



途上国における貧困削減と制度・市場・政策
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Rainfall and Temperature Index Insurance in India
— Project Documentation —

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1 Introduction

Farmers around the world face a variety of risks during agricultural production. In particular, uninsured weather risk has been a significant barrier to farmers engaging in ex-ante risk management and coping with ex-post risk. Irrigation is often not available in developing countries, and hence, agricultural profits largely depend on seasonal and temporal weather variations. Therefore, uninsured weather risk could be a significant cause of production inefficiency and resultant income poverty. For example, a study by Rosenzweig and Binswanger (1993) found that a one-standard-deviation decrease in weather risk would raise the average profits by 35% among the poorest quartile in India, suggesting that there might be an unmet demand for insurance that covers weather risk.

The current study focuses on India, where dependence on monsoons is known to be very high. Nearly 70% of India's cultivable land is rain-fed. Weather risk is the primary determinant of income variability in semi-arid areas, cited by 90% of the sample households analyzed by Cole et al. (2013) as the most important risk they face.¹ Hedging weather risk would be essential to improve household welfare by enabling production and smoothing consumption opportunities.

Since the 1990s, there has been remarkable progress in theoretical and empirical literature on risk and insurance in developing countries. One of the main issues in development economics is how farmers can mitigate various kinds of risks. For example, Rosenzweig and Binswanger (1993) and Morduch (1995) found that poorer farmers diversify their income portfolio by farming different kinds of crops and engaging in off-farm job opportunities. Morduch (1994, 1995) and Dercon (2005) discussed how informal insurance, such as mutual help and rotating savings and credit associations (ROSCAs), play an important role when the access to credit markets is limited. Certain studies showed that there are, albeit partial, informal insurance mechanisms against idiosyncratic shocks (Townsend, 1994; Udry, 1994, Ligon et al., 2008).

However, among villagers, the role of such informal insurance might not be large

¹ Farmers were asked to rank different kinds of risks (weather risk, price risk, lack of money, lack of family labor, lack of land, and lack of infrastructure) from the most to the least serious. The same question was asked to the sample farmers of the current study, and 88.4% of them answered that weather risk is the most serious risk they face.

against weather risk, such as drought, floods, and typhoons, which are highly covariate. In addition, self-insurance mechanisms, such as storing crops and holding livestock, as a means of precautionary savings against weather risk are often suboptimal; otherwise, farmers could invest in such more productive opportunities. Therefore, formal insurance would be indispensable for farmers to diversify village-level covariate shocks.

Historical experience suggests that traditional crop insurance is unsustainable. Indemnity payouts and administrative costs were usually far more than collected premiums (Goodwin 1993, Miranda and Glauber 1997). The claim payouts are determined on the basis of individual harvests, and hence, an insurance agent has to assess the loss of each client. However, the costs of obtaining accurate information on the loss and of monitoring farmer behavior are prohibitively high, raising the problems of moral hazard and adverse selection (Besley, 1995).

As an alternative formal insurance mechanism, weather index insurance contracts have been attracting much attention from academics, policy makers, and NGOs (Hazell, 2003; Skees, et al., 2005; Morduch, 2006; Chantarat, et al., 2007; Alderman and Haque, 2007; Nakata, Sawada and Tanaka, 2010; Mobarak & Rosenzweig, 2012). Weather index insurance products are available in many countries, including Canada, Mexico, Guatemala, Peru, Nicaragua, China, India, Vietnam, Mongolia, Malawi, South Africa, Romania, and Zambia (Sakurai and Reardon, 1997; Skees et al., 2001; McCarthy, 2003; Morduch, 2004; Lilleor et al., 2005; Miura and Sakurai, 2012; Cole et al., 2013). In weather index insurance, payouts are usually based on the amounts of weather parameters (rainfall, temperature, air moisture, and satellite-measured vegetation level) observed at a particular weather station. Typical rainfall insurance starts with a contract by which an insurer indemnifies a farmer for his income loss if the amount of precipitation in a given phase is below the pre-determined cutoff. The primary advantage of this insurance is that claim payments are made only on the basis of observable and verifiable indices, not for individual losses. Therefore, the effort of producers is unaffected. Second, the contract also significantly mitigates adverse selection problems because the claim payments are independent of the characteristics of insured farmers. Finally, in practice, the implementation cost is less than that of indemnity-based insurance in that an insurance agent is not required to assess individual damages, ensuring prompt payments with minimum costs.

However, index insurance would not be a panacea. It only covers a fraction of income

loss incurred by farm households. If there is a difference between the insurance claims derived from indices in the reference weather station and the realized loss at the farm level, the claim payouts cannot perfectly cover the exact damages. This residual risk is called basis risk. Casual observations from the field of the current study indicate that people are less willing to take up such insurance when they live far away from a reference weather station. Previous studies also found that the take-up of rainfall insurance remains low around the world. Gine et al. (2008) studied a rainfall insurance scheme in Andhra Pradesh in India and found the take-up rate to be a mere 4.6%. They concluded that, “early in its introduction, the insurance [they] study has not yet succeeded in proportionately reaching the most vulnerable households who presumably would benefit most from protection against drought.” With intensive marketing interventions, Cai (2012) and Cole et al. (2013) found significantly higher take-up rates of 20% and 23%, respectively. Yet, these take-up rates are still low. These observations motivate the central question addressed in this project: What are the barriers keeping farmers from taking up this insurance product?

This paper presents details of surveys implemented under this project and describes the key variables collected. It offers directions for quantitative research using the analyzed dataset. The rest of the paper is organized as follows. Section 2 discusses the related literature on weather index insurance. Section 3 describes the detailed insurance contracts examined. Section 4 presents basic information about the study sites and explains our sampling strategy. Section 5 provides the summary statistics of variables on sampled farmers, and Section 6 contains concluding remarks.

2 Literature on weather index insurance

In the last decade, there has been important progress in empirical literature on weather index insurance. Given that the take-up rates of index insurance products have been low, existing studies tried to identify the barriers to facilitating take-up. Price is certainly one reason if an insurance premium is set at a level higher than the actuarially fair level. Non-price frictions could also be important. For example, households with less land and less wealth are less likely to participate because of binding liquidity constraints and/or high risk aversion (Gine et al. 2008). Households purchase insurance at the start of the growing season when there are many competing uses for the limited cash available, such as payments toward labor for land preparation, on seeds, and on fertilizer. Gine et

al. (2008) and Miura and Sakurai (2012) found that risk averse households are less likely to take up insurance. Their interpretation of this result is that households are unfamiliar with the insurance product and the product itself is regarded as risky. Cole et al. (2013) provided another view, stating that framing is also important. The “use of negative language” has a strong and positive effect on the take-up of insurance. This intervention turned out to be very influential on whether their subjects decided to take up the insurance product.

Informational frictions, such as a lack of understanding about the product, are also a possible explanation for non-purchase, given that people have only limited financial literacy and are not always able to evaluate the insurance (Cai 2012; Cole et al., 2013). Cai (2012) conducted a field experiment on a social network in China in which she provided financial education to farmers. Having an additional friend receiving financial education raises insurance take-up by almost half as much as obtaining financial education by themselves.

