

Improving Farmers' Access to Agricultural Insurance in India

*Olivier Mahul
Niraj Verma
Daniel J. Clarke*

The World Bank
Financial and Private Sector Development Vice Presidency
Non-Banking Financial Institutions Unit
&
South Asia Region
Finance and Private Sector Development Unit
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Abstract

India's crop insurance program is the world's largest with 25 million farmers insured. However, issues in design, particularly related to delays in claims settlement, have led to 95 million farmer households not being covered, despite significant government subsidy. To address this and other problems, the Government of India is piloting a modified National Agricultural Insurance Scheme, a market-based scheme with involvement from the private sector. Compared with the existing scheme, the

new program has a design that can offer more timely, claim settlement, less distortion in the allocation of government subsidies and cross-subsidies between farmer groups, and reduced basis risk. Implementation and technical challenges lie ahead which can be addressed but will require a comprehensive strategy, innovative solutions, and timely roll out. This paper describes and analyzes both programs, and discusses lessons learned in developing and implementing the new program.

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Improving farmers' access to agricultural insurance in India¹

Olivier Mahul, *Program Coordinator, Disaster Risk Financing and Insurance Program, Non-Banking Financial Institutions Unit and Global Facility for Disaster Reduction and Recovery, World Bank*

Niraj Verma, *Senior Financial Sector Specialist, South Asia Finance and Private-Sector Development Unit, World Bank*

Daniel J. Clarke, *Department of Statistics, University of Oxford*

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1. Introduction

Agriculture is an uncertain business in India, partly due to its high dependence on the weather, leaving 120 million farmer households vulnerable to serious hardship. By providing claim payments to farmers in the event of crop failure, agricultural insurance can directly improve the welfare of risk averse farmers, particularly the 80 percent of 'small and marginal' Indian farmer households operating less than two hectares. Perhaps even more importantly, affordable agricultural insurance can in effect act as collateral against loans, increasing the creditworthiness of farmers and allowing them the opportunity to invest in appropriate inputs to increase agricultural productivity (Hazell 1992). By strengthening markets for agricultural credit while providing reliable protection that is attractive to the most risk averse, crop insurance may be a more attractive channel for government support to rural livelihoods and risk mitigation than ex-post disaster transfers, which offer no ex-ante guarantee to farmers and may therefore have limited impact on ex-ante decisions, or loan waiver or input subsidy programs, which may adversely distort behavior.

However, the provision of agricultural insurance is challenging, particularly in developing countries. Multiple Peril Crop Insurance programs, where each policyholder is indemnified against their own crop loss, were fraught with moral hazard, fraud and adverse selection, leading to high costs (Hazell 1992, Skees et al. 1999). By comparison, recent experience with voluntary weather indexed insurance has been somewhat underwhelming, with low voluntary demand (Cole et al. 2009, Binswanger-Mkhize 2011).

The Government of India, having historically focused on crop insurance as a planned mechanism to mitigate the risks of natural perils on farm production, is responsible for the world's largest crop insurance program with 25 million farmers insured. The National Agriculture Insurance Scheme (NAIS) is the main crop insurance program in the country, and in states and union territories that choose to participate, insurance for food crops, oilseeds and selected commercial crops is compulsory for all farmers that borrow from financial institutions and is voluntary for non-borrowing farmers without loans. The NAIS operates on an area yield indexed basis, whereby claim payments to farmers depend on the average yield of the insured crop measured across the insurance unit, typically an administrative block, in which they live. Area yield indexed crop insurance offers a middle ground between indemnity-based multiple peril crop insurance and weather based index-based weather insurance, with the potential for a greater resilience to moral hazard, fraud and adverse selection than the former and lower basis risk, the risk of a mismatch between incurred losses and indexed claim payments, than the latter (Carter et al. 2007).

However, the NAIS is not without its challenges, most notably the open-ended and highly variable fiscal exposure for state and central government, significant delays in the settlement of the farmers' claims, and dependence on an inefficient crop yield estimation process. The insurance premium rates paid by the farmers are capped and claims in excess of the capped premium volume are borne equally by the state and the central governments after harvest; for every 1 rupee of farmer premium paid between 2000 and 2008 the total claim payment to farmers was 3.5 rupees. The ex-post funding arrangement leads to an open ended fiscal exposure for governments and volatile annual contributions that are difficult to predict in advance of harvest. Indemnity payments tend to get extremely delayed (up to 9-12 months) in part because of administrative and budgetary processes for post-disaster funding of the excess losses. Finally, the crop yield estimation process conducted by the states, used for insurance claims, is subject to reporting delays, inconsistency and moral hazard. In addition, the current NAIS suffers from poor risk classification, which has led to a somewhat arbitrary allocation of government subsidies, and poor marketing.

It was in this context that the Government of India formed a joint task-force with the Ministries of Agriculture and Finance and the public insurance company, the Agricultural Insurance Company of India (AICI) to enhance the crop insurance program and improve insurance coverage. The report

(Joint Group 2004) suggested action on the following items: review current underwriting methodology; develop an actuarially sound design and pricing methodology based on international best practice to act as the foundation for a move to an ex-ante funded, market-based crop insurance program; develop product design and pricing methodology for new weather index insurance products; and suggest cost-effective catastrophe risk financing solutions for the public crop insurance company.

This joint work eventually led to the design and implementation of a modified NAIS (mNAIS), with planned pilot period lasting for three seasons starting winter 2010-11 (Table 1). This is potentially a major initiative given the significant scale of NAIS. If well implemented, an improved program would result in increased benefits for millions of current farmer clients and lead to greater coverage of the insurance program. However, significant challenges remain.

Table 1: Two potential successors to NAIS

	National Agricultural Insurance Scheme (NAIS)	Weather Based Crop Insurance Scheme (WBCIS)	Modified National Agricultural Insurance Scheme (mNAIS)
Scheme maturity	Established	Potential successor	
Year started	1999	2007	2010
Index	Area yield	Weather	Area yield & weather
Farmers covered in 2010	>22m	>3m	340,000 (Winter season 2010 only)
Government financing	Ex-post	Upfront premium subsidy	
Open to private sector	No	Yes	
Average claims ÷ farmer premiums	3.5 (2000-2008)	1.4 (2007-2010)	(Expected to be similar to WBCIS)

This paper aims to offer an overview of the entire policy process, from the NAIS to the modified NAIS and beyond, and is structured as follows. Section 2 offers a stylized overview of the existing scheme, the NAIS, and Section 3 discusses the range of policy options available to the Government of India in designing a successor. Section 4 introduces the new scheme, the modified NAIS, and Section 5 outlines remaining challenges and options for the future. Section 6 concludes.

2. Background: The National Agricultural Insurance Scheme (NAIS)

Key features of the NAIS

In 1999 the National Agricultural Insurance Scheme (NAIS) replaced the Comprehensive Crop Insurance Scheme (CCIS) as the main instrument for providing risk management to India's farming community. In states and union territories that choose to participate in NAIS, insurance for food crops, oilseeds and selected commercial crops is mandatory for all farmers that borrow from financial institutions and is voluntary for non-borrowing farmers without loans. The public insurance company, Agriculture Insurance Company of India (AICI), is the only organization authorized to sell NAIS products to farmers, and both farmer insurance premiums and claim payments are channeled

through the banking system. Since 2007-8 the NAIS has been supplemented by the Weather Based Crop Insurance Scheme (WBCIS).²

The NAIS is based on an “area yield” indexed approach: if the observed seasonal area yield per hectare of the insured crop for the defined insurance unit falls below a specific threshold yield, all insured farmers growing that crop in the defined area will receive the same claim payment (per unit of sum insured). The insurance unit size is chosen by the state and is often chosen to be a subdistrict.

