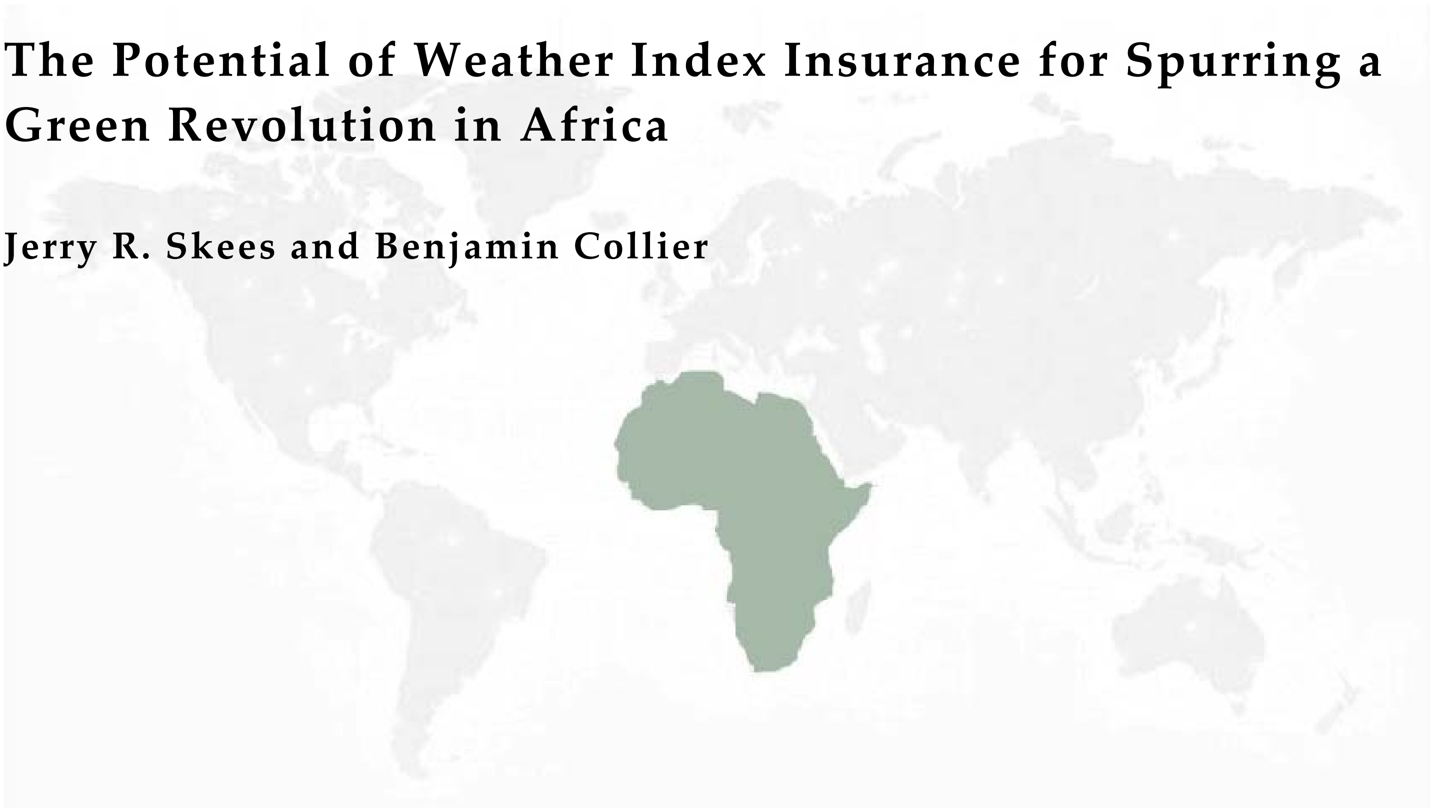
# The Potential of Weather Index Insurance for Spurring a Green Revolution in Africa

Jerry R. Skees and Benjamin Collier



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# The Potential of Weather Index Insurance for Spurring a Green Revolution in Africa

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Innovation in index insurance products to transfer weather risks is capturing the attention of the development community. The use of index insurance can be documented in about twenty-five countries. Two noteworthy projects in Africa demonstrate the scope of the potential applications of these new products. The Ethiopia drought insurance for food security targets funding emergency food aid for an international organization and was purchased by the World Food Programme (WFP) in 2006. The ongoing Malawi pilot program encourages lending and adoption of improved technology among smallholder groundnut farmers. The World Bank, GTZ, and others are actively engaged at some stage of development in several other African nations (e.g., Senegal, Tanzania, Kenya, Morocco, Mali, etc.).[1] While these activities are promising, developing sustainable weather insurance products will not be easy. Numerous constraints must be addressed: 1) data limitations; 2) inadequate legal and regulatory frameworks; 3) insufficient *ex ante* financing for insuring largely correlated risks; and 4) limited delivery systems for smallholders. In addition, there is a need for capacity building for insurance companies and educational efforts for potential buyers.

The quest for a green revolution in Africa depends principally upon the development and adoption of appropriate agricultural technologies. While there are many impediments to the adoption of technology, the economic development literature is clear in citing risk as being a dominant constraint. Poor households must be conservative in the choices they make as they can ill-afford to make significant investments in new technologies only to experience dramatic income shortfalls due to perils such as crop failure or low prices.[2] This aversion to risk causes poor households to engage in livelihood strategies that reduce risk but also greatly limit income potential. Thus, risk contributes to locking the poor into poverty. At a more aggregate level, risk constrains economic growth because society's resources are not directed to their highest and best use, which further constrains economic opportunities at the household level. *Thus, the realization of a green revolution in Africa is dependent not only on the development of appropriate technologies but also on the development of effective risk transfer instruments that will facilitate technology adoption by the poor*. Such risk transfer instruments can contribute to meeting the dual objectives of poverty reduction and economic growth.

[1] Annex A is reproduced with permission from the World Bank. Annex A reviews some ongoing activities in price and weather risk management in eastern and southern Africa.

[2] Throughout this manuscript the term "poor" refers to households with very limited assets (including household labor) that can be employed in income-generating livelihood strategies. These households should be distinguished from those that are destitute, in the sense that they do not possess sufficient assets to even maintain nutritional subsistence. The focus here is on households that are not destitute but are seemingly locked into low-income, low-consumption thresholds. Thus, the interventions discussed here focus on stimulating investment and asset accumulation. Households that are quite literally destitute require very different types of interventions.

This paper focuses on the potential of index-based weather insurance products for contributing to a green revolution in Africa[3]. We begin by building a conceptual framework that links poverty, risk, and missing financial markets. Next, we present the case for why weather risk transfer and agricultural insurance can contribute to development. We then review the fundamental problems with traditional agricultural insurance products, which motivated efforts to develop alternatives such as index-based insurance products. Still, as we will demonstrate, there are numerous preconditions for making index insurance workable. Considering these preconditions in practice — which constraints can be overcome and which ones cannot — led to the development of our business model, which outlines the steps needed to develop sustainable weather insurance markets.

Both the conceptual discussion of index-based insurance and the pragmatic suggestions of how to develop these markets provide a foundation for analyzing four distinct products that we believe may be applicable in various parts of Africa. The weather risks that most affect African nations are drought and flooding.[4] Index insurance for drought is currently much further developed than index insurance for other perils. Thus, most of the focus in this paper is on drought. Nonetheless, our experience working with flood risk in Peru and Vietnam also motivates our thinking about index insurance.

For household-level products, we focus in this paper primarily, though not exclusively, on poor households engaged in smallholder agriculture. Smallholder households dominate the rural African landscape. But it becomes clear that if the smallholder market can be reached, larger-scale farming operations can also be served. We use the Malawi case study to focus on one class of household-level products that is well-integrated into the value chain with the specific goal of giving farmers loans to adopt new technology. While the intent of this product is very sound, the implementation and data constraints make it difficult to replicate. We also review is the WFP drought product that was designed to pay at the country level when drought creates food security problems. In this case study, we provide some additional ideas about how this class of food security products could be targeted at the sub-region level to provide timely resources to mitigate emerging food security problems. Given the implementation and data constraints, and building on the Malawi experience, we introduce other products that could be targeted at smallholder households and intermediaries in a fashion that encourages technology adoption. The review of existing products and the ideas we present lead to recommendations for how to advance the development process of weather index insurance products in Africa, including ideas for how donor and other public support can be most effectively used to spur market development for weather index insurance in Africa.

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[3] Given the importance of price risk management, we also include Annex B, which reviews how and when price risk management instruments can be used for food security issues.

[4] United Nations Office for the Coordination of Humanitarian Affairs

## Weather Shocks, Poverty, Risk, Economic Growth, and Missing Markets

Though many factors contribute to lagging development in Africa — poor institutions, civil unrest, geographic difficulties, etc. — natural disasters remain a significant impediment to growth in many African nations. Natural disasters are particularly problematic in Africa because so many households rely on agriculture for their livelihoods.

### Poverty Traps and Livelihood Strategies

When a weather shock occurs, it can affect most or even all the livelihood strategies of poor households. A drought can devastate a farmer's crops. Extreme weather events can override the improved agricultural productivity promised by technologies, such as drought-resistant plant varieties, irrigation systems, hardier livestock, etc., but the damage does not stop there. To manage risk, poor households tend to diversify labor across a variety of activities. For example, in some regions livestock are kept both as a source of income and a form of savings. The landless or those with limited access to land may depend on income (paid either in cash or in-kind) from harvesting crops for someone else in the community. The well-being of those earning incomes from farming activities also often depends on off-farm jobs. However, diversifying household labor across these various livelihood strategies will not significantly reduce income risk if all of the strategies are negatively affected by widespread (correlated) weather catastrophes such as drought. Furthermore, if everyone in the community suffers from the same catastrophic event, traditional risk coping strategies that involve reciprocity or principles of informal mutual insurance may also break down. When a widespread disaster occurs, few households are in a position to help their neighbors. Distressed sales of livestock during droughts create significant downward pressure on prices because many households sell livestock at the same time. Left with no other choice, some households may have to resort to selling livelihood assets, reducing consumption, taking children out of school to either work or to save on school costs, etc. All of these strategies can lead to chronic poverty as they reduce current and/or future opportunities for generating income. As a result, shocks can plunge households into permanent poverty or they can keep knocking households down preventing them from growing out of poverty.[5]

Regretfully, these poverty dynamics are repeated constantly across the African continent. To repeat, these dynamics hurt both the individual household and the overall economy. The *ex post* impacts of a major shock like a drought or flood are quite obvious. Such events can knock individual households into poverty, from which they may never recover. However, it is critical that policy makers also recognize the *ex ante* impacts of shocks. If the risk of such shocks cannot be effectively transferred using instruments like insurance, households will engage in behavioral responses that impede technology adoption and wealth accumulation. For example, Rosenzweig and Binswanger (1993) estimate the opportunity costs of the low-risk, low-return livelihood choices of Indian farmers and found that implicit premium rates (in the form of

[5] To ease the flow of this paper, in text citations are kept to a minimum. For further reading suggestions, please see the Recommended Readings list, organized by topic and by case study countries. For example, relevant material for this section can be found in the Recommended Readings topic section, Poverty Traps, Risk Coping, and Risk Management Strategies Used by the Working Poor.

foregone opportunities to earn higher incomes) exceeded 30 percent. In the aggregate, the impact of these household-level decisions is slower economic growth.

While the economic foundations for understanding how risk negatively influences technological adoption, development, and poverty are well-established, only recently have economists taken the logical next step to argue that the failure of financial markets compounds the problems that are created by risk. High transaction costs severely limit the access of the poor to financial services (including risk transfer) and global markets, resulting in suboptimal risk coping strategies. Credit, savings, and insurance markets are largely missing in rural areas of lower income countries. Each of these financial markets provides opportunities for smoothing incomes across loss events. With such opportunities, household decision makers can take on more risk, including the adoption of new technology. Increasing evidence indicates that lower income countries that have both strong banking and insurance sectors grow faster than countries with only a banking sector.

