

# Integrating Seasonal Forecasts and Insurance for Adaptation among Subsistence Farmers:

## The Case of Malawi

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June 2008



## Abstract

Climate variability poses a severe threat to subsistence farmers in southern Africa. Two different approaches have emerged in recent years to address these threats: the use of seasonal precipitation forecasts for risk reduction (for example, choosing seed varieties that can perform well for expected rainfall conditions), and the use of innovative financial instruments for risk sharing (for example, index-based weather insurance bundled to microcredit for agricultural inputs). So far these two approaches have remained entirely separated. This paper explores the integration of seasonal forecasts into an ongoing pilot insurance scheme for smallholder farmers in Malawi. The authors propose a model that adjusts the amount of high-yield agricultural inputs given to farmers to favorable or

unfavorable rainfall conditions expected for the season. Simulation results—combining climatic, agricultural, and financial models—indicate that this approach substantially increases production in La Niña years (when droughts are very unlikely for the study area), and reduces losses in El Niño years (when insufficient rainfall often damages crops). Cumulative gross revenues are more than twice as large for the proposed scheme, given modeling assumptions. The resulting accumulation of wealth can reduce long-term vulnerability to drought for participating farmers. Conclusions highlight the potential of this approach for adaptation to climate variability and change in southern Africa.

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This paper—a product of the Sustainable Rural and Urban Development Team, Development Research Group—is part of a larger effort in the department to study the implications of climate change for development, and the appropriate policy responses. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The first author (consultant to the World Bank) may be contacted at [deo@iri.columbia.org](mailto:deo@iri.columbia.org).

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# **Integrating Seasonal Forecasts and Insurance for Adaptation among Subsistence Farmers: The Case of Malawi**

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## 1 INTRODUCTION

Southern Africa is particularly vulnerable to climate variability and change. Droughts, which are strongly associated with the El Niño/Southern Oscillation (ENSO), are expected to become more frequent and intense under a changing climate (Hewitson and Crane, 2006; IPCC, 2007). This poses a major risk for the subsistence agriculture sector, which is the main source of livelihood for the majority of the population in this region.

The international development community is paying increasing attention to insurance against climate-related hazards, seeing it as a potentially effective ex-ante risk management strategy (Linnerooth-Bayer & Mechler., 2007; World Bank, 2005). Insurance-related instruments that spread and pool risks are emerging as important candidates for supporting adaptation to climate-related disasters in developing countries (Linnerooth-Bayer et al., 2002). The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol call upon developed countries to consider actions, including insurance, to meet the specific needs and concerns of developing countries in adapting to climate change. Similarly, the Hyogo Framework for Action calls for the development of risk-sharing mechanisms, particularly insurance and reinsurance against disasters (UNISDR, 2005). To date, however, there is little understanding or agreement on the role that insurance and other forms of risk sharing can play in assisting developing countries to adapt to climate change and reduce disaster risk.

Several micro-insurance schemes have emerged in recent years to address drought risk among smallholder farmers (Linnerooth-Bayer & Mechler, 2007). An innovative pilot drought insurance scheme, under way since 2005 in Malawi, offers index-based weather insurance to smallholder groundnut farmers. Insuring farmers improves their credit worthiness and therefore their

ability to access credit needed for investing in higher-yielding and more profitable production technology (Hellmuth et al., 2007). Banks generally consider lending to smallholder rainfed farmers who lack collateral to be excessively risky due to the high systemic risk of default in the aftermath of droughts. By coupling bank loans with weather insurance, farmers can receive the requisite credit for seeds and other agricultural inputs, and can expect net gain after repayment of the coupled loan-insurance contract.

Seasonal climate forecasts have not played a role in the structure and pricing of index-based weather insurance contracts in the first two years of piloting in Malawi. Seasonal forecasts for both the 2005/2006 and 2006/2007 seasons did not show a higher probability of a wet or dry season for either year and, together with the operational constraints and limitations of launching a pilot, there was no impetus to consider the forecast issue and how it could be incorporated into the program. Yet, since enhanced probability of drought will eventually be forecast, it is necessary to define how the resulting increase in probability of crop loss will affect the insurance price – a conventional approach to risk-sharing products (Wang et al., 1997; Tsanakas and Desli, 2005).

In contexts outside of agriculture, insurance pricing can offer incentives to better manage risk. For example, car theft insurance can encourage the reduction of theft risk if premiums are reduced for those who install an anti-theft alarm system (Grabosky, 1998). Kleindorfer and Kunreuther (1999) examine the impact that insurance coupled with specific risk mitigation measures could have on reducing losses from hurricanes and earthquakes. We are interested in a similar goal: using the bundled loan-insurance concept to provide incentives for production choices that reduce drought risk.

The purpose of this paper is to explore the potential integration of seasonal rainfall forecasts into a weather insurance scheme, with the Malawi pilot as a case study. Section 2 presents an overview of seasonal climate forecasts in southern Africa and their potential role in reducing risk. Section 3 describes the Malawi pilot scheme that bundles microcredit with index-based insurance. Section 4 discusses challenges and opportunities for integrating forecast-based risk reduction approaches into this kind of risk-sharing mechanism. Section 5 outlines a proposed approach to such integration, presenting the models used to simulate the climatic, agricultural and financial dimensions of such approach, as well as model results. Section 6 concludes, highlighting implications for risk management and climate change adaptation.