The seasonal area yield estimate for a given crop in a given insurance unit, the *actual yield*, is determined by harvested production measurements taken at a series of randomly chosen Crop Cutting Experiment (CCE) locations. Approximately 500,000 CCEs are conducted across India every year (Joint Group 2004) with the number of CCEs increasing in the size of the insurance unit; for example a minimum of 8 CCEs are to be conducted if the insurance unit is a village Panchayat and 16 if the insurance unit is an administrative block (AICI 1999). The claim payment per unit of sum insured depends on the actual yield and the contractual threshold yield (TY) as follows:

$$NAIS \text{ claim payment rate} = \max(0, TY - \text{Actual Yield})/TY \quad (1)$$

The threshold yield is calculated as

$$\text{Threshold Yield (TY)} = \text{Indemnity level} \times \text{Probable Yield} \quad (2)$$

where the probable yield is calculated for each season and each insurance unit as

$$\text{Probable Yield} = \begin{cases} 3 \text{ year moving average actual yield for rice and wheat} \\ 5 \text{ year moving average actual yield for all other crops} \end{cases} \quad (3)$$

and the indemnity level is typically uniform across each state for a given crop, and based on the ten year coefficient of variation of actual yields (CV).³

$$\text{Indemnity level} = \begin{cases} 60\% \text{ if } CV > 30\% \\ 80\% \text{ if } 15\% < CV \leq 30\% \\ 90\% \text{ if } CV \leq 15\% \end{cases} \quad (4)$$

For example, if the most recent five year average actual yield for groundnut in a particular insurance unit is 1,950 kg/ha and the average ten year coefficient of variation for groundnut across the state is 28% then the threshold yield for the insurance unit is given by $1,950 \times 80\% = 1,560$ kg/ha.

Under NAIS, premium rates paid by farmers in respect of food crops are determined by the following rule.⁴ For Kharif crops the farmer premium rate is 3.5% for all oilseed crops and bajra and 2.5% for all other food crops. For Rabi crops the farmer premium rate is 1.5% for wheat and 2% for all other food crops. Premium rates paid by farmers in respect of commercial and horticultural crops are determined at the state level for each crop using a Normal Theory Method, under which yields are assumed to be normally distributed with mean and variance calculated using ten years of data for that insurance unit. For all crops, small and marginal farmers receive a 10% premium rate subsidy, and therefore only pay 90% of the above rates.

² See Clarke et al. 2011b for a description of the WBCIS.

³ The coefficient of variation is the ratio of the standard deviation to the mean. Kharif and Rabi calculations are performed separately, with Kharif calculations using historic Kharif data only and Rabi calculations using historic Rabi data only.

⁴ A premium rate is the ratio of the premium to the sum insured, where the sum insured is the maximum possible claim payment. Under NAIS, the maximum possible claim payment occurs when the actual yield is zero.

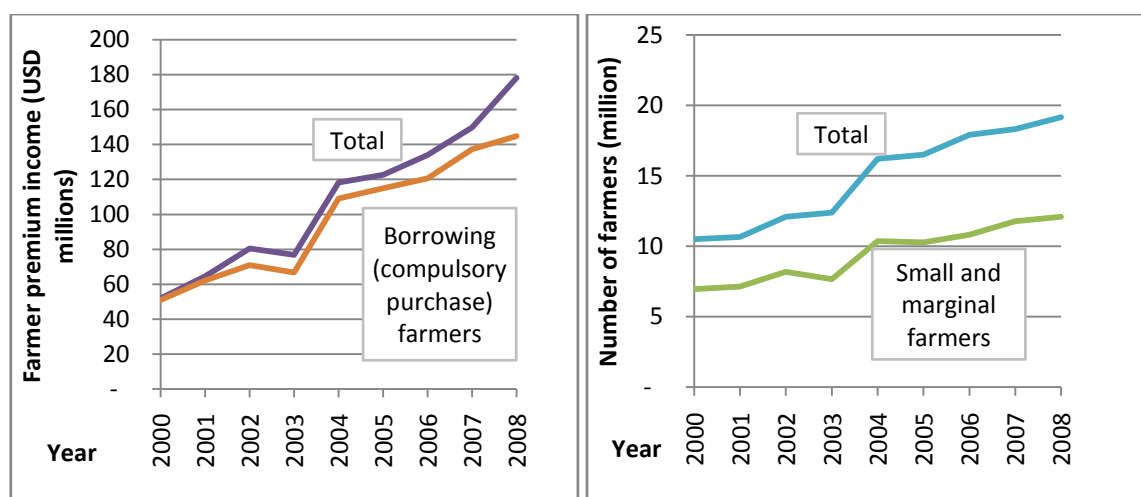
The NAIS portfolio

Following James and Nair (2009) and Nair (2010), the NAIS portfolio takes the following form. The NAIS program covered about 19 million farmers during the Kharif season 2008 (June to September) and the Rabi season 2008-9 (October to December), as shown in Figure 1. On the basis of there being approximately 110 million farmer households in 2008, the annual crop insurance penetration was approximately 17 percent. However, for borrowing farmers, approximately two thirds of the insured farmers, NAIS purchase is compulsory. The penetration for non-borrowing farmers, for whom purchase is not compulsory, is therefore around 6 percent. Small and marginal farmers account for two thirds of the farmers covered under NAIS.

The NAIS farmer premium volume reached almost Rs.800 crores (US\$178 million) in 2008 having steadily increased since 2003 (see Figure 1).⁵ Food crops represent about 75 percent of the total NAIS premium volume and small and marginal farmers contribute to about half.

The average premium per farmer insured slightly exceeded Rs.400 (US\$9) in 2008, ranging from Rs.250 (US\$5.5) for non-borrowing farmers to about Rs.500 (US\$11) for borrowing farmers. The average area insured per farmer has slightly decreased from 1.56 ha in 2004 to 1.34 ha in 2008.

Figure 1: NAIS Premium Volume and Farmers Covered, 2000-2008

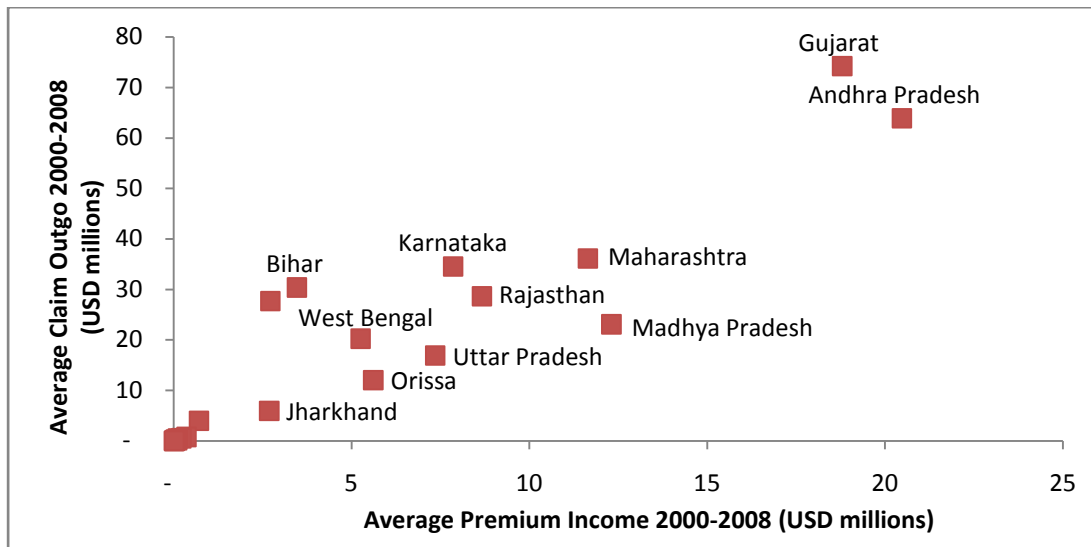


Source: Data from AICI

The demand for crop insurance is concentrated in the states where crops grow under rain-fed conditions and natural risks are greater, including Andhra Pradesh, Gujarat, Karnataka, Orissa, Uttar Pradesh and Rajasthan (Figure 2). Some states, such as Bihar, Karnataka and Gujarat, have historically collected more claims in proportion to their premium contribution than other states.