Sakurai and Reardon (1997) estimated demand for drought insurance in Burkina Faso, and found that demand varied according to the individuals’ self-insurance strategies. Mobarak and Rosenzweig (2012a, 2012b) offered index insurance to Indian farmers by using a “Delayed Monsoon Onset” index, insuring farmers against agricultural losses because of delayed rainfall.² They found that the availability of caste-based informal risk sharing arrangements lowered the take-up of their product, as the caste network could cover both idiosyncratic and aggregate risk. Yet, they also found that the existence of informal risk sharing enhanced take-up when the index insurance carried basis risk.

Certain studies focused on the supply-side issues. Carter et al. (2011) built a theoretical model that incorporates the interlinkage of credit and index insurance, and showed that farmers could adopt a high-yield, but risky technology. Gine and Yang (2009) offered a bundle of loan and insurance to randomly selected individuals from their sample in Malawi.³ The authors found that take-up was 33% higher for farmers who were offered the uninsured loan. Implicit insurance against downside risks provided by the limited liability clause of the loan contract might reduce demand for index insurance. de Janvry

² Monsoon onset is defined as a certain level of rainfall accumulation (between 30–40 mm), as measured by the block-level Automatic Weather Station. The onset date is considered delayed if the target amount of rainfall is not reached by one of three pre-selected “triggers” or payout dates.

³ Loan was provided to purchase high-yield hybrid maize and groundnut seeds.

et al. (2012) constructed a theoretical model of group insurance, and showed there would be a free-riding problem as group members try to take advantage of a member who chooses to insure. A risk-averse member might not have an incentive to insure if other members of the group do not.

Other studies analyzed household behavior. de Nicola (2010) and de Nicola et al. (2012) calibrated that the provision of weather insurance to farmers would increase agricultural investment, leading to welfare gains. Fuchs and Wolff (2011) found that mandatory participation of weather insurance increased maize yields and income by 6% and 8%, respectively.⁴ Karlan et al. (2012) conducted experiments in Ghana, where they randomly offered cash, index insurance, and a combination of the two. They found an increase in investment among the households that took the insurance. Furthermore, farmers' demand for insurance increased in subsequent years after they received claim payouts and because neighbors in their social network received payouts.

Existing literature has suggested that basis risk is one of the most important reasons for weather index insurance not being attractive to potential clients. A theoretical study by Clarke (2011) showed that a farmer might be worse off with the insurance than without it. The existence of basis risk means it is possible that a farmer pays the premiums, experiences a loss, but then, does not receive an insurance payout. On the basis of a theoretical model, Clarke (2011) showed that the demand for index insurance of risk-averse agents would be low when the basis risk is high.

Existing empirical studies have also addressed the significance of basis risk. In order to measure the basis risk, Gine et al. (2008) used: i) a dummy variable, which takes a value one if a farmer uses accumulated rainfall to decide when to sow and ii) the percentage of land used for Kharif crops. Mobarak and Rosenzweig (2012a, 2012b) used perceived distance reported by the study participants, which was converted to zero if the weather stations were situated in the village.⁵

In our project, unlike the indirect measures used in the existing studies, we employ direct measures of basis risk captured by physical distances between farmers' *houses* and a weather station. This proxy is reasonable in that farmers are likely to estimate

⁴ The planted area was decreased by 8%. The intuition behind these results would be that farmers used their land for other cash crops, which would further increase their income.

⁵ The mean of the reported distance was 4 kilometers, with a standard deviation of 5.9 kilometers.

their basis risk on the basis of differences in weather between their houses and the station at the time of purchase. As discussed later, we collected geocodes (latitude, longitude, and altitude) of the respondents' houses and the weather station.

3 Contract design

In our project, we study two insurance products, rainfall index insurance and temperature index insurance, sold by one of the major insurance companies in India.⁶ The products are called Barish Bima Yojna (BBY: rainfall insurance scheme) and Mausam Bima Yojna (MBY: temperature insurance scheme), respectively.⁷ BBY is indexed to the precipitation during the Kharif season, while MBY is indexed to temperature during the Rabi season. The company started BBY in 2004 and, after a few years, started MBY. There are two main crop seasons in India, Kharif and Rabi: a Kharif crop is a monsoon or autumn crop, with sowing usually occurring in June–July and harvests in September–November. A Rabi crop is a dry season or spring crop, dependent on the moisture in the soil from the latest monsoon. In this case, sowing is usually done in November–December and harvests, in March–May. For this reason, an agricultural year in India is defined by combining Kharif and Rabi crops in this order, and we denote it as, for example, 2011/12 (that is, Kharif 2011 plus Rabi 2011/12).

While the insurance company sells these insurance products across India, the current study will focus only on the state of Madhya Pradesh, which is one of the company's biggest markets. To date, the company covers more than 110,000 farmers across the state. The insurance product is offered to all farmers, regardless of the variety of crops they cultivate, but they have to be eligible to borrow from the District Central Cooperative Bank (DCCB). The DCCB is an agricultural bank affiliated with cooperative societies.⁸ Landowner farmers usually borrow money from the DCCB once

⁶ This is a subsidiary of an ex-public fertilizer company.

⁷ Although Mausam Bima Yojna literally means “weather insurance scheme,” we term MBY as “temperature index insurance” considering its contract terms.

⁸ The DCCB's branches are usually located at (or next to) a cooperative society's buildings. Prior to the beginning of Kharif or Rabi, a farmer visits his society manager to ask for a new loan. The society manager approves and sets the loan limit. The loan limit is usually determined by the landholdings, repayment status, and crop portfolio. Then, the society accountant fills in the farmer's passbook with a certificate and the farmer brings his passbook to the bank branch to receive the loan. The gross interest rate for a short-term (one-year) loan is 12% (9% is subsidized by the local government). There are other financial institutions, including informal moneylenders, from which farmers can borrow, but interest rates are generally higher than those offered by the DCCB.

or twice a year.

3.1 Design of BBY 2007–11

BBY (rainfall index insurance) is sold in May–June, prior to the beginning of the Kharif season. The details of the contract vary in different districts and from time to time. In this subsection, we describe the contract design that was in force in our study field until Kharif 2011. We specify the year to denote the agricultural year for which the BBY was designed. For example, BBY 2011 corresponds to the rainfall index insurance for Kharif 2011. The insurance design was changed between BBY 2011 and BBY 2012, as explained in the next subsection.

The per acre premiums and trigger levels are listed in Tables 1 and 2. In the past, the government offered a subsidy for the insurance premium, but this was not available for BBY 2011. The premium rate increased from 4.5% in 2007 to 8% in 2011 (Table 1).⁹ This is both because the subsidy from the government stopped and the area became “riskier” from the insurer’s viewpoint as more claim payouts were made in 2007 and 2008. The premium of each insurance product is higher than the actuarial fair level and the average markup is around 25%.¹⁰

Clients chose the amount of the sum insured (Rs), which is the maximum possible claim payout. The actual premium payment is calculated as (the premium rate) \times (SI).