## **2 SEASONAL CLIMATE FORECASTS AND RISK REDUCTION**

Year-to-year climate variations are influenced by interactions between the atmosphere and the more slowly-varying ocean and land surfaces, such as those associated with the El Niño-Southern Oscillation (ENSO) in the tropical Pacific. Improvements in our understanding of interactions between the atmosphere and its underlying sea and land surfaces, advances in modeling the global climate system, and substantial investment in monitoring the tropical oceans now provide a degree of predictability of climate fluctuations at a seasonal lead time in many parts of the world.

Seasonal climate prediction can play a crucial role in reducing risk of food insecurity. If a seasonal forecast indicates that a drought is likely to strike a certain area, this information can facilitate the process of delivering food aid in time, or help farmers choose a drought-resistant crop variety (resulting in larger food stocks in rural households). Similarly, a seasonal forecast suggesting high likelihood of good rains can help reduce the long-term vulnerability of

subsistence farmers. For example, if they can implement sustainable, high-yield farming practices, farmers can increase production and accumulate wealth. This can help reduce future risks by making farmers more able to withstand the negative impact of future droughts on agricultural production. A review of studies addressing seasonal forecast use in Africa is available in Patt (2007).

This paper focuses on vulnerable systems that could benefit from climate predictions but lack the decision capacity to do them. As stated by Nicholls (2000), most producers are restricted in their flexibility to respond to forecast information; the poorer and more vulnerable the producer, the greater the restrictions to decision capacity. The differential effect of communicating climate information without adequate planning can have profound effects on the distribution of benefits and costs (Stern and Easterling, 1999, Roncoli et al., 2001). Phillips et al. (2002) suggest that, if forecasts are widely disseminated and adopted in the future, appropriate market or policy interventions may need to accompany the information to optimize societal benefit of climate predictions.

### **3 THE MALAWI INDEX-BASED INSURANCE PILOT IMPLEMENTATION**

#### **3.1 Drought risk in Malawi**

Malawi is one of the most food-insecure countries in the Southern African region. Recurrent droughts, the AIDS pandemic, chronic malnutrition, declining soil fertility, shortages of land (most farmers have small holdings, from 0.49 to 3.0 ha) and inadequate agricultural policies contribute to the country's vulnerability. Life expectancy in Malawi is only 38 years. About 6.3 million Malawians live below the poverty line – the majority in rural areas where more than 90%

depend on rain-fed subsistence farming. Chronic food insecurity is widespread. Evidence suggests that increased droughts and floods may be exacerbating poverty levels, leaving many rural farmers trapped in a cycle of poverty and vulnerability (Action Aid, 2005).

Hess and Syroka (2005) point out the strong linkage between food security and weather risk management. According to the authors, Malawi should be a net exporter of food since agro-climatic conditions are relatively good, despite the volatility in rainfall patterns. The management of drought risk in Malawi should involve adapting production, making markets function, establishing effective social safety nets and preparing for food.

Droughts not only pose a risk to food security, but they also inhibit farmers from planting higher-yielding hybrid seeds. Smallholder farmers lack traditional collateral. Because rural banks are reluctant to issue credit to the heavily exposed agricultural sector, farmers cannot obtain the capital needed to purchase high-yield seeds. Not only is there a high risk of default due to droughts, but banks seeking to diversify their lending portfolio into the agricultural sector are constrained by their inability to manage covariate drought risk (World Bank, 2005).

### **3.2 A package of index-based insurance, credit and production technology**

To address the credit constraints discussed above, the World Bank Commodity Risk Management Group, in collaboration with local stakeholders, designed a weather insurance scheme in Malawi for the 2005/2006 crop season in order to enhance groundnut farmers' ability to manage drought risk and, in turn, access loans for improved agricultural inputs. A more detailed description of the scheme is available in Hellmuth (2007). Bundled loan and insurance contracts were offered in four pilot areas: Kasungu, Nkhotakhota, Chitedze and Lilongwe. These



pilot areas were chosen because the National Smallholder Farmers Association of Malawi (NASFAM) had farmer clubs located near meteorological stations with reliable precipitation data. Additionally, the relatively good rain patterns for Malawi standards made the pilot scheme more feasible there. The most vulnerable Malawian farmers, located in more drought-prone areas are currently excluded from this scheme.

In November 2005, through their NASFAM clubs, 892 smallholder farmers bought the weather insurance that allowed them to access a loan package for 32 Kg of improved groundnut seed – enough to cultivate 0.405 ha (one acre). Before the rainy season, participating farmers receive improved agricultural inputs through a contract that specifies (i) an index-based weather insurance component, in which the premium is calculated based on the probability of a payout estimated using the entire available rainfall record (regardless of ENSO), and (ii) a loan component - at the end of the season the farmer will owe the lending institution an amount equal to the cost of agricultural inputs plus insurance premium plus interest and taxes. If rains are good (as measured in a nearby weather station operated by the meteorological service), then the insurance company keeps the premium and farmers repay the loan with proceeds from the (presumably good) harvest. If measured rains are below certain trigger values (based on critical stages of the groundnut growing season), then the insurance company pays part or all of the loan directly to the bank. For a more detailed description of the contract design, see UNDESA (2007). The 0.405 ha bundled package is the only option offered to eligible farmers.