### Correlated Risk and Intermediaries

The risk and poverty dynamics we describe have clear implications for the risk faced by any intermediary trying to deliver inputs and/or financial services to the poor. Spatially correlated risk constrains the delivery of services to the poor.

The role of intermediaries as providers of inputs and financial services to smallholder rural households in developing countries is critical if these households are to have access to global markets. An increasing concern is that poor households are bypassed as multinational firms make direct linkages with the largest producers in developing countries. Many factors explain this — high transaction costs, information asymmetries, and risk. Thus, midsized intermediaries seem to be the primary agents for linking smallholders to larger markets.

Despite the opportunity to reduce transaction costs by delivering multiple services, midsized intermediaries must still deal with correlated risk problems that often limit business investments and opportunities in rural areas. While due diligence practices of small and intermediate firms have improved, many of these advances ignore the inherent risks largely outside the control of the firm-level decision maker. For example, those intermediaries offering credit to households involved in small-scale farming must be concerned with underwriting the individual integrity of the household in paying back the debt. However, they must also be concerned with events that are outside the control of the household, such as weather risks, large downward movements in commodity prices, or adverse movements in currency exchanges that affect global competitiveness. Such correlated risks have a major influence on the revenue stream from farming activities and thus on the revenue stream for firms supplying inputs or financial services to those farm households.

Spatially correlated risks are almost impossible to cope with at the local level as nearly everyone within the community may be affected by the same event.[6] Similarly, when a large number of customers experience a severe reduction in cash flow or agricultural output at the

[6] This is why more familiar risk-coping strategies among households in the same community are largely ineffective against spatially correlated loss events.

same time, the intermediaries providing services to farmers will also be adversely affected. This is particularly problematic for the midsized intermediaries that service smallholder farmers since these intermediaries tend to be geographically concentrated and thus cannot spread correlated risk across space. For example, if a microfinance institution (MFI) is geographically isolated, a single disaster can challenge its solvency. Thus, MFIs either choose to ration credit to businesses that are exposed to the same correlated loss events (such as agriculture) or rely on international donors to recapitalize the MFI in the event of a correlated catastrophic loss event. The former reduces technology adoption and slows economic growth. The latter is clearly an unsustainable business practice.

If midsize input and product market intermediaries are to compete, they must be able to transfer their exposure to correlated risk out of the local area. A consequence of this is that, should such risk transfer markets emerge, intermediaries may be more willing to serve some areas that are now underserved. Therefore*, innovation in risk transfer is also an important component of developing input and product market intermediaries* in lower income countries. The use of index-based weather insurance, futures markets, or other risk transfer mechanisms, can be critical to reducing risk exposure and making it possible for input and product market intermediaries to offer services to smallholder farmers. If there are no mechanisms for risk transfer, the risk may preclude development of such services.

### Relief Efforts

At the macro level, regional disasters translate into large government costs in terms of disaster relief, rebuilding efforts, and lost tax revenues. Given the lack of financial services for most rural households in Africa, properly functioning safety net programs play a vital role in maintaining long-term household productivity when weather shocks occur. Of course, such safety net programs will not work for those who are already in chronic poverty; other social solutions are needed for the poorest of the poor. Absent financial instruments such as insurance, households that experience shocks often are forced to liquidate productive assets in order to maintain even minimal levels of consumption. Safety net programs are designed to provide timely interventions that forestall the need for liquidating productive assets. Still, disasters result in high opportunity costs for governments and donors. While national-level crises often gain media attention and assistance from the international community, unpublicized regional-level crises may have the biggest impact on the budgets of governments and local donors. Especially when disasters occur relatively commonly, such as with drought in some African nations, these costs result in constant interruptions to government and donor development agendas including programs that improve agricultural productivity. Thus, many governments and donors could potentially benefit from purchasing index insurance products that would pay an indemnity in the wake of a widespread natural disaster.

In sum, natural disaster risk hinders economic development at all levels — micro, meso, and macro. Thus, for households, intermediaries, governments, and donors, developing effective market mechanisms for transferring natural disaster risk is key to stimulating technology adoption and long-term economic growth.

## Recent Developments in Insurance Markets to Transfer Weather Risk

Despite a clear need and some strong arguments for why weather and agricultural insurance is important for economic development, the struggle to find appropriate agricultural insurance solutions for lower income countries has been long and arduous. In the 1970s and 1980s, many donors worked to resolve this problem only to abandon the efforts due to the classic problems that plague agricultural insurance:

1. Moral hazard
2. Adverse selection
3. Correlated risk and potentially large financial losses
4. High monitoring cost
5. High delivery cost
6. High loss adjustment cost
7. Smallholder farms that exacerbate the high per-unit costs for farm-level products

The seminal work by Hazell, Pomareda, and Valdés (1986) demonstrates that traditional solutions to crop insurance are far too expensive to offset the benefits. Since the mid-1990s, scholars have focused on new approaches that trigger indemnity payments based on the value of an underlying index.[7] This work has renewed the interest of donors in the potential for insurance in rural areas of lower income countries. As a result, a number of pilot programs that use index insurance for agricultural losses are now underway (e.g., India, Malawi, Ethiopia, Mongolia, and Mexico).[8]

Index insurance is significantly different from traditional insurance in that the indemnity payments are based on data that is outside the influence of the insured. The index is created using data that serve as a proxy for loss, eliminating the need for costly individual loss assessments. The index is based on an objective measure such as rainfall, livestock mortality, county yields, temperature, water levels in a river, etc. These measures should be highly correlated with the economic losses (crop failure, death of livestock, loan defaults, etc.) that might be experienced by an insured entity but (unlike the actual loss) *the insured has no ability to affect the index*.

As an example, consider a drought index insurance contract that pays an indemnity anytime that cumulative rainfall during a critical two month period of the growing season is less than 100 millimeters. Indemnity payments would increase proportionately as the measure of rainfall declines until a pre-specified limit is reached. For example, the maximum indemnity will be paid whenever cumulative rainfall is less than or equal to 50 millimeters. In this example, the contract is said to have a threshold (or strike) of 100 millimeters and a limit of 50 millimeters. For

[7] Early work on an area-based index insurance (the Group Risk Plan in the United States) that uses the index of county yields (rather than farm-level yields) as the mechanism for indemnity payments led the way for a renewal of interest in revisiting agricultural insurance by the World Bank in the mid 1990s (see Recommended Readings topic section, Group Risk Plan). Please refer to Recommended Readings topic section, Index Insurance for Lower Income Countries, to learn more about the background, motivation, and uses of index insurance.

[8] Further readings for each case study can be found in the Recommended Readings section by country.

simplicity, assume the insured purchases a sum insured of $1,000. The payment rate for every 1 millimeter of rainfall deficit below 100 millimeters is calculated as (100 − 50)/$1000 or $20. Thus, if cumulative rainfall over the period were equal to 90 millimeters (or 10 millimeters less than the threshold) the indemnity would be 10 x $20 = $200.

Among the many advantages of index insurance are 1) low moral hazard and adverse selection; 2) no expensive loss adjustment for small units; 3) potentially less complex data requirements; and 4) potentially less complex and more transparent contracts. Nonetheless, index insurance can have a significant limitation — basis risk — when individuals have loss and do not get paid, or, they have no loss and receive payment. Additionally, data systems may not be adequate to develop the most desirable index insurance contracts. Finally, as weather represents a correlated risk, it is also critical that the potential large losses associated with writing weather index insurance be addressed from the outset and should be done in collaboration with the global reinsurance markets.

### Evaluating the Potential for Weather Index Insurance

There are a number of preconditions for creating sustainable weather index insurance, including: 1) exposure to one or more spatially correlated weather events that can generate catastrophic losses; 2) historical data regarding the weather event(s) of sufficient quantity and quality; 3) local capacity for delivering insurance contracts; 4) a supportive legal and regulatory environment; 5) effective market demand for the insurance product at prices that will be acceptable to insurance suppliers; and 6) access to risk sharing partners such as global reinsurers.

The first two preconditions can be evaluated via a risk assessment. The third and fourth preconditions require an evaluation of the local institutional structure. In many lower income countries investments in technical assistance will be required before these two preconditions can be met. Later, we discuss the legal and regulatory environment in some detail. There are a number of reasons why weather index insurance should be developed as insurance products rather than weather derivatives in lower income countries. The major reason is that there is generally a framework for regulating insurance products, whereas lower income countries have very limited experience regulating derivatives products.

A market demand analysis is required to evaluate the fifth precondition. There is no reason to invest resources in developing an insurance product if it is unlikely that there will be significant market demand. The final precondition is largely conditional on the other preconditions. If they are to share the risk on the insurance product, reinsurers must be convinced that the underlying risk exposure has been accurately assessed, the local institutional structure is adequate to support the insurance market, and there is effective demand for the product.

Significant investments are required to evaluate these preconditions, provide any necessary technical assistance, and develop prototype insurance products. These investments have “public goods” characteristics; however, once these types of investments have been made and a product is offered in the market, “free-riding” can occur — competitors can easily copy the product and thus capture the benefits of the investments made by others. Recognizing this, private-sector insurers are generally reluctant to bear the full cost of these initial investments. Thus, having donors and host countries support these initial investments to stimulate the development of weather index insurance markets is a form of a public good. We address these issues in the last section of the paper. In the remainder of this section we describe issues that must be addressed in a risk assessment.

**Risks must be highly correlated**. Weather index insurance is only effective in transferring spatially correlated risks. Catastrophic risks (e.g., drought) are more likely to be spatially correlated than are mild to moderate risks (e.g., a moderate shortfall in rainfall). If the underlying weather variable is not highly spatially correlated, the basis risk will be too great for an index insurance product to provide effective risk protection. This can occur because of the nature of the risk (e.g., hail losses are generally less correlated than drought or flood) or because of geographical heterogeneity (e.g., areas that are characterized by many microclimates).

**Risk cannot occur too frequently**. Part of the risk assessment involves carefully examining data and various contract designs to determine if the frequency and severity of losses can be properly assessed (see Box 1: Pricing Weather Index Insurance). If the risk being examined occurs too frequently (e.g., significant losses occur at least once every seven years), the transaction costs of insuring against the risk will be prohibitive. At the same time, insurance purchasers may grow impatient if they have not received an indemnity after purchasing the insurance for many years. Compounding this is the fact that individuals tend to underestimate their exposure to extremely low-probability, high-severity natural disasters.[9] However insurers do not have this problem. To the contrary, they must take a more conservative position to assure that they are prepared to make insurance payments for the most extreme events. These characteristics of buyers and sellers can cause catastrophic insurance markets to fail if the price being charged by insurers is more than what the buyers are willing to pay.

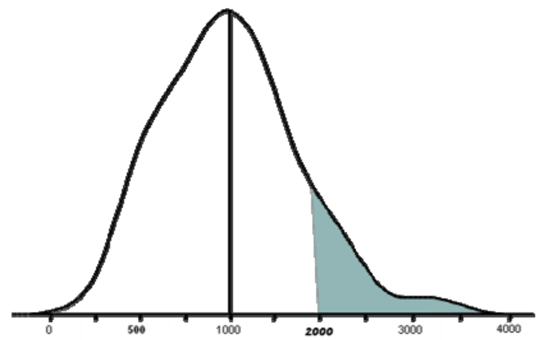
To evaluate the frequency and magnitude of loss for weather index insurance contracts, reliable historical weather data are required — ideally, at least 30 years of daily or dekadal (10-day) measurements.

