facilitate adaptation to climate change emerges from recognition that vulnerable decision makers are becoming more vulnerable due to changes in the climate and so these decision makers need to adjust their management decision to reduce their vulnerability. This relationship between vulnerability and management decisions is particularly important for policymakers to consider when encouraging the use of climate insurance. Some policies such as insurance premium subsidies have the potential to delay rather than encourage adaptation.

Many cases exist to demonstrate the changing vulnerability of stakeholders to climate risks due to land use and resource management decisions. At some risk of getting the story only partially right, we use the recent flooding in Thailand to suggest some problems. This event represents that largest insured payout for an emerging economy in history, at insured losses between USD 10 and 15 billion. Japanese manufacturing companies appear to have suffered the largest insured losses. Questions are being raised about why this happened. Estimates are that the rainfall event was somewhere between a 1-and-30- and 1-in-50-year event. Typically, engineers and risk manager would not locate valuable assets in a region where catastrophic flooding would occur with this frequency. The evidence is still being collected to understand this event more thoroughly, but it seems that the flood risk may have increased in recent years because to management decisions upstream: 1) increased deforestation leading to more water runoff, and 2) the increased volume of water held in reservoirs to serve irrigation needs, leading to more limited capacity to absorb excess rains

The extreme loss in New Orleans provides another illustrative story. While the levies were designed to withhold the force of a category five hurricane, they failed with a category three hurricane. Historic data were used by engineers to develop the design. Yet, over the past decades the marshlands surrounding New Orleans have changed — water levels have risen. Thus, the sea surge that accompanied a category three hurricane was enough to create catastrophic failure.

Theme Two — Insurance Is Infeasible for Probable Events

Insurance can help decision makers better understand their risk. Insurance provides the additional benefit of giving risk an explicit price in the production process. Insurance becomes a potential cost of a certain production strategy. Typically, when risky events become frequent, e.g., with a probability of 1 in 5 or more frequent, adopting alternative production strategies will be more efficient than insuring the status quo. As a result, insurance markets for highly probable events do not develop.

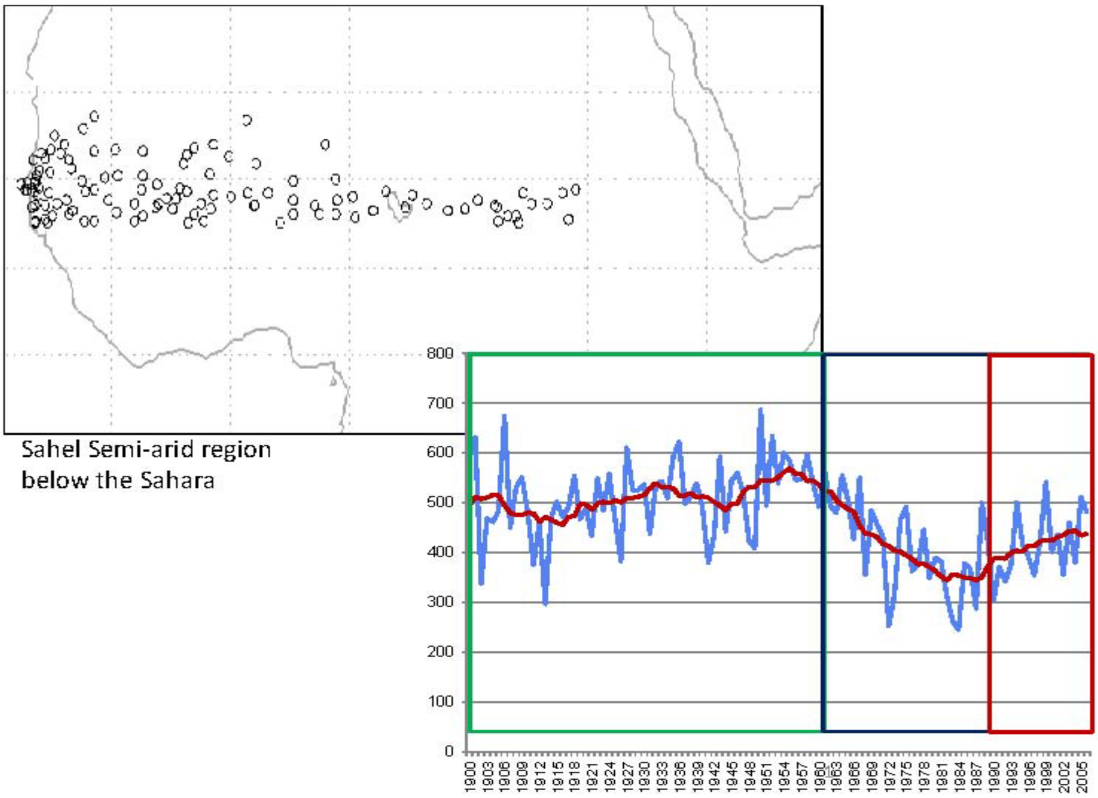
This concept has important implications for climate change. Highly probable events such as an increase in the average air temperature and rising sea levels (IPCC, 2007a) are not well suited for insurance. Probable events are properly addressed by investment and other forms of adaptation. The influence of climate change on regional climate anomalies (i.e., extreme events) does represent potential climate insurance markets.

In our collaboration in Vietnam with the Southern Institute for Water Resource Planning, we worked to use historic weather data to develop flood maps given the current infrastructure of dikes and canals. This was an important risk assessment process to learn more about the feasibility of creating a flood index insurance for the Mekong Delta that would pay when water crossing the border with Cambodia reached certain thresholds. This work reveled that there were areas under rice cultivation that would result in crop damage from flood 1 out of 3 years. We recommended that managing a risk event occurring at this level of probability is more efficiently done through adaptation than insurance. For example, these areas could be flooded and used for aquaculture. This risk assessment was performed in collaboration with a highly respected Vietnamese institution, and our recommendations motivated a considerable discussion among policy makers.

Theme Three — If Climate Change Increases Climate Risk, the Cost of Insurance Must Also Increase

In situations where climate change is systematically affecting the distribution of the climate risk, insurance does not protect decision makers from the cost of these trends. To illustrate some of the complexity of this story, we have previously used weather station data on annual rainfall across the Sahel supplied by the IRI at Columbia University (Collier, Skees, and Barnett, 2009). It is useful to reproduce that story here. Figure 2 maps the source of rainfall data from 1900 to 2007 for the Sahel region of Africa. Using a composite annual value of these stations, the time-series graph in Figure 2 shows some distinct and troublesome patterns in annual rainfall.

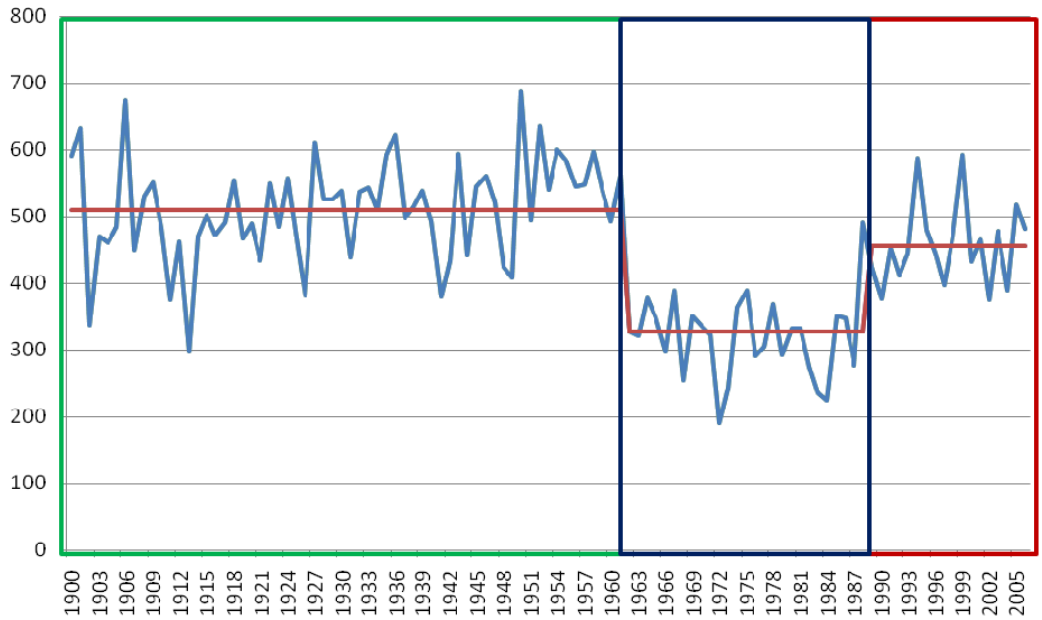
Figure 2 Regional Climate Variability for the Sahel, Africa



Source: Sahel data 1900 – 2007 Courtesy of IRI at Columbia University

In our previous paper, we developed three scenarios for the entry point of an insurance underwriter: 1) using data from 1900 to 1961; 2) using only data from 1962 to 1989; and 3) using only data from 1990 to 2007. In other words, we can assume that the insurance underwriter appears on the scene in 1963, 1990 and 2008 and has access to the segments of data that are separated by the lines in figure 2 (and described above). In the first time period, there are no discernible trends in the data. They can be used to develop a probability distribution function (pdf) and this pdf can be used to price any thresholds of a rainfall insurance contract. In the second time period (1962 to 1989) there is a distinct negative trend. The last time period has a positive trend in rainfall. After adjusting for trend, the three panels given the different vantage points (1963, 1990, and 2008) appear in Figure 3.

Figure 3 Adjusted Weather Data from Vantage Points (1962, 1990, and 2008)

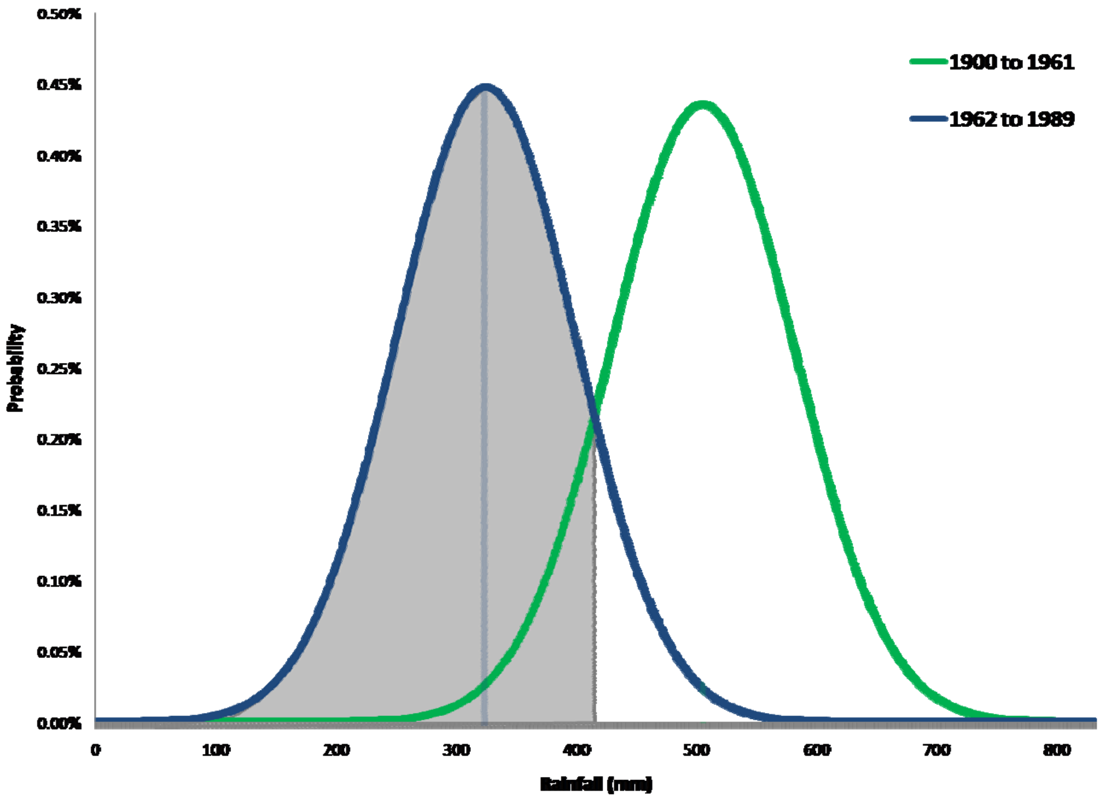


Source: Collier et al., 2009

To drive the point home for how these different vantage points would influence the insurance underwriter's view of the underlying risks (or the pdf), we simply fit a normal distribution to the data from figure 3, 1990 to 1961 and 1962 to 1989. The mean for the first data series is 510 mm. The mean for the second data series is 328. If one designed a weather insurance contract that paid for rainfall below 425 mm using a liner payout function, the pure risk for the first period is about 2 percent. That value jumps to 44 percent for the second period. Following Theme 2, this high level of risk is uninusrable.