Since the farmers targeted by this scheme typically do not have legal title to their land, the insurance is used to guarantee the loan by requiring the farmer to purchase insurance so that the maximum liability is equal to the loan size including interest.

In contrast to traditional indemnity-based crop insurance, the contracts are index based, which means that the insurer will pay the contractual claim if rainfall falls below a specified level regardless of crop damage. In other words, index-based insurance is against *events* that cause loss, not against the loss itself (Turvey, 2001). Because payouts are independent of the farmers' practices, index-based insurance greatly reduce transaction costs and eliminate moral hazard. By enabling farmers to engage in more productive agriculture, the insurance program can operate independent of subsidies, and appears thus to be a win-win proposition for all the stakeholders: the farmers expect a substantial net gain, and the market actors involved in the scheme foresee a lucrative new market.

A household survey of 160 farmers that participated in the first pilot was implemented in Lilongwe and Kasungu. Survey data shows that 86% of subjects wanted to join the scheme again the following season, and 67% said they had encouraged other farmers to join. In response to farmers' demand, hybrid maize and maize-related fertilizer were added to groundnuts in the second season as a choice for farmers. A total of 2536 farmers joined the scheme in October and November 2006, and plans for covering more farmers and more regions are under way.

Stakeholders interviewed during this research indicated that they expect demand to systematically exceed supply for the foreseeable future.

There is a need to develop a strategy for addressing the interactions between index-based weather insurance and seasonal climate predictions. In addition to promoting an actuarially fair approach to insurance, it may be possible to formulate risk-sharing mechanisms that help farmers make better decisions with regards to crop production. This possibility is discussed in the following sections.

### 3.3 Opportunities to incorporate prediction into insurance

While the weather derivatives market has received substantial attention with regards to the growing role of climate predictions (Jewson and Brix, 2005), little has been done to formally study the implications of seasonal forecasts on index-based weather insurance schemes like the Malawi pilot. Cabrera et al. (2006) and Mjelde and Hill (1999) explored the farm value of ENSO-based forecasts in the context of common crop insurance contracts. Skees et al. (1999) refer to the possibility that improved skill in seasonal climate forecasting may negatively affect certain index-based insurance schemes. Adverse selection resulting from asymmetric information can create problems for the financial viability of such schemes (Luo et al., 1994). Yet in southern Africa, asymmetric information poses a different kind of problem. Acquiring potentially useful seasonal forecasts may prove too expensive for some subsistence farmers (e.g. even the cost of batteries for listening to the forecast by radio may be prohibitive), and insurers may take advantage of this asymmetry at the expense of the farmers that are supposed to be the main beneficiaries of the Malawi pilot scheme.

Figure 1 (based on Hess and Syroka, 2005, page 29) shows simulated payouts during the period 1962-2004, based on a slightly different contract design and set of assumptions. Without considering the ENSO state, the probability of a payout on any given year was 19% (8 payouts in 42 years). If only El Niño years are considered, the probability of a payout rises to 40% (4 payouts in 10 years). The absence of simulated payouts in La Niña years in the study period, indicating a low probability of payout, although the small sample size prevents estimation of the probability of a payout in future La Niña years.