⁵ Indian rupees (INR) have been converted to US Dollars (USD) using an exchange rate of 45.23 INR to 1 USD.

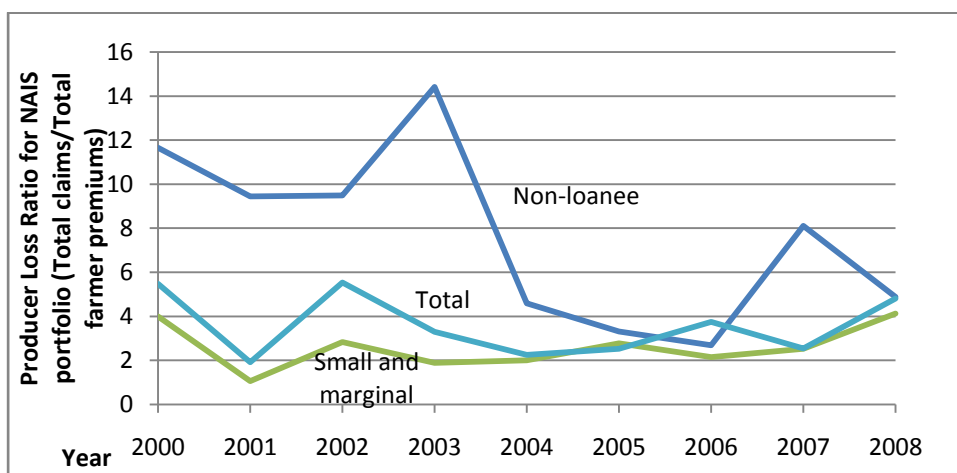
Figure 2: NAIS Historical Farmer Premium Income and Insurance Claims by State, 2000-2008



Source: Data from AICI

Following Mahul and Stutley (2010) one measure of the value of the NAIS to participating farmers is the producer loss ratio, taken to be total claim payments to farmers divided by total farmer premiums. Since its inception, the producer loss ratio has been always higher than 100 percent, i.e., the total claim payments paid to farmers exceed the premiums received (including premium subsidies). This is a direct consequence of the caps imposed on the premium rates of oilseeds and food crops, described in the previous subsection. Between 2000 and 2008 the producer loss ratio was 3.5, but this hides a large disparity between non-borrowing farmers with producer loss ratio of 6.4 and borrowing farmers with producer loss ratio of 3.0 (see Figure 3). This disparity illustrates the impact of adverse selection: non-borrowing farmers choose to insure their riskier crops (James and Nair 2009). It should also be noted that the producer loss ratio of small and marginal farmers has tended to be less than the producer loss ratio of all farmers, perhaps suggesting that small and marginal farmers have been less adept at selecting against the insurer.

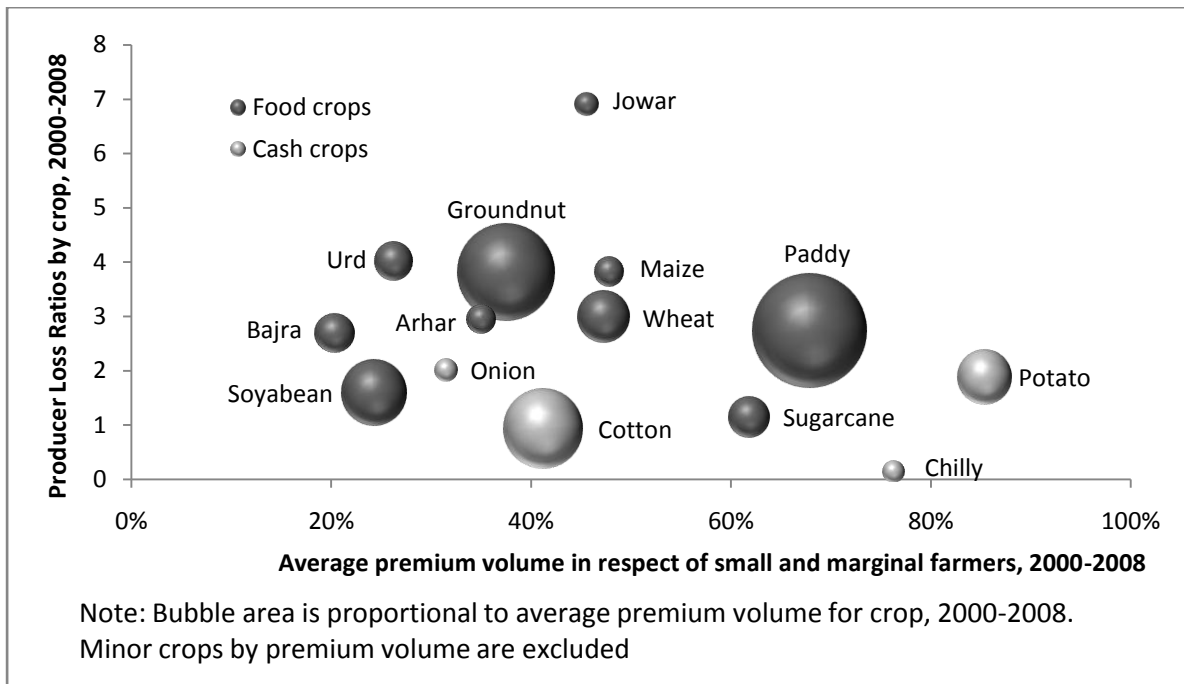
Figure 3: NAIS producer loss ratio (claims/farmer premiums), 2000-2008



Source: Data from AICI

There is also a wide variation in producer loss ratios by crop, with higher average producer loss ratios for most food crops than most cash crops, and producer loss ratios above four for Groundnut, Maize, Urd and Jowar (Figure 4). Two crops, paddy and groundnut, represent 40 percent of the total farmer premium volume.

Figure 4: Historical weighted average producer loss ratio for major crops, 2000-2008



Source: Data from AICI

Strengths of NAIS

The NAIS has significant advantages as compared to both multiple peril crop insurance (MPCI) and weather indexed insurance. First, individual MPCI would have been prohibitively expensive, or even impossible on technical and administrative grounds, in a country such as India with so many small and marginal farms (Hazell, 1992). Further, the method of using an 'area based approach' has several other merits including, most importantly, the mitigation of moral hazard and adverse selection.

Second, the mismatch between claim payments and losses incurred, known as basis risk, from weather indexed insurance is usually considered to be higher than that from area yield index insurance (Carter et al., 2007). This is partly because area yield insurance can cover more perils than weather based insurance. Also, in an Indian context insurance unit size is typically smaller under NAIS than WBCIS, due to limited weather station infrastructure, leading to an increased ability of NAIS to cover localized perils.

Finally, by using the banking system both to collect farmer insurance premiums and to channel payments, the NAIS has low supply-side transaction costs. This low-cash and transaction point intensity, together with the 'area based approach', has enabled low leakages in the channeling of claims.