While there may be some question about all of the underlying causes of this climate variability in the Sahel, Giannini et al. (2003) conclude that this pattern was largely due to interdecadal teleconnections. We have a great deal to learn about the climate. Certainly one would not want to have had rainfall insurance that was priced using data from the period of 1900 to 1961 by the 1970s and 1980s. Having such insurance that would have been clearly underpriced would have slowed the process of adaptation. By the same token, introducing premium subsidies to co-finance regional climate insurance would have the same effect — slowing adaptation. One value of regional climate insurance is that the price will communicate the underlying cost of risk and create even more information that may motivate different practices (e.g., adaptation).

Figure 4 PDFs Using Adjusted data from 1990 to 1961 and 1962 to 1989



Source: Collier et al., 2009

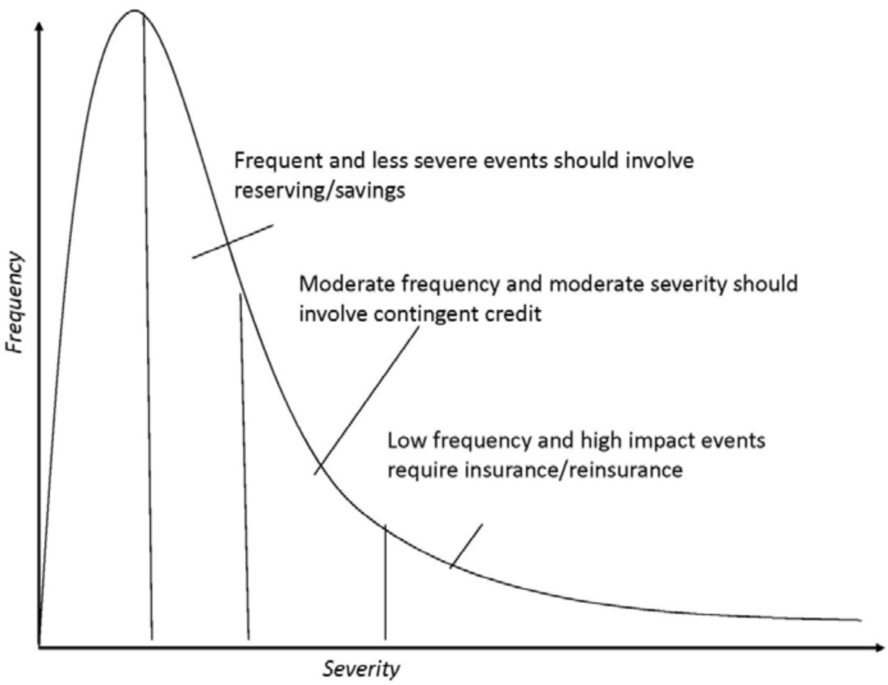
Besides illustrating these three themes, these cases emphasize an important point — using scientific knowledge with the lens of an insurance underwriter is a critically important activity in its own right. It can inform better policy and better risk management decisions. In some cases, the risk assessment will demonstrate that insurance is not the answer. Still, as will be demonstrated, regional climate insurance can and should play an important role for as a larger portfolio approach to ex ante financing in many cases and for a wide range of stakeholders who are negatively affected by extreme regional climate anomalies.

Core Principles for Ex Ante *Financing of Natural Disasters*

By this point, it should be clear that some extreme climate events are uninsurable. If it the event is going to happen on a frequent basis, insurance is going to be too costly and other solutions are in order (e.g., adaptation where practices are changed to face the realities of the climate). Another scenario that can emerge involves the quality of forecast data. With proper sales closing dates, this problem can be address. This latter point is extremely important as the value of forecast information about pending regional climate anomalies improves. If the insured or the insurer can use forecast information to adversely select on the other party, the insurance will also not be sustainable. There are numerous examples of agricultural insurance where this is a problem. Luo et al. (1994) demonstrated that the 90 day forecast from the climate prediction center of NOAA which was released on April 1 had valuable information for U.S. farmers to adversely select on the U.S. crop insurance. As a consequence the Federal Crop Insurance Corporation moved the sales closing date from April 15 to March 15. Thus, insurance can be designed so that forecast information does not give either party an advantage. It is a matter of knowing the lead time on the information.

Financing economic losses tends to be most efficiently done through a combination of savings, credit, and when appropriate, insurance. Layering risks with this framework has become a standard recommendation by the World Bank, among others. Figure 5 provides a graphical depiction of these different approaches to financing losses using a probability distribution. Think of the median value as the most likely rainfall levels and for simplicity, the optimal level of rainfall for our production strategy. With any level of rainfall above the median, there will be some level of economic loss. Thus, in the first range of excess rainfall, the losses are frequent and less severe. For this level, reserving or savings tends to be the most efficient choice. As the levels increase to moderate and moderately severe events, managing losses with credit becomes more efficient. In this framework, insurance is most efficient for low-frequency and high impact events.

Figure 5 PDF Demonstrating Layering Risk Financing Solutions



Source: Authors

Finding Solutions

As part of the process to finding solutions to extreme regional climate anomalies, a risk assessment must involve proper consideration for how the losses and consequences associated with these events are absorbed by a wide range of stakeholders within society. Somebody pays, whatever the economic or political structure.

- **Governments** pay with disaster relief and recovery expenses, destroyed infrastructure, macro-economic instability, social unrest, downgrades in sovereign credit ratings, etc.;

- **Communities** pay as infrastructure breaks down, economic growth slows, and poverty increases;
- **Households** pay (and particularly poor households pay) through asset and income losses, breakdowns in social safety nets, trapping larger numbers in poverty, and indirect economic impacts (limited access to finance) that slow growth;
- **Private companies** pay as transportation systems are disrupted, factories are damaged or destroyed, supplies of important inputs are disrupted (e.g., agriculture), value-chain linkages are disrupted, etc.; and
- **Financial institutions** pay with capital losses, large increases in nonperforming loans, disruptions in liquidity, and reduced opportunities to lend.

Sovereign Risk

A major focus from the Development Finance Institutions (DFIs) has been the fiscal exposure that is created by natural disasters in developing economies. The fiscal consequences of an extreme event for a developing economy are generally much larger than they are for a developed economy. One metric used to measure the relative potential impact of an event is to consider the estimated damage as a percent of the domestic output. Hurricane Katrina is the most costly event in U.S. history (about USD 150 billion in losses). This represented about 1.2 percent of the U.S. GDP in 2005. By contrast, St. Lucia suffered losses of about USD 1 billion in 1988 as result of Hurricane Gilbert. This event represented 365 percent of the GDP for St. Lucia in that year (Cummins and Mahul, 2008). In recent years, DFIs have explicitly placed natural disaster risk into their planning when making loans to developing economies. There are good reasons. When a natural disaster strikes, it can be difficult for the country to repay loans to DFIs. Forgiving sovereign debt has been a common response. This practice creates perverse incentives; moral hazard on the part of the country-state as it grows to depend on this practice which, in turn, reduces its incentives to become pro-active in planning for natural disasters. Additionally, if these events are not planned for, funds that were targeted for other development projects will be diverted to coping with the natural disaster.

Regional and Community Risk

Localized disasters can have dire consequences for regions within countries and for communities. Natural disasters can affect the expenses, assets, and incomes of regional and local governments. These governments have responsibilities to their citizens when a natural disaster strikes which can include providing food, shelter, medical supplies, household evacuation, etc. Sudden onset disasters such as cyclones, earthquakes, and floods also destroy government assets such as buildings; roads; bridges; electric, irrigation, drinking water, and sewage infrastructure, etc. Concurrent to these increased expenses and asset losses, local and regional governments can expect reduced tax revenues due to the income disruptions of their citizens.

Communities suffer as a result of disaster risk. Vulnerability to disasters can prevent private sector investment in some communities. When disasters occur, social risk sharing and safety net arrangements that work effectively for idiosyncratic risks (e.g., death of a household breadwinner) can be quickly overwhelmed by all the needs in the community. For example, during extreme El Niño events in Peru, some rural communities were isolated for months because roads and bridges were destroyed, leading to food shortages. Some disasters can increase the incidence of water-borne illnesses such as typhoid and illnesses carried by pests such as malaria and dengue fever.

Household Risk

Of course, it is individual households that suffer as a result of the effects on communities described above. Households also suffer in a number of others ways because of disaster risk. Vulnerability to disasters can limit or prevent household access to financial services and integrated supply chains. Vulnerable households also sometimes manage production risks in ways that greatly reduce their expected returns. For example, Rosenzweig and Binswanger (1993) estimate the opportunity costs of the low-risk, low-return portfolio choices of Indian farmers and found that these strategies reduce expected returns by 30 percent.

When disasters occur, they can reduce household income, increase their expenses, and destroy their assets. Each of these effects, especially asset destruction, greatly disrupt their progress in generating wealth and improving household quality of life, and households productivity can be compromised for years after an event, or even permanently (Carter et al., 2007).

Private Company Risk

Firms are less productive because of disaster risk. Many firms have new production opportunities due to the increased integration of developing economies into global supply chains in recent years, yet vulnerability to disasters affects who can participate in international markets and under what terms. The ability to provide a commodity at a consistent quantity and quality can be particularly important in these networks. Risks of disruption in this supply tend to reduce outside investments and production contracts for vulnerable firms. When disasters occur, private firms an also expect reduced income, increased expenses, and potentially asset losses.

Financial Intermediary Risk

Financial Intermediaries (FIs) are especially sensitive to natural disaster losses because they tend to be more highly leveraged than other firms. As a result, when a disaster occurs and borrowers cannot repay their loans, lenders' capital can become critically low. Disasters can also create liquidity problems. Depositors withdraw savings to manage disasters, and in some cases, depositors can lose confidence in the FI, leading to bank runs. The FIs that survive the disaster and are not recapitalized by their equity holders must slowly rebuild their capital bases through retaining earnings and making fewer loans, a process that can take months or even years. While the supply of credit shrinks during this time, the demand for credit increases because households and firms need funds to recover and rebuild after the disaster.

As a result, vulnerability to disasters sometimes prevents FIs from investing in regions or economic sectors that they deem particularly risky. Some of these sectors, such as agriculture, may be quite profitable in nondisaster years and so opportunities to enhance the ability of FIs to manage disaster risks may facilitate economic growth significantly.

Vulnerability to disasters can also limit the ability of FIs to attract and maintain investors. For investors, the prospect of working with a new FI represents a set of fixed costs because of the courting, vetting, and due diligence costs investors incur when building a relationship. Questions about the long-term viability of a vulnerable FI will tend to reduce investor willingness to take on these fixed costs. When investors are willing to take on these costs, the risk profile of the FI can be expected to alter the terms of investment, e.g., increasing the cost of funds or reducing FI capital, and so limiting its outreach.

