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# CONCEPT NOTE: AREA-BASED YIELD INSURANCE PILOT PROJECT FOR PERUVIAN COASTAL AGRICULTURE

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## Introduction

The provision of a functioning and sustainable agricultural insurance system promises economic impacts at multiple levels. At the farm level, insurance should enhance the willingness and capacity of small farmers to carry risk and employ more commercial strategies that promise higher returns on average. At a market level, the provision of insurance should make it easier for existing rural micro lenders to expand the agricultural side of their portfolios. In addition, it should facilitate the entrance of new lenders (e.g., banks) that have traditionally avoided agricultural loans because of risk and asymmetric information. Finally, at a political economy level, insurance should break the logic of post-drought (or other climatic disaster) in which the government solves farm indebtedness problems by canceling debts. While such “financial rescues” have their logic, their unintended consequence is the creation of a financial sector unwilling to lend to agriculture.

In short, insurance promises to remake the fundamental economic and political economic landscapes that heretofore have resulted in a vicious circle of underperforming rural financial markets, lower economic growth and higher rates of rural poverty. The remainder of this memo outlines a scheme for breaking this circle and creating a sustainable scheme of agricultural insurance offered by private sector agents.

## 1. Overview of the Pilot Project

### *1.1 Advantages and Challenges of Area-Based Yield Insurance*

The Area-based Yield Insurance Pilot Project (ARBY) will implement a yield insurance scheme for small and medium scale agricultural producers in selected valleys of the Peruvian coast. Insurance payouts will be based on aggregate (valley-wide) yields, and hence should be free of the moral hazard and adverse selection problems that make traditional, *individual* insurance financially infeasible and unsustainable in lower income countries with numerous small-scale producers.

ARBY offers important advantages over other types of index insurance, such as weather insurance or insurance written on the supply of irrigation water. Specifically, ARBY should present the farmer with lower basis risk and hence be a more valuable insurance product. In their analysis of the potential for index insurance schemes in the Peruvian rice-producing valley of Lambeyeque, Carter *et al.*[1] calculate that farmers’ willingness to pay for ARBY insurance should be twice as high as their willingness to pay for an insurance based on a water flow index.

Despite these advantages, four major challenges confront the creation of an ARBY insurance scheme:

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[1] Carter, Michael R., Francisco Galarza and Stephen Boucher (forthcoming). “Underwriting Area-based Yield Insurance to Crowd-in Credit Demand and Supply,” *Savings and Development.*

- *Assuring high quality yield data* to permit the pricing of the insurance and determining when payouts should be made to insured farmers;
- *Establishing effective demand* for an ARBY insurance product by farmers unfamiliar with insurance in general and index-based agricultural insurance in particular;
- *Devising a cost-effective way of delivering* ARBY insurance to small and medium scale producers; and,
- *Incentivizing insurance companies* to bear the costs and parameter uncertainties associated with the development and initial implementation of ARBY insurance/

Solutions to each of these problems will now be described.

### *1.2 A Two-Track Strategy for Solving the Quality Yield Data Problem*

The Peruvian Ministry of Agriculture has time series average yield data stretching back as many as 50 years for the primary crops grown in coastal valleys. These data are assembled each year through a consultative process with key informants in each valley. Comparing these data with the statistically sound data from the Ministry's ENAPROVE yield surveys (available only for the 2002-2005 period) suggests that the historical data are reliable. The historical data should thus provide a reasonable guide to the underlying probability structure driving yields in Peru. We have thus used the Ministry's historical data as the basis for initial estimates of ARBY insurance premiums for Pisco and Ica, two of the river valleys in the department of Ica on Peru's south coast.[2]

However, the *ad hoc* data collection process does not make these data sufficiently reliable as a basis for future insurance payoffs. In particular, the existence of ARBY insurance schemes would radically alter the incentives for the reporting of this data by key informants. Rather than let this problem derail the ARBY scheme (as has happened elsewhere), we thus propose as part of the ARBY project to implement a statistically sound and reliable yield information system in the pilot areas.

In particular, in each pilot area we will use appropriate statistical methods to create a sample of adequate size to reliably estimate yields. We propose to do this using a short (one-page) survey that would be implemented by a respected survey research firm (probably the firm *Cuanto*). Farmers would be asked to report yields. Data could be verified by using receipts from cotton or rice mills. This data will be used to create an official ARBY Yield Index (AYI) that will reported immediately after the harvest.

The above process should certainly work fine for an early pilot stage in which the ARBY insurance has been made available to only a subset of farmers. As the insurance becomes more widespread, there may be some concern that survey respondents will have an incentive to mis-report yields. If physical records from mills and gins are not sufficient to ally this fear, then the project could move toward a more reliable (but more expensive)

[2] The methodology used develop these estimates is described in detail in the Statistical Annex.

crop-cutting methodology for determining yields. The initial pilot stage will not, however, require this additional expense of crop-cutting.

More generally, we anticipate that ARBY insurance will ultimately create a demand (and willingness to pay) for this improved information system such that the reliable data collection scheme will be sustainable in the future.