Table 1. Premium Rate of BBY 2007-11

2007	4.50%
2008	4.50%
2009	6.07%
2010	NA
2011	8.00%

Source: Prepared by the authors (as are the following tables and figures, unless otherwise indicated).

⁹ BBY was not sold in 2010 because of capacity constraints of the supplier.

¹⁰ Markup is calculated by the authors. The data used to calculate the actuarially fair premium was taken from National Climate Data Center, Climate Data Online of National Oceanic and Atmospheric Administration: <http://www7.ncdc.noaa.gov/CDO/cdo>.

BBY 2007–11 was indexed to the total rainfall from June to September. The monsoon rainfall in Madhya Pradesh is concentrated into these months, and thus, the cumulative precipitation over June–September is a good measure of the monsoon conditions. The trigger level was 768.8 mm, which was calculated and specified by the insurer. The insurer pays claims if the amount of total precipitation over the four months is below the predetermined cutoff. The payment schedule is provided in Table 2.

Suppose a farmer is eligible to borrow Rs 20,000 from the DCCB, and the loan is distributed prior to the beginning of Kharif. In May, an insurance agent approaches the farmer about possibly taking up insurance. If the farmer agrees, he decides the amount of the sum insured (SI). Suppose the farmer’s SI is Rs 10,000. If the premium rate of the area is 8.00%, his premium will be Rs 800. This will be deducted from his bank account. Cash is not required for the premium payment, and hence, liquidity constraints are not a reason for withdrawing from the index insurance contract. After the coverage period, the insurance provider declares the amount of the claim on the basis of the weather data reported by the Indian Meteorological Department. If there are positive claim payouts, an insurance agent visits the cooperative society to distribute checks to the individual clients before the beginning of the next season. A claim payout is calculated according to the deficiency rate. The deficiency rate (%) is defined as $1 - [(total\ observed\ rainfall) / (trigger\ level)]$. As shown in Table 2, if the deficiency rate is 30%, the insurer will make an insurance payment of 10% of the SI.

Table 2. Claim Schedule of BBY 2007-11

Deficiency Rate (%)	Claim Rate
0%	0%
10%	0%
20%	0%
30%	10%
40%	15%
50%	25%
60%	35%
70%	45%
80%	75%
90%	90%
100%	100%

Note: The claim rate is defined as a percentage of the sum insured.

3.2 Design of BBY 2012

Prior to Kharif 2012, the insurer changed the design of BBY, in effect extending the coverage offered for drought conditions, to include excess rain and consecutive dryness. The premium, defined in terms of insured land, is Rs 750 per acre. Now, farmers are asked to state the number of acre(s) they want to insure. For simplicity, the insurance provider specified the SI of BBY 2012 to be Rs 9,000. The details of the new BBY are summarized below.

There are four phases, and strikes and notionals are different for each phase. In order to calculate the claim payout on rainfall deficiency of Phase I, suppose that the actual precipitation is denoted by $R(\text{mm})$. There are two ranges of strikes. Denote the upper and the lower bounds of the two strike ranges as U_1, L_1, U_2, L_2 ($U_1 > L_1 = U_2 > L_2$). Notionals for each range of the strike are N_1 and N_2 , respectively. Then, the claim payout (Rs) is calculated as follows:

$$\text{Per Acre Claim Payout} = \begin{cases} N_1 \times (U_1 - R) & \text{if } L_1 < R < U_1 \\ N_1 \times (U_1 - L_1) + N_2 \times (U_2 - R) & \text{if } L_2 < R < U_2 \end{cases}$$

As Table 3a shows, for Phase 1, $\{U_1, L_1, N_1, U_2, L_2, N_2\} = \{60, 30, 10, 30, 10, 47.5\}$. If the rainfall of Phase 1 is 40 mm, the claim amount will be $10 \times (60 - 40) = \text{Rs } 200$. If the cumulative rainfall of the phase is 11 mm, the claim amount will be $10 \times (60 - 30) + 47.5 \times (30 - 11) = \text{Rs } 1,202.5$.

A claim for excess rainfall is paid when the cumulative rainfall of any two consecutive days in a phase is more than the strike. The strikes, notionals, and maximum payouts for each phase are listed in Table 3b. The claim is calculated as: Per Acre Claim Payout = $\max \{(\text{Cumulative rainfall of any two consecutive days} - \text{Strike}) \times \text{notional}, 0\}$.

The consecutive dry days' index is applied from July 5 to September 15 (Table 3c). A claim is paid when the total number of consecutive days with a daily rainfall of less than 2.5 mm exceeds a strike. The total claim payout of BBY 2012 is the sum of the payouts for all three covers.

Table 3a. BBY 2012: Deficit Rainfall Cover

	Phase 1 6/15 -7/10	Phase 2 7/11-7/31	Phase 3 8/1 – 8/31	Phase 4 9/1– 10/15
Strike 1 (mm) $[L_1, U_1]$	[30,60]	[35,65]	[50,125]	[10,40]
Strike 2 (mm) $[L_2, U_2]$	[10,30]	[10,35]	[10,50]	[0,10]
Exit (mm)	10	10	10	0
Notional of Strike 1 (N_1)	10	7.5	7.5	12.5
Notional of Strike 2 (N_2)	47.5	41	17.5	87.5
Maximum Payout (Rs)	1,250	1,250	1,250	1,250
Maximum Total Payout (Rs)	5,000			

Table 3b. BBY 2012: Excess Rainfall Index

	Phase 1 6/15 -7/10	Phase 2 7/11-7/31	Phase 3 8/1 – 8/31	Phase 4 9/1– 10/15
Strike (mm)	47.5	60	60	62.5
Notional (Rs)	5	6	5	5
Maximum Payout (Rs)	700	600	600	600

Table 3c. BBY2012: Consecutive Dry Days Index

Cover Period	7/5 – 9/15					
Strikes (No. of CDD) $[L_3, U_3]$	[17,22]	[22,28]	[28,35]	[35,50]	[50,60]	[60,72]
Claim Payout (Rs)	175	250	375	500	1,000	1,500
Maximum Payout (Rs)	1,500					

3.3 Design of MBY 2012

MBY (temperature index insurance) is a unique index insurance product that covers against damage to crops attributable to extreme heat during the growing and flowering periods for Rabi crops. For instance, wheat, which is the main Rabi crop, is highly vulnerable to high temperatures during January–February. If a high temperature hits the wheat crop during these months, the harvest reduces substantially. The details of the contract vary in different districts and from time to time. In this subsection, we describe

the contract design in force in our study field (see Section 4). Although MBY has been available in other places, it was introduced for the first time to our study region for Rabi 2011/12. Since the insurance is indexed to the temperature in early 2012, we refer to it as MBY 2012, and describe it in this subsection.