A Brief Inventory of Innovative Projects

Table 1 provides a sample of some innovative projects that are underway to address the problem of natural disasters for different stakeholders. This is by no means an exhaustive list of projects. Surminske and Oramas-Dorta (2011) document over 100 schemes. They identify 19 schemes that cover a single hazard and 74 schemes that cover multiple hazards. The vast majority of these involve agriculture (about 25 index-based projects and 40 indemnity based projects). At the moment, we have included Annex A to provide a stronger context for our views about the role of index insurance. Later the themes will be weaved into this document to make a more coherent story.

At this stage of development, some of the most progress has been made at the institutional level with projects that deal with sovereign risk of governments. We don't want to leave the impression that this will always be the entry point for innovation. However, as will be developed, what is happening with the architecture that was build with the Caribbean Risk Insurance Facility for other sectors (households, banks, agriculture, etc.) is a good example of how to build on a strong foundation. We are working in much the same fashion in Peru which is also explained below. However, in the case of Peru, the biggest climate risk (extreme El Niño) provided an entry point for working first with the markets and more recently with the government to transfer risk. The same approach of building a strong foundation with the legal and regulatory work and the access to a sustainable market was used in Peru. When one reviews the vast majority of household products, serious questions must be raised about the scale and sustainability of these efforts (World Bank, 2011; GlobalAgRisk, 2011).

Table 1 Sample Instruments and Sample of Innovative Projects

Who Is Vulnerable?	Sample Instruments	Sample of Innovative Projects
Governments National Regional Communities	Reserve Funds CAT Bonds Weather Derivatives Index Insurance	Mexican FONDEN Caribbean Risk Insurance Facility (CCRIF) African Risk Capacity for Food Security (ARC)
Households (Especially the poor)	Traditional Insurance Index Insurance	Malawi Haiti Fonkoze Ethiopia HARITA Mongolia IBLIP Kenya Indonesia Vietnam
Private Companies Agricultural Energy Transport	Traditional Insurance Index Insurance	Peru Extreme El Niño Insurance Private Weather Derivatives
Financial Institutions MFIs Banks Insurance Companies	Traditional Insurance Index Insurance Reinsurance	Peru Extreme El Niño Insurance Philippines Tropical Storm (GIZ) Ghana Index Insurance (GIZ)

Source: Authors

Innovation in Managing Sovereign Risk

Classic insurance text books emphasize that a pre-condition of insurance is that the risk being insured must be independent (e.g. auto insurance, life insurance, accidents, etc.). Basic statistical aggregation properties demonstrate that the variance of the pool will be lower than the variance of the individual being insured. These properties allow insurance to provide an efficient mechanism for society to share risk. When insuring natural disasters such as extreme regional climate anomalies, the basic principle of independent risk breaks down; losses will be highly correlated and if a geographically concentrated insurance company attempts to insure such events they will face serious solvency issues if they go it alone In the developed world, insurance companies have used a variety of mechanisms to assure solvency when writing policies that pay when there are natural disasters. For example, U.S. insurers provides who sell property and causality insurance will share the premium with global reinsurers who then develop a portfolio of catastrophe risk; making what is highly correlated risk fit the principles of independent risk. To be sure, this process involves relatively high transaction costs as reinsurer must evaluate the policies offered by each insurance company that they reinsure.

In the past 15 to 20 years, Alternative Risk Transfer (ART) mechanisms have emerged to share catastrophe risk associated with natural disasters. The emerging of Catastrophe Bonds that involve largely institutional investors sharing in a risk that is not correlated with equity markets is the most striking example. This evolution involves a convergence of capital and reinsurance markets. Cummins (2008) concludes "CAT bonds have grown to the extent that they now play a major role in completing the market for catastrophic-risk finance (p. 23)." This major development promises to give access to significantly more capital for natural disasters. CAT bonds also represent some of the first significant activity at using parametric measures as the basis for transferring risk (e.g., earthquake Richter scale measures, wind speed, etc.).

Innovation in Turkey — Turkish Catastrophe Insurance Pool (TCIP)

Insurance markets for catastrophic events have taken time to develop in the developed countries. They are only in their infant stages in developing economies. One of the first global efforts at creating a Country insurance pool in a developing economy occurred after the 1999 earthquake in Turkey. The Turkish Catastrophe Insurance Pool (TCIP) was created in 2000 (Gurenko et al., 2006). The World Bank was involved in providing technical assistance that included organizing the concepts of aggregating and pooling risk across local insurance companies to gain better access to global reinsurance. By pooling risk and have a larger transaction, the TCIP was in a better position to obtain improved pricing on reinsurance versus having each insurance company approach the reinsurance market with smaller and more geographically concentrated transactions. The TCIP was the first project where the World Bank entered an agreement to provide contingent credit to backstop extreme losses that would not be covered by retained premiums, reserving, and reinsurance.

Innovation in Mongolia — Pooling Index-Based Livestock Insurance (IBLI)

Next this learning was extended with the Mongolian Index-based livestock insurance project (IBLIP) as the government of Mongolia and the World Bank entered into a project to pool losses from the IBLIP for participating insurance companies. Importantly, this project also included contingent credit for losses from the pool that could not be paid by the retained premium and some up-front reserving from participating insurance companies. The project has now attracted global reinsurance to cover a certain layer of risk. Thus, in turn, the pool premium with some reinsurance premium in the pool acts as the first funding to pay for the pooled losses across Mongolia; next the global reinsurer pays for a layer of losses, and finally the contingent credit is used to pay for losses that cannot be paid in these other steps. Again, reinsurance cost is reduced by creating a structure that pools the risk across the country and effectively organizes a layering of risk (Maul and Skees, 2006).

Recently, the experience of using contingent credit to backstop extreme losses from natural disaster has been institutionalized within the World Bank with what is the Catastrophe Deferred Drawdown Option or CAT DDO.[4] CAT DDO allows countries to have quick access to financing immediately following a natural disaster. There must be a declaration of a state of emergency and the country must have a disaster risk management plan. CAT DDO is limited to either $500 million of 0.25 percent of the countries' GDP. Thus, CAT DDO is basically designed to provide short-term liquidity for emergency response and it is not meant to provide funding for reconstruction. More typical World Bank loans can be used for that purpose.

Innovation in Mexico — MultiCat for Sovereign Risk

As these experiences have evolved, Mexico has been a leader in taking action on using risk financing strategies to manage their own fiscal exposure to natural disasters. Mexico is exposed to catastrophes

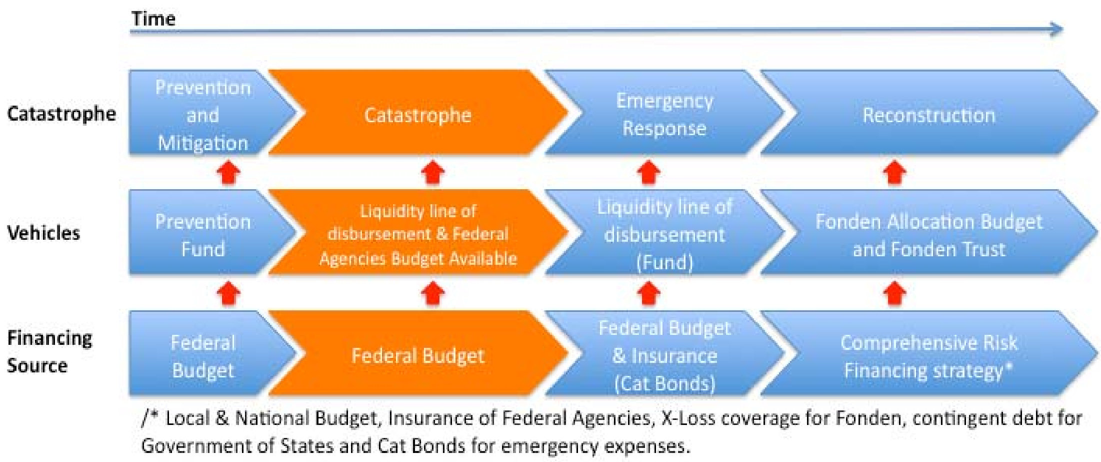
[4] http://treasury.worldbank.org/bdm/htm/risk_financing.html

with tropical storms from both the Atlantic and Pacific. Additionally, it is one of the highest seismic zones in the world as it is located along the world's 'fire bet' where 80 percent of the world's seismic and volcanic activity takes place. The catastrophic earthquake of 1985 was the catalyst for Mexico to begin public polices to plan for financing natural disasters. That event killed 6,000 and had direct losses of about USD 8 billion in 2011 dollars (Cardenas, 2012). Mexico developed a dual structure: First, the government created a regulatory framework for an ex ante strategy for catastrophe preparedness and emergency management. This included an interlinked system which coordinates national agencies, regional governments and municipalities, headed by the Ministry of the Interior. Next, Mexico focused on creating innovative financial risk management strategies that would be focused to cover sovereign risk (fiscal exposure). This was focused on expenses for public infrastructure, emergency expenses, and strengthening innovative for financial mechanisms like using weather index insurance for smallholder agricultural producers.

Sovereign risk financing of Mexico against natural disasters could be understood in the following three stages (in Figure 6, these stages are illustrated beginning from the bottom):

1. Financing source: the Mexican government has created a set of funding sources, which are activated before, during and after a catastrophe. Funding sources are strongly supported by federal budget (FONDEN), insurance, catastrophe insurance, CAT Bonds, and contingent debt for States with federal guarantees. Each of these sources of financing are layered to achieve the most cost effective and efficient financing solutions possible.
2. Vehicles: "for the Mexicans it is clear that it is not enough to have the money on the table if you do not know how to spend it efficiently". Thus there are a set of financial and regulatory vehicles; which are mixed with structured insurance products, altogether creating a solid source of funding.
3. Catastrophe: Once that the catastrophe has occurred (even before during prevention activities projects) through each vehicle starts a flow according to the financing needs (emergency expenses or reconstruction).

Figure 6 Three Phases of Sovereign Risk Financing against Natural Disasters, Mexico



Source: Secretaría de Hacienda y Crédito Público (SHCP), México

Innovation in the Caribbean (Caribbean Catastrophe Risk Insurance Facility – CCRIF)

The first multi-country risk pooling facility begin in the Caribbean in 2007. The small country states in the Caribbean are highly exposed to hurricanes and earthquakes. Since 1970, the *average* losses per year have been about 2 percent of GDP. As mentioned previously, in some of the most extreme events have exceeded the country GDP. Four needs are being addressed by the CCRIF: 1) high vulnerability; 2) low insurance coverage; 3) the need for immediate access to financing; and 4) the large fiscal exposure for smaller nations with high debt that can't afford to self insure (Simon 2011a).

The CCRIF uses parametric insurance to provide the basis for financing the extreme risk represented by hurricanes and earthquakes. There are currently 16 participating countries that must pay initial membership fees. In the case of the CCRIF, the facility was capitalized by donors to provide the first protection against the first layer of risk (more frequent and less severe events. The facility is operated as a not-for-profit entity with each government paying a premium related to their exposure and the amount of sum insured they take on. The benefits are that this form of risk pooling allows for diversification of the risk as a group of country states. This allows for better access to reinsurance and better pricing. The fact that parametric triggers are used also improves the transparency of the system and gives the added advantage of rapid payouts.

The CCRIF has not been without problems. There have been events where the parametric insurance design did not match the losses. Adjustments are being made and with better scientific information and other financing mechanisms to manage this form of 'basis risk' one can expect that these problems will be less serious in the future.