Challenges faced by NAIS

However, despite NAIS insuring 25 million farmers, 95 million are not yet insured. Ignoring the 11% of farmers for whom purchase of NAIS cover is a compulsory precondition for taking out a loan for agricultural purposes, only 6% of farmers voluntarily purchase cover. This is particularly surprising given the large subsidies afforded to NAIS: for every 1 rupee of farmer premium paid between 2000 and 2008, NAIS disbursed 3.5 rupees in claim payments. The challenges faced by NAIS fall into the following seven categories.

Public financing: The current NAIS is mainly funded by ex-post public contributions, whereby at the end of the crop season aggregate claims exceeding premium income are funded 50-50 by the state and central governments. While subsidy for agriculture insurance programs are used around the world and can be justified as a development measure (Mahul and Stutley, 2010), this post-disaster funding arrangement leads to an open ended fiscal exposure for governments and volatile annual contributions. This post-disaster funding arrangement was in turn partly necessitated on account of a lack of an actuarially sound premium rating methodology without which predicting likely payouts was not feasible.

Delays in claims settlements: Another critical problem has been the systematic delay of NAIS claims settlement by 9-12 months or more. This has been partly caused by the time taken for the CCE data to be collated, but perhaps more importantly by state and central governments providing funding on an ex-post basis without adequate ex-ante budgeting. Delays in claims settlements not only cause cash flow problems for farmers already under the stress of a poor harvest, but also mean that they are not eligible for the next round of formal credit from banks for the next crop cycle, which follows immediately from the previous cycle. This can expose them to a debt trap and continued financial stress at the household level. This delay in claim settlement has contributed to the relatively low take up of crop insurance, despite significant increase in outreach in recent years. In a recent survey of farmers in Andhra Pradesh, over half of farmers cited delays in claim settlement as the key issue facing NAIS (Raju and Chand 2008), consistent with the findings of Joint Group (2004).

Risk classification: The NAIS rules for designing and pricing products, mean that the value of NAIS coverage for any given crop varies considerably across insurance units in the same state, and changes significantly year to year, even though farmers' premium rates are uniform for each crop. As an illustration, consider two insurance units which are exposed to the same level of agronomic risk but where one insurance unit has suffered a serious crop loss in the last five years but the other has not. The threshold yield for the former insurance unit would be much lower than the threshold yield for the latter insurance unit, since the five year moving average yield would be much lower. However, this difference in threshold yields is not from a fundamental difference in the risk in each insurance unit, just from one insurance unit having been unlucky in the previous five years and the other having been lucky (Joint Group Report 2004).

From a statistical point of view, a three or five year average yield is not an efficient estimate of the true mean yield; it may not be representative of the true long term average yield because of unusually good or bad years having occurred in the last five years. Further, the fixing of premium rates and indemnity levels across the state implicitly relies on the probability distribution of yields in different insurance units across the state varying only through scaling by the average yield. This may be unrealistic if, for example, yield risk is much higher in hilly insurance units than in plains.

Poor risk classification has three negative side effects. First, the NAIS portfolio is exposed to significant adverse selection from farmers voluntarily purchasing cover in high risk insurance units or when the three or five year moving average yield is above the true mean, and therefore the NAIS product was unusually valuable. There is strong evidence for adverse selection in the NAIS portfolio (see James and Nair, 2009 and Figure 3).

Second, poor risk classification leads to an inequitable distribution of the public subsidy among farmers. The actuarial value of the NAIS public subsidy per hectare of land varies substantially, even for one crop within one state. Moreover, much of this variation is arbitrary, being caused by large fluctuations in the three or five year average moving average yields.

Third, poor risk classification can lead to poor agriculture policy signaling. When premium rates do not reflect the inherent actuarial cost farmers could be incentivized to make economically inefficient decisions to grow crops with lower farmer insurance premiums, despite them having higher risk or lower expected yield.

Data quality: CCE quality is likely to vary considerably between states due to disparities in the levels of accountability, expertise and capacity of the agencies responsible for CCEs. A lack of accuracy in CCEs increases the basis risk experienced by farmers by increasing the non-sampling error.

CCEs are also exposed to manipulation risk, whereby the reported yield from a CCE could be intentionally lower than the true yield, triggering a higher claim payment to farmers. Although manipulation may benefit certain farmers in the short term, it would lead to high premiums and withdrawal of cover in the medium term.

Involvement of private sector: In its current form, NAIS is closer to a compensation scheme than an insurance program, and there is no involvement of the private sector.

Basis risk: Under the NAIS it is possible for a farmer to experience a large crop loss but receive no claim payment because, although the farmer's yield is low, the average yield in the insurance unit is not low enough to trigger a claim payment. Large subsidies mean that basis risk is unlikely to limit take-up from the wealthy, who can afford to pay upfront premiums and wait for delayed claim payments. However, basis risk is likely to severely limit voluntary take-up from the most risk averse, even in the presence of large subsidies, since purchase worsens the worst that could happen: without indexed insurance the worst that could happen is that a farmer loses her entire crop, but with indexed insurance a farmer could lose her entire crop and have paid an insurance premium yet receive no claim payment due to basis risk (Clarke 2011).

Adverse selection: As mentioned above poor risk classification allows farmers to select against the insurer by choosing cover in high risk insurance units or when the three or five year moving average yield is above the true mean, and therefore the NAIS product was unusually valuable. In addition, it has been possible to purchase NAIS cover well into the growing season when pre-existing drought conditions were known, allowing farmers to purchase voluntary cover in advance of a predictable drought.

3. Options for designing and implementing an enhanced version of the NAIS

Designing a successor to the NAIS is complex since the various components of any crop insurance program are interrelated. This section discusses the options available to designers of a modified NAIS, and provides foundation to the next section's discussion of the mNAIS, as being piloted in the Rabi season 2010-11.

Public financing

The post-disaster funding arrangement of the NAIS is one of the main causes of significant delays to claim settlement for farmers. A range of alternative funding structures is available to increase the timeliness of claim settlement.

At one extreme, government could retain all insurance risk but pre-fund NAIS claim payments. For example, government could deposit substantial reserves with the public insurer, AICI, which would then have liquidity to be able to make claim payments as they fall due. This could increase the speed of claim settlement for farmers, but is otherwise lacking in merit. Based on the 2008-9 NAIS portfolio, government would need to set aside an estimated US\$1.8 billion to withstand a 1-in-100 year loss. From an economic perspective, reserving this amount of liquidity solely for agriculture in India is wasteful: liquidity is valuable and should be used to bear a diversified portfolio of risks. Moreover, under such an arrangement government would still ultimately bear all insurance risk: if large claim payments depleted AICI's reserves, government would be required to inject additional capital. Finally, by endowing one public company with substantial assets it would be difficult to obtain beneficial competition in the market for agricultural insurance.

At the other extreme, government could fully insure or reinsure the NAIS portfolio. For example, at the start of each crop season, all farmer premiums and government premium subsidies could be paid to one or more private insurers who would then be responsible for settling claims as they fall due. Under this approach, government would bear no risk, and government's liability would be limited to upfront premium subsidies, determined as the difference between the insurance premium and total farmer premiums. However, insuring the entire NAIS portfolio is likely to be more costly than retaining the risk and government would in any case have to be heavily involved in product design or approval and monitoring claim payments.

Between these extremes are various alternatives. For example, government financing could be in the form of upfront premium subsidies, but there may be a public insurer, such as AICI, able to compete with private insurers. The private and public insurers would be able to retain some risk but would also be free to purchase private sector reinsurance against extreme years in which the total claim payments across the NAIS portfolio were unusually high. As is common in many countries with established crop insurance programs the government could still act as reinsurer of last resort, offering reinsurance to NAIS insurers against catastrophic events.⁶

Whilst private sector insurers typically retain risk by holding large reserves, it may be challenging for a public insurer to hold an adequate level of reserves for political economy reasons, thereby forcing it to purchase more reinsurance than would otherwise be optimal and leaving it vulnerable to the fluctuations and cycles of the reinsurance market. In such a circumstance it may be appropriate for a public insurer to supplement reserves with a contingent (or direct) credit facility which could allow it to retain an optimal level of insurance risk within a sound financial framework.