### *1.3 Experimental Economic Insurance Games to Solve the Effective Demand Problem*

The historical absence of agricultural insurance markets in Peru raises two questions: (1) Will farmers have an effective demand for ARBY insurance? And, (2) Will farmers sufficiently understand a complex index insurance product like ARBY so that they can make an informed purchase decision and not be surprised when the insurance fails to cover individual specific (or idiosyncratic) crop shortfalls?

To deal with these issues, we have developed an experimental insurance game that offers farmers the chance to 'buy' ARBY insurance over a series of game rounds that simulate multiple crop seasons. After substantial pre-testing, the game seems to work very well. Out of a test group of 31 cotton farmers in Ica, 85% chose to buy the insurance option in the final rounds of the game (after playing numerous learning rounds). Moreover, post game discussions revealed both good understanding of the insurance as well as substantial interest on the part of farmers at seeing ARBY insurance offered.

As a prelude to the rollout of any actual pilot program, we will visit the local water users associations *(comisiones de riego*) and play the experimental game. Given that we include an information and education session about ARBY insurance, this will permit us to not only estimate demand for the insurance, it will also assure that farmers can make informed insurance purchase decisions when the product is offered to them.

### *1.4 A Cost-Effective Implementation Model for Area-Based Yield Insurance*

Cotton farmers on the Peruvian coast include large numbers of beneficiaries from the land reform of the 1970s. These beneficiaries (and their heirs) cultivate between 3 and 5 hectares. Direct marketing of an insurance product to them would potentially be costly, especially given that the Peruvian insurance industry currently has relatively little presence in rural areas.

In order to reduce transactions costs, the ARBY insurance product (which will be offered by a consortium of Peruvian Insurance Companies) will be packaged as an add-on to working capital crop loans offered by rural *Cajas*, the type of financial institution most active in the agricultural loan market. Additional marketing costs will be almost zero (given the education approach outlined in 1.3 above).

The *Cajas* themselves will bundle the demand and formally purchase coverage from the insurance provided for the number of hectares covered. The *Cajas* will recover insurance premiums by charging extra interest points on the loans of those farmers who purchase coverage. Indemnity payments will be deposited in the borrower's account with the lending financial institution. The institution will have first claim on indemnity payments to cover the borrower's outstanding loan liabilities for the crop loan.

Among other things, this arrangement should radically reduce default risk for the Cajas (see the Carter *et al.* paper cited in note 1 above). As noted by members of the Peruvian insurance companies, this should lead the Cajas to reduce the risk premium currently incorporated into their interest rate charges, further lessening the net cost of the insurance to farmers (and increasing demand).

*1.5 Integrated Research Design to Measure Impact*

The ARBY insurance scheme will be rolled out experimentally so that its impacts (on credit supply, credit demand and household income and local growth) can be fully and reliably evaluated. Within a given valley, we will randomly select irrigation sub-districts (*comisiones de riego*) where *Cajas* will offer the ARBY product. Random samples of farm households in both selected (treatment) and non-selected (control) sub-districts will be interviewed and provide the information needed for the evaluation. In addition, market level data will be monitored to evaluate the impact of ARBY on financial market contracts, market entry and depth.

While this work is important for development policy, it also offers an opportunity to resolve pending questions about the feasibility of a generalized ARBY scheme. For example, despite the fact that ARBY insurance would seem to be moral hazard proof, some people still worry that insured farmers will become lazy and that the valley-wide yield distribution will decline. From a theoretical perspective, this is unlikely to happen (indeed, we might expect the yield distribution to improve). Nonetheless, it is important question from the perspective of private sector participants and merits an thorough answer.

Finally, the research offers an important learning opportunity not only for the private sector, but also for governments. The Peruvian government recently approved $30 million to strengthen rural financial markets; a top priority for these funds is the creation of index-based insurance products. So far, there are no concrete proposals about how that budget should be used. We will form a research steering committee comprised of government, private sector and academic representatives. This group will be involved in the design of the research component of the project and will be thus positioned to learn from our pilots. Preliminary interest from the Ministry of Agriculture is extremely high.

## 2. The Cotton Pilot Project in Ica

### *2.1 Overview of Cotton in Ica*

The department of Ica, approximately 250 kilometers south of Lima, is one of the most important agricultural regions of Peru's coast. Agriculture in Ica is concentrated in four separate river valleys. The two most important, and the ones for which we develop separate initial estimates of premiums for ARBY insurance products, are Pisco and Ica. Ica, with 37,000 irrigated hectares, is slightly larger than Pisco, with 30,000 irrigated hectares.

Cotton has been the dominant annual crop in Ica for over half a century. While several new export crops, including wine grapes, asparagus, and paprika chile peppers have increased area in recent years, cotton continues to dominate the rural landscape. In 2006, a total of just under 30,000 hectares were planted in cotton across the Pisco and Ica valleys. Much of the local economy and the rhythm of daily life revolve around the annual cotton cycle.