Of significant interest to the themes of this paper, the architecture provided by the CCRIF is now being used to expand access to catastrophe insurance to other stakeholders (beyond the sovereign risk of the country states). The German Environment Ministry (BMU) along with the Munich Climate-Insurance Intitative and MicroEnsure are now taking a multi-sectoral approach to protect livelihoods of households and to work toward providing insurance opportunities for other important sectors (e.g. agriculture, agri-finance institutions, and lender portfolios for other financial institutions). At the mico level, this activity has linked to a financial institution – Fonkoze. When an event triggers, the group-lending model is used as clients submit their claims through their Solidarity centers. The basic principle is that the group will have the discipline to rank members who suffer the greatest loss. The aggregate index finances the losses and Fonkoze reimburses clients suffering losses via their loan balance at a flat rate which is equal to about USD 125. This innovation is certainly interesting and worth further investigation. Questions to be pursued must be the longer term sustainability of such systems and the legal and regulatory requirements needed for consumer protection and to assure solvency of the financial institution.

Multi-Country Innovations Underway

The World Bank is heavily engaged in attempting to replicate the CCRIF for Pacific island states. Additionally, the World Food Program and the World Bank are working with an African Risk Capacity system to replicate the concepts of multi-country risk pooling for drought events that create serious food security problems in many African nations[5].

Lessons Learned and Logical Extensions — The Case of Peru

This section describes the potential for insurance markets to address climate conditions more directly than is possible with weather insurance products. Again, in the case of Peru the work started by focusing on stakeholders in the market (financial institutions, value-chain firms, fisheries, etc.) and,

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[5] More will be developed on these initiatives in the next version of this paper.

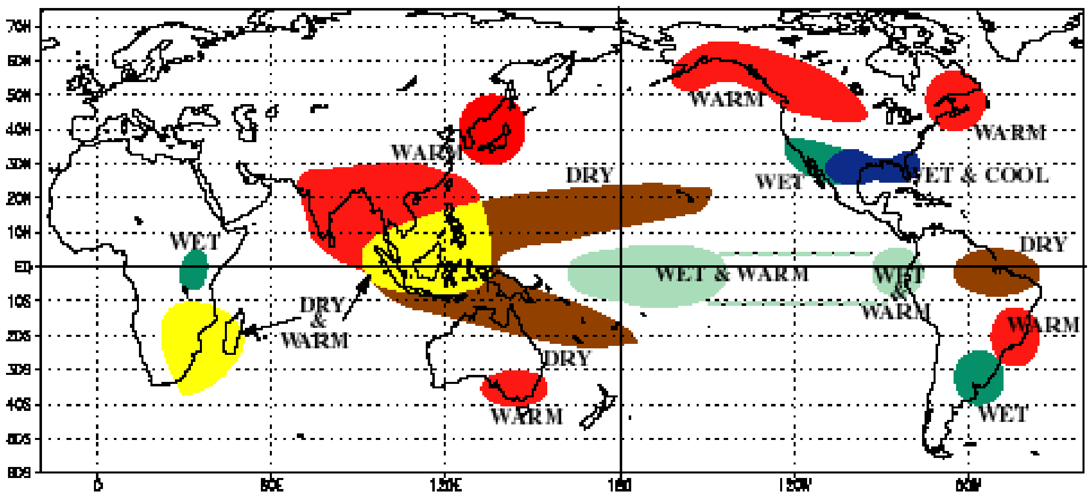
only recently has the same instrument been presented to the national and regional governments as well as local entities like municipal water treatment plants.

In Peru, there is another important distinction. It is here that we have developed the first regulated forecast insurance as a mechanism which may be used to facilitate adaptation to regional-level climate change. Forecast insurance would make a payment based on a forecast of regional climate conditions, and this payment could be used by the insured to alter its production strategies. Forecast insurance may create opportunities for adaptation that would not occur given discrete forecast information and insurance products.

Teleconnections and Opportunities for Forecasting

Climate researchers are increasingly recognizing the importance of teleconnections in explaining regional climates. Teleconnections describe patterns of atmospheric pressure and the flow of ocean currents which drive climate conditions on a global scale. The most prominent is the El Niño Southern Oscillation (ENSO) which influences regional climates in many parts of the world (Figure 7 shows the influence of El Niño events); other important teleconnections include the North Atlantic Oscillation, which influences rainfall and temperatures in Western Europe and West Africa; the Arctic Oscillation, which affects winter conditions in many areas of the northern hemisphere; and the Indian Ocean Dipole, which influences the monsoon season in India and rainfall in Australia and Southeast Asia.

Figure 7 NOAA Map of Areas Influenced by El Niño



Source: http://www.srh.noaa.gov/mfl/?n=winteroutlookforsouthflorida

Because of the causal relationship between teleconnections and regional climates, teleconnection data can be used to forecast regional conditions. Forecast information creates important production enhancing opportunities. In theory, forecasts help producers update the probability of different weather outcomes so that they can adjust production strategies accordingly. This information helps producers move from a production strategy based on a (potentially large) set of possible outcomes to more specialized production strategies based on a subset of these outcomes.

Experience with disseminating forecasts has been mixed. A number of projects have tested disseminating model-based regional climate forecasts in developing countries. Two general challenges emerge from this work 1) limited uptake of forecast information among potential users, and 2) limited capacity to use forecast information strategically. Regarding the former challenge, limited uptake of forecast information, some studies have recognized that indigenous forecasting methods can crowd out demand for model-based forecasts. Education is a positive predictor of the use of model-based forecasts, and increased applications for model-based applications are likely to increase their use (Luseno et al., 2003). Regarding the latter challenge, limited capacity to adapt, agricultural producers cite limited degrees of freedom in adjusting their production strategies given the land and equipment that they possess and the timing of the forecast, but also note that adaptation is significantly hindered by access to funds as many producers are credit-constrained, especially when forecasts predict undesirable outcomes such as drought that reduce lender willingness to extend credit (Ingram et al., 2002). In some cases, producers limitedly used forecast information to make adjustments, indicating reluctance among producers to rely on forecasts.

Much of this research has focused on the potential use of forecasts by households; however, forecast information may be relevant to decisions many decision makers. For example, Everingham et al. (2002) describe opportunities to use forecast information to enhance productivity at each stage of the sugarcane value chain. Also, Goddard et al. (2010) describe how the International Federation of Red Cross and Red Crescent Societies has used probabilistic forecast information to organize and deploy resources for disaster relief before the disaster occurred.

Forecast Insurance: Enhancing Opportunities to Adapt

Forecast insurance may combine the benefits of insurance and of forecast information to create additional opportunities to adapt. Forecast insurance would make a payout based on a forecast of regional climate conditions. This forecast could be based on the measure of an important teleconnection, which is the design of the El Niño insurance in Peru (described below), or it could be based on a model that combines information from several indices. The insurance would increase the funds of the insured as adverse conditions developed locally, and those funds could be used to adjust production strategies.

Forecast insurance may be particularly important in the context of climate change. Because teleconnections have a longer time-horizon of annual or even multiannual cycles than discrete weather events, insuring against their extreme oscillations may facilitate longer-term adaptation strategies. In other words, it provides opportunities for more permanent adaptation decisions as an extreme event emerges. For example, producers planning to lose increasingly vulnerable perennial crops (e.g., fruit trees) might use an insurance payout to begin planning a switch to a production strategy more appropriate to emerging conditions. Forecast insurance also has the positive externality of providing a market price for the regional climate risk. In situations where undesirable climate conditions are becoming more frequent or severe, the price of these changes should be reflected in insurance premiums, improving producer information regarding the tradeoffs of adaptation.

An additional externality of forecast insurance is that it is likely to improve the information provided by forecasters. Currently, reviews regarding the use of forecasts note a mismatch between the information that potential forecast users want and that provided by forecast scientists (Goddard et al., 2010). Forecasts are only worthwhile if they change behavior, and forecast insurance will only be purchased if the forecasts are relevant to the exposure of the target market. Forecast insurance should benefit scientists by increasing the value of their information and by motivating private-sector investments in forecast to support expanding insurance markets. Thus, forecast insurance could motivate market forces to direct investment toward more relevant forecasts for end users.

Insuring against Extreme El Niño in Peru — A First Test in Forecast Insurance

Perhaps nowhere in the world is the relationship between a teleconnection and local climate conditions more acutely felt than in northern Peru. ENSO describes the air circulation and ocean flow patterns across the equatorial Pacific. El Niño events occur due to a disruption in those patterns and are associated with warming in the Pacific sea surface temperature (SST). This warming increases convection and this warm, moist air meets the cold air descending the Andes in northern Peru, causing heavy rains in northern coastal regions (McPhaden, 2002).

In living memory, several extreme El Niño events have occurred as a result of very warm SSTs with devastating consequences for northern Peru. During the extreme El Niño events of 1983 and 1998, rainfall was roughly 40 times normal levels from January to May, causing catastrophic flooding. Extreme El Niño washes out roads and bridges, inundates crops, destroys homes and businesses, disrupts markets and government services, closes ports, and increases pest and disease problems.

The risk of extreme El Niño limits business opportunities, slowing economic growth and perpetuating poverty in northern Peru. For example, El Niño risk affects credit expansion. After the 1998 El Niño, some lenders decided to avoid certain vulnerable regions and economic sectors, such as agriculture. Additionally, El Niño risk seems to limit the integration of smallholder households into international agricultural value chains and affect the contracts of exporting firms in the region.

Extreme El Niño events are forecastable. During the 1998 event, the Peruvian government posted official warnings of an impending event as early as June 1997, over seven months before heavy rainfall would begin. Surveys conducted with households in the region suggest that roughly 60 percent of the population had received forecast of an impending El Niño by June 1997 (Orlove et al., 2004). Forecasting information becomes stronger moving closer to the event and forecasts in Peru moved from forecasting the presence of an impending El Niño to estimating its magnitude. Households reported making many risk mitigating investments such as securing their homes for heavy rainfall, even in a period where households expected reduced incomes due to the impending disaster (Orlove et al., 2004). In our more recent interviews with households and firms, they offer many additional strategies that would help them mitigate their losses due to El Niño. For example, agricultural producers often report that cleaning and enhancing the drainage infrastructure in their fields would reduce their extreme El Niño losses. These stakeholders also note that a lack of access to funds severely limits their opportunities to adapt.

The financial intermediaries (FIs) providing financial services to households and firms in the region also use forecast information to manage their portfolio. In our analysis of the 1998 El Niño, we found that one lender was restructuring loans in December 1997, weeks before catastrophic flooding began (Collier et al., 2011). Moreover, FI managers report that one strategy to manage their exposure to extreme events is to reduce lending based on El Niño forecasts. While such a strategy is an understandable business practice, reducing credit in the community just before the disaster further limits adaptation opportunities.

Forecast Insurance against Extreme El Niño

With initial funding from USAID, GlobalAgrisk begin work in Peru in 2004. The focus was to be on developing index insurance for agriculture. We quickly learned that extreme El Niño events would make it impossible to develop sustainable agricultural insurance. The lead time for forecasting when an extreme event would occur did not match sales closing dates for any agricultural insurance products – introducing the clear opportunity for adverse selection. Further, we learned that agricultural insurance was being developed in the mid 1990s. When the extreme El Niño of 1997-98 occurred all efforts stopped as there was not adequate reinsurance to pay all losses. For these reasons our attention turned to extreme El Niño events. We developed an insurance product for extreme El

Niño events based on the SST, which is the key metric that climate scientists use to identify the severity of El Niño. Because SSTs predate the torrential rains and catastrophic flooding in the region, we designed the insurance to pay *before the disaster begins* — the current version of the insurance pays in January and during the 1998 El Niño flooding began toward the end of January or early February. The Peruvian insurance regulator has approved the product. Thus, to our knowledge, this El Niño insurance is the first regulated forecast insurance in the world.