Another option would be for the existing public insurer AICI to become a public reinsurer, providing technical assistance and reinsurance to private insurers offering agricultural insurance. Such a structure is currently in operation in Mexico, where Agroasemex both offers reinsurance and technical assistance to farmers' self-insurance groups (Ibarra 2004). Such a public reinsurer could also serve other roles, including that of product design or approval. The financing requirements for such a public reinsurer would be similar to that for a public insurer.

Any solution with upfront premium subsidies from government would require government and insurers to be able to estimate the expected value of all future costs associated with each product. Upfront premium subsidies from government would then be calculated as the difference between these actuarially sound commercial premium rates, and the premium rates paid by farmers.

Improving the quality, speed, and robustness of CCEs

Any area yield-based insurance scheme relies heavily on the veracity of yield estimates; if yield estimates can be manipulated the scheme is unlikely to be sustainable. Under NAIS, state governments are responsible for ensuring that CCE yield estimates are an accurate reflection of the yields experienced for each crop in each insurance unit, and have in place some safeguards to ensure that CCE reports are protected from the possibility of fraudulent yield estimates. However, for there to be any risk transfer to the private sector at reasonable cost the NAIS product must be beyond robust to the threat of CCE manipulation: it must be demonstrably robust to the standards of international reinsurers. Any move towards more risk transfer away from states would have to be combined with formalization of existing safeguards, and the addition of new safeguards. For example, the current paper-based CCE reporting system could transition towards an electronic

⁶ In the following countries a public reinsurer offers protection against catastrophic agricultural events: Canada, Israel, Italy, Republic of Korea, Portugal, Spain, United States, Brazil, Mexico, Poland, Turkey, China, India and Morocco (Mahul and Stutley 2010).

reporting system under which CCE reports are submitted to the insurer by SMS on the day of the CCE, allowing the insurer to visit farms in advance of harvest in the event of suspected manipulation.

In addition to protecting the NAIS portfolio against manipulation, the CCE process could be improved to increase the speed of CCE report submission to insurers, thereby reducing delays in claim settlement, and to improve the accuracy of CCEs, thereby reducing basis risk experienced by farmers.

Combining weather and area yield indices

The basis risk from area yield index insurance is usually considered to be lower than that from weather index insurance (Carter et al. 2007). This is partly because area yield insurance can cover more perils than weather based insurance. Also, in an Indian context Insurance Unit size is typically smaller under NAIS than the Weather Based Crop Insurance Scheme (WBCIS), due to limited weather station infrastructure, leading to an increased ability of NAIS to cover localized perils.

However, area yield index claim payments depend on the results of Crop Cutting Experiments (CCEs) and so claims could not be settled until CCE reports have been submitted and verified. In contrast, weather index claim payments can be prompt, since claims depend only on weather station data which can be collected in real time.

Offering an insurance product that depends on both an area yield index and weather indices could combine the strengths of NAIS (e.g., more accurate loss estimates and more comprehensive coverage) and WBCIS (e.g., faster claim settlement). In theory such a product could reduce basis risk relative to both NAIS and WBCIS, in addition to offering quick part-settlement. One approach would be for the total claim payment to farmers to be the maximum of the two indices, where the claim payment due from the weather index was paid at, or even before, harvest and any additional top-up due to the area yield indexed claim payment exceeding the weather indexed claim payment being paid at the end of the season.

Table 2: Relative strengths and weaknesses of area yield and weather index insurance

Area Yield Index	Weather Based Index
All peril cover (drought, excess rainfall, flood, pest infestation, etc.)	Single (sometimes multiple) peril cover (drought, excess rainfall, low temperature).
Easy-to-design index (estimated aggregate yields in a given area)	Technical challenges in index design (peril, crop, farming practices, agro-meteorological zone, etc.)
Low start-up costs	High start-up costs
High loss assessment costs (CCEs)	Lower loss assessment costs
Slow claims settlement	Faster claims settlement

Risk classification

The design and pricing methodology for NAIS products has led to poor risk classification: the premiums paid by farmers bear little relationship to the actuarial value of NAIS cover. Whilst there are, of course, legitimate political economy questions as to the degree and targeting of any government subsidies, the current NAIS is inadvertently inequitable and may lead to poor agriculture policy signaling and adverse selection.

An actuarial, experience based approach to design and ratemaking would use long term data and incorporate spatial dimensions of yields across India to increase the quality of risk classification. By comparison, the existing approach to design and ratemaking for the NAIS uses the three year moving average yield as the average yield estimate for some crops, despite over ten years of yield data being available. An actuarial approach would also allow for noticeable trends in historical yield data caused by changes over time to farming practices, technologies, or inputs.

The statistical subtleties of risk classification are important. For example, consider the case of the NAIS cotton product in Gujarat leading up to 2009. The rapid uptake of Bt cotton across Gujarat, reaching 66% of the cultivatable area under cotton in 2009, led to a substantial increase in the average cotton yield over the 2000s.⁷ However, the NAIS farmer premium rate was calculated using a Normal Theory Method without detrending, and so this trend in yields was mistaken for uncertainty. The NAIS farmer premium rate for cotton in Gujarat rose from 11.9% in 2003 to 17.2% in 2008 without a commensurate increase in the threshold yield. This product was increasing considered to be poor value by farmers and over the period 2000 to 2008 insured acreage for cotton in Gujarat state fell by 96%, from 567,000 ha to 20,000 ha. Incorporating a detrending methodology led to a decrease in farmer premiums by up to 80% (see Table 3).

Table 3: Statistical investigation of aggregate linear trends for six NAIS cotton products

State	Crop	Premium, no detrending	Best estimate trend (kg/ha/year)	P-value	Indicative premium, with detrending	Percentage premium reduction due to detrending
Gujarat	Cotton	17.4%	111	4.8%	6.2%	64%
Maharashtra	Cotton	17.3%	62	0.4%	3.1%	82%
Karnataka	Cotton (irrigated)	8.5%	28	2.4%	3.1%	64%
Andhra Pradesh	Cotton (irrigated)	10.5%	80	0.2%	1.6%	85%
Gujarat	Groundnut	26.6%	83	32.7%	n/a	n/a
Gujarat	Pearl Millet	17.4%	40	17.1%	n/a	n/a

Note: Premiums are commercial premiums rates, based on the existing NAIS normal theory method without detrending, and using an indemnity level of 60% and within-state weighting by 2007 area sown.

Source: World Bank (2011a), based on data from AICI.

For risk classification to be possible, there must be flexibility to determine either premium rates or threshold yields on an actuarial basis, that is using statistical analysis of past experience, incorporating expert opinion and allowing for noticeable trends in past experience. Under the NAIS, neither the premium rate nor the threshold yield is flexible, but rather determined using simple formulae, and in practice there is significant inequity within states.

For political economy and administrative reasons, varying the threshold yields across the state may be preferred over varying the premium rates across the state. One attractive option would be for threshold yields to be determined on an actuarial basis with government mandating the premium rate to be paid by farmers and the premium subsidy rates to be paid by central and state governments. The underlying actuarial premium rates would therefore be uniform across each state: for the same premium rate high average yield, low-risk areas would be offered a higher

⁷ Estimate of the degree of Bt cotton planting across Gujarat from Business Standard, 25 March 2009.

threshold yield than low average yield, high-risk areas, even while the nominal premium rate would be constant across the state. Such an approach would likely *reduce* the variation in threshold yields within each state, relative to the current rule for threshold yields, since much of the current variation in threshold yields is driven by statistically inefficient estimation of average yields.