**Specific opportunities create a suitable index.** A concurrent component of a pre-feasibility analysis involves understanding what extreme weather events cause severe losses and when the vulnerability to losses is greatest. Index insurance requires a reliable and easily measurable index (e.g., rainfall) that proxies the severity of losses (e.g., shortfalls in crop yields). In addition to having adequate historical data on the index, it is critical that reliable measures of the index will continue to be available in the future. These measures should be conducted by a trusted third party (e.g., a national or international meteorological association). Using reliable third-party data helps ensure that neither the insurer nor the insured can influence the likelihood of payouts. Because the index is the basis for insurance payments, it is important that it be measured at locations close to the insured. For example if rainfall is the index, rain gauges should be located within a few kilometers of the insured. Thus, many weather index insurance products require well-maintained weather station infrastructure close to the insured.

[9] For further reading on cognitive failure see Recommending Readings topic section, Index Insurance for Lower Income Countries.

### Box 1 Pricing Weather Index Insurance

**Price of Insurance** = Pure Risk
+ Reserve Load
+ Ambiguity Load
+ Administrative Costs




**Pure Risk.** The pure risk is the insurer's estimate of the amount of losses the insurer expects to pay. Insurers use historical weather data, i.e., the frequency and severity of weather events in the past, to develop a probability distribution. The figure is a probability distribution from 100 years of rainfall data for August in Andhra Pradesh, India. Consider the possibility of an insurance policy that makes a payout whenever rainfall is in excess of 2000 mm — shown as the shaded area. Based on the probability distribution and the structure of insurance payouts, the insurer could estimate the pure risk. For example, a pure risk of 7 percent would indicate that insurers expect to pay USD 7 for every USD 100 insured. Because this is the expected level of losses, it is the foundation for the insurance contract. The other costs of doing business are added to this base.

**Reserve Load.** Reserve or catastrophe (CAT) loads are added to the price of insurance due to the risk of large payouts occurring early in the program — the most extreme event can occur before adequate reserves are built. To deal with this possibility, insurers use a mixture of ready access to capital that may include cash reserves and purchasing reinsurance to manage large financial losses. Reinsurance is a means for insurers to transfer the most extreme risks to international markets. Reinsurance protects the solvency of insurers and is almost always essential when selling index insurance.

**Ambiguity Load.** Ambiguity loads account for the possibility that the available data do not represent the actual underlying risk. For example, if insurers only have a short time frame of data, they will increase ambiguity loads in case the data represent better-than-average years. In general, the more data, the less are the uncertainties and therefore ambiguity loads will be smaller. Changing weather patterns and concerns about climate change will undoubtedly create uncertainty and increase the cost of insuring the risk. Furthermore, ambiguity loads will be added when the quality of the historical data is poor.

**Administrative Costs.** Delivery costs, marketing and education, research and development, staff and office overhead costs are some of the important administrative costs that must be included when pricing the insurance. Delivery and education, in particular, can be difficult and expensive if products are intended for households in remote locations.

One of the most significant advantages of weather index insurance is that lower transaction costs should be lower than for traditional agricultural insurance. This is particularly critical for smallholders for whom the transaction costs of traditional agricultural insurance are prohibitive. The major limitation of weather index insurance is basis risk. Thus, the tradeoff between lower transaction costs versus basis risk is one way to evaluate how well a weather index insurance product may work. Attempts to reduce basis risk by developing complex insurance contracts or creating and maintaining a densely populated set of weather stations may prove too costly. In some areas and for some products, one may need weather stations that are only a few kilometers apart. More spatially correlated catastrophic events may require less investment in infrastructure.

### Lessons Learned from Risk Assessment and Product Development

The findings from a risk assessment are important regardless of whether an index insurance product is ever developed. Decision makers are often unaware of the probability and magnitude of potential catastrophic weather events. A risk assessment incorporates these factors into an estimate of the annualized expected cost of each extreme weather event. Seeing their risk exposure expressed in this way can be "eye opening" for many decision makers. For example, some early risk assessment work for weather index insurance began in Morocco in the late 1990s.[10] A drought insurance contract was designed; however, due to a declining trend in rainfall, the price of the risk was greater than anyone had anticipated. This effectively halted efforts to develop drought index insurance for this region of Morocco.

Although efforts in Morocco did not lead to a drought insurance program, the findings of the risk assessment and the pricing of an insurance product led to a useful policy dialogue. The risk assessment suggested that the government was supporting cereal production in areas that had become climatically unsustainable.

In the risk assessment and product development work we have performed, a number of important lessons have emerged:

1. When catastrophic weather risks are present, the cost of these risks are being paid somewhere in the society. For example, the poor can be absorbing the cost both directly (by direct losses) or indirectly (by making conservative decisions that reduce their willingness to adopt new technologies and their ability to accumulate productive assets). But also, indirect losses can be absorbed by the public sector in *post hoc* strategies that have many hidden costs and create perverse incentives, or by donors and others that provide assistance after a national disaster.
2. Assessing who is currently paying for catastrophic weather risk helps determine if there is a potential role for index insurance.
3. Pricing weather risk provides useful information for a wide range of stakeholders who may use the information to reconsider current farming systems and institutional mechanisms that are used to cope with or compensate for losses after they occur.[11]

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[10] See Recommended Readings country section, Morocco.

[11] For example, through mapping flood risk in Vietnam, we found that there were areas growing rice that were vulnerable to extreme flooding losses in about 1 in every 4 years. This discovery created a new discussion about whether these areas should be converted to other uses.

4. Relative risk exposure and thus the price of insurance can vary greatly across regions within the same country.
5. The relative risk must be reflected in the pricing of insurance or it will result in inequities, potential adverse selection, and serious inefficiencies.
6. When developing insurance products one must be aware of the potential for adverse selection — a common problem with existing index insurance products seems to be a failure to set the sales closing dates in advance of information that can help the insured know that the probability of a loss in higher than normal. Farmers and others use many systems to forecast weather for the coming season.
7. Insurance products should be developed to complement existing risk coping and risk management strategies.

## Weather Data in Africa — A Serious Constraint

The lack of available and reliable weather data is one of the major constraints when considering weather index insurance for Africa. As was described above, the availability of data is at the core of risk assessment and product development. The absence of quality weather data emerges as a chief constraint to the spread of weather index insurance in many regions of Africa. Given the importance of data and the potential cost of creating and maintaining new data systems, we review possible data that can be used for weather index insurance products in Africa. Data limitations shape many of our views about what products may be used responsibly and effectively in the near term and the sequence of development in our business model that may be most practical for market development in Africa.

There are roughly 1,000 weather stations with quality-controlled, internationally available rainfall data — the type of stations most likely needed for obtaining reinsurance coverage — if stations were evenly distributed this would be one weather station for every 30,000 $km^2$ (Funk et al., 2003). In some locations in Africa (e.g., the Sahel and South Africa), the level of weather station infrastructure is actually declining (Ali et al., 2005; Sawunyama and Hughs, 2008). Without historical weather data, weather risks cannot be understood sufficiently to allow for the design and pricing of weather index insurance contracts. If the future availability of reliable weather data is not assured, no weather index insurance is possible. In many regions of Africa weather station infrastructure is simply too sparse and poorly maintained to successfully replicate the weather index insurance products sold to households in other countries (e.g., India).

When weather station infrastructure is not in operation near the target user, the weather risk can be more crudely estimated using alternative methods. Data from weather stations can be interpolated to create a grid with estimated values between stations. These grids must take into account the topography (e.g., mountain ranges and bodies of water) that may affect weather patterns between the weather stations. Interpolating weather data tends to underestimate extreme events.

Models adding satellite data to rain gauge interpolation and topography estimates such as the Collaborative Historical African Rainfall Model (CHARM, described in the Ethiopia case study) can contribute to weather risk gridding. Satellite data can be a valuable check, providing actual data values between the rain gauges; however, a process for matching satellite data to true ground-level values has not been perfected. Satellite data used in these models currently lack the specificity needed to estimate extreme events accurately at a specific location. For example, the Climatology Prediction Center Merged Analysis of Precipitation (CMAP) is based on a 2.5° x 2.5° longitude-latitude grid (over 100,000 $km^2$ at its smallest point) for each value (Xie and Arkin, 1997). Ali et al. (2005) compare several rainfall products (e.g., the Global Precipitation Climatology Center, the Global Precipitation Climatology Project, CMAP, and the Geostationary Operational Satellite precipitation index) that use rain gauge, satellite imagery, or a hybrid of the two to estimate rainfall in the Sahel. These products also underestimate extreme events, but Ali et al. (2005) find rain gauge data predict low rainfall values (values in the 25 percent quartile of the reference measure) more accurately than hybrid products, which, in turn, predict more accurately than pure satellite imagery products.

A number of organizations (e.g., the National Oceanic and Atmospheric Administration, World Meteorological Organization, Famine Early Warning System Network (FEWS NET), and International Livestock Research Institute) use some combination of rain gauge interpolation, satellite data, and models with other indicators to estimate regional weather for a variety of purposes. Choosing which rainfall data product to use often depends on the region of interest and the purpose for using the product (Ali et al., 2005). Because of the investments of these organizations and others, products using satellite data continue to improve, providing more precise and real-time estimates of weather in remote locations in Africa (e.g., Sung and Weng, 2008).

For our purposes, the alternative data sources described above can be very useful for conducting the risk assessment because they do provide estimates of the rainfall distribution over space and time. Thus, the sub-regional impact and frequency of events can be determined. Despite the benefits of these data sources for understanding weather risk, they are often inappropriate to use when developing farm-level weather index insurance for the reasons described above — a lack of specificity and the tendency to underestimate extreme events. These products are especially inappropriate for weather index insurance for moderate losses of a household in a specific location, such as the Malawi rainfall insurance. For some of the other products presented below, it may be possible to use systems other than ground-level weather stations to estimate and insure regional drought conditions.

Alternative data sources exist that may offer more appropriate indexes on which to base insurance contracts. Satellite data represent a promising low-cost alternative to weather station data for index insurance. Satellite rainfall estimates originated in 1980 and have become increasingly more accurate over time (Dinku et al., 2007). Thus, there are nearly 30 years of data available in many regions. Unfortunately, even this accuracy is dependent on using ground-level weather stations as a means to calibrate the information. Thus, there may be limitations for using these data in a number of African nations for some time.

In addition to lower costs, satellite data have other benefits relative to weather station data. First, unlike weather stations in some areas, satellite data are real-time data that can track emerging weather trends as they occur. Second, certain types of satellite data, and models that accompany that data, can be more inclusive than weather station data and have the potential to lower basis risk for some products. Unlike weather station data whose values are interpolated between stations, satellite data are spatially continuous and can provide actual measurements for these points.

The Normalized Difference Vegetation Index (NDVI) measures the amount of near-infrared light absorbed by plants and is a measure of vegetation density. NDVI data are available at resolutions of one square kilometer, which is much more site specific than CMAP or the other data sources described above (Ali et al., 2005; Peters et al., 2002). NDVI values are a measure of plant health. By comparing historical NDVI values to present values, the NDVI is being used to assess drought in some contexts (Bayarjargal et al., 2006; Peters et al., 2002). Satellite data also provide estimates of rainfall and temperature, which have been used in conjunction with NDVI data to create other drought estimation models; however, these different models yield differing results. Determining which NDVI-based models are most appropriate given the region and intended use of the model is still being worked out (Bayarjargal et al., 2006).

Synthetic Aperture Radar (SAR) is demonstrating significant potential. This technology penetrates cloud cover and, with the proper models, can provide localized estimates of soil moisture as well as a clear image for identifying water inundation from flooding. The World Bank is researching the use of SAR images for developing flood index insurance. Floods endanger households, disrupt business, and destroy agriculture, infrastructure, and other assets. If SAR images were found to be reliable measures of loss, this would be very significant for flood-prone regions in Africa with little or no access to insurance.