Cotton is a relatively water intensive crop. Cotton growers rely primarily on surface water that originates in the Andean mountains in the department of Huancavelica. Natural lagoons in the highlands permit some storage of rain water, which falls between December and March. Coastal farmers, organized in water users associations (*comisiones de regantes*) manage the release of water from the lagoon and its distribution across farmers on the coast. Both the timing and amount of rain are critical to farmers. If rain comes late or is scarce, farmers must complement surface water with groundwater. In the valley of Ica alone, over 1,000 tube wells exist and, along with them, an active market for groundwater.

Cotton is also an expensive crop to grow, requiring high outlays on chemical inputs, machinery, and labor. The ENAPROVE survey data suggest that average expenditures (excluding family labor) are around $1,000 per hectare. Outside financing is thus critically important. Primary sources of loans include the Cajas and informal lenders including input supply stores and textile mills. Interest rates are high. Annualized rates in the formal sector are currently around 45%, while the informal sector charges up 100%.

### *2.2 Pricing*

We have developed initial estimates for ARBY premiums for both the Pisco and Ica valleys. Here we provide an overview of the methodology and the premiums. Details of the methodology underlying our estimates are provided in the Statistical Annex. The Ministry of Agriculture published historical yield data for Pisco and Ica valleys for 1986 – 2006.[3] As detailed in the Statistical Annex, we used these data to estimate the

[3] 50 years of data are available at the department level; however these more aggregated data mask potentially important differences across valleys and would thus result in a less valuable ARBY insurance product.

probability distribution of average cotton yields in each valley. These distributions then allowed us to design an actuarially fair ARBY insurance policy for each valley. By actuarially fair, we mean that the premiums collected are set equal to the expected value of indemnizations to be paid out.

We calculate premiums for three different strike points. The strike point is the level of average yields in the valley below which the insurance policy begins to pay out indemnizations. The three strike points we consider are 100%, 85%, and 65% of the expected average cotton yield. The expected average cotton yields in Pisco and Ica respectively are 1,968 and 2,381 kilograms per hectare. For example, with an 85% strikepoint, the policy begins paying out indemnizations when the average yield in Pisco falls below 1,673 kilograms per hectare. Under this policy, if the average yield in Pisco turned out to be 1,500 kilograms per hectare, the indemnization paid to policy holders would be the monetary equivalent required to "replace" 173 kilograms per hectare. Based on our estimates, the premium required to make this policy actuatially fair is $35 per hectare. The premium for the same policy in Ica would be $45 per hectare. The premiums for 100% and 65% strikepoints for each valley are provided in the Statistical Annex.

In addition to yield risk and the strikepoint, the cost of the product will depend upon administrative costs. Additional work is required to determine the costs associated with training personnel and administering the product. Initial conversations with Peruvian insurance executives suggest that administrative costs would raise the premium by approximately 50%. Thus the premium for the 85% strikepoint policy in Pisco would increase from $35 to $52.5 per hectare.

The insurance product will be offered in conjunction with a loan.[5] The cost of the insurance contract will be added as percentage points to the interest rate. Assuming a premium of $52.5 per hectare, this would imply an increase of 5.25 percentage points on the loan interest rate in order to fully cover costs.[6] Given that the insurance policy would lower the risk of default, we anticipate that the interest rate on the bundled loan would not increase the full 5.25 percentage points.

*2.3 Partners*

The pilot project will be implemented by one of Peru's largest and most respected insurance companies, La Positiva, working in cooperation with the Rural Savings and Credit Bank (Caja Rural de Ahorro y Crédito, or CRAC) Señor de Luren. CRAC Señor de Luren is the formal financial institution with the largest agricultural portfolio in Ica. In the 2006-07 agricultural season, CRAC Señor de Luren made 1,296 loans to cotton growers in the Pisco and Ica valleys. The average loan size was $2,743, and the average area of cotton financed was 1.4 hectares per farmer. CRAC Señor de Luren already markets micro life insurance products for La Positiva and enthusiastically supports the idea of bundling the proposed ARBY insurance product with their agricultural loans.

[5] We are also exploring the possibility of offering a stand-alone insurance contract.
[6] This calculation is based on a $1,000 per hectare loan.

Working with funding provided by the US Agency for International Development to the BASIS Collaborative Research Support Program, the University of Wisconsin working in collaboration with the Instituto de Estudios Peruanos and the university of California will provide technical support to the project, including the design and implementation of a yield measurement survey and a simulation game-based training material for perspective ARBY clients.

*2.4 Timeline*

Given the strong interest expressed by all parties, we would like to be able to offer a randomized rollout of the program beginning in the next agricultural season. This implies the following timeline:

- November 2007-February 2008: Design final product design and obtain regulatory approval and reinsurance.
- April-Mary 2008: Training of personnel at La Positiva and Señor de Luren about the product and the simulation game.
- May 2008: Conduct experimental games to elicit demand and willingness to pay for ARBY insurance throughout ICA.
- May-June 2008: Marketing of the ARBY insurance product
- June-July 2008: Sale of product bundled with production loans for the 2008-09 agricultural season in randomly selected “treatment” irrigation commissions.
- July-August 2008 Conduct pre-insurance baseline survey of cotton growers in “treatment” and “control” areas.
- July-August 2008: Cotton planting in Pisco
- March 2009: Conduct follow-up survey to measure impact of ARBY on: credit market participation, farm investment, income, and consumption.

