Report no. 61491-IN

Enhancing Crop Insurance in India

April 2011

India Country Management Unit
South Asia Finance and Private Sector Unit
Global Capital Market Non Banking Unit

Co-funded by the Global Facility for Disaster Reduction and Recovery (GFDRR)

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The report was jointly led and prepared by Olivier Mahul (Insurance for the Poor Program, Global Capital Market Non Banking, Finance and Private Sector Development, World Bank) and Niraj Verma (Finance and Private Sector Development, South Asia Region, World Bank), with significant contributions from Daniel Clarke (Actuarial Consultant, World Bank). Additional inputs were also provided by Saket Saurabh (Insurance Consultant, World Bank), Raghvendra Singh (Insurance Consultant, World Bank) and Ligia Vado (Insurance Consultant, World Bank). Sumriti Singh provided support in formatting the report. This non-lending technical assistance (NLTA) report has been prepared as part of an NLTA to the Agriculture Insurance Company of India (AICI) to enable them to make a transition to an actuarial regime. This report focuses on the National Agriculture Insurance Scheme and the Weather Based Crop Insurance Scheme.

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ABBREVIATIONS

AICI	Agriculture Insurance Company of India
APF	Agricultural Policy Framework
APH	Actual Production History
APR	Assumed Pure Rate
BBF	Balance Back Factor
BP	Base Pure Rate
CCE	Crop Cutting Experiment
CCIS	Comprehensive Crop Insurance Scheme
CIF	Crop Insurance Fund
CV	Coefficient of Variation
EBA	Experience-Based Approach
eWBCIS	enhanced Weather Based Crop Insurance Scheme
FCIC	Federal Reinsurance Fund
FP	Final Pure Rate
FRF	Federal Reinsurance Fund
GIS	Geographic Information Systems
GOI	Government of India
GRP	Group Risk Plan
HE	Hail Endorsement
IQR	Inter-Quartile Range
IU	Insurance Unit
mNAIS	modified National Agricultural Insurance Scheme
MPPI	Multi-Peril Production Insurance
NAIS	National Agricultural Insurance Scheme
NASS	National Agricultural Statistics Service
NDVI	Normalized Difference Vegetative Index
NOAA	National Oceanic and Atmospheric Administration
NTM	Normal Theory Method
PPR	Pure Premium Rate
PRF	Provincial Reinsurance Fund
PVI	Pasture Vegetative Index
PY	Probable Yield

RAF	Risk Adjustment Factors
RFP	Request for Proposal
RMA	Risk Management Agency
SAS	Statistical Analysis Software
SCC	Selected Crop Climate
TA	Technical Assistance
TY	Threshold Yield (also called guaranteed yield)
UP	Unbalanced Pure Rate
U.S.	United States of America
USDA	United States Department of Agriculture
UT	Union Territory
WBCIS	Weather Based Crop Insurance Scheme

EXECUTIVE SUMMARY

1. ***The broad structure of National Agricultural Insurance Scheme (NAIS), the main crop insurance program in India, is technically sound and appropriate in the context of India.*** The NAIS is based on an indexed approach, where average crop yield of an insurance unit, IU, (i.e., block) is the index used. The insurance is mandatory for all farmers that borrow from financial institutions, though insurance cover is also available to non-borrowers. The actual yield of the insured crop (as measured by crop cutting experiments) in the IU is compared to the threshold yield. If the former is lower than the latter, all insured farmers in the IU are eligible for the same rate of indemnity payout. Individual crop insurance would have been prohibitively expensive, or even impossible, in a country such as India with so many small and marginal farms. Further, the method of using an 'area based approach' has several other merits and, most importantly, it mitigates moral hazard and adverse selection.

2. ***However, there are a number of areas in which the NAIS could be further strengthened.*** In particular: the current NAIS is mainly funded by ex-post public contributions, entailing an open-ended and highly variable fiscal exposure for state and central governments. Government administrative and budgetary process for this ex-post funding has led to systemic delays in settlement of NAIS claims (up to 9-12 months or more). Risk classification is currently poor, leading to adverse selection and inequity between farmers in nearby insurance units.