Risk classification is less critical for the NAIS portfolio than for commercial portfolios due to the large subsidies afforded to the NAIS; under a reasonable system of risk classification, the expected claim payment rate would be greater than the farmer premium rate for every NAIS product, and so participation in NAIS would be in the interests of all farmers, even if products were better value for some and poorer value for others.

Involvement of private sector

In theory the Government of India should not need risk capital from the private sector for the NAIS portfolio: the 1-in-100 year loss of the NAIS portfolio is estimated to be US\$1.8 billion, and is small compared to annual government expenditure of US\$161 billion (World Bank 2011b). However, in practice, government could benefit from the prompt claim settlement and technical expertise of specialist reinsurers and private sector insurers, as well as from commercial innovations in, for example, the conduct and monitoring of CCEs. Experience tends to suggest that implementation of agricultural insurance is most efficient and effectively managed when there is some involvement of the private commercial agricultural sector (Mahul and Stutley 2010).

As with all services, competition with and between private sector insurance and reinsurance companies can lead to beneficial innovation in the products and services offered to farmers. However, area yield and weather indexed insurance products are complex and it may be challenging for individuals or even state governments to compare the value of different products. It may therefore be beneficial for government to standardize certain features of the products and allow competition along a small number of dimensions, such as the premium rate. For example, state governments could hire a firm on a multiple-year contract to design products across the state, and allow insurers to compete on price to offer these products.

As an alternative to restricting the design of subsidized products, government could require standard information disclosure for subsidized products. In many developed countries lenders must publicize the Annual Percentage Rate (APR) of their loans to allow a simple, if somewhat crude, comparison between products; government could require that for all subsidized products the insurance provider must disclose the claim payments that would have been due under this product in each of the most recent ten years.

Basis risk

Loosely speaking, basis risk experienced by farmers could be reduced in three main ways. First, farmers could soak up basis risk through local, semiformal, mutual institutions. Basis risk in an area yield index scheme arises both from the yield of individual farmers differing from the average yield in the insurance unit, and from sampling error, whereby the average yield as measured from a sample of crop cutting experiments does not reflect the true average yield. If there are sufficient crop cutting experiments conducted per insurance unit, the sampling error should be low, and area yield index insurance should accurately reflect capture aggregate shocks that affect farmers across each insurance unit. The remaining basis risk, idiosyncratic within the insurance unit, could be removed by localized risk pooling within local institutions such as individual or groups of Self Help Groups.

Second, the formal contract form could be amended to incorporate information from other sources. For example, crop cutting experiments at the block or district level for each crop could be used to

determine the average claim payment rate for the district, with this total rate split between village Panchayats or Blocks using high resolution remote sensing imagery or local weather data. As another example, insured farmers could receive a claim payment based on block or district level yield estimates, with potential for a top up if local weather or remote sensing imagery data suggests unusually low local yields.

Third, the insurance unit size could be reduced, for example from the level of the block to the village Panchayat. However, without village Panchayat-level historical data it would not be possible to compute the actuarial premium rates for village Panchayat-level insurance units and so any reduction in insurance unit size would have to be considered to be a ‘social benefit’ paid for by government and not be passed onto the insurer, at least till the time a sufficient data series is created. Any reduction in the insurance unit size would also require a large increase in the number of crop cutting experiments to be conducted from 500,000 to an estimated 5.5 million (Joint Group 2004), and possibly even up to 10 million (author estimates). This may make it challenging to concurrently increase the quality, speed and reliability of crop cutting experiments.

4. The pilot modified National Agricultural Insurance Scheme (mNAIS)

In September 2010, the Government of India approved the modified National Agricultural Insurance Scheme (mNAIS), moving from a social crop insurance program with ad-hoc funding from the Government of India to a market-based crop insurance program with actuarially sound premium rates and product design. Given the technical and operational challenges associated with moving from the NAIS to the mNAIS, implementation began with a three-season pilot, starting with 34 districts across 12 states for the Rabi 2010-11 crop, and scheduled to increase to 50 districts (around a tenth of India). In Rabi 2010-11 approximately 340,000 farmers purchased policies under this scheme, with a premium volume of approximately US\$10 million, and over time it could be expanded to India’s 110 million farmer households.

The mNAIS comprises a suite of innovations to NAIS, most notably the move to an actuarial regime, where farmer premiums and government subsidies will both be paid upfront at the start of the crop season to the insurer (Table 4). The insurer, which could be the public insurer AICI or a private sector competitor at the choice of each state, will then be responsible for settling all claims as they fall due. Whilst for Rabi 2010-11 most states have opted for mNAIS cover through the public insurer AICI, two states have selected private insurers and around five international reinsurers are providing substantial reinsurance to the insurance providers, both on an excess of loss and quota share basis. Increasing competition and expanding the role of the private sector in crop insurance contributes to the promotion of effective public-private partnerships in agricultural insurance.

Table 4: Summary comparison between NAIS and mNAIS

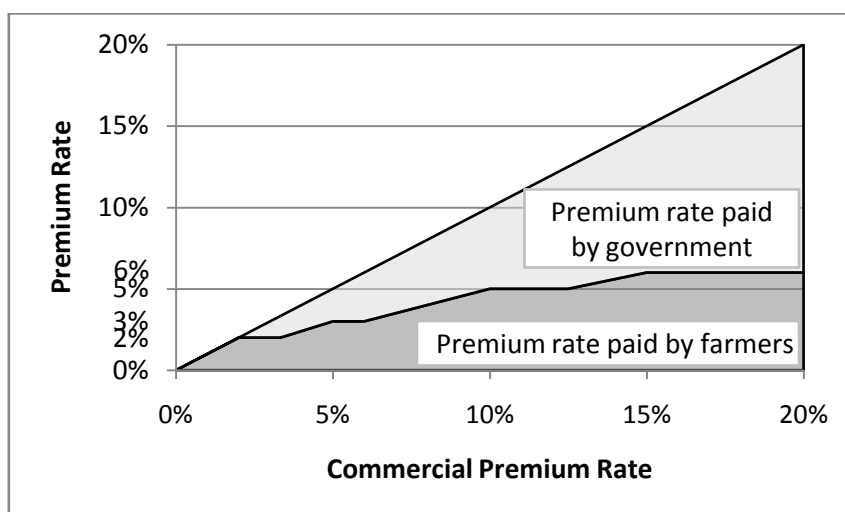
Key Issue	NAIS	modified NAIS
Public financing	Ex-post subsidy structure leads to open ended fiscal exposure, high variability in annual payments and delay in claims settlement	Ex-ante financing, in the form of upfront premium subsidies. Insurer to receive premiums (farmer collections + premium subsidies from the government) and is responsible for managing the liability of the mNAIS on a sustainable basis, through risk transfer to private reinsurance markets and risk retention through its reserves.
Delays in claims	Delay in NAIS claim payments due to the time taken to	Ex-ante financing and streamlined CCE procedure.