**Statistical Annex: Methodology for Pricing Area Based Yield Insurance for Cotton in Pisco and Ica Valleys**

## Pisco Valley

The following steps were taken to characterize and price an ARBY Product for the Pisco Valley:

1. The historical yield data for the 1986 to 2006 period (the blue line in Figure 1) were used to estimate a yield growth trend. Several specifications were tried, but in all cases the estimated yield growth was very modest and not statistically significant. The straight green line in Figure 1 shows expected yields (accounting for yield growth) based on the following linear model:

   $$y_t = 1550 + 5.8t + \hat{\varepsilon}_t,$$

   where *t* is a linear time trend and $y_t$ are cotton yields (measured in kilos/hectare in year *t*. Under this model, predicted yields for 2006 ( $\overline{y}_{2006}$ ) are 1672 kilograms/hectare, or $1045/hectare.[8]

2. To account for the (modest) estimated yield growth, the historical data were adjusted to contemporary (2006) yield levels as follows:

   $$\hat{y}_t = \overline{y}_{2006} + \left(\frac{\overline{y}_{2006}}{\overline{y}_t}\right)\hat{\varepsilon}_t.$$

   Note that this centers the time series about the predicted 2006 yield level and then adds back in the actual historical deviation from expected yields ( $\hat{\varepsilon}_t$ ). Note also that the deviations were inflated (by the factor $\left(\frac{\overline{y}_{2006}}{\overline{y}_t}\right)$) in order to reflect the idea that with higher yields, deviations should also be larger. These adjusted data are shown in Figure 1 as a solid red line.

3. The adjusted time series data were used to estimate the probability function that best describes the data. A number of functional forms were tried, and the one that best fit the data was a Weibul function with parameters 6.00 and 1806.1.[9] The orange curve in

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[8] Here and throughout this annex, kilograms of cotton are converted to dollar using a price of @S/. per kilo and a market exchange rate of 3.2 S/./$US.

[9] The Weibul probability function for a yield value of *x* is defined as $f(x) = ab^{-a}x^{a-1}e^{-(x/b)^a}$.

Figure 2 shows the estimated probability function for the adjusted Pisco yield data. Under this distribution, long-term expected yields are $1230/hectare (or 1968 kilos/hectare).

4. Indemnity payments under Area Based Yield Insurance are triggered when average valley yields ( $\bar{y}_t$ ) fall below a critical value (or strike point). For strike point $y^c$, indemnity payments $p_t$ are defined as:

$$p_t = \begin{cases} y^c - \bar{y}_t \ \ if \ \ \bar{y}_t < y^c \\ 0, \ otherwise \end{cases}$$

   Figure 2 graphs indemnity payments as a function of realized average yields for a three ARBY insurance products: one with a strike point at 100% of long-term yields, one with a strike point at 85% of long-term average yields and a third with the strike point set at 65% of long-term yields. Note that lower strike points make indemnity payouts less likely. They also make the amount of the payout lower for any realized yield level.