MBY is sold in October–November, prior to the beginning of the Rabi season. The contract details of MBY 2012 are summarized in Table 4. The contract divides the season into two phases and six periods. Trigger levels and strikes are different for each phase. The indices are two-week averages of the daily *maximum* temperature and two-week averages of the daily *average* temperature. The per acre premium of MBY 2012 is Rs 560. For simplicity, the insurance provider specified the SI of MBY 2012 to be Rs 7,000.

To calculate the claim payout of Phase I, suppose that the actual temperatures observed during Period 1 and Period 2 were $X_1(^{\circ}\text{C})$ and $X_2(^{\circ}\text{C})$. Let us denote the triggers (the average of the average temperature and average of the maximum temperature) of the two periods to be $T_1(^{\circ}\text{C})$ and $T_2(^{\circ}\text{C})$, respectively. The strike and exit for each period are defined as $S(^{\circ}\text{C})$ and $E(^{\circ}\text{C})$, respectively. Then, the claim payout (Rs) is calculated as follows:

$$\text{Per Acre Claim Payout} = 350 \times \min[\max\{(X_1 - T_1) + (X_2 - T_2) - S, 0\}, (E - S)]$$

Suppose there is a farmer who purchased this product for one acre. He paid Rs 560 for the premium. Suppose, further, that the average observed maximum temperature of Period 1 (X_1) was 28°C . As shown in Table 4, this is larger than the trigger level ($T_1 = 27$) of Period 1 in Phase I by one degree. Similarly, suppose that the average maximum temperature of Period 2 (X_2) was 36°C . This is larger than the trigger level ($T_2 = 30$) of Period 2 in Phase I by six degrees. Therefore, the total number of degrees exceeded throughout Phase I was seven degrees. This is larger than the strike ($S = 4$) by three degrees. Therefore, the farmer will be paid $350 \times 3 = \text{Rs } 1,050$.

In MBY 2012, the actual claim payout was Rs 157. This was paid to clients in May–June 2012. The claim payout for Phase II is calculated in a similar way.

Table 4. MBY 2012

	Phase I		Phase II			
	Period 1 1/1- 1/15	Period 2 1/16 - 1/31	Period 1 2/1 - 2/14	Period 2 2/15 - 2/28	Period 3 3/1 - 3/15	Period 4 3/16 - 3/31
Trigger (°C)	27	30	22	24	26	28
Strike (°C)	4		2			
Exit (°C)	14		23			
Notional (Rs)	350		166.7			
Max payout (Rs)	3,500		3,500			

Note: The index of Phase I is the two-week average of the daily maximum temperature. The index of Phase II is the two-week average of the daily average temperature.

4 Study sites and data

4.1 Study sites, sampling strategy, and primary surveys

Given the large geographical size of Madhya Pradesh state, we decided to focus our study on one district of the state. For logistical reasons, along with our counterpart insurance company, we chose Burhanpur District in East Nimar region of Madhya Pradesh. The weather station whose records are used for BBY and MBY is situated at the center of the district, inside the district hall.¹¹

Burhanpur District is known for rain-fed agriculture. Tubewells are only available in a few areas. Table 5 shows the proportions of cultivated land for major crops in the district, in comparison with the total of the state. Cotton is the most important cash crop, occupying the largest share of the gross cultivated area (23.3%). It is a Kharif crop, although its harvest may extend into months of the Rabi season, as it would usually take six to eight months to complete one crop cycle. The main cereals are jowar (sorghum) in Kharif and wheat in Rabi, both of which are suitable for the rain-fed agriculture. These crops are mostly grown for subsistence purposes. As a whole, cereals account for only 14.8% of the gross cultivated area. Other important cash crops are soybean and banana (classified as “Fruits” in Table 5). Soybean is mostly grown as a Kharif crop, although it is also cropped in Rabi. This is a fairly new crop in Indian agriculture, and its production spread throughout Madhya Pradesh during the 1990s as a cash crop for

¹¹ The pictures of the weather station are shown in the Appendix.

vegetable oil extraction. Banana cultivation takes, on average, two years to harvest. Therefore, it is not classified as either a Kharif or Rabi crop.

In Burhanpur District, formal insurance is not new at all; governmental crop insurance, motor, property, life, and health insurance are available in some parts of the district. The government crop insurance was provided by Agriculture Insurance Company of India Limited (AIC).

**Table 5. Area under major crops in Burhanpur District and Madhya Pradesh
(Agricultural Year 2006/07)**

	Burhanpur		Madhya Pradesh	
	1,000 ha	(%)	1,000 ha	(%)
Cereals				
Rice	2.3	(1.17)	1,634.9	(4.18)
Wheat	10.4	(5.27)	4,089.3	(10.45)
Maize	3.5	(1.77)	841.8	(2.15)
Jowar (Sorghum)	12.8	(6.49)	534.9	(1.37)
Total cereals	29.2	(14.79)	7,671.6	(19.60)
Pulses				
Chickpea (Gram)	2.5	(1.27)	2,655.7	(6.79)
Pigeonpea (Arhar, Tur)	3.7	(1.87)	300.5	(0.77)
Total pulses	8.5	(4.31)	4,383.7	(11.20)
Oilseeds				
Soybean	14.3	(7.25)	5,187.9	(13.25)
Total oilseeds	15.0	(7.60)	6,544.7	(16.72)
Sugarcane	2.6	(1.32)	77.2	(0.20)
Cotton	45.9	(23.26)	618.0	(1.58)
Fruits	14.4	(7.31)	48.9	(0.12)
Vegetables	0.7	(0.36)	204.2	(0.52)
Others	81.0	(41.06)	19,592.5	(50.06)
Grand total	197.4	(100.00)	39,140.7	(100.00)

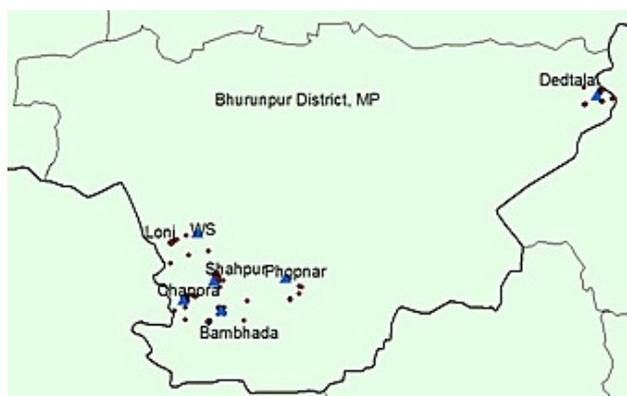
Source: Compiled by the authors using the district-level database for *Area and Production of Principal Crops in India*, Ministry of Agriculture, Government of India.

As BBY and MBY are sold through cooperative societies, a cooperative society is the

first tier from which we drew the sample. A cooperative society is an agricultural unit of which each farmer holds his share. Farmers often visit the cooperative society to purchase inputs such as seeds and fertilizer and gather regularly to hold meetings. The office building of a cooperative society is usually located within 5–10 minutes from each house on foot or by motorcycle. Our strategy was to draw a random sample of farmers belonging to each cooperative society, with a substantial variation in the geographical distances to the weather station. This is because the physical distance to the weather station provided us with the proxy for the basis risk. To obtain precise information on geographical locations, we collected GPS information of all farmers' houses, as discussed later.