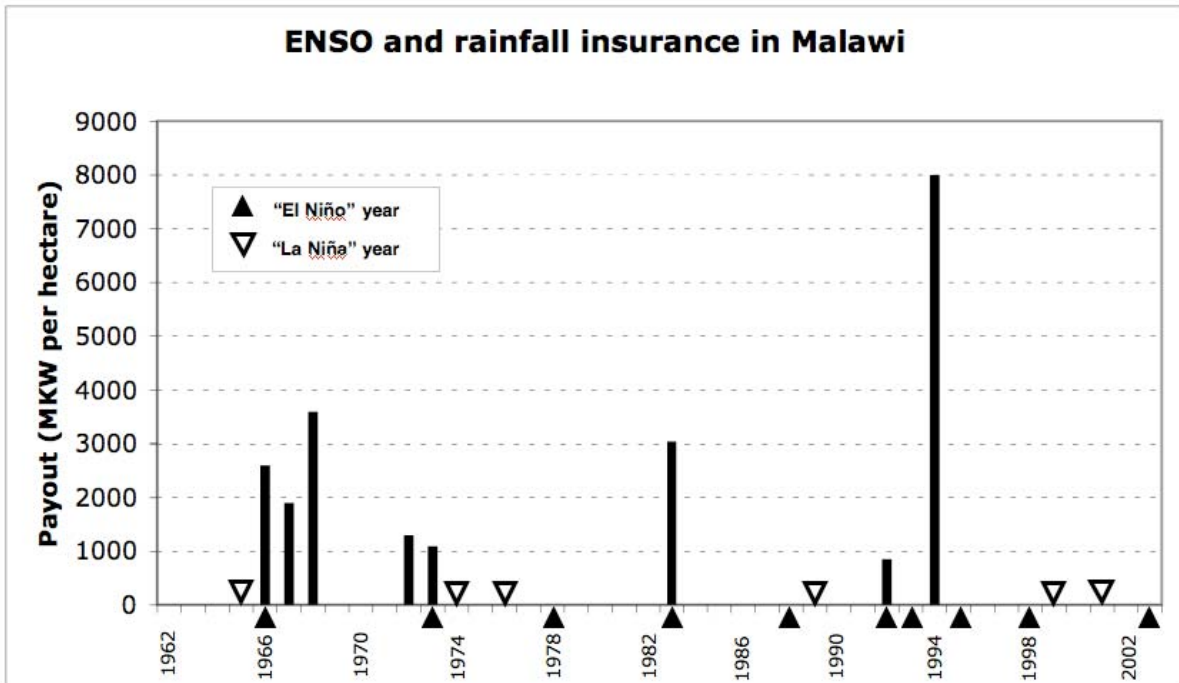


FIGURE 1: Simulated payouts (Hess and Syroka 2005), and El Niño and La Niña years (based on Null 2004).

During participatory workshops held with NASFAM club members in the Kasungu and Lilongwe pilot areas, farmers expressed that they were aware of the relationships between El Niño and seasonal rainfall in their region, and were interested in exploring possibilities of adjusting the insurance scheme depending on the ENSO-based prediction. Results of the household survey mentioned in section 3.2 suggested that integrating seasonal forecasts into the pilot scheme is feasible, particularly if participating farmers are adequately educated about the marketed product (Suarez et al., 2007).

Representatives of the insurance sector involved in the Malawi pilot scheme interviewed in 2006 were fully aware of ENSO and its relationship to seasonal rainfall, and asserted that if an El Niño

were to become evident before the implementation of contracts, they would want to address the increased risk of drought by raising the premium. When presented with additional information about ENSO-based forecasts, they expressed interest in exploring a range of options for incorporating that information. Assuming availability of capital and institutional capacity for design and implementation, a variety of approaches could be explored for integrating seasonal climate forecasts into the bundled credit-insurance Malawi scheme. Variables that could be controlled based on predictions include premium price, size of individual loans, kinds of inputs provided and total number of participating farmers. We are interested in exploring potential schemes that not only share the financial risk associated with droughts, but also actually reduce the vulnerability of subsistence farmers to droughts and climate change. One way to accomplish this goal may be to adjust the kinds and/or quantities of agricultural inputs given to farmers in accordance to expected rainfall conditions.

#### **4 METHODS**

Building on the 2006 index insurance package for Kasungu, Malawi, we formulate a contract structure in which ENSO-based insurance pricing is used to adjust the size of the loan. The approach builds on a theoretical framework for the relationship between forecasts, production, decisions and insurance proposed by Carriquiry and Osgood (2006). For the sake of illustration, we considered a hypothetical farm with 3.14 ha of arable land, in which the farmer uses only the inputs provided by the proposed ENSO-adjusted scheme, using the planting density and fertilizer application recommended for the 2006 package. The insurance contract was designed to support a loan for inputs for 0.405 ha (1 acre) of hybrid maize production, using the prices, parameters, and constraints that stakeholders negotiated for the 2006-2007 season. Although the packages

implemented in 2006 included both groundnut and maize, we present a hypothetical maize-only package to simplify interpretation of results. Maize is highly sensitive to water stress, represents varieties that have been relatively well characterized for agronomic modeling, requires a substantial investment in inputs, and is supported by relatively good historical data.

#### 4.1 Insurance pricing

We calculate what insurance payouts would have been if the 2006 maize contract for Kasungu had been applied to rainfall observed from 1962 to 2006. The 2006 insurance contract calculated the premium as:

$$Premium = Average Payout + Loading * (Value at Risk - Average Payout) \quad (1)$$

with *Loading* set to 6.5% and *Value at Risk* based on the 99th percentile. Because distributional assumptions are required for an estimation of the 99th percentile when there are approximately 50 years of data, for the sake of transparency, the 2006 insurance was officially priced using the maximum payout as an approximation of the 98th percentile, with a loading factor of 6.5%, which was increased to adequately load the lower 98th percentile size *Value at Risk*. We do not use that pricing in our analysis because it is based entirely on the largest payout, which could lead to idiosyncratic results. The plans for future pricing of the 2007 implementation of the Malawi insurance are not based on largest historical payout. Historical burn pricing, used here, relies on payouts determined from historical data, without attempting to characterize the underlying distributions. Although this technique may be overly simplistic, we utilize it because it is highly transparent, and because was the pricing method used for determining the official price of the Malawi insurance.

To examine the implications of conditioning insurance premiums on forecast rainfall for the coming growing season, we calculate the ‘historical burn’ insurance price appropriate for each ENSO phase. ENSO years were classified based on anomalies of the NINO3.4 sea surface temperature (SST) index in the eastern equatorial Pacific, observed in October when contracts are signed. A year was identified as El Niño if the NINO3.4 index was more than 0.5°C warmer than average, or La Niña if it was at least 0.5°C cooler than average. The remaining years were categorized as neutral. We choose the premium payment of the current insurance scheme as a constraint for the premium for all phases, using the ENSO-based insurance rate to adjust the maximum liability, and therefore the respective loan size and budget for inputs.