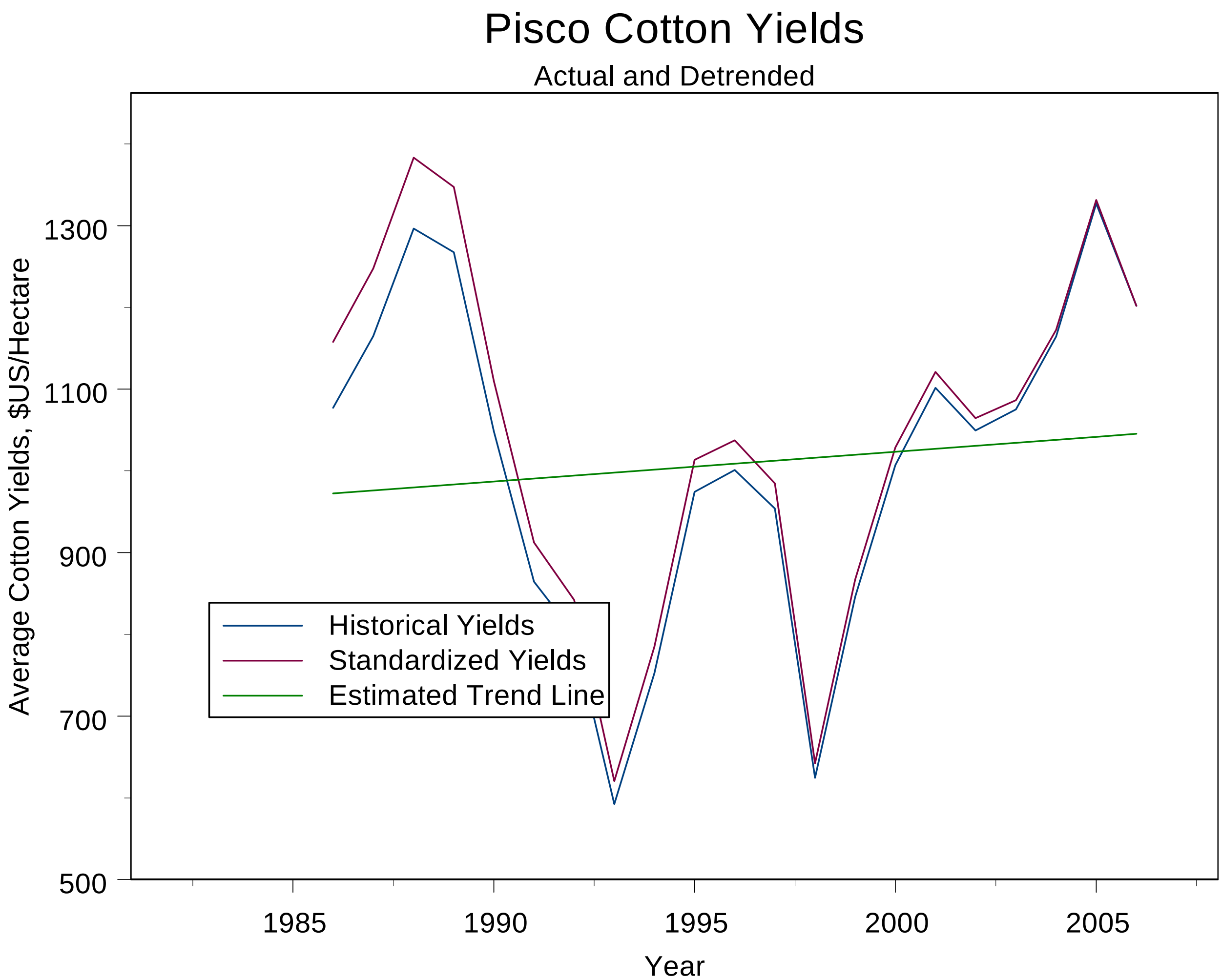
5. Included in Figure 2 are the actuarially fair premiums that would be required for each variant of the ARBY insurance. The actuarially fair premium is simply the premium that equals the expected indemnity payment. Note that this premium does not cover administrative, marketing or other costs of providing the insurance. As can be seen, with the insurance strike point set at 100% of long-term average yields, the ARBY insurance would cost $99/hectare. The 85% strike point insurance would cost $35/hectare and the 65% insurance would cost only $6/hectare. While these latter two forms of insurance are less expensive, they of course also protect the farmer against fewer risks.

6. As can be seen from Figure 2, there is almost no probability that average yields in Pisco will fall below about $300/hectare (which corresponds to a physical yield of 500 kilos/hectare). At this extremely low and unlikely outcome, payments under the 100% ARBY insurance would be $918/hectare. Under 85% and 65% ARBY insurance these maximum conceivable payments would respectively be $733 and $487 per-hectare. To put these numbers in context, the lowest registered average yields in Pisco since 1986 were 950 kilos/hectare (or $620/hectare) in 1992. Similar, but slightly higher yields were recorded following the most recent El Nino year (1998).

The Table below gives some additional information on the likelihood of payouts under the different strike point options.

| | 100% ARBY ($99 premium) | 85% ARBY ($35 premium) | 65% ARBY ($6 premium) |
|---|---|---|---|
| **95% of the time, indemnity will be less than:** | $418/ha | $233/ha | $50/ha |
| **85% of the time, indemnity will be less than:** | $230/ha | $46/ha | 0 |
| **75% of the time, indemnity will be less than:** | $168/ha | 0 | 0 |
| **65% of the time, indemnity will be less than:** | $45/ha | 0 | 0 |
| **50%** | 0 | 0 | 0 |

**FIGURE 1**



Pisco Cotton Yields
Actual and Detrended
Average Cotton Yields, $US/Hectare
1300
1100
900
700
500
1985
1990
1995
2000
2005
Year
Historical Yields
Standardized Yields
Estimated Trend Line