3. ***At the request of Government of India (GOI), the World Bank has provided technical assistance to the public insurance company, Agriculture Insurance Company of India (AICI)***: to develop an actuarially-sound rating methodology and improve the contract design of the area-yield based National Agriculture Insurance Scheme (NAIS) to reduce delays in claim settlement; to propose design and ratemaking of new weather index insurance products under the Weather Based Crop Insurance Scheme (WBCIS); and to perform a risk assessment of AICI's insurance portfolio and suggest cost-effective risk financing solutions (including reinsurance).

4. ***In September 2010, the GOI approved a plan to move from the NAIS into a modified NAIS (mNAIS) under an actuarial regime on a pilot basis from Rabi 2010.*** This is a major initiative given the significant scale of NAIS. The *mNAIS* reflects many of the suggestions in this report and the accompanying policy note (World Bank 2010) and, if implemented well, could offer farmers improved crop insurance products and timely claims settlement and achieve greater coverage. Such an improved program could result in increased benefits for millions of current farmer clients and lead to greater coverage of the insurance program. Such a move could also help reduce both government contingent liability and delays in claims settlement.

5. ***This report offers detailed analysis of a number of technical and operational issues which should be addressed if mNAIS is to be implemented.*** GOI is to be complemented on its bold vision of the future of agriculture insurance through modifying NAIS, an action which, if well implemented, has the potential for significant economic and political economy gains. The policy note World Bank (2010) supported this vision and offered specific policy recommendations for *mNAIS*, with reference to the Joint Group report (2004). This technical report is intended as a complement to World Bank (2010) and also to the previous technical report World Bank (2007a), by offering detailed technical analysis of a number of issues that will be critical to the success of *mNAIS*.

6. ***As GOI moves towards modifying NAIS, a critical action relates to the crop yield estimation process that needs to be enhanced, both by improving the accuracy of yield estimates and implementing a formal framework for protecting the mNAIS from moral hazard risk.*** Currently, state governments are responsible for ensuring that crop yield estimates are an accurate reflection of the yields experienced for each crop in each Insurance Unit. However, for an actuarial regime to be successfully implemented these procedures and safeguards must be formalized and strengthened. Additional safeguards, including the conduct of randomized independent CCE audits, are suggested. A systematic improvement in the accuracy of yield estimates, through process standardization and training, has the potential to reduce basis risk, the risk that insurance claims do not accurately reflect incurred losses.

7. ***It is suggested that the insurance product offered under mNAIS could be of a standardized product design, and could include both an early payment based on a weather index and a final payment based on an area yield index.*** The modified NAIS and WBCIS products should be of a standard shape for each crop, varying only limited parameters. Current NAIS products are of a standard shape, but the current design process for WBCIS products exposes the WBCIS portfolio to a form of data mining which can lead to systematic under-pricing. An early weather based payment would offer early part-settlement of claims, and a late area yield based payment would ensure full cover for perils that cannot be accurately estimated through weather indices. Two general types of double index products can be considered: one in which any early weather index payment is offset against any late area yield index payment, and one in which there is no such offsetting.

8. ***Products could be designed and priced to enable efficient risk classification in the interest of equity and protection against adverse selection.*** The current procedure for determining premium rates and Threshold Yields under NAIS leads to poor risk classification: NAIS products offered in two Insurance Units in the same state can have very different value to farmers, leading to inequity and adverse selection. This is because the current procedure for determining Threshold Yields is not robust to statistical outliers.

9. ***GOI could specify the design of mNAIS products and uniform premium and expected claim payment rate, while AICI would be responsible for calculating the coverage level based on a robust statistical methodology.*** For operational and political economy reasons it is difficult for risk classification to be conducted by charging different premiums for the same crop in different Insurance Units within a state. The experience-based approach suggested for the ratemaking of the modified NAIS (World Bank 2007a) can be adjusted to allow AICI to set a flat premium rate across a state, and classify risks by varying the products sold across the state. The suggested approach could lead to better risk classification and lower variation in premium rates and products within districts than the existing NAIS and WBCIS approaches.

10. ***The proposed approach to ratemaking and product design would be robust to technological trends, and risk loading would be determined on a portfolio basis.*** Alternative de-trending methodologies have been analyzed and illustrated for the case of cotton in Gujarat. Prototype software for the de-trending process has already been tested by AICI in Gujarat, Madhya Pradesh and Maharashtra for cotton in Kharif 2009, leading to lower premium rates and an increased uptake from 180,000 farmers in Kharif 2008 to almost 300,000 farmers in Kharif 2009.