In sum, using satellite imagery to underwrite index insurance is still considered experimental; however, these data are widely used in other venues and have been proposed for use in upcoming index insurance pilot projects. Further research and pilot testing are needed. Additionally, the receptivity of potential target users to insurance products based on satellite data remains untested. Still, NDVI, SAR, and other satellite data measured at high resolutions hold promise as potential indexes for areas where ground-level weather data sources do not exist or are insufficient.

## Case Studies and Alternative Approaches to Consider

As we review the following case studies and present some alternative approaches, it becomes clear why we spent extra time reviewing weather data constraints in Africa. Data constraints limit the type of products and approaches that can be successfully implemented. While there are a number of developments in weather index insurance in Africa in recent years, projects in Ethiopia and Malawi have the longest history. These two projects also merit special attention as they represent two ends of a very wide spectrum of how weather index insurance products might be used in Africa. In Ethiopia, a product was purchased by an international organization (WFP) to supplement emergency aid; in Malawi, a product is purchased by smallholder farmers as part of a loan and an input package that can spur technological adoption. Data for the Ethiopia product are important, but not as critical as they are for implementing the Malawi project. The reasons are quite intuitive. Ethiopia involves estimating aggregate shortfalls in basic food production across the country. Thus, the refinements of the data are not as critical. Malawi involves estimating shortfalls of rain for individual farmers during critical time periods. Farmers who farm at significant distances from weather stations will not be served as well as those nearby the weather stations.

The Ethiopia project addresses emergency aid for a quick response to food security problems created by widespread drought. This important and potentially precedent-setting project opens the way for new approaches to getting emergency assistance into countries before a full-blown food crisis emerges. We review the Ethiopia project and then provide some additional ideas for how to extend this type of product. Importantly, we also caution that weather index insurance cannot guard against the current food crisis problems that are driven by dramatic increases in worldwide prices of basic commodities. Given the importance of this topic, Annex B briefly presents how and when price risk management instruments may be used.

The Malawi project sets the standard for projects that are working to integrate weather index insurance to spur lending and technology adoption. Farmers are gaining access to loans because there is weather insurance. More fundamentally, the loans are being used to fund improved varieties of seeds. Nonetheless, the challenges associated with replicating the Malawi experience are daunting. Data and capacity constraints are significant and must be overcome. In many contexts, the cost of implementing such a project may become prohibitive.

Beyond the case studies, we also introduce two alternatives that may offer opportunities for market development in many regions of Africa. Both of these ideas should require less infrastructure development for weather stations than the Malawi case. First, we introduce the idea of “Catastrophic Weather Events Livelihoods Insurance.” The idea of this weather index insurance is that it would not be targeted to a specific crop. Rather it would represent lower thresholds for payment and be designed to help farming households cope with a wide array of problems that are created by extreme weather events. As such it may require fewer weather stations as the target events would be more widespread catastrophes. The second alternative we introduce is weather index insurance for intermediaries, who serve smallholder farmers (agricultural lenders, input suppliers, and buyers). By removing some of the weather risks in the value chain, more economic activity should occur that should lead to technology adoption and economic development.

### African Case Study 1: Ethiopia[12]

Ethiopia contains approximately 22 million farmers (CIA, 2008). The entire Ethiopian economy and food security for rural households can be threatened by low rainfall levels that damages agricultural production. The first prototype weather insurance for Ethiopia food security was designed by Skees et al. (2004). In 2006, the WFP purchased a weather index contract that was structured as a derivative to provide contingent financing in the case of extreme drought during the March–October agricultural season. The value insured was USD 7 million. The WFP purchased the contract from Axa Re (now Paris Re) for a premium of USD 930,000 (Alderman and Haque, 2007). Payments were triggered when the cumulative rainfall from March to October was significantly below the 30-year average, indicative of widespread crop failure and potential famine. In the case of a triggering event, the payment made to the WFP would be transferred to the Ethiopian government for distribution to vulnerable households according to the government’s existing cash-for-work poverty support program using community-based

[12] References for much of the information in this section that are not cited appear in the Recommended Readings country section, Ethiopia.

targeting methods. The contract was expected to benefit up to 63,000 households in 60 districts with maximum payments of about USD 100 (WFP, 2006).

Daily rainfall data from 26 weather stations were collected by the Ethiopian meteorological agency and served as the basis for this contract. These data were submitted to an independent agency for validation. These represent the best weather stations in Ethiopia in terms of having complete and long historical datasets. They are over half of the 44 stations in Ethiopia for which historical data with few missing observations are available and roughly a fifth of the 120 official stations in Ethiopia. Few weather stations with good historical data exist in the pastoral regions; consequently, these regions were excluded from the pilot (Alderman and Haque, 2007).

Ethiopia is dependent on agriculture, which employs eighty percent of its labor force and accounts for roughly 50 percent of GDP (CIA, 2008). The vast majority of crops in Ethiopia are rainfed and, as a result, household income is highly correlated with rainfall. Drought is the most common and most devastating disaster risk in Ethiopia. Significant droughts occurred in 2000, 2002, and 2003. In data from 1900 to 2006, drought accounts for eight of the ten worst natural disasters on record (famine accounts for the other two), all 10 of which have occurred since the early 1980s. On average, almost 4 million people are affected and roughly 26,000 people perish when drought occurs in Ethiopia (UN/ISDR, 2008).

While drought risk affects stakeholders at all levels, roughly seven percent of the Ethiopian population have food insecurity problems regardless of weather conditions. In drought years, the number of food-insecure households can easily double. Households have very limited access to credit. In Ethiopia, land is held publicly so it cannot be used as collateral. This has been a major impediment to lending. To address this, local governments sometimes provide loan guarantees for farmers. Thus, local governments are greatly exposed to the risk of natural disasters adversely affecting loan repayments for agriculture. Finally, at the macro level, safety net programs in Ethiopia are almost entirely funded by donor organizations. Because of the chronic food insecurity problems, food aid in Ethiopia is a constant. When drought occurs, donor programs (e.g., the WFP) require large and rapid increases in funding to provide relief to households entering the ranks of the food insecure. Drought relief efforts can often divert resources from other donor organization programs that are aimed at sustainable development. Thus, the risk assessment of drought in Ethiopia revealed that households, lenders, and donor organizations were all experiencing significant negative consequences associated with drought risk.

Rainfall data for the risk assessment were provided by the FEWS NET in the form of daily CHARM data for 80 zones in Ethiopia for 43 years (1960–2003). CHARM uses interpolated weather station, satellite, and land elevation data to create a grid of rainfall in Africa. CHARM results in an improved estimate of rainfall over simple interpolated weather station data; however, compared to the interpolated weather station values, CHARM tends to underestimate extreme rainfall events — the most important events for insuring against drought at refined local levels. Additionally, specificity of CHARM is somewhat limited, especially in areas of complex topography, so it is best used for understanding rainfall patterns over large regions (Funk et al., 2003).

Though basis risk may be too high for households to directly utilize index insurance based on CHARM data, these data can be effectively used for understanding drought risk in Ethiopia. Average rainfall declined over the 43 years of weather data, indicating drought risk is increasing. Ethiopia comprises five distinct regions based on rainfall patterns. In general, Ethiopia receives 60 to 90 percent of rainfall in the rainy season, or *kiremt* (June–September). However, many areas also receive a springtime rain, called *belg*. Farmers in these regions can alter crop choices based on the timing and intensity of these rains. For example, they may choose to plant two seasons of short-cycle crops such as wheat and teff, or if the rains are late, farmers may choose to plant a single, long-cycle crop such as maize that is planted in belg but harvested in kiremt.

In designing a weather insurance product, the initial work highlighted the importance of early payouts that can be structured with weather index insurance — even in the middle of the rainy season — given clear evidence that drought will be a problem. Because drought is a slow onset event, timely payments are critical because they can provide payments as the disaster emerges — before stakeholders are truly experiencing crisis. Thus, the early work suggested indemnities be determined on a monthly basis during the rainy season and that consideration be given to defining several points for payouts during the season.

To emphasize the need for early payments, consider the case of drought in northern Kenya. In this region, drought is associated with famine measured as the prevalence of at least 20 percent of children severely wasted (Chantarat et al., 2007). Low mid-upper arm circumference (MUAC) is a common estimate of child (aged 6 to 59 months) wasting and is predictive of infant mortality (Mei and Grummer-Strawn, 1997). Beyond infant mortality, childhood malnutrition, especially in the first 2 to 3 years of life, is associated with life-long stunted growth and cognitive and social-emotional deficits that result in lower education completion, less learning per year of education, and lower economic potential (Grantham-McGregor et al., 2007). Children experiencing even a single famine during the first year of life continued to show lower cognitive and social-emotional deficits thirty years later (Galler and Barrett, 2001). Thus, protecting households from famine can be very important and provides a clear rationale for well-functioning food aid safety nets. However, the protection must come sooner than it does with current systems.

Currently, food aid procurement requires months, challenging its ability to protect households from even slow onset events. For example, the average time from the formal request for U.S. food aid to delivery is 5 months (Barrett and Maxwell, 2005). Because malnutrition can be so detrimental to lifelong developmental outcomes, mechanisms that expedite the food aid process can potentially have significant effects on household well-being and economic development.

Chantarat et al. (2007) show that that rainfall estimates can be used to insure against famine in this region as a component of a safety net program. Rather than designing the contract to make payments based on indirect estimates of household well-being such as crop yields, they suggest designing rainfall insurance contracts that makes timely payments based on early indicators of drought and at levels that prevent famine (i.e., prevent severe child wasting from reduced consumption).

### Lessons Learned from Ethiopia

The pilot conducted by the WFP represents a valuable experiment in safety net financing. Based on our illustrations above, early and timely payouts would likely be of interest to a number of governments and donors. In particular, these products could be used to insure against sub-regional disasters that fail to capture media attention, thus, they also fail to receive relief from the international community. For these products, payouts could be based on an aggregate of rainfall data (as was done in the WFP pilot) or satellite data. Thus, even in regions with very little weather station infrastructure, developing a food security index insurance product may be feasible.

Additionally, insuring against sub-regional disasters may also be effective for localized price shocks. When local markets are not highly integrated, insuring against weather yields on the regional level may hedge against commodity price spikes that are created by localized shortages.[13] Price increases will often occur when yields are low in the region due to correlated losses (e.g., a weather event or pest). In regions where drought is a major risk and markets are not well-integrated, a drought index insurance contract purchased by the government or a donor could fund the costs of bringing food relief into the region in a timely fashion. Alternatively, if this insurance product were injecting cash into a sub-region that has an inadequate food supply, food prices may increase enough for markets to overcome the high transport costs (previously contributing to poor integration of local markets) and to sell commodities in the food insecure region. In other words given the infusion of cash, the need resulting from food shortages could potentially be met through arbitrage within the country. This is a logical extension of what was begun in Ethiopia with the WFP. Such weather index insurance contracts at the sub-region level can also be developed using data systems other than weather stations as described earlier. Thus, these contracts are more feasible in the short term. It should be clear that such contracts are limited — they will not protect against global price spikes. They only provide localized protection when there is a crop failure in regions where the country infrastructure is not sufficient to have well-integrated price markets. Another critical issue that must be addressed and merits further consideration is how to distribute the cash infusion.

### African Case Study 2: Malawi

As far as design and intent for an index insurance program, the Malawi pilot project is most consistent with the goal of spurring lending and the adoption of improved technology that could lead to a green revolution in Africa. The product is bundled with a loan and a specific input package that has improved seed. Without the associated drought index insurance, farmers would not be offered credit to purchase the improved seed varieties. The weather index insurance protects the loan to some extent as the lender is the one who receives any insurance indemnity.

Drought is the most frequent weather disaster in Malawi. In terms of the number of individuals affected, all six of the most severe natural disasters in Malawi were droughts. On average over 3.5 million individuals are affected when drought occurs in Malawi (UN/ISDR, 2008). Largely due to drought risk, crops tend to have low yields associated with low access to credit, poorly functioning input markets, and low uptake of technology (Hess and Syroka, 2005).