Following the above, the sample size of the current study was 433 farmers. The sampled farmers were active account holders of the DCCB,¹² and were all landowners.¹³ A unique characteristic of our sampling strategy is thus to target the population that has access to DCCB credit. In previous literature, one suggested reason for the low take-up of weather index insurance is a liquidity constraint. However, our project controlled for this factor, enabling us to focus on other potential factors causing the low take-up. There were six cooperative societies: Loni, Shahpur, Bambhada, Chapora, Phopnar, and Deditalai (Figure 1). BBY was available in Shahpur, Bambhada, Chapora, and Phopnar since 2007, but was not available in Loni and Deditalai because of the insurer's supply constraints. MBY was introduced to all the six societies for the first time in Rabi 2011/12.¹⁴ As summarized in Table, claims were paid in 2007, 2008, and 2012.

Figure 1. Map of Burhanpur District



¹² Defaulting farmers were excluded from the sample.

¹³ Landless farmers are not eligible to borrow agricultural loans from the DCCB.

¹⁴ MBY has been available in other places in previous years.

Table 6. History of the index insurance

	Kharif 2007	Kharif 2008	Kharif 2010	Kharif 2011	Rabi 2011/12	Kharif 2012
	BBY 2007	BBY 2008	BBY 2010	BBY 2011	MBY 2012	BBY 2012
Claim paid?	Y	Y	N	N	Y	Y

The current dataset comprises the information collected in two rounds of surveys. The first survey (denoted as “Survey 2011”) was conducted in October–November 2011, when MBY 2012 was being sold. The second survey (denoted as “Survey 2012”) was conducted in May–June 2012, when BBY 2012 was being sold.¹⁵ In both Surveys 2011 and 2012, sample farmers were invited to the buildings of their cooperative societies to be interviewed on the basis of a structured questionnaire. The information on the past take-up of BBYs was collected in a retrospective way from each farmer, and validated by crosschecking it with the administrative data maintained by the insurance company. An example of the timeline during Kharif is summarized in the Appendix.

Table 7 shows the geographical attributes of the sample households across societies. The number of samples collected at each society is proportionate to the size of the society. The mean distance to the weather station is 12.6 km, and the mean altitude (above sea level) is 267.6 m. The variance in altitude is very small, which implies that the area is flat.

Table 7. Geographical attributes of the sample by society

Society		Obs	Mean	S.D.	Min	Max
Loni	Altitude (m)	54	245.18	10.61	211.23	276.45
	Distance (km)		1.99	0.29	1.20	3.58
Shahpur	Altitude (m)	82	242.80	14.02	188.67	273.71
	Distance (km)		4.74	0.12	4.42	5.00
Chapora	Altitude (m)	118	256.52	17.43	219.46	298.70
	Distance (m)		7.59	1.11	6.21	9.47
Bambhada	Altitude (m)	126	262.89	10.49	226.16	294.13
	Distance (km)		7.85	112.4	7713.5	8142.1
Phopnar	Altitude (m)	17	286.42	14.48	261.21	306.63
	Distance (km)		10.17	0.84	9.14	11.04
Dedtalai	Altitude (m)	36	311.66	4.79	299.92	323.09
	Distance (km)		37.24	0.74	36.01	38.68
Total	Altitude (m)	433	267.58	26.67	188.67	323.09
	Distance (km)		11.60	12.87	1.20	38.68

Note: Altitude (m) is a vertical distance from the sea level. Distance (km) is the physical length from the reference weather station. Summary Statistics under "Total" are for the pooled sample. They therefore denote the sum of within- and between- society variations.

¹⁵ A pilot survey was conducted in 2010 by one of the authors (Matsuda).

4.2 Measurement of the basis risk

Ideally, to estimate the basis risk, we need detailed precipitation data measured on both individual plots and weather stations.¹⁶ However, installing rain gauges on plots of 433 farmers was not practically possible, because of financial and logistical constraints, given that farmers usually have multiple plots. Instead, we used the physical distance between farmers' houses and the weather station as a proxy variable for the basis risk. This proxy is reasonable in that farmers are likely to estimate their basis risk subjectively on the basis of the difference between the weather at their house and that at the nearby weather station during the insurance marketing meeting. Therefore, we collected geocodes (latitude, longitude, and altitude) for the weather station and for each respondent's house.

In contrast, Gine et al. (2008) used: i) a dummy variable, which takes the value one if a farmer uses accumulated rainfall to decide when to sow and ii) the percentage of land used for Kharif crops. These variables are indirect measures of basis risk, as they state that an "alternative variable for measuring basis risk would be the distance to the rain gauge or some other direct measure of the difference in weather between the farm and the weather station." Mobarak and Rosenzweig (2012a, 2012b) used the perceived distance, as reported by the study participants. This distance was converted to zero if the weather stations were situated in the village. Hence, we believe our measures are more likely to reflect the true basis risk.

5 Characteristics of sample farmers

Both Surveys 2011 and 2012 collected detailed information on socio-economic conditions, such as family roster, assets, income, agricultural activities, insurance take-up and claim receipts, and consumption. The following tables present the summary statistics.

¹⁶ Miura and Sakurai (2012a, 2012b) collected rainfall data on individual plots for 48 households in Zambia.

5.1 Assets and farming activities

Table 8 summarizes the information on assets and farming activities. As already described, all sample farmers own land. The average landholding size is 4.7 acres. The average landholding size is only slightly larger than the average size in Madhya Pradesh (3.68 acres in 2003),¹⁷ indicating that ours is not a sample of wealthy farmers, but contains a number of small and medium farmers. Of the 4.7 acres, 4.03 acres are irrigated.¹⁸ The average value of a house is Rs 334,728.3 (that is, USD 6105.26).

In Table 8, we report the total agricultural income for each season. The total agricultural income during Kharif 2011 is Rs 135,687.9 (= USD 2,474.9). To produce this amount, the sample farmers used crop loans of an average value of Rs 85,584.0 (= USD 1,561.01). The total agricultural income during Rabi 2011/12 is Rs 111,217.5 (= USD 2,028.6), while the average loan of the same period was Rs 63,787.0 (= USD 1,163.44).

In the sample, 97% of the farmers are clients of the fertilizer company. This is important because, in selling the insurance products, the insurance provider takes advantage of this familiarity with its parent fertilizer company. By this, mistrust in the insurer would be reduced. The questionnaire also included eight arithmetic questions to determine the farmers' financial ability. The average number of correct answers was 3.1 (S.D. 3.4).

Areas under each crop are also listed in Table 8.¹⁹ Consistent with state-wide statistics, area under cotton is the largest throughout the agricultural year. The area under banana is much higher than the district average (Table 5), implying that our sample comprises farmers with a stronger commercial orientation than the district average. After cotton and banana, jowar accounts for about 4% in Kharif, and wheat, for 10.5%. These crops are highly susceptible to extreme weather.