We have been working with supply-side stakeholders to facilitate a market for El Niño insurance in Peru. The insurance is being offered by a Peruvian insurance company with reinsurance from an international reinsurer. To increase market supply, we have met with brokers, insurers, and reinsurers and many have expressed enthusiasm for El Niño insurance. Some of these supply-side stakeholders are working diligently so that they can participate in this market. Reinsurers in particular are excited because not only does El Niño insurance facilitate their access to an underdeveloped insurance market in an emerging economy, but extreme El Niño events are negatively correlated with hurricanes in the Gulf of Mexico and eastern seaboard of the U.S. (Elsner, Bossak, and Niu, 2001; Pielke and Landsea, 1999; Saunders et al., 2000; Tartaglione, Smith, and O'Brien, 2003). Thus, El Niño insurance represents a natural hedge to the biggest financial exposure of the reinsurance industry.

Potential Uses of Forecast Insurance against Extreme El Niño

Extreme El Niño events are devastating enough that they affect every stakeholder that we identified earlier. Thus, we have also worked to extend El Niño insurance to target markets including the national government, government agencies, firms, and households. Our work with governments is consistent with the sovereign risk discussion above as we have worked with the Ministry of Economics and Finance in Peru to identify national-level planning. We have also worked with local and regional government agencies such as the civil defense and water and sanitation authorities. We have also researched and made recommendations for ways to develop El Niño insurance markets for households.

Perhaps some of the most noteworthy aspects of our work in Peru has been that conducted with firms, namely FIs and agricultural firms. We call these firms "risk aggregators" because the risks of the many households they serve accumulate into systemic problems for their operations.

Financial Intermediaries. FIs are especially sensitive to natural disaster losses because they tend to be more highly leveraged than other firms. As a result, when a disaster occurs and borrowers cannot repay their loans, lenders' capital can become critically low. The FIs that survive the disaster and are not recapitalized by their equity holders must slowly rebuild their capital bases through retaining earnings and making fewer loans, a process that can take months or even years. While the supply of credit shrinks during this time, the demand for credit increases because households and firms need funds to recover and rebuild after the disaster.

El Niño insurance can help by protecting bank capital. Insured FIs receive an insurance payout before the disaster occurs which can offset capital losses from borrower defaults. This payment protects the FI from insolvency and allows it to lend more heavily after the disaster. Moreover, the early payment based on forecast information may allow FIs to reduce their losses by adjusting their risk management strategies. For example, insured FIs could increase lending in the months leading up to an extreme El Niño for its borrowers to invest in adaptive strategies that reduce their losses. By reducing borrower losses, insured FIs should experience fewer loan losses from the disaster.

Recently, an FI in Peru started insuring its portfolio against extreme El Niño events in order to expand lending in vulnerable regions. The shareholders of the FI have given it a mission to increase financial inclusion in Peru, especially among the underserved rural poor. The managers of the FI recognized that El Niño insurance would facilitate that goal. We worked closely with this FI to analyze its risk and model the value of the insurance for its portfolio. Our modeling indicated that choosing a sum insured of approximately four to six percent of the value of the loan portfolio would lead to the best financial performance for the FI; however, because El Niño insurance is an innovative and untested mechanism, we suggested that partially insuring might be an astute strategy the first year and the FI decided to partially insure. Those analyses also indicated that the business opportunities created by the insurance protecting the capital base of the FI are greater than the cost of the insurance — that is, our modeling suggests that the insured FI should have a higher expected return and experience less volatility in returns.

Currently, we are collaborating with the FI to obtain formal recognition of the value of El Niño insurance from the banking regulator, credit rating agencies, and funders of the FI. Compared to managing its risk with capital reserves alone, the FI can demonstrate that El Niño insurance reduces its solvency risk and allows the FI to lend more consistently, increasing stability in the credit supply. We believe an appropriate response from banking regulators wanting to reward better systemic risk management would be to allow for such insurance mechanisms to count as a substitute for some portion of bank capital in calculating minimum capital requirements. From the perspective of investors, reducing the risk of the FI should result in lower borrowing costs.

Beyond Peru, we are working to extend these ideas to investors in microfinance. For example, we have been working in Indonesia where thousands of small FIs provide microfinance and are exposed to earthquakes. For portfolio-level insurance against disasters for FIs to be scalable, investors must capture a vision for the benefits of this improved risk management. From a social perspective, improving the resilience of FIs increases stable access to financial services for their clients, and as the case in Peru suggests, can increase access to financial services for vulnerable groups. From a financial performance perspective, each FI represents a sunk cost to investors because of the courting, vetting, and due diligence costs investors incur when building a relationship with a new FI. Thus, helping FIs become more resilient to disasters may increase returns for investors.

Agricultural Firms. The lessons learned from working in the agricultural value chain are perhaps less generalizable than those in the financial services sector due to differing production risks across commodities. One important theme that emerges from our collaboration with agricultural producers and exporters in Peru is the consequences of their risk management strategies on production investments. Some have noted that they hold up to 20 percent of their assets in cash to manage catastrophic climate conditions. For these highly productive firms, this risk management strategy comes at a high opportunity cost and could be managed more efficiently through insurance.

An example from our collaboration with a banana exporter demonstrates another interesting potential application of forecast insurance. The manager of this firm noted that she was concerned about maintaining her staff when production came to a halt during an extreme El Niño event. She noted that forecast insurance against extreme El Niño would allow her to keep these employees on payroll, and because production would be temporarily low, requiring fewer employees, she would send them to the fields to help farmers prepare for and recover from the event by cleaning and improving drainage systems and shoring up or repairing damaged roads on their farms.

Next Steps in Peru, Developing a Three-Year Contract

In the next stage of our work in Peru, we intend to develop three-year El Niño insurance contracts. ENSO has a cyclical aspect such that the conditional probability of an extreme El Niño event in the year after an extreme El Niño event is almost zero. As a result, we anticipate cyclical buying behavior from insureds. This cyclicality in demand creates a challenge for the market. A dynamic buying strategy also changes the risk profile of Peruvian stakeholders from one year to the next, which can affect their funding costs, investment opportunities, etc.

Instead, we believe a three-year contract may better serve this market. We are suggesting a contract in which the premium would be paid at the beginning of the coverage period and the insurance would protect the insured from a single extreme El Niño event over the life of the contract. This insurance would better match the risk perceived by borrowers and could be offered at a lower annualized premium rate. That insurance would also provide the insured with a more consistent risk profile than a one year contract that may be more attractive to longer term investors. By developing multi-year El Niño insurance, we intend for this coverage to be more relevant to long-term planning decisions that have a greater potential to be shaped by climate change.

Forecast Insurance beyond Peru

El Niño insurance is one type of forecast insurance tested in a single country. As we have already noted, the relationship between teleconnections and local climate conditions may be stronger in Peru than almost anywhere else. While we believe in the strong principles underlying forecast insurance as described above and are enthused by experiences in Peru, this research is at a very early stage and much needs to be done. In this section, we note some additional considerations regarding the opportunities and challenges of forecast insurance in other places and for other risks.

Demand Issues

Demand for forecast insurance is unclear. Arguably, the places where demand may be easiest to foster is in regions where firms and households already use teleconnection and forecast information. In some areas, the public already has some understanding of a direct linkage between the teleconnection, typically ENSO, and local climate conditions. For example, daily ENSO measures are reported by the media in some regions of Australia. In developing countries, a noteworthy example is drought conditions associated with ENSO that emerge in south-eastern Africa. Phillips et al. (2002) surveyed households in Zimbabwe before the 1998 El Niño. Ninety-five percent of participants reported hearing a forecast of the extreme El Niño event. Roughly 50 percent of those participants reported that they intended to change the crops they would plant, and 50 percent reported that they would change the area they planted based on this forecast. At the aggregate level, two of these regions reported areas planted that were 25 percent less than the average area planted in these regions. The influence of ENSO is not limited to Zimbabwe. Osgood et al. (2008) and Vicarelli, Osgood, and Giannini (2009) note that the influence of ENSO on rainfall in Malawi, Kenya, and Tanzania challenges the development and sustainability of drought insurance in these countries, which includes the possibility that households would use ENSO forecasts to adversely select to purchase insurance in El Niño years when payouts are more likely.

In other places, local awareness of model-based forecasts is increasing because models are continually improving and being used in new applications. For example, Soulza Filho and Lall (2003) and Lima and Lall (2010) use model-based forecasts to predict streamflow in Brazil, an important variable for access to drinking water, irrigation, and hydropower. Additionally, the Famine Early Warning Systems Network[6] is integrating a variety of data on climate, household and firm production, local market prices, and trade to forecast food insecurity in Africa, Central American, Haiti, and Afghanistan. This information is useful for governments and international agencies, but also has many potential applications for households and firms. There are many other examples of innovative applications of model-based forecasts (e.g., Sahai, Chattopadhyay, and Goswami, 2008; Luseno et al., 2003). As described above, forecast insurance could potentially complement some of

[6] www.fews.net

these applications and contribute to increased awareness and use of model-based forecasts in these regions.

Forecast Insurance and Basis Risk

Forecast insurance is a form of index insurance. Index insurance makes payouts on the measurement of an occurrence of an event. The specific event that the insured is insuring against is a forecast of adverse local climate conditions. One of the major limitations of index insurance is basis risk — the potential for a mismatch between the measurement of the event and the insured's experience of the event. Unlike other forms of index insurance, forecast insurance is not exposed to basis risk. Both the insured risk and the mechanism for determining payouts are a specific set of forecast conditions. As described above, for forecast insurance to work, potential buyers must recognize the value of the forecast and be making behavioral adjustments because of it. As a result, the forecast itself has consequences for insureds as it affects their behavior.

Tradeoffs in Forecast Insurance Design

Earlier forecasts provide greater degrees of freedom to potential users but also provide less skilled predictions. As a result a tradeoff exists between designing forecast insurance to make payments early enough to allow insureds to adapt in a variety of ways versus basing payouts on later forecasts that more accurately capture the severity of local climate conditions. These decisions will tend to be contextual and based on the opportunity sets of key target markets and the skill of the forecast. The El Niño insurance in Peru is designed to pay just as the disaster is emerging locally. In this context, insured estimate the amount they would like in the occurrence of a severe event and get the benefit of an early payout. In some cases, two insurance products might be preferred: one paying based on an estimate of the disaster, and another on the forecast. The two contracts approach would allow for the possibility of an earlier payment. The El Niño insurance market in Peru is still in its nascent stages and these mechanisms may evolve there.

Conclusions

This paper clearly identifies a need for innovation in *ex ante* financing of regional climate anomalies. As is clear, the same thinking — use a portfolio approach to layer risk and use different financing mechanisms — extends to other natural disasters like earthquakes. Insurance solutions are most certainly part of the solutions. However, as we emphasize, insurance does not always work, and if the extreme event occurs too frequently, other systems will be needed.

Furthermore, this paper focuses on clarifying how the term*, climate insurance*, should be used. Early on, we establish that financial markets are not suited to insure against long-term anthropogenic climate change. Nonetheless, the threat of climate change only serves to intensify the need to develop risk transfer markets given risk assessment with the current climate risk. The fact that climate also includes a spatial dimension that is quite important brings us to emphasize that climate insurance be about developing insurance solutions for regional climate anomalies. Working now to develop new solutions, such as insurance that uses reliable forecast to pay for highly likely regional climate anomalies, can build part of the foundation for adaptation to anthropogenic climate change.