[13] See Annex B for more information for the use of price insurance instruments for food security.

Malawi has 22 government-managed weather stations that are of sufficient quality to develop a drought insurance product. The Malawi Meteorological Service has been a willing partner in providing historical and ongoing data to make payments in this World Bank project. Of the 22 government-managed stations, 13 were used for the initial risk assessment. Stations having long histories (about 40 years) of data with very few missing values were selected. These stations were also dispersed throughout the country to assess the weather risk in disparate regions. Drought was defined as 75 percent of cumulative average rainfall over the rainy season (October–April). On average, drought occurs at two weather stations each year when measured in this way. This is roughly a 1-in-6-year event, which should be insurable. The historical data reveal localized, regional, and national drought occurring in Malawi (Hess and Syroka, 2005; Kimball, 2006).

Groundnut farmers in Malawi wanting to plant with certified groundnut seed were unable to obtain credit because of the high default risk in the event of a drought (Alderman and Haque, 2007). A drought in 2004–2005 led to high default rates ranging from 30 percent to 50 percent for agricultural loans. Many lenders refused to offer credit for agriculture after this event (Mapfumo, 2007). A pilot was launched in the 2005–2006 growing season linking the Insurance Association of Malawi; the smallholder farmers union, National Smallholder Farmers' Association of Malawi (NASFAM); and two lenders (Alderman and Haque, 2007). The two lenders provided loans to smallholders who agreed to purchase index insurance. The loan covered the costs of seed and insurance premiums (Opportunity International, 2005). These products were presented as a bundled packet, which results in lower delivery costs than using an insurance sales agent.

Farmers who purchase the index insurance agree to sell their yields to NASFAM. NASFAM acts as a delivery channel for the loan and insurance payouts and deducts the price of the loan from its payments to farmers for their yields. Insurance policies only cover the cost of seed for which farmers borrow from the bank, paying premiums at 6–7 percent of loan values. In the event of a payout, NASFAM deducts the amount from the farmer's loan and passes the payout on to the bank. NASFAM deducts the leftover loan liability from farmers' yield proceeds. In the event of a total payout, indemnities equal the value of the loan, and NASFAM does not deduct any amount from yield proceeds for loan payments (Opportunity International, 2005).

Malawi yield data are limited and may be unreliable, and thus, alternative methods for structuring the rainfall insurance payout were pursued after the first year of the pilot (2005). The Malawi product used the FAO Water Requirement Satisfaction Index (WRSI) to establish the contract structure for drought insurance for groundnut. The WRSI is the ratio of water availability for a crop to water requirements for a crop during a season. The WRSI is weighted based on water needs during critical stages of development. Other, more robust crop growth models are available that mimic the physiological growth process of groundnut; however, given the limited data available, the WRSI was chosen for this project (Syroka, 2005). The WRSI requires several data inputs:

1. Historical dekadal (10-day) rainfall data for a weather station;
2. Average dekadal potential for the weather station;
3. Water-holding capacity of the soil;

4. Water use patterns for the insured crop in the region (these are defined for the critical stages and interpolated between these stages);
5. Maximum crop root depth;
6. Seasonal-yield response factors for each crop, which allow the WRSI to be converted into yield estimates; and
7. Start- and end-of-season time periods, and thus, the length of the growing period.

Thus, the project designed the contract based on WRSI modeling of the effects of rainfall on groundnut crop yields. The benefit of using the WRSI is that the only input variable expected to vary is rainfall — all other model inputs are expected to remain constant. Thus, it can isolate the effects of rainfall on models of crop yields (Syroka, 2005). However, the drawback of the WRSI is that it assumes constant soil quality (e.g., constant water-holding capacity), which can differ dramatically within a region, especially in Africa.

Contracts are divided into three phases, with emphasis on rainfall levels during the first two phases. The contracts were structured so that payouts would begin when rainfall levels were such that the expected decline in yields was 16 percent or 23 percent of optimal yield levels, depending on the region. Average yields in the pilot regions are between 88 and 96 percent of optimal yields. Thus, while the contracts are described as insuring against catastrophic risks, they are designed to protect against moderate declines in rainfall. The findings of this project concluded that rainfall at 65 percent of optimal levels was associated with total crop failure. Thus, payout limits were based on this amount and ranged from 58 to 68 percent, Syroka, 2005).

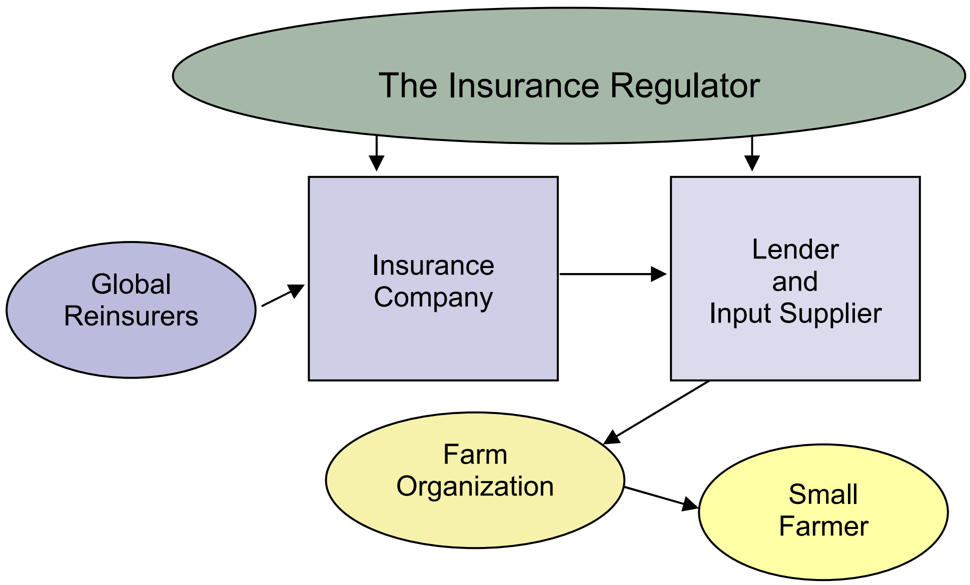
The product has been piloted in four areas, and to keep basis risk at an acceptable level, households must be within 20 km of a weather station to participate (Syroka, 2005). In the 2005–2006 period, 892 farmers purchased weather insurance for a total sum insured of USD 35,000. In the 2006–2007 growing season farmer uptake increased to 1,710 groundnut farmers and a rainfall-based insurance contract was also purchased by some 826 farmers for maize production. Client uptake of the rainfall index insurance product may have been inhibited by the good 2006 groundnut crop. No claims were paid and there was no demonstration effect. However, farmers report that yields when using hybrid seed rose by 140 percent (Mapfumo, 2007).

#### Lessons Learned from Malawi

The Malawi pilot project has required a great deal of resources. However, this product is among the first to be carefully integrated into the value chain, and lessons learned should make future products of this nature easier to develop. The government of Malawi supports this activity, and the program has been incorporated into a larger World Bank project to support agricultural development. Other crops are being added as well. An expanded project will soon be considered by the World Bank board. Should the project be approved, it will support the installation of more weather stations (see Annex A). Additionally, the project will involve a local broker to work more closely with the lender, agribusinesses, insurance companies, and insurance regulator.

The Malawi case is an excellent example of working with farmer organizations, lenders, and the input supplier and should remain a case study for improving linkages in the value chain for stakeholders considering using index insurance in new contexts. The key stakeholders for this type of contract are represented in Figure 1.

**Figure 1 Key Stakeholders for Malawi-type Weather Insurance**




Depending on the local setting, loans may be made by non-bank entities in the value chain, such as input suppliers or buyers of products. When this is the situation, the linkages in the value chain would be more direct. In every case, it must be clear that the insurance company is holding the weather risk and not the lender, an important regulatory concern that must be clearly stated in the contract language.

A concern associated with weather index insurance products targeted to specific crops is these products can give farmers the mistaken impression that they are substitutes for traditional crop-yield insurance policies. The educational and marketing efforts that must accompany these products are quite important. In their efforts to develop insurance products where the underlying index is highly correlated with yields for a specific crop, developers have considered a wide range of crop-yield models. Given that field-level, crop-yield data are nearly nonexistent in most African settings, developers generally use plant growth simulation models that link rainfall or soil moisture to the plant growth process, as was done in Malawi. This is a logical and necessary step. Still, several cautions are in order. First, these models assume that all farmers are using the same production methods and are farming the same type of soil. This assumption is questionable given the variety of farming techniques and soils in many regions of Africa. Second, these models may rely on limited or unsecured weather and crop data with missing values. These data are less likely to estimate extreme crop losses accurately. Finally, in some cases, these index insurance products are designed to insure moderate declines in crop yields, potentially creating more misunderstanding of their potential value if basis risk remains high. In short, these models can over-fit the weather index insurance product to the available data, leading product designers to overestimate the effectiveness of their design as a proxy for household-level losses.

Insurance regulation can improve transparency for this class of insurance products by setting standards for marketing and education and assuring that the insurance contract is clear. It is important that insurance regulators are made aware of strengths and weaknesses of weather index insurance products. One of the responsibilities of insurance regulators is to protect the consumer. While it is useful to have these products tied to a specific crop, it must be remembered that they are still weather insurance and *not* crop insurance. Contracts that clearly and simply outline the specific rules for payouts and the crop(s) that are covered can also increase transparency and reduce misunderstandings. In index insurance contracts, the insured should always be required to sign a statement that indicates that they fully understand that they can have a loss and not be paid. Misunderstandings from smallholder farmers about the products they purchase can create serious problems for long-term sustainability of these products.

With its 22 government-supported weather stations, Malawi was chosen for a weather index insurance pilot because its weather station infrastructure is one of the strongest in the region (Hess and Syroka, 2005). This infrastructure, plus planned additional investments in rain gauges, may make scaling up weather index insurance to the national level feasible in Malawi. However, Malawi appears to have a better infrastructure of weather stations than many African nations. We would not recommend attempting to replicate a Malawi-type insurance product in countries with less-developed weather station infrastructure. Instead, products that rely on aggregated data will be more feasible in those regions; however, using aggregated data may limit development of weather index insurance products that attempt to insure against household-level yield losses for specific crops.

In sum, Malawi is an innovative and interesting case that seems to have facilitated valuable linkages within the value chain. It is an infant program in a single country and questions regarding its international scalability and sustainability remain, yet valuable lessons can be learned from its development and implementation.

## Catastrophic Weather Event Livelihoods Insurance

Weather index insurance could potentially insure any business affected by a particular catastrophic weather event. Rural households in Africa are likely to be involved in a number of livelihoods strategies. Some of these strategies will involve producing crops and livestock for market or for home consumption. Many of the rural poor are landless even though their livelihood strategies and labor activities may strongly depend on good weather. Furthermore, many small farmers in Africa are net food purchasers. Thus, when there is a localized drought they are paying a much higher percentage of their income for food. This is from normal levels that exceed 50 percent. As was discussed earlier, the very livelihood strategies meant to diversify income can fall apart if an extreme weather event creates simultaneous problems for several of the strategies. In Africa, households sometimes even plant different crops in the same field — a practice known as intercropping. Tying weather index insurance to a single livelihood — agriculture — and a single crop may be inconsistent with the type of protection that many households need.

Weather index insurance that protects households against catastrophic losses that affect a number of livelihood strategies may be most beneficial. In a sense, we are recommending a new class of “business interruption” insurance for smallholder households against catastrophic weather risks. We prefer to call it “catastrophic weather event livelihoods insurance.”