#### **4.2 Management scenarios**

Banks participating in the Malawi index insurance implementation imposed the constraint that the loan plus interest must be equal to the maximum liability of the insurance, which in the current scheme is constant across years and designed to cover inputs for 0.405 ha (1 acre). According to focus groups and the household survey, most farmers were interested in obtaining larger loans, and were able and willing to dedicate at least 1.62 ha (4 acres) to the improved varieties and management that the loans support. Farmers elsewhere in southern Africa are known to adjust cultivated area in response to predicted rainfall as a rational means of avoiding losses and exploiting opportunity (Phillips et al., 2002). For this exploratory exercise we propose to adjust the total area cultivated with high-yield inputs provided by the bundled loan-insurance contract, depending on expected rainfall. When La Niña conditions suggest a low probability of drought, farmers receive more inputs and can therefore cultivate more land with the hybrid seeds and fertilizer provided by the scheme. When El Niño indicates high risk of crop

failure, the total amount of inputs given to farmers is reduced.

We considered two management scenarios. In scenario A, farmers plant as much area to hybrid maize as their loan can support, up to a maximum of 1.62 ha. The remainder of their farm is assumed to be fallow. In scenario B, farmers again adjust the area under hybrid maize according to the size of their loan, but allocate the remainder of their land to the locally-available traditional maize with no purchased inputs. For both scenarios, we assumed 2006 prices, and the planting density and fertilizer application rates recommended within the 2006 package.

### **4.3 Analyses**

We base the comparisons on an estimate of gross margin in a given year, based on information from the Malawi 2006 contract design process, and maize yields estimated using the CERES-Maize simulation model V. 4.0 (Ritchie et al., 1998).

The gross margin for a given year is the difference between gross receipts and variable costs, where gross receipts are maize grain yields multiplied by the farmgate price, plus any insurance payouts in that year. Variable costs include production inputs, the insurance premium and interest on the farmer's loan. The 2006 cost of inputs for hybrid maize, 9633 MKW ha<sup>-1</sup>, included the seeds and fertilizers for the management package recommended for the 2006 implementation. The loan interest rate was 27.5%. We assumed the same 20 MKW kg<sup>-1</sup> maize grain price that was used for the 2006 contract. We assumed that maize prices are constant, although we recognize that in reality, supply-driven price fluctuations would tend to dampen the income benefits of forecast-based insurance packages. To simplify our presentation, we omitted a small tax that was part of the 2006 implementation. For some comparisons, we calculated the



shadow cost of alternate uses for the farmland and labor. The approximate exchange rate at the time of initiating the pilot project was 1 US dollar = 140 MKW. The annual inflation rate in Malawi has been on the order of 17-25%.

## 5 RESULTS

### 5.1 ENSO-based pricing, fixed loan size

The mean payout values are recognizably different (see Table 1), with average payouts in El Niño phases substantially higher than average, and average payouts in La Niña years much lower than average. Since the maximum liability of the insurance remains constant, the premium price decreases by roughly an order of magnitude in La Niña years.

Table 1. Key parameters of the insurance scheme for the hypothetical farm as a function of ENSO state when loan size is fixed.

Years	Insurance		Mean	Number of		Payout
	rate	price (MKW)	payout (MKW)	payouts	years	relative frequency
All	0.112	1078	580	6	44	0.14
El Niño	0.157	1411	984	2	12	0.17
La Niña	0.018	160	108	1	11	0.09
Neutral	0.111	1002	573	3	22	0.14

If the scheme were modified to simply change the price of the insurance premium based on ENSO without modifying the input package, the impact on farmers' gross margin would be negligible (less than 0.1% change among ENSO states). The insurance premium itself is only a very small fraction of the gross margin (on the order of 100,000 MKW). From the perspective of farmers participating in this pilot, the adjustment of insurance premiums based on seasonal

forecasts makes no difference with regards to agricultural production and has negligible impact on cumulative gross margins. There is no risk reduction resulting from this strategy.

## 5.2 ENSO effects, fixed per-farm insurance price

Table 2 presents the elements of a package that is scaled to reflect ENSO-adjusted premium price ratios. Holding the cash price of the premium at the level that farmers reported they were willing to pay, the changing ratio between price and maximum liability leads to a maximum liability in La Niña years that is almost an order of magnitude larger than in other years. The budget available for inputs in a La Niña year is 7.75 times larger than in the fixed premium package, with an El Niño budget approximately three quarters of the fixed package.

Table 2: Key parameters for an insurance scheme for the hypothetical farm that scales loan size depending on ENSO state

Years	Rate	Price (MKW)	Loan (MKW)	Interest (MKW)	Input budget		Max. liability (MKW)
					(MKW)	% All yrs.	
All	0.120	702	4603	1266	3900	100%	5869
El Niño	0.157	702	3515	967	2812	72%	4482
La Niña	0.018	702	30,916	8502	30,213	775%	39,418
Neutral	0.111	702	4949	1361	4246	109%	6310

## 5.3 Income effects – hybrid maize area scaling only (scenario A)

For management scenario A, basing insurance price on ENSO state more than doubled mean gross margins, and increased the maximum gross margin by a factor of more than six relative to fixed insurance pricing (Table 3). Figure 2 illustrates the differences across seasons in gross margins between the ENSO-adjusted and the fixed price package, showing that the gains result

from very high gross margins in a small number of La Niña years. In El Niño years, the gross margin is slightly smaller for the ENSO-adjusted scheme because of the smaller area planted. The variability of annual gross margin that the farmer faces is much higher because the farmer has the opportunity to earn substantially more in years with abundant rains.