settlements	process CCEs and publically fund claims on an ex-post basis	Early non-repayable 'on account' part-payment up to a value of 25% of 'likely claims' to be made in cases where weather indices and other local information suggest that a large loss has been incurred.
Risk classification	Both premium rates and threshold yields determined based on simple formulae. Wide variation in the actuarial value of NAIS products within a state.	Actuarial design and ratemaking based on a statistically robust Experience-Based Approach. Probable yields are based on 7 year moving average of actual yield, with Bühlmann credibility smoothing between nearby insurance units. Indemnity levels and commercial premium rates are determined at the district level for each crop using ten years of actual yield data. Farmer premium rates are increasing in the commercial premium rate (Figure 5).
Data quality	A lack of standardization, trained personnel, and monitoring for CCEs exposes the NAIS to significant delays, basis risk and the risk of manipulation.	Use of technology, standardization and monitoring to improve the quality of CCEs. CCEs to be video recorded with GPS-tagged footage. Data to be provided to the insurer by SMS at the time of the CCE to allow real time monitoring. Remote sensing data to be used to target the number of CCEs to be conducted at harvest in insurance units, and to monitor CCE reports.
Involvement of private sector	No private sector involvement	Domestic insurance companies authorized to compete with AICI to offer mNAIS. Private sector reinsurance capacity. Possible use of private sector in conducting or auditing CCEs.
Basis risk	Basis risk, whereby a claim payment to an individual farmer does not adequately reflect yield experience.	Reduce the size of the insured unit from the level of the administrative block to the individual village Panchayat for major crops. Expand coverage to include cover for prevention of sowing, replanting, post-harvest losses and localized risk, such as hail losses or landslide.
Adverse selection	Adverse selection caused by non-borrowing farmers being able to purchase cover well into the growing season when pre-existing drought conditions are known.	Uniform sales cut-off dates to be introduced in advance of the sowing season for all farmers.

The move away from unfunded ex-post government subsidy, combined with planned changes to crop cutting experiments, should allow claim settlement within 1 month of harvest, rather than the current 9-12 months. The addition of an early 'on account' payment based on weather indices can allow claim payments to farmers even before harvest, if the weather is sufficiently poor. This combines the strengths of area and weather based index insurance, providing farmers with both the speedy payment of weather-index insurance and the lower basis risk of area yield insurance. Central and state governments will also benefit from improved budget management, where the full cost of government support to mNAIS will be known at the start of each crop season.

This move to an actuarial regime is made possible by risk-based pricing whereby the commercial premium rate for each product, accounting for the full commercial cost of providing cover, is paid to the insurer by farmers and government at the start of the crop season (Clarke et al. 2011a). The premium rate paid by farmers is increasing in the commercial premium rate, improving agronomic signaling as compared to the flat premium rates of NAIS (Figure 5). The product design formula for mNAIS also differs from that for NAIS, with the intention of reducing the local variation in commercial premium rates for each crop; the previous probable yield rule, equation (3), would have led to a large variation in the value of benefits, and therefore a large variation in commercial premium rates. Improved risk classification is also expected to reduce adverse selection and increase equity amongst farmers by spreading government subsidy more evenly.

Figure 5: Split of mNAIS commercial premium rate



Source: AICI (2010)

5. Remaining challenges and suggestions for future research

The move to mNAIS, whilst a very positive step forward, introduces new challenges.

Improving robustness of yield estimation: The implementation of mNAIS at a lower insurance unit level (village Panchayat), while offering the prospect of lower basis risk for farmers and therefore providing improved benefits, creates both challenges and costs for the state governments in the implementation of the crop cutting experiments (CCEs). These need to be addressed in the medium term. Moving to a lower insurance unit for major crops significantly increases the number of CCEs to be conducted, as at least 8 CCEs have to be conducted for each of these crop in each Gram Panchayat. While mNAIS is currently being piloted in only 50 districts, issues related to the costs, potential outsourcing of CCEs, quality control including possible applications of technology, and sampling framework need to be addressed in advance of wider expansion.

To deal with the challenge of significantly increased number of CCEs, new technology and partial outsourcing of the yield estimation process could be piloted to increase the efficiency of the CCE process and to reduce the number of CCEs. Technology could be utilized in the conduct of official CCEs, for example by requiring that all CCEs are video recorded on inexpensive mobile phones. Insurers and state governments could watch a random selection of CCE videos, to verify that the correct procedure was being followed and to highlight areas for future training of field staff. CCE data could be transmitted to the insurer on the day each CCE is conducted to allow real time monitoring by local staff and comparison with other data sources, such as remote sensing imagery. Remote sensing imagery could also be used to reduce the number of CCEs needed: a higher number

of CCEs could be conducted in areas where potential crop yield losses are large, and thus insurance payouts are anticipated to be large, whilst a lower number of CCEs could be conducted in other areas. The partial outsourcing of CCEs could also be considered, supplemented by a strong audit mechanism. For example, partial outsourcing to private sector service providers, banking correspondents or NGOs could be considered.

Regardless of the improvements in the targeting and conduct of CCEs, there is a tradeoff between reducing basis risk and increasing the number of CCEs to be conducted. Currently it is challenging to assess this tradeoff for each crop in each state since the cost of conducting CCEs for insurance purposes are not factored into the insurance premium. Were this to change, the tradeoff may be clearer, leading to improved decision making.

The move to an ex-ante premium subsidy system increases the exposure of the mNAIS portfolio to fraudulent crop cutting experiment reports by local state employees. Under NAIS, states contributed towards any claim payments and therefore had an incentive to monitor crop cutting experiments. However, under mNAIS, states contribute towards claim payments through upfront premium subsidies and underreporting of yields would lead to large claim payments to local farmers at no additional short term cost to the state. Any perceived moral hazard will increase reinsurance prices, leading to high commercial premiums to be paid by farmers, states and central government. Were systematic underreporting to occur in practice in any state it would be damaging to the long term prospects of mNAIS in all states.

Another approach would be to note that states are in a better position than the insurer to monitor the quality of crop cutting experiments, and for the insurer to use a statistical sample of manipulation-free crop cutting experiments as an independent check on the full set of statewide crop cutting experiments. For example, the insurer could conduct or co-observe a sample of crop cutting experiments across the state and use this data to estimate the manipulation-free aggregate claim payment to be paid to farmers in the state. If the aggregate state-wide claim payment rate arising from the full set of crop cutting experiments is sufficiently higher than this manipulation-free estimate based on the manipulation-free sample, then the insurer has reasonable grounds for believing that there has been systematic manipulation of crop cutting experiments across the state. Conducting random audits of, say, 5% of all CCEs would be much less expensive than conducting audits of all CCEs. However, for random auditing to be effective, the maximum punishment in the event of detected manipulation of CCEs must be large enough to deter manipulation. The threat of future exclusion from the mNAIS may be sufficient to ensure that states conduct sufficient monitoring of their employees. Insurers could also incorporate independent data, such as remote sensing or weather station data, in their validation of CCEs.

Learning how to increase outreach: Currently, most of the insured farming households are covered on a compulsory basis, with 95 million farming households not insured. With a subsidized premium, improved product design and faster claim settlement, the mNAIS product should be attractive to most farmer households across India: most farmers will pay around a third of the commercial premium and for every 1 rupee paid in premium will expect to receive approximately 2 rupees in claim payments. (Whilst this was true on an aggregate basis under the NAIS, expected claim payments were not evenly distributed between insurance units and so NAIS was poor value for some farmers.). However, designing a good insurance product is not enough to guarantee voluntary purchase; insurance is never bought, always sold. If the mNAIS is to offer protection to the poorest, most vulnerable farmers, insurers must actively market the product to these farmers.

Communication is particularly important since farmers who, under NAIS, were paying a maximum premium rate of 3.5% may be paying up to 6% under mNAIS, albeit for a more valuable product. Communicating the changes between NAIS and mNAIS is therefore important both to encourage existing policyholders to renew, and for increasing voluntary purchase. In a recent survey of farmers

in Andhra Pradesh, only 5% of farmers stated that they would be willing to pay an insurance premium above 2% (Raju and Chand 2008).