This new form of insurance would be less restrictive on a couple of important fronts. First, regulators should be more comfortable with an index insurance product framed as “business interruption.” In traditional business interruption insurance, one can never know exactly the magnitude of foregone profits due to the business interruption event; the loss adjustment is based on a number of logical assumptions. This is consistent with many other forms of business interruption insurance. For example, if a firm purchases a business interruption insurance against fire, the loss adjustment process may examine previous years of profits to forecast what the profits would have been in the absence of the fire. In general, regulators are typically more tolerant of what is accepted as a loss assessment for business interruption insurance. This eases some of the burden to prove that the index insurance will be a close proxy for loss. With respect to index insurance, the loss assessment is based on a pre-agreed relationship between the index and the losses.

Second, a typical insurance requirement is that the insured be able to demonstrate an insurable interest. Thus far, weather index insurance targeted at crops also requires that the insured control some plantings of the crop that is being insured with the weather index insurance. This excludes the landless poor even though they may actually be more vulnerable to the extreme weather event than someone who has control over plantings. With catastrophic weather event livelihoods insurance, any household in the region whose livelihood could be affected by a specified extreme weather event (e.g., drought or flood) would be considered to have an insurable interest and thus could purchase this insurance. Regulators may want to place an upper limit on the sum insured to protect against gambling behavior.

The primary benefit of livelihoods insurance over more specialized commodity-specific weather index insurance is that it may more closely proxy the impact of catastrophic weather events on a household’s entire portfolio of livelihood strategies. If weather index insurance only covers losses associated with production of a specific commodity, households may find that much of their portfolio of livelihood strategies remains exposed to the targeted extreme weather event. Weather index insurance that is not tied to a specific livelihood strategy would be easier to design. There would be no need to use sophisticated plant growth simulation models to try to design the underlying index or insurance parameters to optimize the correlation with production shortfalls for a particular commodity. The insurance could also be marketed differently. Currently, weather index insurance is typically marketed as a substitute for traditional crop insurance. But if a single catastrophic weather event can simultaneously affect multiple livelihood strategies, the outcome can literally be life-threatening for many poor households. Thus, catastrophic weather events livelihoods insurance might be marketed in ways that are more similar to life insurance.

This form of insurance could also be marketed and bundled with technology and lending just as is currently being done with crop-specific index insurance in Malawi. However, we believe that this general livelihoods insurance is also appropriate for situations where data are more limited, 1) because it does not require data for crop models or yield estimates, and 2) because it insures against catastrophic events (e.g., drought). These catastrophic events are by nature more highly spatially correlated than more shallow loss events. For drought, the payout threshold would be set well below the expected value. Thus, a basket of weather station measures or even some form of satellite data could potentially serve as the index for this product.

We believe that throughout much of Africa there are insufficient weather and crop yield data to support highly complex forms of weather index insurance contracts. We also believe that more straightforward contracts have an advantage in that they are easier for stakeholders to understand. Of course, basis risk will *always* be a problem with index insurance contracts and this issue must be presented in a clear fashion.

The “all crops” weather index insurance contract currently used in India, presented in Figure 2, could serve as a basis for developing catastrophic weather event livelihoods insurance. Such a contract is clearly generic and organized for the critical time periods for the growing season.

There are at least two limitations associated with the proposed catastrophic weather event livelihoods insurance product. First, in comparison to the product currently being offered in Malawi, livelihoods insurance is less directly tied to a *specific* technology adoption strategy. Still, livelihoods insurance could be bundled and sold with technology. Additionally, the livelihoods approach may represent an optimal use of limited funds for insurance premiums and, to the extent that household decision makers recognize that these products reduce risks they should be more willing to invest in higher-risk, higher-return activities. Thus, this type of product could still encourage more risk taking on the part of the working poor, including the adoption of technology. A particular challenge for product developers will be designing products that make payouts frequently enough to maintain household interest in the product, but not so frequently as to make the products unaffordable. Designing products for weather risks that occur at a 1-in-7- to 1-in-10-year frequency seems to balance these two needs. A second potential limitation is that insurance for catastrophic risks may be more difficult to sell if individuals indeed tend to underestimate their exposure to very low-frequency catastrophic loss events. Yet, increasing evidence indicates that poor households are willing to purchase life insurance — protection against a rare but catastrophic event — so they may be willing to purchase a livelihoods weather insurance product if it were marketed in a similar way.

**Figure 2 Sample Termsheet for Weather Index Insurance in India**

**TERMSHEET FOR WEATHER INDEX INSURANCE**

| | |
|---|---|
| **Product Reference** | NA06 |
| **Crops** | Any crop in the district |
| **Reference Weather Station** | Nalgonda |
| **Index** | Aggregate rainfall during the cover phases in mm.<br>If rainfall on a day is < 2 mm it is not counted in the aggregate rainfall<br>If rainfall on a day is > 60 mm it is not counted in the aggregate rainfall<br>Above condition applicable only for deficit rainfall cover and not for excess rainfall cover |
| **Definition of Day 1** | month of June at reference station is observed >= 50 mm<br>If above condition is not met in June, Policy invariably starts on July 1 |
| **Policy Duration** | 110 days |

| **Cover Phase** | **I** | **II** | **III** |
|---|---|---|---|
| **Duration** | 35 days | 35 days | 40 days |
| | **PUT** | | |
| **Strike (mm) <** | **60** | **80** | - |
| **Exit (mm) <** | **10** | **10** | - |
| **Notional (Rs / mm)** | 10.00 | 10.00 | - |
| **Policy Limit (Rs)** | 1,000 | 1,000 | - |
| **Phase premium (Rs)** | **90** | **90** | |
| | **CALL** | | |
| **Strike (mm) >** | - | - | **240** |
| **Exit (mm) >** | - | - | **340** |
| **Notional (Rs / mm)** | - | - | 10.00 |
| **Policy Limit (Rs)** | - | - | 1,000 |
| **Phase premium (Rs)** | - | - | **110** |

| | |
|---|---|
| **Combined Premium (Rs)** | **280** |
| **Combined policy limit (Rs)** | 3,000 |
| **Data Source** | Indian Meteorological Department |
| **Settlement Date** | Thirty days after the data release by IMD and verified by Insurer. |

*Source: BASIX of India; a similar contract appears in Manuamorn, 2007*

## Weather Insurance for Intermediaries

Intermediaries exposed to the financial problems created by correlated risk, such as droughts or floods, should also benefit from access to catastrophic weather event livelihoods insurance. Input suppliers can have business interruption problems if, as a result of an emerging drought, local farmers do not purchase seeds and other production inputs. Similarly, if crop losses cause financial stress among farmers in the area, they may have to reduce their purchases of inputs for the subsequent production season.

Processors or other aggregators of the output from agricultural activity will also face business interruption costs as the profits from this sector are directly tied to the output in the region. Through-put of commodities is critical to maintain the infrastructure investments that are made to store, ship, or process commodities. Undoubtedly, correlated weather risks account for at least some of the lack of investment by processors and transporters of agricultural output throughout some parts of Africa.

Correlated weather risk also leads to credit rationing in some rural areas. If agricultural banks could transfer some of their exposure to correlated risk with weather index insurance products, they may be able to improve their financial performance and increase lending in the region. An index insurance product could help lenders offset the real costs associated with loan defaults and debt restructuring in the wake of a catastrophic loss event (Skees and Barnett, 2006). Furthermore, weather index insurance could offset some of the costs associated with regulatory requirements for increased provisioning when repayment is in arrears. Weather index insurance could also reduce liquidity problems since depositors tend to draw down savings following catastrophic events. Thus, business interruption insurance could provide timely access to capital for lenders.

### Passing Benefits to Households

Allowing lenders to pass through the benefits of the large indemnity payment from weather index insurance may be the most efficient way to deal with the large transaction costs associated with providing more complete financial services to poor rural households. This does not mean that the lender would be underwriting the weather risks, but rather the lender would link the benefits of the aggregate index payments to the loans held by households. More sophisticated arrangements that make payments based on risk zones for group lending and group indemnity could also evolve to address special regulatory standards for microinsurance products. In turn, those in higher risk zones would be required to pay higher interest rates for this form of composite product.

The value of weather index insurance is actually enhanced when it is blended with banking and credit services. The role of index insurance is to manage the correlated risk of widespread losses by shifting those losses to those willing and better able to assume the risk — generally financial and reinsurance markets. In turn, the local banking sector should be able to work with individual producers to help them manage idiosyncratic and basis risk. If a producer has an independent loss when the index insurance does not pay an indemnity, it should be possible to borrow from the bank to smooth that shock. By combining insurance with banking in this manner, it is possible to address one of the main concerns associated with index insurance — basis risk.

### Data and Assessing Losses

Given the data constraints and the discussion about alternative data systems for many regions in Africa, it will likely be easier to develop more aggregated weather index insurance contracts for intermediaries than localized contracts for households. More to the point, the level of refinement needed to capture a regional weather catastrophe is much less than what is needed to capture weather events affecting individual households.

Drought risk is the event that merits the most serious attention for weather index insurance targeted to intermediaries. As was described in the data section, a number of approaches are emerging to capture regional drought risk. Understanding the relationship between true business costs and drought risk requires working directly with experts in the business, and in many cases, getting management to consider scenarios that may have occurred ten or fifteen years prior, a time when many of the entities were not in business. The business must consider their current base today and project the impact on cash flow should a historic catastrophic event reoccur in the current year. This scenario analysis can be mapped to the severity and frequency of past events in a fashion that gives everyone a base for considering how much weather index insurance should be purchased and how such insurance may assist in offsetting economic losses.

#### Business Interruption and Flood Risk

As flooding is also a major disaster event in Africa, there may be opportunities to use index insurance for flooding events. However, floods are among the most difficult events to insure and there are little historical data on flooding in lower income countries. Flooding events can be created or made worse by how dikes, dams, and water catchments are managed. Management is not an insurable risk. Thus, it will not be easy to develop flood index insurance for intermediaries in Africa. GlobalAgRisk has worked on the development of flood index insurance in Peru and Vietnam (Skees, Hartell, and Murphy, 2007). A brief summary of that work follows to give some perspective on how such insurance might be organized for Africa.

#### ENSO Insurance in Peru

In the northern region of Peru, extreme flooding can be directly linked to El Niño events. As the Pacific Ocean temperature increases beyond certain thresholds, warm air moves into the region. In the foothills of the mountains this warm air mass meets the cold air cascading down the Andes. This phenomenon creates massive rainfall that lasts for several weeks. The two most recent severe El Niño events (1983 and 1998) devastated a number of regions in Peru with massive flooding. The flooding washed away crops, destroyed basic infrastructure, and disrupted all forms of small trade. Default rates for all MFIs operating in the northern coastal department of Piura prior to the 1998 El Niño were around 8 percent. After El Niño, default rates increased to about 18 percent. While not all of this increase can be attributed to El Niño, much of it was driven by the major disruptions created by El Niño flooding. We proposed a simple insurance contract that would pay when the ENSO (El Niño Southern Oscillation) 1.2 exceeds a value of 2.0. This means that the water temperatures in the zone off the coast of Peru are roughly 2 degrees Celsius above normal — a clear signal that flooding would be severe. The insurance regulator of Peru approved this class of ENSO insurance products for lenders and other stakeholders at risk when such extreme events create problems for their portfolio. At this point, an insurance company in Peru and a global reinsurer are pursuing the market and several lenders have expressed an interest in purchasing the contract to offset economic losses that are created during these periods.

#### River Flood-Level Index Insurance in Vietnam

In Vietnam, early flooding in the Mekong Delta creates serious problems for smallholder rice farmers who cannot harvest in time to avoid the damage that will occur. For those who harvest early, the quality of rice is poor and prices are much lower. In this case, we organized an index based on river levels as the water crossed the border between Vietnam and Cambodia. By working closely with the Vietnam Bank for Agriculture and Rural Development (VBARD) and with Vietnamese experts on flooding who produced flood zones that matched the river levels, we demonstrated the relationship between loan portfolio performance in one province and water levels. A Vietnamese insurer and a global reinsurer offered a business interruption flood insurance product to VBARD in May, 2008. Unfortunately, the contract was offered too late. VBARD was monitoring the levels of water in the Mekong River and knew that the likelihood of a flood event was very low. The contract was designed to pay for flooding in late June and early August. VBARD has expressed an interest in this contract for next year.