Table 3: Statistics of whole-farm gross margins from fixed and ENSO-based insurance pricing, and increase from conditioning on ENSO phase, assuming scaling of only hybrid maize (scenario A), and adjusting proportion of hybrid and traditional maize production (scenario B).

	<b>Scenario A (hybrid maize only)</b>			<b>Scenario B (hybrid + traditional)</b>		
	<b>Fixed (MKW)</b>	<b>ENSO- based (MKW)</b>	<b>Change (%)</b>	<b>Fixed (MKW)</b>	<b>ENSO- based (MKW)</b>	<b>Change (%)</b>
Mean	89,035	246,798	177%	12,978	37,129	186%
Minimum	-5869	-6310	8%	6683	6565	-2%
Maximum	145,951	1,113,942	663%	19,932	152,823	667%
CV (unitless)	0.49	1.32	170%	0.30	1.37	361%

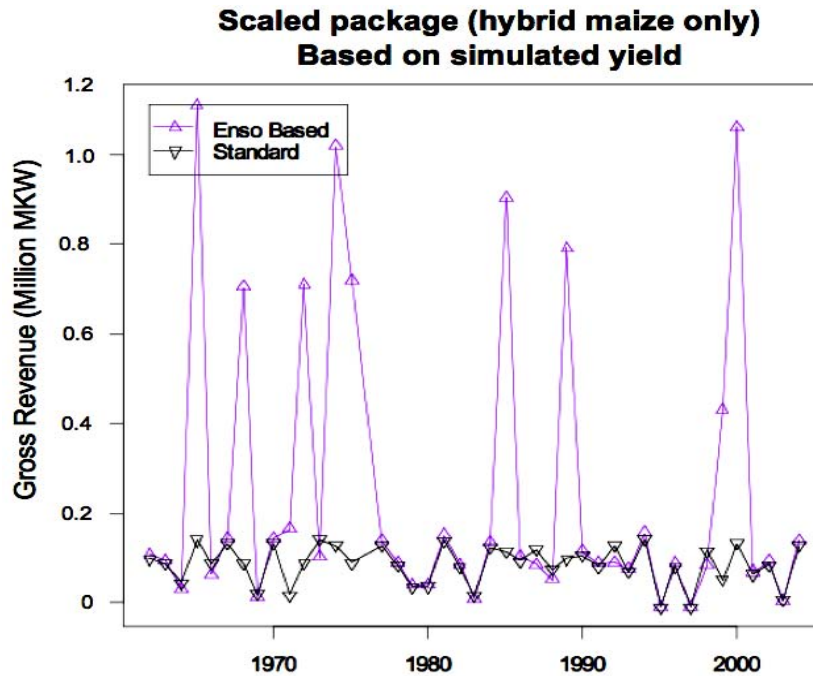


FIGURE 2: Gross margins for the ENSO-scaled and the standard approaches using simulated yields in a hypothetical farm which plants only the hybrid maize given by the bundled scheme.

The histograms in Figure 3 illustrate how the ENSO scaling shifts the gross margins of a relatively small number of La Niña years to much larger values. Of course, these large benefits depend on the hypothetical farm being able to fully capitalize on these extremely productive years. If household labor, storage or transport capacity prevents intensive production on an expanded area, or if maize prices fall during those years, the benefits would be reduced. In addition, these figures represent a farm in which there is a zero shadow cost of scaling up. In reality, the farm would sacrifice revenues from alternate crops that are displaced or would face increased costs due to the additional labor of cultivating a larger amount of land. Including shadow costs into the simulation, we find that a shadow cost of approximately 160,000 MKW would be required to reduce the mean gross margin of the ENSO-scaled package to a value equal to that of the fixed premium package. Since the average gross margins of the fixed hybrid maize

package are less than 90,000 MKW, a farmer who is interested in the fixed insurance package is unlikely to have a shadow value for labor and land that is this high.

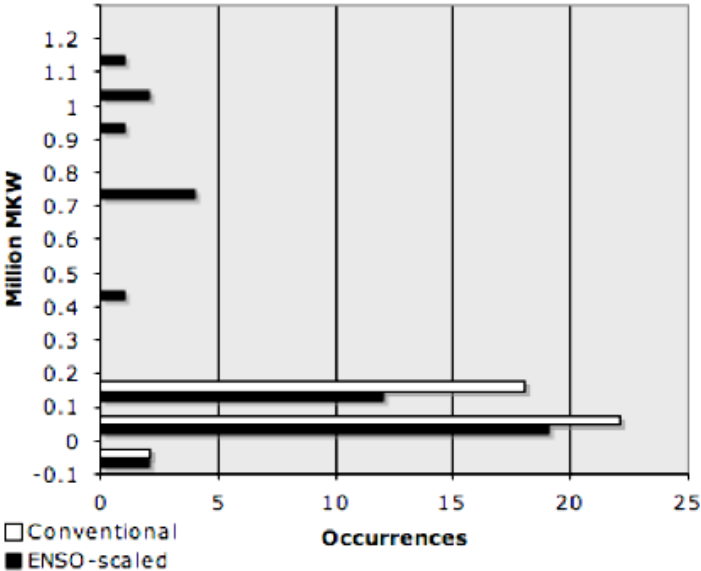


FIGURE 3: Histogram of gross margins for ENSO-scaled and fixed insurance pricing for scenario A, using simulated yields.