¹⁷ This figure excludes data on landless households and is taken from Statement 4 (state-wise average size of household ownership holdings), NSSO (2006), p.15.

¹⁸ The change in landholding between the two surveys was very small.

¹⁹ The area under cotton in Rabi 2011/12 shows the percentage of land occupied by cotton belonging to the Kharif 2011 crops. The numbers for Kharif 2012 were planned because Survey 2012 was conducted right before Kharif 2012. Disbursement of the Kharif crop loan was also in process.

Table 8. Assets and farming activities

	Mean	S.D.	Min	Max
<i>Major assets at the time of Survey 2011</i>				
Landholding (acre)	4.70	(5.05)	0.25	60
Irrigated land (acre)	4.03	(5.02)	0	60
House value (Rs)	334728.3	(538397)	0	7000000
Literacy of the account holders (%)	0.53	(0.50)		
Score in arithmetic questions	3.1	(3.4)	0	8
<i>Agricultural production during Kharif 2011</i>				
Area under cotton (%)	52.1%			
Area under banana (%)	29.3%			
Area under maize (%)	7.9%			
Area under Jowar (%)	3.6%			
Area under soybean (%)	4.4%			
Total Income(Rs)	135687.9	(167960.5)	0	1500000
Crop loan from DCCB	85584.0	(104234.3)	0	1280000
<i>Agricultural production during Rabi 2011/12</i>				
Area under banana (%)	22.2%			
Area under cotton (%)	45.2%			
Area under wheat (%)	10.5%			
Area under maize (%)	13.9%			
Area under Jowar (%)	3.3%			
Client of MBY (%)	0.72	(0.45)		
Average insured land under MBY(acre)*	1.14	(0.74)	0.5	10
Total Income (Rs)	111217.5	125821.6	0	1000000
Crop loan from DCCB (Rs)	63787.0	(64339.7)	0	440000
<i>Agricultural production during Kharif 2012</i>				
Planned area under cotton (%)	58.2%			
Planned area under banana (%)	19.2%			
Planned area under maize (%)	10.8%			
Planned area under Jowar (%)	4.7%			
Planned area under soybean (%)	5.0%			
Client of BBY (%)	0.39	(0.48)		
Average insured land under BBY (acre)*	1.00	(0.88)	0.5	10
Crop loan from DCCB (Rs) **	43474.60	(63372.5)	0	600000

Note: Scores in arithmetic questions are the number of correct answers, which takes values from 0 to 8. ** The disbursement of Kharif 2012 loan was in process.

5.2 The take-up of weather insurance

The incidence and depth with respect to the take-up of BBY and MBY are summarized in Table 9. Of the sample, 24% of the farmers had purchased BBY prior to our project. This low level of penetration is consistent with existing studies.

In late 2011, 72% of the respondents purchased MBY 2012. This take-up rate is extremely high when compared to existing studies. While a future study will investigate the reason of this high take-up, our sample differs substantially from that of the existing studies in that the income level is higher, credit constraints are less likely to be binding, and index insurance is not at all new.

BBY 2012 was sold prior to the monsoon season and was purchased by 39% of the respondents. This decrease might be because people were disappointed by the small (yet positive) claim amount from the previous season. A future study will also analyze the heterogeneity in the take-up in previous years in relation to the quantities demanded in 2012.

To elicit individual demand for insurance, in both Survey 2011 and Survey 2012, the enumerators offered four different levels of subsidy (0%, 25%, 50%, and 75%). The procedure was identical between MBY 2012 (Survey 2011) and BBY 2012 (Survey 2012). For each level of the subsidy, the subject was asked to specify their demand in terms of acres. Then, the subjects rolled an eight-sided dice. Each face value of the dice corresponded to the four options (1 and 2 for 0%, 3 and 4 for 25%, 5 and 6 for 50%, and 7 and 8 for 75%). Suppose a farmer answered 0 acres for 0%, 0.5 acres for 25%, 1 acre for 50%, and 2 acres for 75%. If the number on the dice he rolled was 7, then the actual amount payable by him would be $576 \times 2 \times 50\% = \text{Rs } 576$.²⁰ The difference between the discounted premium and the non-discounted premium is the subsidy paid to the subject by us. By using this method, we elicited four price-quantity pairs per subject. The results of this subsidy experiment are summarized in Table 9. The table clearly shows that insurance demand is a decreasing function of insurance premiums. A casual look at the figures appears to suggest that the price elasticity is steeper for MBY 2012 than for BBY 2012. Estimation of the insurance demand function is left for further research.

²⁰ Owing to financial and logistical constraints, the maximum subsidy was set to be Rs 576. If the calculated subsidy exceeded this limit, it was explained to the subject that the rest had to be paid by him (i.e., deducted from his account).

Table 9. Take-up of weather insurance

	Mean	S.D	Min	Max
<i>Experience with previous insurance and related activities</i>				
Fertilizer client at Survey 2011 (dummy)	0.97	0.16		
Client of BBY ever until BBY 2011 (dummy)	0.24	0.42		
Client of BBY 2011 (dummy)	0.13	0.34		
Client of BBY 2008 (dummy)	0.11	0.31		
Client of BBY 2007 (dummy)	0.07	0.26		
<i>MBY 2012 for Rabi 2011/12</i>				
Take-up (dummy)	0.72	0.45	0	1
Demand (acre) if Take-up=1 and subsidy=0%	0.92	0.75	0.5	10
Demand (acre) if Take-up=1 and subsidy=25%	1.09	0.75	0.5	10
Demand (acre) if Take-up=1 and subsidy=50%	1.25	0.79	0.5	10
Demand (acre) if Take-up=1 and subsidy=75%	1.31	0.82	0.5	10
Average demand (acre) if Take-up=1 over all subsidy levels	1.14	0.74	0.5	10
Premium payments (Rs)	671.5	443.0	288	5760
<i>BBY 2012 for Kharif 2012</i>				
Take-up (dummy)	0.39	0.49	0	1
Demand (acre) if Take-up=1 and subsidy=0%	0.92	0.89	0.5	10.0
Demand (acre) if Take-up=1 and subsidy=25%	0.98	0.89	0.5	10.0
Demand (acre) if Take-up=1 and subsidy=50%	1.04	0.89	0.5	10.0
Demand (acre) if Take-up=1 and subsidy=75%	1.08	0.90	0.5	10.0
Average demand (acre) if Take-up=1 over all subsidy levels	1.00	0.88	0.5	10.0
Premium payment (Rs)	581.1	518.7	288	5760

5.3 Difference across cooperative societies

Table 10 shows that there is a substantial heterogeneity in the baseline characteristics, farming activities, and insurance-related characteristics across societies. Phopnar and Loni are the richest societies. Even though the landholding in Dedtalai is the largest, access to irrigation is limited there, and thus, the income level is the lowest.²¹ Cotton occupies the largest share in the cropping pattern in all the societies, except Shahpur. Banana is also very important in all societies, other than Dedtalai, where its cultivation is almost impossible because of a lack of water. The area under banana slightly reduced in Kharif 2012, probably because the banana production cycle ended in the previous season. However, given that these numbers are only planned figures, the actual cropping pattern might not be that different to that of Kharif 2011. Future research will analyze the relation between farming activities and insurance take-up.