## Recommendations for Market Development for Weather Index Insurance

For some time, we have been developing weather index insurance based on some fundamental principles about where insurance fits best for different levels of risks. For frequent and low-consequence risk, those exposed should absorb the risk via traditional risk coping mechanisms. For less frequent, but moderate-consequence risks, individuals may use savings, lending, and some insurance solutions. When truly catastrophic risk occurs (low-frequency, but high-consequence events), some form of catastrophic insurance is needed. In some cases, this may involve a level of government or donor support. In many situations this blend of risk retention, savings, lending, and then insurance can be more optimal than putting insurance into place to deal with events that happen too frequently. This is part of what motivates our “rule of thumb” — not to create weather index insurance for events that occur more frequently than 1 in 6 or 1 in 7 years and motivates our business model — to “get the big risk out of the way first.”

As we have seen, existing data systems may not be sufficient to support well-defined farm-level index insurance products in many regions of Africa. To the extent that data can support what we present as catastrophic weather event livelihoods insurance, this may be a better starting point for household insurance products. Households with catastrophic risk coverage can benefit from the improved business opportunities described above: new linkages to lending or improved inputs, and the timely indemnity payments that offset income losses.

Even catastrophic weather event livelihoods insurance may be difficult to develop and in some cases, addressing the big risk first has led us to recommend introducing the insurance product for other stakeholders (e.g., lenders) that are affected by the correlated risk. These efforts develop a foundation for the market by building local capacity with weather index insurance. In turn, this market can lead to new products. In some cases, pass-through arrangements may be possible. For example, a bank could potentially disperse a large insurance payment among its clients. In addition, bundling loans or savings accounts with weather index insurance for households is possible, as this has been done with other microinsurance products. Also, more investments in delivery could be made in this process, such as using technology to deliver products to households.

## The Role of Governments and Donors[14]

In this section, we outline what public goods investments might be most beneficial for governments to make for spurring the use of weather index insurance products in economic development contexts in Africa. We recognize that governments are investing in a myriad of public goods that contribute to development, and in many cases, donors are assisting governments with important contributions. That being said, we hope if donors decide to implement any of our suggestions they do so only with the knowledge and support of the government. Thus, our discussion focuses on public goods with the assumption that donors will often be involved in these investments.

For long-term sustainability of insurance markets, governments are best suited for the role of facilitator, not the direct deliverer of insurance products. This role includes establishing an appropriate enabling environment and providing certain public goods. More specifically, a government or donor can support such things as:

- Improvements in data systems and data collection;
- Improvements in the legal and regulatory environment;
- Educational efforts about the use of weather insurance;
- Product development; and
- Financing for catastrophic losses.

In some cases, governments or donor agencies may choose to provide financing for catastrophic losses as discussed below. In general, however, governments should not be in the business of providing insurance. In any case, governments should rarely provide direct premium subsidies, which often undermine the incentives of private-sector insurance companies. Also, such subsidies generally favor wealthier farm households and thus erode poverty objectives. Even targeted premium subsidies rarely work as planned.

### Supporting Improvements in Data Systems and Data Collection

Improving data infrastructure is likely the highest priority public good for stakeholders hoping to spur the use of weather index insurance in Africa. First, governments can have a direct and immediate effect by providing greater access to existing data because many governments are missing quality systems for archiving and sharing historic weather data. Second, African governments wanting to pursue household-level weather index insurance products will likely need to make immediate investments in weather station infrastructure. However, investing in new weather stations will be ineffective unless explicit plans for ongoing maintenance are included.

Because data are critical to the development of weather insurance markets, the equipment involved in developing weather data must be reliable, accurate, and secure from any potential tampering, and professionals who work with the equipment must be trustworthy. Other types of information are also important in the development of weather insurance. Examples include yield

[14] This section is based on Skees et al., 2006, a document that GlobalAgRisk prepared for USAID.

data and other information on losses caused by extreme weather events, changes in land use and input use intensity, and records of past disaster management activities or infrastructure changes. Government can play an important role in facilitating index insurance by collecting, maintaining, and archiving the data needed. These data should be made available for public use and for use by those with commercial interests wishing to develop innovative weather insurance products.

### Supporting Improvements in the Legal and Regulatory Environment

As with any market, a legal and regulatory environment must exist for creating enforceable contracts that both buyer and seller can trust. Additionally, making laws and regulations consistent with international standards improves the chances of gaining access to global markets for risk transfer, which is crucial for making weather index insurance sustainable. Unfortunately, in many African countries, laws and regulations are simply not in place to accommodate the development and use of weather insurance products. Human capacity building and technical assistance are essential for preparing the legal and regulatory environment to govern index insurance programs.

If an effective legal system is not in place, insurance contracts may lose validity, or there may be a reluctance by insurers and reinsurers to enter the market. For example, it is not uncommon for insurance companies to refuse to pay valid claims simply because there is no effective oversight, which undermines public confidence and demand for insurance. On the other hand, insurers may be reluctant to sell policies if there is a possibility that the government could alter the terms of the insurance contract after the insurance is sold. If judges and lawyers do not have a good understanding of insurance law, insurers may be forced to make indemnity payments in excess of their obligations under the policy.

In sum, basic contract enforcement and regulations that attempt to assure insurer solvency may be lacking in many locations in Africa. Effective regulation and contract enforcement will be very important to the long-term reputation and performance of weather index insurance programs; therefore, investments to improve the legal and regulatory environment through technical assistance and capacity building are vital for many African countries. These governments should refer to international experience and best practice guidance to establish an appropriate enabling environment, provide public goods that support market development, and undertake any other interventions.

### Supporting Educational Efforts about the Use of Weather Insurance

Potential users must be educated about the advantages and disadvantages of index insurance products. To increase the likelihood that information is presented in a balanced way and that sufficient investments are made in a broader educational effort for an untested product, public funds from governments and/or donors may be required. If insurance is not commonly available in the countryside, general education about insurance and risk management may be necessary. Index insurance policies are typically much simpler and easier to understand than traditional farm-level insurance policies. However, potential users may need help in evaluating how well the index insurance works for their individual risks. In particular, products designed for households will require significant educational investments because they will be sold in larger quantities than products for intermediaries, governments, or donors.

Educating members in the value chain may also be an important role for governments and donors, especially if donors have a previous working relationship with a bank, input supplier, etc. Donors may have an advantage for helping these intermediaries consider the benefits of catastrophic weather event livelihoods insurance or a Malawi-type insurance product and how providing incentives for households to purchase these products could improve the business of the intermediary. Thus, education efforts and formalizing linkages in the value chain can be very important for protecting households from weather shocks and for immediately increasing business opportunities.

### Supporting Product Development

One of the challenges associated with private-sector development of new financial products is the ease with which they can be copied and replicated by others. This "free-rider" problem discourages many companies from making initial investments in new product development, especially in underdeveloped markets. Thus, some level of government and/or donor support for product development can be justified. These investments should be targeted at feasibility studies and developing pilot tests of new products with the involvement of local private-sector partners. Every attempt should be made to ensure that the knowledge and technology for new product development is passed on to local experts as soon as possible.

### Supporting Financing for Catastrophic Losses

Until a sufficient volume of business has been established to attract global reinsurers, extreme losses for the insurance pool may need to be underwritten by government and/or donors, perhaps through contingent loans. For example, the World Bank has a contingent loan for the Mongolian Index-based Livestock Insurance Pilot. If losses for the insurance companies and the domestic reinsurance fund are fully exhausted, the World Bank loan can be accessed to make indemnity payments.

Another possible role for government or donors is to provide financing for low-probability, high-consequence events. As indicated earlier, those at risk tend to ignore the probability of the most extreme and infrequent loss events, but insurers do not ignore these events and consider the probability of such catastrophic losses when calculating premiums. This creates a gap between what buyers are willing to pay and what sellers are willing to accept for protection against very infrequent but catastrophic losses. Governments can provide the financing for this extreme layer of risk in a number of ways that still maintains incentives for domestic insurers to operate in a proper fashion. Still, governments engaging in these types of public-private partnerships should do so with caution, in particular, considering who is capturing the benefits from the proposed agreements.

## Conclusions

Weather index insurance shows signs of promise as knowledge of the concepts and experience with pilot programs are rapidly expanding. The growth and maturity of pilot programs may prove to have a significant influence on spurring a green revolution in Africa. We have carefully built the case for why weather risk transfer is important in Africa. We have also developed some details to demonstrate why the development of such markets will take time and resources.

Clearly, the economic literature on poverty traps, risk aversion, and the growth dynamics of the poor suggest that improving financial services can improve risk taking, technological adoption, and asset accumulation for poor households. Consistent with these theoretical foundations, empirical evidence is showing that lower income countries where both the banking and the insurance sector are growing have a faster growth rate than lower income countries that have no growth in insurance markets. Still, as should be very clear from this paper, developing insurance markets to transfer catastrophic weather risk is not an easy undertaking.

The precedent for using weather insurance for humanitarian aid was established by the WFP in 2006 with the first-ever drought contract for food security contract in Ethiopia. Getting timely payments into regions during an emerging food crisis could mitigate problems *prior* to a full blown crisis. This is significantly different from current approaches that move food aid well *after* the crisis has started. In many regions in Africa, commodity markets are not well-integrated. This creates the need for sub-region weather index insurance products to get cash into the areas affected. The cash could also be used to arbitrage markets and market imperfections at some level. Thus, this type of response could facilitate commodity market development as well.

Experience thus far in Malawi is demonstrating how to package weather insurance, loans, and new technology. Farmers who have adopted the use of new seed varieties report significant increases in yield. Many aspects of the Malawi experience will provide valuable lessons so the activity there merits careful watching. However, given data constraints and the high cost of capacity building, Malawi will be difficult to replicate. With these constraints in mind, we introduce a modified system for delivering more generic weather index insurance as a means of protecting a broad range of livelihoods activities that may be negatively affected by extreme weather events. This type of livelihoods insurance product may fit African conditions better than attempting to tailor weather index insurance to a specific crop. Furthermore, it may not require the same infrastructure investments in weather stations if the event affects a large geographic area. We also expand on the idea of businesses in the value chain using weather index insurance as a means for them to cope with the weather-driven problems of their customers. In particular, we believe that these products can be used by agricultural lenders who have loan performance problems following a large weather event that create cash flow problems for their borrowers.

The task of getting all of the ideas, potential use, concerns, and cautions regarding weather index insurance into a single paper is daunting. Undoubtedly, we have omitted items and ongoing activity that are important to this discussion. For this reason, we encourage you to review the Recommended Reading list.

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## Annex A Price and Weather Risk Management in East and Southern Africa World Bank's Agriculture & Rural Development Department Commodity Risk Management Group

**Background**

Over the past few years, operational work of the World Bank's Commodity Risk Management Group has demonstrated that successful application of market-based approaches to commodity risk management depends heavily on a) the commercial involvement of actors within the existing supply chain (such as producer groups, processors, exporters, banks, and insurance companies) and b) anchoring capacity building on commodity risk management in larger programs and operations. Below is a list of ongoing projects in the region focused on providing organizations within the supply chain with the technical skills and capacity to implement risk management programs.