To ensure that CERES-Maize did not result in unrealistic differences in yield distributions among ENSO phases, we compared the results based on the simulations with results derived from using reported district-level historical hybrid maize yields in Kasungu (available since 1984). Results (not shown) are qualitatively similar to the simulation-based results, with mean gross margin from ENSO-based insurance premiums more than twice as high as with the fixed-premium package.

**5.4 Income effect – hybrid area scaling and traditional maize (scenario B)**

We now consider the same hypothetical farm, but allow the farmer to allocate land to the hybrid

maize package based on loan size, and the remaining land to non-hybrid, traditional maize. The assumptions behind this scenario would tend to produce conservative estimates of the benefits of ENSO-based pricing: The price the farmer receives for both types of maize is assumed to be the same. The cost of inputs for the non-hybrid maize is assumed to be the cost of purchasing (or forgoing the sale of) maize at the sale prices that the farmer receives for maize. Planting density is assumed to be equal for the hybrid and traditional variety.

The results of this analysis are shown in Table 3 and Figures 4 and 5. These results are qualitatively similar to the benefits calculated using the simple scaling of simulated or historical yields above, showing that the results are somewhat robust to our assumptions. Again the mean gross margin for the ENSO-adjusted package is more than twice the non-adjusted package.

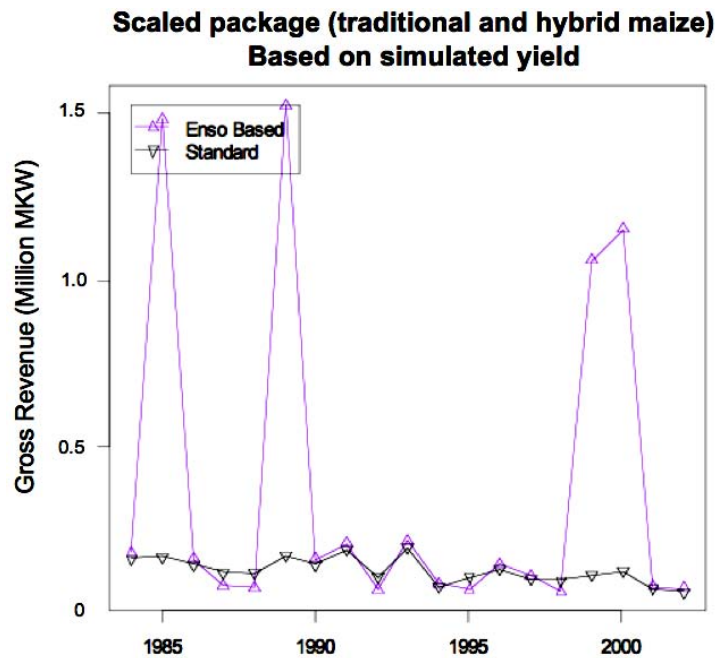


FIGURE 4: Gross margins for the ENSO-scaled and fixed insurance pricing packages in a hypothetical farm where both traditional and hybrid maize is planted.

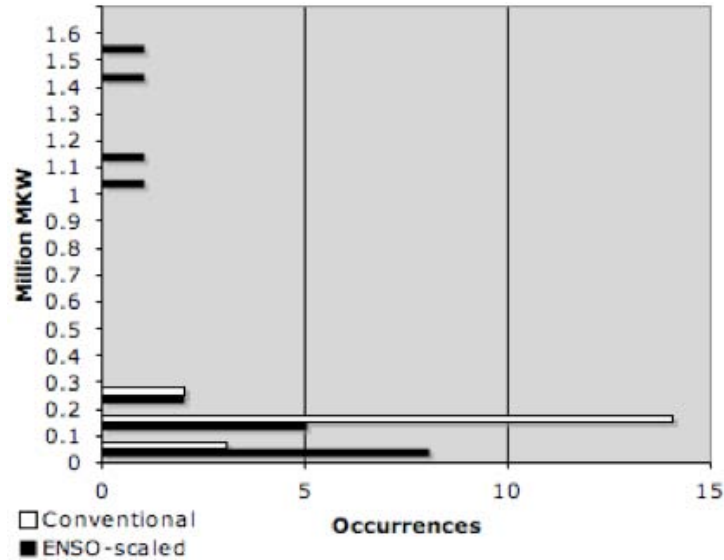


FIGURE 5: Histogram of gross margins for both approaches for model scenario B. The ENSO-scaled option remains robust in its taking advantage of La Niña years.