11. ***Under an actuarial regime, AICI should use the results of portfolio risk assessments to inform decisions about the purchase of reinsurance and/or contingent debt facility.*** Potential risk financing strategies include multi-year reserves, reinsurance and contingent credit. A contingent debt facility could allow AICI to increase its risk retention and reduce its reinsurance costs within a sound financial framework.

12. ***A comprehensive NAIS portfolio model has been developed and could be used to compare the economic and fiscal impact of alternative government subsidy structures.*** Three illustrations of this model are discussed. First, a comparison is made of ex-ante and ex-post government subsidy structures. Second, the existing subsidy structure is compared to five ex-post alternatives in which commercial/horticultural crops receive the same subsidies as food-grain and oilseed crops. Finally, the effect of universalisation on the NAIS portfolio is considered.

13. ***An action plan is suggested, including short term measures that need immediate consideration.*** A detailed action plan is presented, including actions pertaining to improvements in product design, refinement including differentiating risk between farmers and states and allowing greater choice to states, and bringing in the private sector. Given the complexities involved in the move to *mNAIS*, it is suggested to pilot-test the proposed actions, and, if successful, to expand them countrywide. Whilst the GOI subsidy in the first year of *mNAIS* could be entirely in the form of upfront premium subsidies, it is suggested that state

subsidies transition from ex-ante to ex-post during a transition period, whilst the CCE process is being enhanced (doing so, enables mitigation of risk in the CCE process which is conducted by the state government – by being responsible for payments based on CCEs, the risk to insurers/re-insurers is mitigated in the short term as the CCE process gets enhanced).

CHAPTER 1: INTRODUCTION

1.1. Agriculture's share in GDP, while declining, still remains significant at around 18 percent in 2008 and the sector continues to account for more than 60 percent of the labor force. India has 116 million farms (operational farm holdings) covering 163 million hectares with a vast majority of farm holdings being small and marginal in size (approximately 80 percent of farmers operate less than 2 hectares) and a significant proportion of such households are below the poverty line. For these reasons agriculture remains an important priority for the Indian Government. The mandate from the last general elections and recent announcements reinforce government's intention that going forward, considerable attention would be placed on this sector.

1.2. The vast majority of India's 116 million farms cultivate rainfed crops and are particularly vulnerable to the vagaries of the Indian monsoon. An international disaster database[1] estimates that 350 million people were affected by drought in the ten year period ending in 2009. In this context, agricultural risk management products, particularly for the small and marginal farmers, are of critical importance.

1.3. The main instrument for provision of risk management to the farming community was the Comprehensive Crop Insurance Scheme (CCIS) introduced in 1985-86. In 1999, this was replaced by the National Agricultural Insurance Scheme (NAIS) which is now offered by the public crop insurance firm, Agriculture Insurance Company of India (AICI). The main features of the NAIS include availability to all states/union territories (UTs), coverage of food crops, oilseeds and selected commercial crops and use of an "area yield" index (see Box 1.1). This "area yield" approach reduces the traditional problems of adverse selection and moral hazard and lowers the administrative costs relative to traditional, individual yield based crop insurance. AICI is the only player offering such a product to farmers.

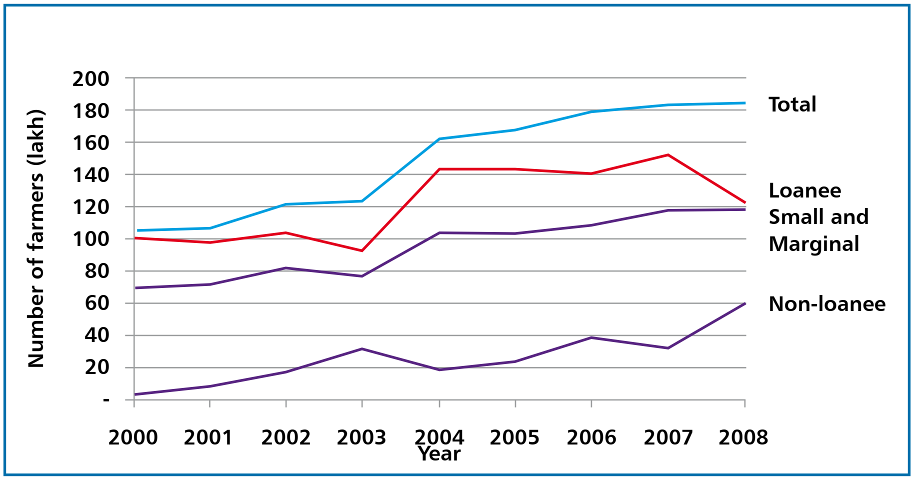
1 EM-DAT: The OFDA/CRED International Disaster Database – www.emdat.net – Université catholique de Louvain – Brussels – Belgium.