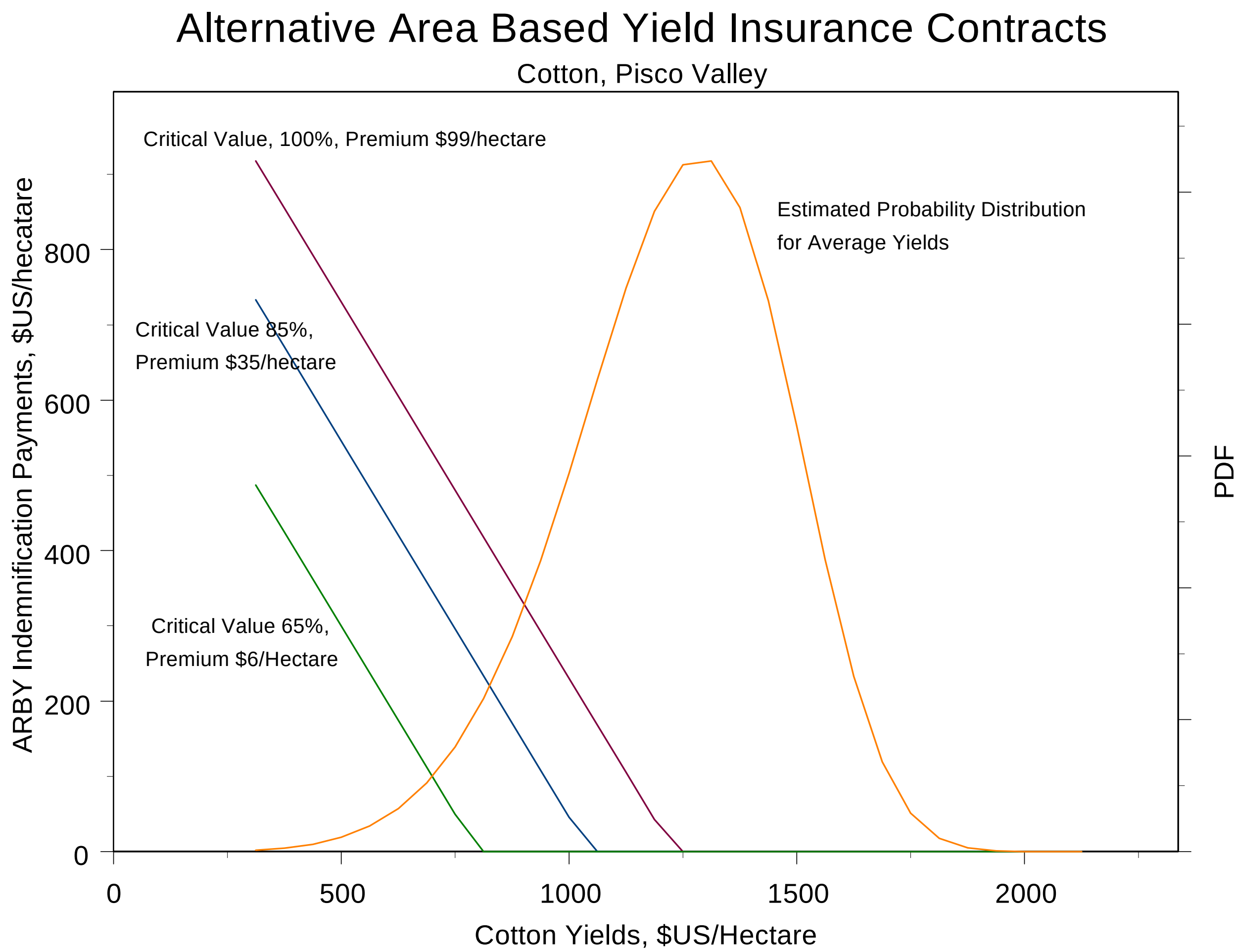

Alternative Area Based Yield Insurance Contracts
Cotton, Pisco Valley
Critical Value, 100%, Premium $99/hectare
Estimated Probability Distribution
for Average Yields
Critical Value 85%,
Premium $35/hectare
Critical Value 65%,
Premium $6/Hectare
ARBY Indemnification Payments, $US/hecatare
PDF
0
200
400
600
800
0
500
1000
1500
2000
Cotton Yields, $US/Hectare

**Figure 2**

## Ica Valley

The following steps were taken to characterize and price an ARBY Product for the Ica Valley:

1. The historical yield data for the 1986 to 2006 period (the blue line in Figure 1) were used to estimate a yield growth trend. Several specifications were tried, but in all cases the estimated yield growth was relatively modest (2.2%), tough statistically significant. The straight green line in Figure 1 shows expected yields (accounting for yield growth) based on the following linear model, which has a better global fit than the log-linear model:

   $$y_t = 1454 + 43.9t + \hat{\varepsilon}_t,$$

   where *t* is a linear time trend and $y_t$ are cotton yields (measured in kilos/hectare in year *t*. Under this model, predicted yields for 2006 ( $\bar{y}_{2006}$ ) are 2376 kilograms/hectare, or $1485/hectare.[10]

2. To account for the (modest) estimated yield growth, the historical data were adjusted to contemporary (2006) yield levels as follows:

   $$\hat{y}_t = \bar{y}_{2006} + \left(\frac{\bar{y}_{2006}}{\bar{y}_t}\right)\hat{\varepsilon}_t.$$

   Note that this centers the time series about the predicted 2006 yield level and then adds back in the actual historical deviation from expected yields ( $\hat{\varepsilon}_t$ ). Note also that the deviations were inflated (by the factor $\left(\frac{\bar{y}_{2006}}{\bar{y}_t}\right)$) in order to reflect the idea that with higher yields, deviations should also be larger. These adjusted data are shown in Figure 1 as a dotted green line.

3. The adjusted time series data were used to estimate the probability function that best describes the data. A number of functional forms were tried, and the one that best fit the data was a Weibull function with parameters 5.55 and 2577.5.[11] The orange curve in Figure 2 shows the estimated probability function for the adjusted Ica yield data. Under this distribution, long-term expected yields are $1488/hectare (or 2381 kilos/hectare).