The innovations underway and the challenges ahead leave many areas that merit greater attention. More thinking is needed to understand the role of contingent financing from the Development Financial Institutions like the World Bank. For example, while the World Bank Deferred Drawdown Option (DDO) is an exciting innovation, one would still need to carefully consider how and when to use it. There remains that possibility of creating moral hazard issues on the part of the sovereigns, and there may even be conflicts in advice provided by the World Bank as the incentives may be to use this option rather than other, possibly more efficient *ex ante* financing approaches. The question of how to crowd markets in with public-private partnerships is fundamentally important. It is also clear that the innovations underway were not going to emerge from the market in isolation. The transaction costs are too high and the protection of the early innovators' intellectual property remains a challenge. Thus, public investments carefully targeted to serve the public good aspect of market development are still needed, including efforts such as: the World Bank support for developing the CCRIF; funding for risk assessment and feasibility studies; investments in improved data systems; and public investment to clarify and standardize legal and regulatory issues with a better focus on emerging markets rather than developed markets. Finally, exciting economic work is ahead for gaining richer insights to conditions under which forecast insurance is likely to facilitate climate change adaptation. We intend to develop accessible, rigorous reports from these analyses that foster additional research as well as inform real-world applications. These results are intended to guide climate change adaptation priorities and private-sector investment decisions in insurance market development.

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New Approaches to Designing Index Insurance — Insuring against Consequential Losses[7]

Index insurance is an innovative risk transfer tool that has the potential to address financial market failures associated with correlated weather and natural disaster risks threatening the economic well-being of many rural communities in lower income countries. Translating its potential to markets continues to challenge practitioners despite nearly a decade of experimentation. GlobalAgRisk is preparing several themed briefs that propose new thinking and offer guidance to practitioners seeking to develop viable index insurance markets. These briefs draw from ideas presented in our state of knowledge reports funded by The Bill and Melinda Gates Foundation (see Box 1).

Box 1 Background Studies

GlobalAgRisk. "State of Knowledge Report — Data Requirements for the Design of Weather Index Insurance." Project report, Innovation in Catastrophic Weather Insurance to Improve the Livelihoods of Rural Households, The Bill and Melinda Gates Foundation, Seattle, WA, June 30, 2010; Revised November, 2011.

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GlobalAgRisk. "State of Knowledge Report — Market Development for Weather Index Insurance: Key Considerations for Sustainability and Scale Up." Project report, Innovation in Catastrophic Weather Insurance to Improve the Livelihoods of Rural Households, The Bill and Melinda Gates Foundation, Seattle, WA, November, 2010; Revised November, 2011.

Most index insurance applications in lower income countries to date have focused on insuring rural households against reduced yields for a single crop (or enterprise) in a single year. However, the effects of catastrophic weather often are more far-reaching — households and firms can suffer a broad range of losses and costs, not only in the immediate aftermath but also from reduced wealth positions in the long run. In this brief, we discuss a new approach to index insurance design that has the potential to address broader economic consequences of weather risk. Many of these concepts also apply to other natural disaster risks, such as earthquakes.

Although existing applications are too few to draw definitive conclusions, product designs that recognize the many consequential losses individuals and firms are likely to incur in the wake of extreme weather may offer greater value to a wider market compared to products that focus exclusively on returns from a single investment. In certain contexts, framing index insurance in this

[7] This briefing note was prepared by Nadezda Nikolova, summarizing key themes from GlobalAgRisk SKRs, with assistance from Barry Barnett, Jerry Skees, Jason Hartell, and Richard Carpenter, and is based on research funded by The Bill and Melinda Gates Foundation. The findings and conclusions contained within are those of the authors and do not necessarily reflect positions or policies of The Bill and Melinda Gates Foundation.

way could help stimulate demand. From a supply perspective, where applicable, a *consequential loss design* lowers data requirements and allows insurers to tap into a heterogeneous market, which can lead to greater market volume and increased potential for commercial viability. When the local context allows product developers to harness the different advantages associated with consequential loss design, the prospects for creating scalable and sustainable index insurance markets are greatly improved.

Index Insurance — An Introduction

Index insurance has been piloted in a number of lower income countries mostly as a means to help farmers manage their exposure to spatially correlated, catastrophic weather risk (see Box 2). In contrast to traditional agricultural insurance that indemnifies the actual losses a policyholder incurs, weather index insurance payouts are triggered when an index (that serves as an indicator of the insured risk) reaches a predetermined threshold (e.g., a rainfall level measured at the weather station). Basing payments on an index has many advantages compared to indemnity-based, multiple peril crop insurance. It eliminates the need for on-site inspections, expedites payments, and lowers transaction costs — especially in remote rural regions lacking transportation infrastructure.

Box 2 Poverty Implications of Unmanaged Weather Risk

In rural areas of lower income countries, formal insurance markets for transferring spatially correlated, catastrophic (low-frequency, high-consequence) events are sparse or missing altogether. Most natural hazard risks, including weather risks that result in multiple perils, violate the independence condition of insurability. This and other violations increase the marginal cost of insurance and reduce market supply. In lower income countries, insurance markets commonly fail due to a lack of effective legal systems to enforce contracts, covariate risk, asymmetric information, and high transaction costs.

Market failure has serious poverty implications. Unprotected communities suffer enormous losses of life, assets, and income in the wake of weather-related disasters. The poor are sometimes thrust into permanent poverty traps, having to liquidate productive assets to meet immediate consumption needs. Indirect consequences of unmanaged weather risk also play an important role in creating and perpetuating poverty, as businesses and individuals adopt costly risk management strategies in anticipation of future losses. Banks increase interest rates and ration credit to hedge against poor loan recovery during unfavorable years; farmers diversify into less profitable crops and forego investments in productivity-enhancing technologies. In turn, these low-risk, low-return behavioral responses to weather risk retard economic growth and reduce the resiliency of the local economy to future shocks.

Using an index also significantly reduces adverse selection and moral hazard problems related to traditional insurance. While spatial correlation causes traditional crop insurance to falter, it is a necessary condition for index insurance since it improves the likelihood that policyholders' losses will match the losses recorded by the index. Moreover, index insurance is uniquely positioned to transfer spatially correlated weather risk into global markets through private sector risk sharing mechanisms such as reinsurance and catastrophe bonds. For these reasons, index insurance holds considerable potential as a tool for poverty reduction and economic development in lower income countries. However, index insurance has important drawbacks. For example, practitioners must manage basis risk (see Box 3), while understanding that it as an inherent consequence of using index insurance and cannot be completely eliminated.

Box 3 Basis Risk

Basis risk, a well-known consequence of index insurance, refers to a discrepancy between payouts and losses: it is possible that a policyholder does not receive a payout and suffers a loss, or, receives a payout without incurring any loss. While a number of factors can cause basis risk (e.g., distance from the weather station, having another weather event that creates the loss, the insurance contract does not adequately capture the risk, etc.), one source that can never be eliminated arises from the very feature that makes index insurance so effective in the first place---using a third party measure, the index, to determine payments. Although small levels do not interfere with the effectiveness of the instrument, high basis risk can leave policyholders exposed to the insured risk and potentially cause them to be worse off than if they had not purchased the insurance. Demand for index insurance hinges to a large extent on its usefulness and credibility; therefore, although basis risk cannot be fully eliminated, efforts toward reducing it remain important.

Additionally, index insurance requires large start-up investments for product development, capacity building, and educational outreach, driven to a large extent by the reality that index insurance products must respond to a host of geographic, meteorological, cultural, economic, and institutional factors that vary greatly from one locale to another. The need to conform to the local context greatly limits the potential for creating a one-size-fits-all design that can be applied in diverse settings. With this caveat in mind, we discuss the relative merits and limitations of index insurance that mimics indemnity-based crop insurance and propose contexts in which a consequential loss design may prove more advantageous.

Index Insurance as a Replacement for Crop Insurance

Index insurance has been used in higher income countries as an alternative to traditional crop insurance programs beset by inefficiency problems and low participation rates. These early and ongoing applications in data-rich environments rely on aggregate loss indexes, which require area-yield measurements collected over time and with reasonable accuracy (see Box 4).

Encouraged by these positive results and the compelling logic that such insurance could reach small holders, the development community looked to index insurance as one answer to the agricultural insurance vacuum that has stymied progress in insuring crops in the developing world. In an effort to adapt index insurance to settings typically lacking reliable area-yield measurements, practitioners developed weather-based indexes. However, the emphasis on crop yields largely remained, and with it, the emphasis on direct losses in a single year. Hence, most index insurance applications in lower income countries focus on insuring rural households against reduced yields for a single crop.

Box 4 Two Types of Indexes

Index insurance products that offer protection from weather risk rely on two types of indexes: indexes that aggregate losses over a group (or aggregate loss indexes) and weather-based indexes. Aggregate loss indexes use regionally recorded losses, such as area yield or livestock mortality, as a proxy for the losses of individual policyholders in the group. The Group Risk Plan (GRP) in the U.S.\ uses historic county-yield data for a specific crop as the index for calculating payouts. The Mongolian Index-based Livestock Insurance (IBLI) uses government estimates of soum-level (county-level) livestock mortality by species. With these products, the large scale of aggregate data reduces the likelihood of any individual policyholder significantly influencing a payout.

Weather-based indexes use measurements of weather events that correlate with losses of the policyholder as the basis for an insurance payout. The weather index serves as an indicator or predictor of the risk event itself, e.g., rainfall measurements as an indicator of drought or flood. In lower income countries, weather data are often easier to obtain and may be less prone to manipulation than aggregate data on crop yields; thus weather indexes are used more commonly.

Crop-specific (or enterprise-specific) index insurance certainly has a place in managing correlated weather risk that creates catastrophic losses for individuals or businesses running highly specialized agricultural operations. For example, pastoralists in Mongolia, who depend on their livestock as a major source of food and income, experience livelihood-threatening losses when harsh weather destroys their herds. Therefore, index insurance that is livestock-mortality specific, such as Index-based Livestock Insurance supported by the government of Mongolia under a World Bank project where GlobalAgRisk has been actively involved, has the potential to addresses the largest source of risk Mongolian herders face. Another example is a drought product offered in Malawi to vertically integrated firms in the value chain that specialize in tobacco production. In addition, in settings where different enterprises are susceptible to different natural perils, enterprise or entity-specific policies may be the only viable option.

However, models focusing on a single enterprise such as crop yields may not be appropriate in all or even the majority of settings. One of the important advantages of index insurance is that it can potentially accommodate a wide array of applications. This is only possible, however, when the characteristics of the local context and the target market guide product design. Specifically, practitioners must: 1) recognize the geographic differences in household and business production activities, weather risk vulnerabilities, and the availability of weather and loss data; 2) identify and address catastrophic weather risk transfer needs that will enhance existing risk transfer mechanisms; and, 3) strive for innovation, but also recognize the bounds imposed by local institutions. Unless the target market and the local context play the determining role in selecting product design features, index insurance will either prove irrelevant to policyholders or face operational setbacks that might lead to project failure.

Potential Disadvantages of Tying Index Insurance to a Crop

Framing index insurance as crop insurance may be problematic for several reasons. First, index insurance that protects crop yields faces untenable basis risk problems when diversified farming strategies and data constraints render the index an incomplete proxy for loss. This will often be the case in lower-income settings, particularly for products targeting households.

Crop-based index insurance implicitly assumes that crop yields appropriately capture farmers' loss exposure. While this is generally true for higher income countries, it is less true for the developing world. Agricultural production in developed countries is highly specialized, characterized by homogeneous input packages and abundant data on farm yields and income. This ensures a high correlation between farm yields and the well-being of individual farmers and, hence, the effectiveness of the risk protection offered. Specialization, however, is more an exception than the rule in the developing world, while data constraints remain endemic.

Most households in lower income countries do not rely solely on income generated by planting a single crop. Rather, they tend to engage in multi-cropping and often have diversified livelihood portfolios that include labor activities other than farming. In addition, accurately linking losses to weather outcomes requires historical measurements on individual yields, which are simply not available in most lower-income settings. It is difficult to design an index that effectively proxies for insureds' losses in light of multi-cropping, income diversification, and data limitations. As noted, not having a contract that adequately captures the risks farmers face leads to serious basis risk problems.

In addition, attempts to make statistical inference on how an index relates to household losses while working with limited samples can further exacerbate basis risk and lead to potentially overselling the benefits of index insurance (see Box 5).