Demand for both MBY 2012 and BBY 2012 was lower in Loni and Dedtalai than the

²¹ The share of people under SC/ST is the largest in Dedtalai.

overall average. This could be attributable to the non-exposure to weather index insurance until Kharif 2011. In the case of Dedtalai, the size of the basis risk may have been responsible, since this society is by far the farthest from the weather station (Table 7). Among the four societies with previous exposure, the demand for MBY 2012 and BBY 2012 was the highest in Chapora and lowest in Phopnar. It is tempting to deduce that the large basis risk in Phopnar (this society is the farthest from the weather station of the four) was responsible for the low demand for insurance. However, examining the between-society variation in insurance demand may be misleading, since it may reflect other factors such as the difference in income level, access to irrigation, soil quality, the availability of informal risk-sharing arrangements, and formal risk-coping measures.

6 Conclusion

As an empirical research on weather index insurance in developing countries, we conducted surveys on rainfall and temperature index insurance products in Madhya Pradesh, India. The rainfall insurance covers drought and excess rain during the monsoon season, while the temperature insurance covers against excess heat during the dry season. This paper documented the details of surveys implemented under this project and then described the key variables collected from them.

Five characteristics of the current study distinguish our dataset from previous studies. First, there exists a wide variation among the sample households with respect to the distance to the weather station, which gives us the variation in the proxy for basis risk. Second, a quarter of our sample had experience in purchasing the insurance products prior to our project. This is very different from previous literature, which focuses on the take-up behavior of new clients. Third, almost all the households were familiar with the fertilizer company, which is the parent company of the current insurance provider. This would reduce mistrust of the insurer, which previous literature has shown to be one of the biggest barriers to insurance take-up. Fourth, we drew our sample from the population of farmers who had a bank account for crop loans and whose insurance premium was deducted from their bank account. This implies that our sample farmers did not face liquidity constraints. Thanks to the fourth characteristic, by construction, we can exclude liquidity constraints as a reason for the low take-up of weather insurance. It should be noted that our sample covers a wide range of land holding, including small farmers. Fifth, in collaboration with the insurance company, we

analyzed the actual insurance products with real stakes, not hypothetical stakes in a lab, and experimentally changed the premium rate (the price for insurance) to elicit the individual demand structure. The actual premium amount was determined randomly by rolling a dice.

The descriptive statistics of the data collected in two rounds of surveys in 2011 and 2012 show a substantial variation in demand for insurance across households. The take-up rate of the temperature insurance was 72%, which is higher than that described in existing literature. After six months, the take-up rate of the rainfall insurance declined to 39%, but the magnitude was still high. We found a wide variation in the demand for insurance across cooperative societies through which the insurance product was sold. Some of the variation could be attributable to the between-society difference in the exposure to insurance sales history and the basis risk. However, the results from the descriptive analysis are limited in their ability to disentangle the various correlated factors.

Distinguishing the impact of each of these factors on insurance demand and quantifying the net impact of insurance take-up on household welfare and behavior are left for further research. In investigating the determinants of insurance demand, key factors would be product design, premium rate, basis risk, and trust in the insurer. We collected information on these factors in our two rounds of surveys, and summarized their statistics in this paper. Future research will analyze the determinants of insurance take-up, particularly focusing on its relation to the basis risk.

Table 10. Differences across cooperative societies

Society Name	Loni	Shahpur	Chapora	Bambhada	Phopnar	Dedtalai
Sample Size	54	82	118	126	17	36
<i>Survey2011</i> <i>(Baseline)</i>						
Landholding (acre)	4.80 (2.96)	3.94 (3.40)	4.93 (4.66)	2.95 (2.45)	11.46 (13.72)	8.44 (6.78)
Irrigated land (Acre)	4.15 (2.73)	3.21 (3.28)	4.39 (4.76)	2.45 (2.49)	11.22 (13.78)	6.68 (6.83)
House value (Rs)	672264.2 (998380.7)	474000 (645891.2)	295726.5 (324548.9)	155887.1 (217497.8)	504705.9 (517567.8)	182714.3 (292198.4)
Literacy of the account holders (%)	0.78 (0.42)	0.55 (0.50)	0.63 (0.49)	0.33 (0.47)	0.88 (0.33)	0.31 (0.47)
Fertilizer client (%)	0.94 (0.23)	0.96 (0.19)	0.98 (0.13)	0.98 (0.15)	1.0 (0.0)	0.97 (0.17)
<i>Kharif2012</i>						
Total Income (Rs)	159240.7 (134177.9)	148993.9 (216155.3)	134420.3 (138772.1)	93548.8 (126835.9)	355352.9 (273099.6)	117961.1 (159539.4)
Crop loan from DCCB (Rs)	127722.2 (98893.4)	88634.1 (143401.5)	91931.6 (94262.3)	55891.3 (51773.7)	199529.4 (194008.7)	44916.7 (32948.8)
Area under cotton (%)	56.3%	37.1%	46.6%	58.1%	50.6%	68.0%
Area under banana (%)	16.4%	61.6%	30.2%	25.4%	44.4%	0.0%
<i>Rabi 2011/12</i>						
Total Income (Rs)	146781.6 (135214.9)	141720.8 (103845.7)	125373.9 (138132.7)	48929.73 (72827.1)	162271.4 (175838.6)	125757.6 (159319.8)
Crop loan from DCCB (Rs)	87836.7 (64348.8)	72402.6 (73207.2)	71295.7 (66942.8)	38216.2 (42434.9)	115928.6 (106423.3)	45697.0 (27000.6)
Area under cotton (%)	39.8%	30.0%	41.5%	67.1%	41.5%	52.1%
Area under banana (%)	12.0%	56.6%	22.2%	13.3%	25.4%	0.0%
MBY Take-up (dummy)	0.48 (0.50)	0.73 (0.45)	0.81 (0.39)	0.80 (0.40)	0.47 (0.51)	0.56 (0.50)
Average demand of MBY (acre) if Take-up=1 over all subsidy levels	0.94 (0.44)	1.12 (0.37)	1.27 (0.66)	1.06 (1.02)	1.72 (0.70)	1.01 (0.23)
<i>Kharif2012</i>						
Crop loan from DCCB (Rs) (Disbursement in Process)	45426.3 (57971.3)	24451.6 (43070.3)	62093.5 (64626.6)	36269.3 (68092.7)	101428.6 (106688.4)	20292.9 (27410.1)
Planned area under cotton (%)	55.3%	45.3%	61.1%	67.4%	45.2%	63.5%
Planned area under banana (%)	16.0%	48.6%	15.2%	11.5%	32.3%	0.0%
BBY Take-up (dummy)	0.15 (0.36)	0.33 (0.47)	0.68 (0.47)	0.30 (0.42)	0.18 (0.39)	0.36 (0.48)
Average demand of BBY (acre) if Take-up=1 over all subsidy levels	1.09 (0.37)	1.05 (0.47)	0.90 (0.53)	0.87 (0.75)	1.58 (0.72)	1.71 (2.49)

Note: Mean is shown in the first row of each category. S.D. is shown in the parentheses. Corresponding total values are shown in the previous tables.