Fine-tuning the mNAIS product: Despite the size and importance of the NAIS, WBCIS and mNAIS portfolios, there has been limited empirical analysis of the basis risk experienced by farmers. Insurers and government should engage with academic agronomists, statisticians and economists, to measure the degree of basis risk and develop ways to minimize it, both through improved product design and use of localized risk pooling to soak up idiosyncratic basis risk.

The early 'on account' payments to be payable under mNAIS are most valuable to farmers if they are both early and only paid when yields have indeed been unusually poor. Further research is needed into the level of correlation between yields and weather and satellite data.

Institutional capacity building and supporting development of the crop insurance market: Agricultural insurance is a highly specialized line of business that requires intensive institutional capacity building. The public insurer, AICI, and private insurers have increased their technical and operational capacity to enable them to offer mNAIS products, but further development is necessary. Now that states can decide the insurance provider of the mNAIS for each district, guidelines on the applicable procurement rules could be disseminated to clarify the rules/basis for making such decisions at the state level. In the medium term, the Government of India could also consider the overall agricultural risk market infrastructure and assess the merits of alternate models as well since comparative advantage of different types of insurers could vary and alternate structures could potentially lead to efficiency gains. For example, one model used in Mexico is of a public agricultural reinsurance company (Agroasemex) offering technical assistance and reinsurance capacity to the domestic insurance companies involved in agricultural insurance. In Spain, an agricultural co-insurance pool (Agroseguro), with a lead insurer is deployed.

Monitoring and evaluation: The Government of India is currently piloting two potential successors to NAIS, the WBCIS and the mNAIS (Table 1). It would be possible to use the pilot phase of mNAIS to learn about key policy questions such as how best to design and market the mNAIS product. For example, it would be possible to conduct an experiment to better understand the most cost effective way to increase voluntary insurance purchase, particularly from small and marginal farmers. Such an experiment would be relatively inexpensive to conduct but the results may significantly impact policy decisions when the pilot phase of the mNAIS is at an end.

6. Conclusion

The shift from a social crop insurance program with ad-hoc funding from the Government of India to a market-based crop insurance program with actuarially sound premium rates and product design is a major step forward. The improved product and active involvement of private sector insurance markets is expected to lead to significant benefits for farmers, including faster claims settlement, a more equitable allocation of subsidies and lower basis risk, and political economy gains for government, including better fiscal management, improved agricultural policy signaling and lower adverse selection.

However, key challenges remain for policy makers, insurers and academics. Protecting crop cutting experiments from the threat of moral hazard requires a multipronged approach but is critical if the area yield index based product is to be insurable by private insurance markets. For the product to be pro-poor, small and marginal farmers must purchase the mNAIS product voluntarily, and insurers and government must experiment with cost-effective ways of increasing outreach. The mNAIS product, whilst substantially better than the NAIS product, could still benefit from further fine-tuning, for example to reduce basis risk or increase the value to farmers of the early 'on account' payments. Finally, there may be a role for a central government Technical Support Unit to be

responsible for developing some of these public goods relating to the market infrastructure for agricultural insurance in India, for example by piloting and scaling up improvements in crop cutting experiments and conducting analysis and research leading to best practice guidelines on areas such as product design, procurement and strategies for increasing take-up.

The international community, practitioners and academics, can learn a lot from the Indian experience. Whilst some of the lessons from this project are specific to agriculture insurance in India, others are applicable more generally. First, provision of a cost effective agricultural insurance program requires long term investments in data and capacity beyond the horizon of the private sector. The Government of India has provided widespread agricultural insurance, albeit mostly on a social basis, since the launch of the Comprehensive Crop Insurance Scheme in 1985, and has continued to invest heavily in institutional capacity building and technical inputs. Second, technical tools are necessary to help guide policy dialogue, and these tools should reflect on-the-ground realities and political and economic considerations even if this means that the solutions are technically second best. Third, although much recent work has focused on either weather or area yield indexed insurance, it is possible to design products which combine the strengths of both, such as the pilot mNAIS product. Finally, political economy dimensions cannot be underestimated when it comes to implementation. Reforms of the scale of the mNAIS require significant political momentum from different ministries, most notably the Ministries of Agriculture and Finance, and an enabling policy climate.

Bibliography

AICI, 1999. "National Agricultural Insurance Scheme: Scheme & Guidelines" New Delhi: Agriculture Insurance Company of India

AICI, 2010. "A Discussion note for Actuarial Design and Ratemaking" New Delhi: Agriculture Insurance Company of India

Binswanger-Mkhize, H., 2011. "*Is there too much hype about index-based agricultural insurance?*" mimeo.

Carter, M.R., F. Galarza, and S. Boucher, 2007. *Underwriting area-based yield insurance to crowd-in credit supply and demand*, Giannini Foundation of Agricultural Economics working paper, UC Davis 07-003.

Clarke, D.J., 2011. "*A Theory of Rational Demand for Index Insurance*", Economics Series Working Papers 572, University of Oxford, Department of Economics.

Clarke, D.J., O. Mahul and N. Verma, 2011a. "*Index Based Crop Insurance Product Design and Ratemaking: The case of the modified NAIS in India,*" World Bank, mimeo.

Clarke, D.J., O. Mahul and N. Verma, 2011b. "*Weather Based Crop Insurance in India,*" World Bank, mimeo.

Cole, Shawn A., Xavier Giné, Jeremy B. Tobacman, Petia B. Topalova, Robert M. Townsend, and James I. Vickery, 2009. "*Barriers to Household Risk Management: Evidence from India,*" Working Paper 09-116, Harvard Business School.

Collins, D., J. Morduch, S. Rutherford, and O. Ruthven, *Portfolios of the Poor: How the World's Poor Live on \$2 a Day*, Princeton University Press, 2009.

Dercon, S., 2004. "*Risk, insurance, and poverty: a review,*" in S. Dercon, ed., *Insurance against Poverty*, chapter 1.

Joint Group. 2004. *“Report of the Joint Group on Crop Insurance.”* (Department of Agriculture & Cooperation). New Delhi: Government of India, Ministry of Agriculture

Ibarra, H., 2004. *“Self-Insurance Funds in Mexico,”* in E.N. Gurenko, ed., *Catastrophe Risk and Reinsurance: A Country Risk Management Perspective*, 2004, chapter 18.

James P.C., and R. Nair. 2009. *A Study of Yield based Crop Insurance in India: A Performance Review.* New Delhi: Agriculture Insurance Company of India

Hazell, P., 1992. *The appropriate role of agricultural insurance in developing countries,* *Journal of International Development*, 4 (6), 567-581.

Mahul O. and C. Stutley. 2010. *Government Support to Agricultural Insurance: Challenges and Options for Developing Countries.* Washington, D.C.: World Bank.

Nair, R., 2010. *“Crop Insurance in India: Changes and Challenges”* *Economic and Political Weekly*, February 6th: 19-22.

Raju, S.S., R. Chand, 2008. *“Agricultural insurance in India: problems and prospects,”* Indian Council of Agricultural Research, New Delhi, NCAP working paper

Skees, J.R., P.B.R. Hazell, and M. Miranda, 1999. *“New Approaches to Public/Private Crop Yield Insurance in Developing Countries,”* Environment and Production Technology Division (EPTD) Discussion Paper 55, International Food Policy Research Institute (IFPRI)

Smith, V. and M. Watts, 2009. *“Index Based Agricultural Insurance in Developing Countries: Feasibility, Scalability and Sustainability,”* Gates Foundation.

World Bank. 2007. *“India National Agricultural Insurance Scheme: Market-based Solutions for Better Risk Sharing”* Report No. 39353. Washington DC: World Bank.

World Bank. 2011a. *“Enhancing Crop Insurance in India”* Washington DC: World Bank.

World Bank. 2011b. Data retrieved February 20, 2011, from World Development Indicators Online (WDI) database.