Second, tying coverage to a specific crop could limit market scope. Households that plant crops other than those targeted by the insurance, as well as non-farmers, such as shopkeepers and laborers, whose income is highly correlated with the insured event, are entirely excluded. In addition, crop or enterprise specific products exclude those risk aggregators that have risk exposures extending beyond failed crops.[8] Risk aggregators often face business interruption costs and other consequential losses in the wake of extreme weather.

[8] The term risk aggregator refers to firms whose business is negatively affected by correlated weather risk, either through direct losses or through the effect of the catastrophe on their clients, employees, etc. Examples include rural banks and microfinance institutions, members of the value chain, farmer associations, etc.

Box 5 Compensating for Missing Yield Data

1) Overfitting in-sample data

Overfitting in-sample data is one unintended outcome of attempts to closely mimic indemnity-based crop insurance in data-sparse environments. Practitioners sometimes develop complex statistical models within the available data to show that the index explains a large part of the in-sample variability in crop yields. A concern with such approaches is that in-sample statistical relationships may not hold out-of-sample. As a result, indemnities associated with contracts based on an overfit model may not match losses nearly as well as the model would suggest. Of particular concern is that, relative to more understandable and direct models, complex, overfit models run the danger of underestimating basis risk.

2) Using crop growth simulation models

Practitioners also use crop growth simulation models to compensate for missing historical data on household yields. Crop growth models simulate the relationship between various inputs (including weather variables) and test plot yields for specific crop varieties, farm practices, and regions. Practitioners then use this information to design the indemnity structure for an index insurance contract. As with overfitting, external validity is one major concern about this procedure, for two reasons. First, crop growth simulations models may not work well outside of the specific context in which they were developed; and second, crop growth models are less useful for predicting the effects of extreme weather events on yields---the very domain of index insurance.

The common theme that emerges from basing contract design on models that overfit available data or rely exclusively on crop growth models is the danger of inadvertently overselling the potential benefits of index insurance, since both procedures run the risk of underestimating the true basis risk that will occur out-of-sample. If index insurance is sold based on unrealistic expectations, practitioners will lose credibility that may be difficult to regain in the future, thus undermining any efforts for long-term scalability and sustainability.

Index Insurance for Consequential Losses

Viewing index insurance as an alternative to traditional crop insurance was an important first step in the evolution of its use. However, considering some of the limitations associated with that viewpoint alone, recasting index insurance more broadly merits consideration.

Many settings in lower income countries could benefit from flexible designs that address the needs of a heterogeneous market, as well as reduce quantitative data requirements. One way to achieve this is to experiment with product designs that account for broader economic consequences of weather risk rather than limit index insurance to direct losses only. Such products appear to be most suitable for regions exposed to a major peril that creates losses of catastrophic proportions across a variety of enterprises. For example, a consequential loss design is particularly suitable for the northern regions of Peru, where catastrophic flooding associated with severe El Niño events results in widespread losses that affect that region's entire economy (see Box 6).

Box 6 El Niño Insurance in Northern Peru

In the coastal regions of northern Peru, El Niño can bring catastrophic rainfall and flooding. GlobalAgRisk has developed an index insurance product (El Niño Insurance) based on sea surface temperature (SST) in the equatorial Pacific, which are indicators of El Niño Southern Oscillation (ENSO) cycles. El Niño Insurance is based on the average November and December SST for Niño regions 1+2 measured by the U.S. National Oceanic and Atmospheric Administration.

The initial vision for El Niño Insurance was to protect microfinance institutions from business interruption costs, particularly the risk of loan defaults, thus stimulating an increase in agricultural lending to smallholder farmers. However, risk assessments revealed the many additional costs associated with catastrophic El Niño ---damaged or destroyed crops and fruit trees, erosion of soils and riverbanks, a breakdown in transportation due to damaged roads and bridges, increased incidences of disease, and disruptions in commerce. When individuals and local markets suffer in this fashion, many in the agricultural value chain and other sectors also incur added costs and consequential losses. El Niño Insurance is therefore now being written as a contingency insurance (also referred to as fixed sum insurance) policy that can potentially be used by any legal entity or individual in Peru exposed to the losses and additional costs due to catastrophic flooding as predicted by extreme November and December Niño 1+2 measures. The insurance actually pays before the extreme flooding reaches full force making this the first regulated *forecast insurance* in the world.

Because damages are truly ubiquitous, the consequential loss product applies to various enterprises with different exposures to catastrophic El Niño risk. Local MFIs, for example, could treat an insurance payout as new equity on their balance sheets, bolstering their capital adequacy ratio during a time when it would otherwise be reduced by delinquent or defaulted loans and savings withdrawals. An insured institution would be in a stronger position following El Niño to make new loans during a critically important time and increase investments for years afterwards in comparison to an institution without insurance. Conversely, fisheries off the northern coast, which suffer catch reductions due to the high SST associated with extreme El Niño, could use the payment to offset losses and additional costs. Fruit export associations that contract with farmers in Peru could use insurance payouts to hire farmers whose crops are damaged by El Niño to assist with flood risk mitigation and/or recovery activities. This would allow the associations to maintain relationships with the farmers and support a swift return to full production.

Interviews with household members during the risk assessment phase make a strong case for consequential loss insurance. When these individuals comment on the financial impacts of weather-related disasters, the discussion extends well beyond the impact on crop yields. They talk about reduced income due to depressed output prices when destroyed infrastructure limits market access, job loss, lower crop quality, diminished livestock production, etc. They mention increased expenses due to higher prices of inputs and consumption goods, increased vulnerability to disease and pests, higher irrigation costs, etc. And they enumerate various asset losses: destroyed buildings, lost livestock, destroyed crops, washed away topsoil, depleted savings, family members who have died or been injured, etc. In short, catastrophic weather events affect firms and households in many different ways, reducing both returns on investments and wealth positions.

Many risk aggregators also experience weather risk exposure that extends well beyond yields of a particular crop or similarly narrow portfolio investments. Banks and microfinance institutions, for example, are quite vulnerable to weather and natural disaster perils that result in spatially correlated losses. If a severe drought occurs, many borrowers are likely to experience repayment difficulties concurrently. Such risks may cause banks to restrict or ration their services as a way to reduce their exposure. Evidence of this behavior was seen in northern Peru following the severe 1997–1998 El Niño. Some of the banks in the affected regions suffered increased default rates and other liquidity problems for years afterward. Following that experience, banks reduced the size of their agricultural lending portfolios, leaving some farmers without the ability to access credit and limiting the banks' profitability from an otherwise productive sector.

Risk aggregating firms in the value chain may likewise be vulnerable to catastrophic weather and natural disaster events. Processors, exporters, etc., could experience disruptions to their business, such as a sharp reduction in the supply or quality of a commodity, or limited access to transportation. Lost revenue may then threaten a firm's capacity to keep laborers employed or fulfill contract obligations.

Advantages of Insuring Broadly against Consequential Losses

Designing and presenting index insurance in terms of the many consequences associated with extreme weather could ease important supply-side constraints and stimulate demand.

Supply Side

Consequential loss design lowers quantitative data requirements and can lead to improved product feasibility. Focusing on consequential losses has important data implications. Moving away from crop yields relaxes quantitative data constraints by reducing the need for sparse or missing historical household yield data for designing the index so as to mitigate basis risk. Instead, qualitative information obtained through carefully structured interactions with local experts and stakeholders during risk assessment takes on an important role in understanding the relationship between the index and losses (see Box 7).

Implicit in this risk assessment approach is the recognition that weather risk and resulting losses occur in a larger system affected by various factors: households' livelihood strategies, geography, weather patterns, population dynamics, industry growth, cultural values, etc. As practitioners develop an understanding of the risk in the local context, themes are likely to emerge that guide priorities in product development. Because index insurance is offered in regions where the target market has limited or no experience with insurance, the onus is on practitioners to identify the needs of the local clientele and to design products with a vision for the different ways in which extreme weather events retard economic growth.

Box 7 Supplementing Available Quantitative Data with Qualitative Information Obtained during Risk Assessment

To avoid potential pitfalls associated with complex modeling and crop growth simulation, we recommend a risk assessment process that supplements the limited available quantitative data with qualitative information collected rigorously from local sources. High-quality data obtained in this fashion can give valuable evidence as to individual loss experiences that cannot be captured with incomplete or missing quantitative data. Furthermore, local stakeholders are well positioned to understand the vulnerabilities of their community to future catastrophic weather events. In addition, households, businesses, scientists with specialized knowledge, etc., can help identify events that create large losses and report high-loss years that can be used to corroborate sparse historical data. Importantly, they can help guide product design by voicing what type of weather risk concerns them most.

Demand Side

Consequential loss design has the potential to increase market volume. Framing index insurance in terms of consequential losses has the potential to create value for a large number of customers, which has positive implications for achieving market volume, both in terms of massification (i.e., number of policies sold) and the amount of insurance purchased.

Massification potential improves because the flexibility of consequential loss design renders index insurance appealing to a broader clientele. Policyholders can individualize coverage according to the unique set of risks they face and use indemnities according their own needs and priorities. In Vietnam, for example, GlobalAgRisk designed a product for coffee farmers in the Central Highlands that insures against consequential losses from early season drought. Instead of insuring crop yields specifically (which, according to risk assessment surveys, farmers would not be willing to purchase because they use irrigation to mitigate drought-induced yield losses), the product protects farmers from income shortfalls due to reduced crop quality and extra costs for additional irrigation when early rains fail. In addition, the GlobalAgRisk El Niño Insurance in Peru demonstrates the benefits of having a flexible use of indemnity funds. Because the insurance contract does not restrict the payment to specific types of losses, the product can be purchased to protect against any loss of revenue or extra costs that occur as a result of the ensured event. For example, local microfinance institutions can use the insurance payment to fund the extra costs of locating capital and managing liquidity shortfalls, and restructuring loans resulting from the floods associated with catastrophic El Niño.

Likewise, extending index insurance access to anyone anticipating losses due to a weather peril — irrespective of scale, sector, or industry — improves the potential for massification by tapping into a market that includes a wide range of potential clients that would otherwise be excluded. Within the micro scale, a consequential loss product can be extended to households that plant a variety of crops or derive their income from nonagricultural activities that correlate with the weather risk. Within the meso scale, a consequential loss product would be quite relevant to a wide variety of risk-aggregating firms. Risk aggregators, who use risk pooling to manage idiosyncratic risks but are highly exposed to correlated weather risk, present an important, yet minimally explored, market for index insurance (see Box 8).

Box 8 The Importance of Risk Aggregators for Developing Index Insurance Markets

Opening the door to risk aggregating firms increases the potential success of index insurance, in particular because risk aggregator products face fewer supply-side constraints compared to household products by having less stringent data requirements and being less costly to transact. Policies offered to risk aggregators are also larger in value, which further improves cost-efficiency and enhances the attractiveness of these products to commercial insurers and reinsurers. As a result, risk aggregator products are better positioned to achieve rapid scale-up, thus capturing the attention of regulatory authorities who are integral to long-term product and market sustainability.

As to increased transaction value, if buyers understand that the insurance can be used to protect against a range of losses, they should be willing to purchase more of the insurance. Economic theory on risk aversion supports this notion.

Finally, not having to tie coverage to crop losses simplifies contract design, which helps make index insurance more transparent and accessible. As noted, crop specific contracts often rely on complex indexes composed from several variables and obtained through complex econometric modeling. This creates an educational barrier that could undermine client confidence in the product and adversely affect demand. Consequential loss products, on the other hand, use simple indexes, such as cumulative rainfall or wind speed, and are easy to relate to a target market lacking scientific literacy.