References

Alderman, H., Haque, T. (2007) *Insurance against Covariate Shocks: The Role of Index-Based Insurance in Social Protection in Low-Income Countries*, World Bank.

Besley, T. (1995) “Nonmarket Institutions for Credit and Risk Sharing in Low-Income Countries,” *Journal of Economic Perspectives* 9(3): 115–127.

Cai, J. (2012) “Social Networks and the Development of Insurance Markets: Evidence from Randomized Experiments in China,” mimeo.

Cater, M.R., Cheng, L., Sarris, A. (2011) “The Impact of Interlinked Index Insurance and Credit Contracts on Financial Market Deepening and Small Farm Productivity,” mimeo.

Chantarat, S., Barrett, C.B., Mude, A.G., Turvey C. (2007) “Using Weather Index Insurance to Improve Drought Response for Famine Prevention,” *American Journal of Agricultural Economics*, 89(5): 1262–1268.

Clarke, D.J. (2011) “A Theory of Rational Demand for Index Insurance,” University of Oxford.

Cole, S., Gine, X., Tobacman, J., Topalova, P., Townsend, R., Vickery, J. (2013). “Barriers to Household Risk Management: Evidence from India,” *American Economic Journal: Applied Economics*, 5(1): 104–135.

de Janvry, A., Dequiedt, V., Sadoulet, E. (2012) “Weather Insurance for Members of Groups with Common Interests.”

de Nicola, F. (2010) “The Impact of Weather Insurance on Consumption, Investment and Welfare.”

de Nicola, F., Hill, R.V., Robles, M. (2012) “Interplay among Credit, Insurance and Savings for Farmers in Developing Countries.”

Fuchs, A., Wolff, H. (2011) "Concept and Unintended Consequences of Weather Index Insurance: The Case of Mexico," *American Journal of Agricultural Economics*, 93(2) Proceedings, 505–511.

Gine, X., Townsend, R., Vickery, J. (2008) "Patterns of Rainfall Insurance Participation in Rural India," *World Bank Economic Review*, 22(3): 539–566.

Gine, X., Yang, D. (2009) "Insurance, Credit, and Technology Adoption: Field Experimental Evidence from Malawi," *Journal of Development Economics*, 89(1): 1–11.

Goodwin, B. (1993) "An Empirical Analysis of the Demand for Multiple Peril Crop Insurance," *American Journal of Agricultural Economics*, 75: 425–434.

Hazell, P. (2003) "Potential Role for Insurance in Managing Catastrophic Risk in Developing Countries," *Proceedings of the World Bank Conference on Financing the Risks of Natural Disasters*, June 2–3, 2003.

Karlan, D., Osei, R., Osei-Akoto, I., Udry, C. (2012) "Agricultural Decisions after Relaxing Credit and Risk Constraints." *NBER Working Paper No.18463*

Lilleor, H. B., Gine, X., Townsend, R., Vickery, J. (2005) "Weather Insurance in Semi-Arid India."

Ligon, E. (2008) "Risk Sharing," In S.N. Durlauf, & L.E. Blume (Eds), *The New Palgrave Dictionary of Economics*, Second Edition. Palgrave Macmillan.

McCarthy, N. (2003) "Demand for Rainfall-Index Based Insurance: A Case Study from Morocco," *EPTD Discussion Paper No.106*.

Miranda, M., Glauber, J. (1997) "Systemic Risk, Reinsurance, and the Failure of Crop Insurance Markets," *American Journal of Agricultural Economics*, 79: 206–215.

Miura, K., Sakurai, T. (2012) “Who Purchases Weather Index Insurance? Results from a Field Experiment in Rural Zambia,” *Journal of Rural Economics*, Special Issue, 442–449 (in Japanese).

Mobarak, A.M., Rosenzweig, M. (2012a) “Selling Formal Insurance to the Informally Insured.”

Mobarak, A.M., Rosenzweig, M. (2012b) “Informal Risk Sharing, Index Insurance and Risk -Taking in Developing Countries.”

Morduch, J. (1994) “Poverty and Vulnerability,” *American Economic Review, Papers and Proceedings*, Vol. 84, No.2 , 221-225.

Morduch, J. (1995) “Income Smoothing and Consumption Smoothing,” *Journal of Economic Perspectives*, Vol. 9, No. 3, 103-114.

Morduch, J. (2006) “Micro-Insurance: The Next Revolution?” in A. Banerjee, R. Benabou, and D. Mookherjee (eds), *What Have We Learned About Poverty?* Oxford and New York: Oxford University Press.

Nakata, H., Sawada, Y., Tanaka, M. (2010) “Entropy Characterisation of Insurance Demand: Theory and Evidence.” *RIETI Discussion Paper* 10008.

NSSO (National Sample Survey Organisation) (2006) “*Household Ownership Holdings in India, 2003: NSS 59 Round (January–December 2003)*,” New Delhi: Government of India, Ministry of Statistics and Programme Implementation, NSSO, November 2006, Report No. 491 (59/18.1/4).

Rosenzweig, M., Binswanger, H. (1993) “Wealth, Weather Risk and the Composition and Profitability of Agricultural Investments,” *Economic Journal*, 103, 56–78.

Sakurai, T. and Reardon, T. (1997) “Potential Demand for Drought Insurance in Burkina Faso and Its Determinants,” *American Journal of Agricultural Economics*, 79: 1193–1207.

Skees, J., Gober, S., Varangis, R., Lester, R., Kalavakonda, V. (2001) “Developing Rainfall-Based Index Insurance in Morocco,” *World Bank Policy Research Working Paper*, 2577.

Skees, J., Varangis, P., Larson, D., Siegel, P. (2005) “Can Financial Markets be Tapped to Help Poor People Cope with Weather Risks?” in S. Dercon (ed), *Insurance against Poverty*, Oxford and New York: Oxford University Press.

Townsend, R.M. (1994) “Risk and Insurance in Village India,” *Econometrica* 62(3): 539–591.

Udry, C. (1994) “Risk and Insurance in a Rural Credit Market: An Empirical Investigation in Northern Nigeria,” *Review of Economic Studies* 61(3): 495–526.

Appendix

A. Pictures of Weather Measurement

Weather station



Thermometer



Rain gauge



Measurement



B. Timeline of Index Insurance (BBY 2012) and 2012 Survey with Crop Calendar

Calendar month	May	June	July	August	September	October	November	...	May	
BBY	Sales of BBY	Rainfall measurement					Claim payout			
Survey	2012 Survey									
Kharif crops*	Planting		Mid-season and harvest							

* Cotton harvesting may extend into months of the Rabi season, as it would usually take six to eight months to complete one crop cycle. Banana cultivation takes, on average, two years to harvest.