Although this strategy provides for a relatively stable customer base and income from premiums delivered to the insurance company, it reflects potentially very different values at risk and changes in capital necessary for loans and potential insurance payouts that vary with ENSO state. These ENSO-based variations could provide major challenges for the financial management of the insurance providers and lenders. Yet the availability of innovative financial instruments may allow the design of strategies for managing this issue. Insurance providers and lenders could simply purchase ENSO-indexed insurance or options from reinsurance providers or derivatives markets to stabilize finances, since ENSO impacts are oppositely correlated across different parts of the world. This provides a natural role for reinsurance companies, derivative markets and the emerging Global Index Insurance Facility (GIIF) in supporting local microfinance schemes aimed at integrating risk sharing and risk reduction, whether through pure market approaches or

with donor and NGO support.

## 6 CONCLUSIONS

Climate-related insurance markets need to deal with risks that are not constant. Advance information in the form of seasonal climate forecasts alters risk for agriculture. It has the potential to undermine weather insurance through problems such as inter-temporal adverse selection, and inequitable access to information, if the insurance does not account for the forecast information. On the other hand, if adequately designed to take advantage of predictions, bundled credit-insurance schemes can reduce financial risk for insured farmers and insuring companies, as well as promote risk reduction.

The simple model we presented for integrating seasonal forecasts into the Malawi bundled insurance-credit scheme promotes expanding intensified cultivation when good rains are expected, and reduces financial exposure to drought risk when expected rainfall conditions are less favorable. Our analyses show substantial potential income benefits for farmers, primarily in La Niña years (by a factor of up to six). The resulting increase rate of wealth accumulation can be expected to reduce the farmers' long-term vulnerability to a changing climate. The models we explored did not attempt to be realistic, but offer a set of ideas that can help define a *plausible* approach. While unlikely to be adopted by Malawian stakeholders in their exact form, they illustrate the potential use of climate predictions.

This modeling exercise is based on a number of simplifying assumptions that need to be addressed in future work. These include a linear relationship between agricultural output and amount of inputs provided by the scheme (without consideration for the possibility of increased



labor costs, constraints in land and other factors), as well as no correlation between price of maize and seasonal rain. It is also assumed that the wealth generated during bumper harvests can actually be accumulated by farmers. While these constitute weaknesses of the model, we suspect they are unlikely to invalidate our main conclusion: that a scheme that uses skillful seasonal forecasts to adjust the bundled loan-insurance contract according to expected rains can substantially benefit participating farmers. The example we presented demonstrates that even fairly crude and conservative strategies hold the potential for substantial gains, suggesting that refined approaches may provide greater benefits. There is substantial room to improve seasonal forecast, as the ENSO phenomenon is just one factor affecting seasonal rainfall in southern Africa. There is also room to improve the set of management options in response to a seasonal rainfall forecast (e.g., selecting cultivars with different levels of drought resistance and yield potential, optimizing planting density and fertilizer rates for expected rainfall).

The results presented here depend not only on parameter assumptions, but also on the assumption that future seasonal precipitation will follow the same correlations with ENSO as the 45 years of historical observations used for the model. Future ENSO impacts may not be the same (especially given climatic change). Yet, given the potential for strategic behavior and the potential risk management benefits, one would have to guarantee that future ENSO impacts will not in any way follow the behavior of the past in order to proceed without designing ENSO impacts into the insurance package.

Additional research using more sophisticated forecasts and better characterization of the underlying distributions, correlations, skill and stakeholder preferences and constraints would be necessary before any new contract structure can be implemented in the field. Uncertainty in the

forecast justifies somewhat cautionary responses (Hammer et al., 2001). One option is to design a bundled scheme that moderately adjusts both insurance premium and loan size as a function of ENSO. Integrating seasonal rainfall forecasts into the bundled loan-insurance scheme can make better choices available to farmers, who would in turn be able to make better decisions based on their own risk preferences, their trust in climate information, and a wider set of options for crop production and risk management.

The implementation of this kind of approach can have substantial implications for adaptation to climate change in southern Africa. On one hand, farmers participating in this kind of scheme would become wealthier faster, and would therefore be better able to prepare for changing climatic conditions (including increased risk of disasters). Additionally, integrating communication and use of climate predictions in the decision making processes of subsistence farmers can help set the stage for the dissemination of long-term climate predictions and the promotion of strategies to adapt to the expected patterns of change. Market mechanisms, when adequately structured, can effectively and efficiently guide the allocation of resources for crop production under a changing climate. Insurance markets can take newly available information into account every season, adjusting prices and other variables to convey to economic actors the dynamic nature of relatively predictable climate risks. Lessons from the use of seasonal predictions in the Malawi scheme can help enrich the conceptual framework required for applying insurance solutions to the climate change problem.

## **ACKNOWLEDGEMENTS**

This research was made possible in part by a trust fund provided by the Bank Netherlands

Partnership Program and managed by the World Bank Development Research Group. We are grateful to Joanna Syroka, Joanne Linnerooth-Bayer, Alexander Lotsch, Erin Bryla, Shadreck Mapfumo, Ephraim Chirwa, Ethel Kaimila, Frank Masankha, Xiaoyu Liu, Xavier Giné and Duncan Warren for discussions that helped shape this work. We also extend our gratitude to the Malawian farmers that participated in participatory workshops, as well as to NASFAM and the Malawi Red Cross Society for logistical assistance. Usual disclaimers apply.

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