Consequential loss design may help lower basis risk. Index insurance for consequential losses may be better positioned to address different sources of basis risk compared to products that focus strictly on crop yields. As discussed, complex models designed to explain in-sample yield variability with limited data often introduce a separate source of basis risk. Furthermore, in rural areas of lower income countries, yield losses, which represent only one aspect of a household's portfolio risk, are often not the most important indicator of their well-being. Any product that fails to protect against the most salient livelihood threats will by design suffer large basis risk. Lastly, because losses due to extreme weather are context specific, determined by physical as well as human factors, policyholders will experience different losses from one another as well as across events. Since it is often unclear how an event will affect specific aspects of their wealth positions, a more general product that allows policyholders to address a host of potential problems resulting from the peril is more likely to shield them from losses they actually experience than a product covering a single investment.

An important caveat is that, like any other index insurance design, consequential loss index insurance is also generally ineffective for high-frequency, low-consequence events. Because index insurance works best for high-magnitude events that result in widespread losses, designing contracts that pay when conditions are truly catastrophic is the best way to minimize basis risk.

Developing consequential loss index insurance necessitates extensive outreach to clients; informed clients are more likely to understand and value index insurance. Client engagement and education — an important aspect of any index insurance product development — is particularly relevant to consequential loss designs. Before clients can choose the sum insured or decide how index insurance complements their existing risk management portfolios, practitioners must first help them determine their risk exposures and think about the different strategies they use to deal with consequences of adverse weather. Extensive outreach activities place consumers in a better position to recognize the value of index insurance. In Peru, for example, one-on-one analysis and risk modeling with agricultural lenders has helped them quantify costs associated with strategies to cope with weather risk in the absence of index insurance, such as restricting lending to select sectors, which reduces their profits. These exercises often precipitate awareness-raising discussions that help clients more fully appreciate the unique role that index insurance plays in managing spatially correlated, catastrophic risks.

Classifying Consequential Loss Contracts

A critical first stage in the development of any new financial services product in a country is to assess whether the product is permitted under the laws of the country and how it will be classified and supervised by the relevant authorities. Index insurance is no different.

Perhaps because of its short history, few countries have enacted legislation that expressly recognizes index risk transfer products as a form of insurance and few, if any, regulatory authorities have considered the characteristics required for an index product to be classified as insurance or established specific regulatory requirements for index insurance. Furthermore, despite the relatively large number of pilot projects introduced to test index insurance as a concept, the status of index insurance has not yet been accepted, or even considered, at an international level, whether by the International Association of Insurance Supervisors (IAIS) or other international bodies.

In the circumstances, there is a risk that specific insurance supervisory authorities will either be hesitant to approve index-based products as insurance or will approve products that do no not possess the essential features of an insurance contract. In any event, it is the courts and not insurance supervisors that are the final arbiters of legal status under a country's law and, even though an insurance supervisor may approve an index insurance product, this does not prevent a court subsequently making a different determination perhaps much later. The legal and regulatory risks attached to index insurance therefore pose a real threat to market development and must be addressed from a product's inception.

Derivatives, which are the more common form of index contract, are a wholly unsuitable form of risk transfer product for consumers, small businesses and other non-sophisticated counterparties. Even if the development and sale of derivatives is regulated and supervised in a country, it is likely that derivatives will be regulated as an investment product and the regulatory and supervisory objectives will therefore be different. If the significant benefits of index insurance are to be extended to consumers and small businesses, it is essential that the index contract is positioned as an insurance product within the country's legal and regulatory framework. Given the very different characteristics of index products, contract design requires careful consideration to minimize the legal and regulatory risks.

Insurance contracts designed to protect against risks to property and business interruption are traditionally written as indemnity insurance contracts. Indemnity contracts have the following characteristics:

- In order to receive a payment under the contract, the insured must have sustained loss or damage, which is subject to proof and is often subject to assessment;
- The insured may only be indemnified in relation to the loss sustained, and with limited exceptions, cannot recover more than the actual loss;
- The contract must specify a maximum sum insured or upper limit; and
- In most countries, the insured is required to have insurable interest in the subject matter of insurance at the time of the loss.

Index contracts, by contrast, have the following characteristics:

- Payment is made against an index;
- There is no requirement for the insured to prove the amount of loss, the loss sustained, or for assessment of the loss;
- There is not even any requirement for the insured to sustain a loss; and
- Payout amount depends only on the premium paid and value of the index.

It is clear that index contracts do not meet the basic criteria for a traditional indemnity insurance contract due to:

- There being no requirement for the insured to have sustained, or to prove, a loss; and
- The fact that the payment made may exceed the insured's actual loss.

It is therefore necessary to consider whether it is possible to classify index insurance as any other type of insurance contract. Although the discussion above focuses on *index insurance*, as noted, contracts can be written based on two different types of indexes: 1) aggregate loss indexes, such as for area yield and livestock mortality, and 2) indirect loss indexes, such as drought or flood indexes.

Under an aggregate loss index, the aggregate loss can be considered as a proxy for individual loss. An argument can be made for positioning an appropriately designed aggregate loss index contract as a new type of valued policy.[9]

Under a valued policy, the payment on an insured loss is based on the parties' pre-agreed estimate of the value of the property insured. If there is a total loss, the payment made under the policy is the pre-agreed estimate of value. If there is a partial loss, the payment is that proportion of the pre-agreed value that equates to the proportion of the loss. For example, if there is a 50 percent loss, the payment made under the contract is 50 percent of the pre-agreed value. The pre-agreed estimate must not be manifestly excessive.

Under an aggregate loss index contract, although the parties do not pre-agree the value of the property insured, or even the loss, it can be argued that they pre-agree on a method of determining total and proportional loss by the use of an aggregate index which serves as a proxy for individual loss. Provided that there is a reasonable correlation between the aggregate index and individual loss, the contract will have characteristics of a valued policy, although it does require the concept to be extended. If there is not a reasonable correlation between the aggregate index and individual loss, there is a risk that any payment made would be considered excessive.

However, no such argument can reasonably be made for indirect loss indexes. Although attempts are often made to fit data to show a correlation between, for example, a drought or flood index and individual loss, the reality is that an indirect loss index is not being used as a proxy for individual loss and attempts to demonstrate such a correlation can generally result in an overfitting of data. For that reason, we take the view that an indirect loss index contract cannot reasonably be classified as a valued policy. It is therefore necessary to consider whether an indirect loss index can be classified as any other type of insurance contract.

Most countries explicitly recognize a type of non-indemnity insurance which may be called contingency insurance or, in some countries, fixed sum insurance. Under a non-indemnity insurance contract, the payment to the insured is made on the basis of the premium paid. The most common form of non-indemnity insurance is life insurance. There is no requirement for the person entitled to the payment under a life insurance contract (the beneficiary) to prove the amount of the loss sustained due to the death of the person whose life is insured, or even that the beneficiary has sustained any loss. Other examples of contingency insurance or fixed sum insurance are accident policies, which pay a predetermined fixed sum on the occurrence of a particular injury, for example the loss of a finger, and some health policies which pay a fixed sum for each day that the insured person is in the hospital.

[9] It is not absolutely clear whether a valued policy is an indemnity or a non-indemnity insurance contract. However, on balance, we consider that a valued policy has more of the characteristics of an indemnity policy than a contingency policy. For further detail please see the Legal State of Knowledge Report referenced in Box 1.

Given that index insurance has similar characteristics, i.e., that payment is dependent solely on the premium paid and the value of the index (the index serving to determine both whether an insured event has occurred and as the multiplier for payment), it may be possible to position index insurance as a form of contingency or fixed sum insurance. However, this does require a shift in thinking as non-indemnity insurance is traditionally limited to personal lines of cover, such as life, health, and personal accident insurance. It also requires a review of the legal and regulatory framework of the country for which the product is being developed, as the current laws in a country may not allow such a classification.

It is important to appreciate that the use of the term, *contingency insurance*, can lead to confusion as, in some countries, insurers sell specific types of insurance policies called, “contingency insurance” policies. These policies may also be called, *event insurance*. Typically they are used to cover the losses caused due to the occurrence or non-occurrence of a specific event due to one or more specified contingencies. For example, the costs associated with the cancellation of a concert due to the illness or death of the performer or the cancellation of a wedding due to the illness of the bride or some other specified contingency. They may also be written to cover the payment of a lottery prize or to cover the costs of litigation. These contingency insurance policies are usually written as indemnity policies. In relation to index insurance, the term, *contingency insurance*, is used to describe the type of non-indemnity insurance, such as a life policy, under which the payment made is determined by the premium paid and the actual measure of the index; there is no requirement to establish actual loss or the amount of any loss sustained.

It is critical that an index contract is appropriately designed if it is to be positioned as contingency or fixed sum insurance. In particular, given that there is no requirement to establish actual loss, insurable interest becomes a matter of significant importance in most countries. In the case of El Niño Insurance in Peru, for example, among a number of potential insurable interest choices, the decision was made to restrict the sale of the policy to persons who are exposed either: 1) to losses sustained, or additional costs incurred, due to extreme flooding in the northern coastal region of Peru as a consequence of an extreme El Niño ; or 2) to losses sustained, or additional costs incurred, due to adverse changes in the fishery (e.g., reduced catch and increased costs) off the coast of Peru due to high sea surface temperatures caused by the occurrence of an extreme El Niño . The Peruvian regulator has approved El Niño Insurance as contingency insurance.

In addition to enabling an index contract to be positioned as insurance, writing the index contract as contingency or fixed sum insurance carries additional advantages. For example, it is the policyholder who chooses the appropriate level of insurance protection, which implicitly forces the policyholder to make a determination of his or her own risk exposure given the events that are tied to the index.

It is important to caution practitioners that we are not aware of any legislation or legal cases that have sought to define index insurance as either a form of valued policy or contingency (fixed sum) insurance. This is a complex and untested area requiring new thinking and approaches that will undoubtedly challenge conventional definitions, which carries a degree of legal and regulatory uncertainty and risk. However, the consequences of attempting to regulate index tied products as derivatives may carry far greater consumer protection risks in emerging markets. Thus, GlobalAgRisk believes that working to classify index-based risk transfer products as insurance products is critically important for emerging markets.

Conclusion

To be scalable and sustainable, index insurance must be framed in a way to offer value to prospective clients, while being responsive to the constraints of the local context. Index insurance for consequential losses has the potential to stimulate market volume by opening the door to a variety of clients whose income, costs, or ending wealth are affected by specific adverse weather (and natural disaster) events. In addition, the flexible design of contingency or fixed sum insurance for business interruption and other consequential losses and costs could prove more effective for transferring insureds' risk exposure than crop- or enterprise-specific insurance, particularly when a major natural disaster is truly catastrophic and losses occur across a variety of enterprises. Finally, framing index insurance in terms of the many consequences of extreme weather relaxes data constraints that present an important challenge to crop-based insurance designs. This is because the index no longer has to proxy for crop yield losses, which is difficult to do with incomplete or missing samples of historical crop yields. It is important to note, however, that consequential loss policies are expected to perform best when a peril causes losses many different enterprises, the likelihood for which increases with the severity of the peril.

Summary of Key Advantages Associated with Consequential Loss Design

Consequential loss design may ease supply-side constraints by:

1. Improving the potential for market volume, thus increasing efficiency gains and prospects for commercial viability; and
2. Lowering data limitations.
   - Consequential loss contract design has less need for long series of quantitative data on yields and losses and for complex modeling.

Consequential loss design may stimulate demand by:

3. Extending index insurance access to a broad and varied clientele; and
   - Anyone with an insurable interest can purchase the insurance, including households and risk aggregators that face multiple sources of livelihood and/or business interruption risk due to severe weather or natural disaster events.
4. Offering additional value.
   - Clients can select their own coverage and prioritize indemnities as they see fit;
   - Indemnities are more likely to approximate losses (i.e., basis risk is lower);
   - Contract structure is more transparent and client friendly; and
   - Client perception of the value of index insurance is improved through risk assessment, outreach, and modeling, which are necessary steps in the product development process.