[10] Here and throughout this annex, kilograms of cotton are converted to dollar using a price of 2 S/. per kilo and a market exchange rate of 3.2 S/. per $US.

[11] The Weibull probability function for a yield value of *x* is defined as: $f(x) = ab^{-a}x^{a-1}e^{-(x/b)^a}$.

4. Indemnity payments under Area Based Yield Insurance are triggered when average valley yields ( $\overline{y}_t$ ) fall below a critical value (or strike point). For strike point $y^c$, indemnity payments $p_t$ are defined as:

$$p_t = \begin{cases} y^c - \overline{y}_t \ \ if \ \ \overline{y}_t < y^c \\ 0, \ otherwise \end{cases}$$

   Figure 2 graphs indemnity payments as a function of realized average yields for a three ARBY insurance products: one with a strike point at 100% of long-term yields, one with a strike point at 85% of long-term average yields and a third with the strike point set at 65% of long-term yields. Note that lower strike points make indemnity payouts less likely. They also make the amount of the payout lower for any realized yield level.

5. Included in Figure 2 are the actuarially fair premiums that would be required for each variant of the ARBY insurance. The actuarially fair premium is simply the premium that equals the expected indemnity payment. Note that this premium does not cover administrative, marketing or other costs of providing the insurance. As can be seen, the premiums are higher in Ica valley compared with Pisco valley. In particular, with the insurance strike point set at 100% of long-term average yields, the ARBY insurance would cost $120/hectare. The 85% strike point insurance would cost $45/hectare and the 65% insurance would cost only $7/hectare. While these latter two forms of insurance are less expensive, they of course also protect the farmer against fewer risks.

6. As can be seen from Figure 2, there is almost no probability that average yields in Ica will fall below about $500/hectare (which corresponds to a physical yield of 800 kilos/hectare). At this extremely low and unlikely outcome, payments under the 100% ARBY insurance would be $988/hectare. Under 85% and 65% ARBY insurance these maximum conceivable payments would respectively be $765 and $467 per-hectare. To put these numbers in context, the lowest registered average yields in Ica since 1986 were 776 kilos/hectare (or $485/hectare) in 1992. Much higher yields were recorded following the most recent El Nino year (1998).

The Table below gives some additional information on the likelihood of payouts under the different strike point options.

| | 100% ARBY ($120 premium) | 85% ARBY ($45 premium) | 65% ARBY ($7 premium) |
|---|---|---|---|
| **95% of the time, indemnity will be less than:** | $543/ha | $320/ha | $22/ha |
| **85% of the time, indemnity will be less than:** | $328/ha | $105/ha | 0 |
| **75% of the time, indemnity will be less than:** | $201/ha | 0 | 0 |
| **65% of the time, indemnity will be less than:** | $104/ha | 0 | 0 |
| **50%** | 0 | 0 | 0 |