**Malawi.** In 2005, the Insurance Association of Malawi (IAM) offered an index-based weather insurance policy, linked with credit supply, to small-scale farmers. This first policy was piloted at four different weather stations during the 2005/2006 growing season and offered again in 2006/2007. In July 2007, OIBM and Alliance One (a major contract farming operation in Malawi) expressed an interest in piloting a weather insurance product for tobacco at the portfolio-level, to insure part of their tobacco loan portfolio against deficit and excess rainfall. This differed from the initial pilot years since the bank, the farmers, and Alliance One shared the cost of the insurance and the policy is acting as protection for the institutions, rather than the farmers. In 2008, the program is being scaled up to include more tobacco and maize farmers, as well as, expand to other crops including paprika, soya, and tea. Technical support is being provided to stakeholders in Malawi on all aspects of program implementation including contract design, business processes for roll-out and product marketing, and insurance/reinsurance arrangements.

The Government of Malawi is also in the process of using risk management tools to strengthen its food security strategy. This work began in 2005 when the Government used a SAFEX-based call option to hedge the price risk of maize imports during the food crisis. In May of 2006 and May of 2007, Malawi faced a projected maize surplus and the Government was struggling with decisions about whether or not to allow exports, and how much to export. In order to demonstrate how market-based approaches could help manage uncertainty associated with this decision, the Bank worked with the government and the private sector to structure contingent export contracts. The contingent export contracts were based on put options, which would have provided an opportunity to sell at a pre-agreed price if it was determined later in the season that the country had sufficient maize. Although the contracts were not taken up, they were useful as a demonstration of how contingent contracting could be used to help manage risk associated with surpluses. Currently, Malawi is facing another project maize surplus, but also a much tighter regional/global market. Within the country, there continues to be a fairly high level of uncertainty about crop estimates. The price/supply risk management tool being considered this year is a repurchase option, which is based on a call option combined with a trade finance structure for grain held in the country. This agreement will help Government arrange, through the private sector, for maize to be held in 3-4 locations throughout the country, until

November/December of next year. Government will have the right to repurchase the maize if it appears that the country might have a shortfall during next year's lean season. If maize is needed in the country, Government will exercise the call option and repurchase stocks which can then be re-sold through the private sector. If maize is not needed in the country, the private sector partners in this arrangement will have the right to export. Export permits, with a validity date one day after the option's exercise date, will be required at the time of signing the repurchase agreement. The objective of this approach is to set up a 2nd layer of grain reserves which operates financially, through the private sector. It also helps the Government address the difficult question of whether or not to allow exports, and how to signal to the private sector its intentions about exports. The repurchase option is expected to be agreed and finalized before the middle of June, 2008.

Along with this, Government is also planning to use, for the first time, an index-based weather derivative contract designed to transfer to the market the financial risk of severe and catastrophic national drought that adversely impacts the Government's budget. With the approval of weather derivatives, the World Bank can for the first time offer financial intermediation services to low-income client countries of the International Development Association (IDA), and will add to the range of risk-management tools available to middle-income client countries of the International Bank for Reconstruction and Development (IBRD).

In the case of Malawi, the World Bank will act as intermediary between the country and reinsurance companies or investment banks that offer weather risk management products. An independent third-party will monitor the weather data which will be then entered into a crop-rainfall model that determines whether Malawi receives a payout. The weather derivative for Malawi requires an upfront premium and is designed to manage the risk of low probability but high severity events, like severe droughts, rather than the risk of events that occur more frequently, like minor or normal droughts.

**Kenya.** In March 2008, FSD Kenya, The Rockefeller Foundation, International Livestock Research Institute and The World Bank's Commodity Risk Management Group ("the partners") convened a workshop for approximately fifty institutions with an interest index-based weather and livestock insurance. On the basis of the outstanding interest from participating institutions, the partners decided to fund a joint program to support the development of multiple product pilots. Interest from participants at this workshop reinforced the likely suitability of weather insurance in Kenya where the agro-meteorological climate is moderate; the availability and quality of weather data — including historical data, which is essential to the construction of an index — is high; there exists a large and dynamic set of insurers and delivery channels, such as banks and microfinance institutions, available to distribute the product; and the market is sufficiently large to attract the interest of reinsurers. A program manager is currently being hired to lead the program activities which should result in a pilot program in March of 2009.

**Ethiopia.** In Ethiopia, the Commodity Risk Management Group is working as part of the Financial Sector Capacity Building Project, a 2 year project, funded by the World Bank and the Federal Democratic Republic of Ethiopia. The Financial Sector Capacity Building Project has four components one which is the promotion of greater financial diversity by supporting and developing new financial instruments, and, specifically, weather insurance. The Bank has been supporting the NBE in developing TORs for consultants who will carry out the primary project activities which include, (a) piloting weather insurance in four different *woredas* by providing technical assistance to insurance companies and end-user beneficiaries; (b) determining the scalability of the insurance product to explore potential linkages to input financing; (c) determining the institutional capacity and infrastructure investments required by the National Meteorological Services Authority to provide efficient and sufficient robust weather information for expansion of the product; and (d) providing capacity building including technical assistance to the banking and insurance sectors. This work is building on research and a pilot program done in 2006 in conjunction with the Ethiopian Insurance Corporation.

**Tanzania.** In Tanzania, a partnership has been developed with CRDB, a local bank responsible for most of the lending to coffee and cotton sectors (it has a portfolio of over USD 80 million) to implement a commodity price hedging program for borrowers. In 2005, in the first-ever such program initiated by a local African bank, CRDB established a commodity risk management unit. CRDB has a well-integrated system to support this operation that involves the Treasury department, which is responsible for booking financial risk management transactions with an overseas market provider (Rabobank in 2005/6) and relationship managers in the Corporate Client Department who are responsible for carrying out the risk assessment and risk management activities with clients (coffee producer groups and cotton ginning companies numbering between 25–35). The risk assessment tools provided to the banks' borrowers and its staff have been integrated into standard business practices in Tanzania, although as mentioned above there is a need for additional capacity building to ensure greater take-up of these tools among the smaller and less sophisticated organizations.

Currently the Bank is continuing to provide technical support to CRDB on a) improvements in the risk assessment tools to make them more user-friendly, b) structuring prototype risk management contracts, c) establishing distribution of bi-weekly market that gives cotton and coffee borrowers independent information about global prices, and d) creating operational guides and procedure manuals to ensure that permanent institutionalization of the program within the bank.

Also in Tanzania, a new project is under development in cooperation with the Common Fund for Commodities to strengthen in country capacity on risk management in coffee and cotton sectors. This joint project will build on the initial work done to develop risk assessment tools which help coffee and cotton marketing organizations identify a) overall position against the market, b) break-even cost/price levels, and c) a mark-to-market value which demonstrates net profit/loss of the overall position against current market prices. Initial capacity building on this issue has started to change marketing behavior since producer groups and ginning companies who have adapted the tools are now able to monitor financial exposure throughout the season and make informed decisions about covering risk through forward selling, minimum price guarantee contracts, or financial options. In addition to improved risk management practices, the tools have helped strengthen the capacity of organizations to improve tracking of inventory, purchases, sales commitments, and quality/grades.

Currently, the risk assessment tools are being revised based on feedback from stakeholders. Although approximately 5–10 coffee producer groups and cotton ginning companies have implemented the new risk management practices, additional capacity building is needed to provide refresher training and reach the rest of the market which includes the 15–20 smaller or less sophisticated organizations.

This work is supported by the Swiss Secretariat for Economic Affairs, the Netherlands Ministry of Foreign Affairs, and the European Union. The EU's All ACP Agricultural Commodities Programme will be supporting activities such as this, in collaboration with other partners. For more information on these activities please contact Julie Dana — jdana@worldbank.org.

## Annex B  Where Do Price Risk Management Tools Fit for Food Security?

Recent rises in food prices have captured global attention regarding the need to manage price risk. While price risk management mechanisms (i.e., forwards, futures, and options) can be very beneficial for short-term risks — year-to-year fluctuations — these mechanisms do not protect against long-term trends in commodity prices. To the extent that current price increases are due to a rise in global demand for food and oil, price risk mechanisms will be ineffective for managing this fundamental change.

Price risk management mechanisms are most helpful for internationally traded commodities. For example, Malawi imports white maize when national yields are low; however, national yields are inversely correlated with the white maize price on the South Africa Exchange Market (SAFEX), so purchasing maize can be very costly when food shortages occur (Dana, Gilbert, and Shim, 2007). In 2005, Malawi purchased an OTC call option — based on the SAFEX price of white maize plus the cost of physical delivery — for food security purposes. During November and December of 2005, the price of white maize increased and Malawi used the call option and received physical settlement, which it used to address food shortages (Dana, 2007). Likewise, put options could be used to hedge risk for exported commodities. Still, several preconditions remain that limit the use of price risk management mechanisms in lower income countries. Specifically, effective price risk management typically requires that:

1. The commodity is traded on international exchange markets;
2. The domestic market is integrated with regional and/or international markets; and
3. Local markets are well-integrated.

Commodities not listed on exchange markets tend to trade in lower volumes and do not have standardized price risk management mechanisms (i.e., futures and options). OTC contracts and forwards contracts can be used, but are more challenging for low-volume commodities in lower income countries due to high transaction costs (e.g., pricing the risk, due diligence, etc.) and the problems associated with nonintegrated markets (Numbers 2 and 3 above).

Domestic market integration with international markets seems to depend on a complex relationship among a variety of factors including tariffs, trade restrictions, agricultural subsidy policies, geography, and transport costs (Barrett, 2001). Integration with international markets may differ among countries within the same region in Africa. For example, coffee markets in Ethiopia and Uganda are integrated with international markets, but not in Rwanda due largely to government subsidies (Rapsominikis, Hallam, and Conforti, 2004).

What may be even more problematic is that, in some African nations, local markets are not integrated. For example in Ethiopia, a surplus of maize resulting in lower prices may occur in one region while drought and food shortages result in higher maize prices in another (FEWS NET, 2006). When local markets are not integrated, households are more dependent on the commodities that they and other community members grow. For example in Mozambique, rural households alter their consumption patterns from each season based on the availability of local commodities (e.g., substituting cassava in the lean season for maize in the harvest season); however, consumption patterns of urban households in Mozambique are more consistent largely because of access to imported wheat-based products (Handa and Mlay, 2006).

Markets should integrate when:

$$p_{1t} - p_{2t} \geq c$$

That is the differences between prices at Market 1 at a single point in time ($p_{1t}$) and Market 2 at a single point in time ($p_{2t}$) are greater than or equal to the transaction costs (c), e.g., transporting the commodity (adapted from Rapsominikis, Hallam, and Conforti, 2004). Two factors substantially increase transaction costs and are the primary constraints to market integration in Africa: transportation and communications infrastructure (Rapsominikis, Hallam, and Conforti, 2004). First, farmers cannot cost-effectively move commodities if roads and bridges, but also trucks, trains, or other methods to transport crops, are unavailable or inadequate. In Mozambique, access to a road was associated with consumption of nonlocal commodities. Farm households that lived within 2 km of a road were less likely to change consumption patterns based on the local growing season than farm households that lived more than 2 km from a road (Handa and Mlay, 2006). Second, when communications infrastructure is inadequate, the transaction costs of collecting price information on other markets (e.g., by traveling to those markets) is likely higher than the expected profit from selling in another market.

When local markets are not integrated, insuring against extreme weather events that dramatically decrease yields on the regional level may be an effective alternative for hedging against high local commodity prices. Price increases will often occur when yields are low in the region due to correlated losses (e.g., a weather event or pest). In regions where drought is a major risk and markets are not well-integrated, an index insurance contract purchased by the government or a donor that paid as a drought emerged could fund the costs of bringing food relief into the region.

FEWS NET provides excellent resources on several African countries regarding regional livelihoods strategies. These reports illustrate the effects of market isolation and natural disasters on local livelihoods. The report on the Southern Nations, Nationalities, and People's Region (SNNPR) in Ethiopia is over 250 pages and divides the region into 38 livelihoods zones (FEWS NET, 2006). Understanding the effects of natural disasters at this level of detail is what is needed for safety nets to effectively protect vulnerable households from food and income shocks.