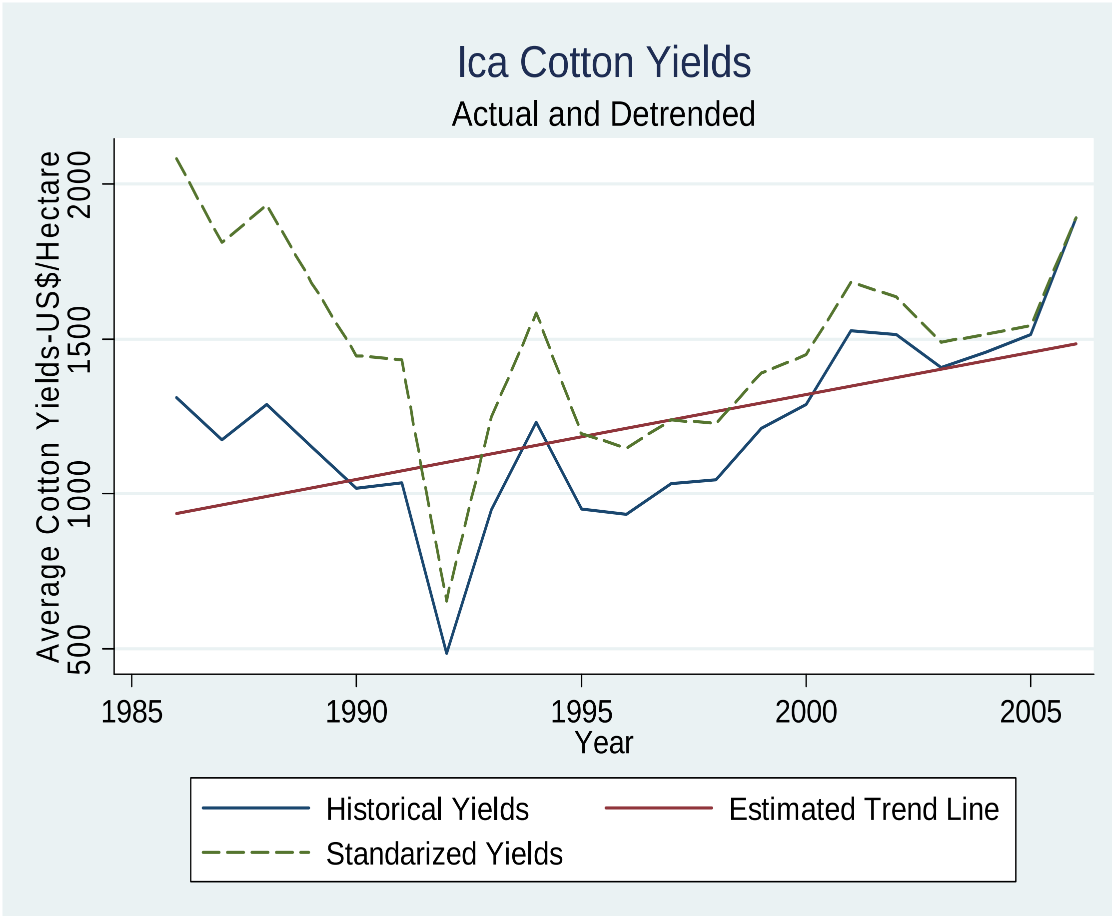
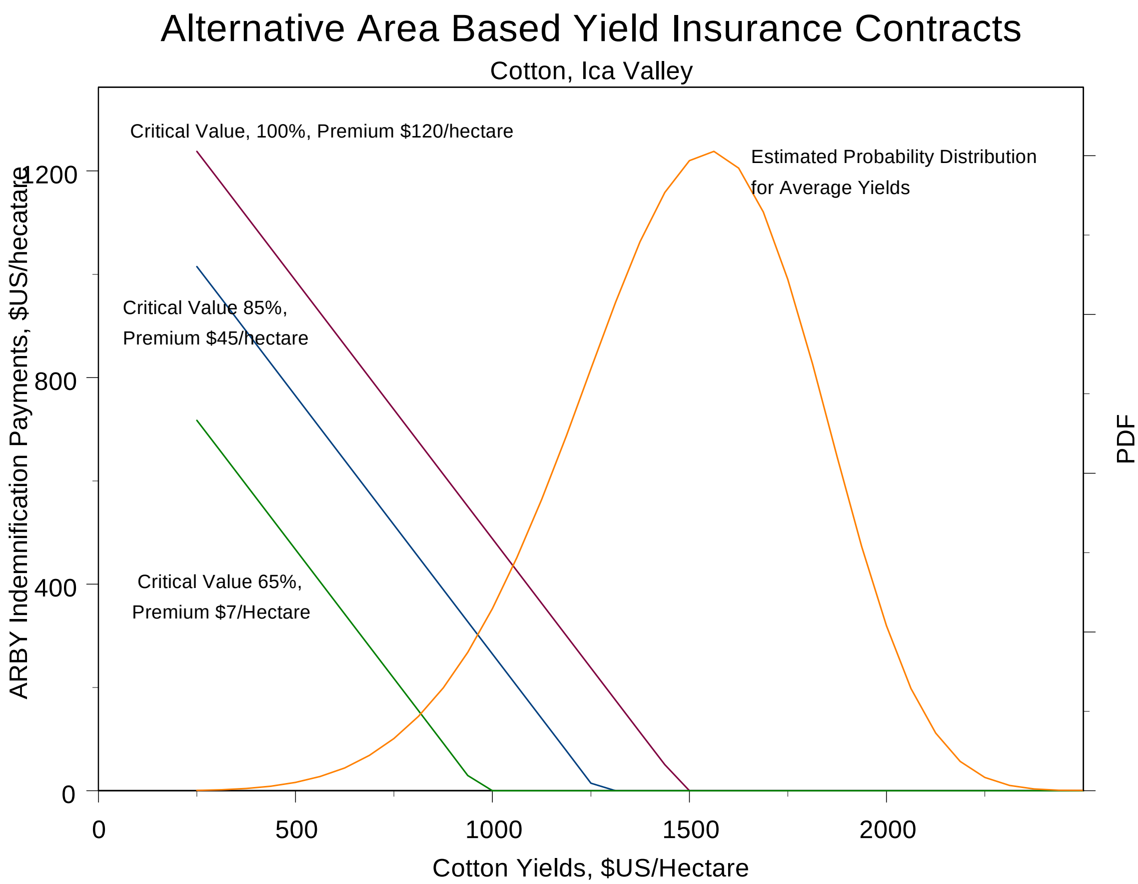

Ica Cotton Yields
Actual and Detrended
Average Cotton Yields-US$/Hectare
500
1000
1500
2000
1985
1990
1995
2000
2005
Year
Historical Yields
Estimated Trend Line
Standarized Yields

**FIGURE 1**

**Figure 2**



Alternative Area Based Yield Insurance Contracts
Cotton, Ica Valley
Critical Value, 100%, Premium $120/hectare
Estimated Probability Distribution
for Average Yields
Critical Value 85%,
Premium $45/hectare
Critical Value 65%,
Premium $7/Hectare
ARBY Indemnification Payments, $US/hecatare
1200
800
400
0
0
500
1000
1500
2000
Cotton Yields, $US/Hectare
PDF