- It operates on an "area-yield-based" approach: if the observed seasonal area-yield per hectare of the insured crop for the defined Insurance Unit (IU) falls below a specific threshold yield (TY), all insured farmers growing that crop in the defined area will get the same claim payments (per unit of sum insured);
- The "seasonal area-yield" estimate is determined by harvested production measurements taken at a series of randomly chosen Crop Cutting Experiment (CCE) locations;
- The probable yield (PY) is based on a three-year moving average of seasonal area yields estimated from CCEs for rice and wheat crops and a five-year moving average for all other crops;
- Three coverage levels are available and the TY can be set at 60, 80 and 90 percent of the area PY fixed by crop at the state level, offered based on coefficient of variation for yields in the ranges of: greater than 30 percent, 16 to 30 percent, and 15 percent or less, respectively;
- The program is available to all states and UTs on a voluntary basis, but once introduced in a state/UT, it must be offered for a minimum of three years;
- The scheme is intended to be compulsory for borrowing farmers and voluntary for farmers without loans; and
- Farmers have the option of buying additional Rupee coverage to a maximum of 150 percent of the TY multiplied by a defined price (market price or floor price established by government).

1.4 The NAIS program covered about 18 million farmers during the Kharif season (June to September) and the Rabi season (October to December).[2] That is, the annual crop insurance penetration is approximately 16 percent. Small and marginal farmers account for two thirds of the farmers covered under NAIS. Borrowing farmers (loanee farmers) account for approximately two thirds of the insured farmers.

2 In 2009, it is estimated that the outreach increased to around 20 million farmers.

Figure 1.1: Farmers Covered under NAIS

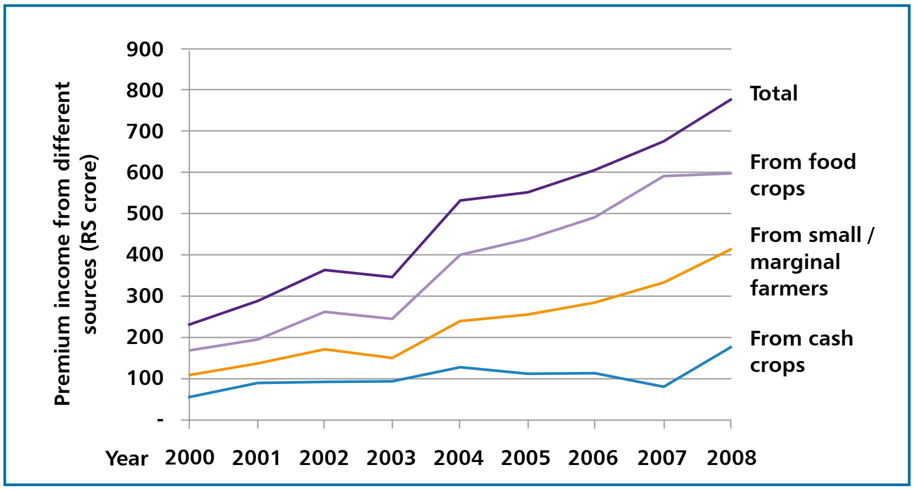


Source: Data from AICI

1.5 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 since 2004 and reached 1.4 ha in 2008. See Annex A.

1.6 The NAIS premium volume reached almost Rs.800 crores (US$178 million) in 2008 and it has steadily increased since 2003. Food crops represent about 75 percent of the total NAIS premium volume and small and marginal farmers contribute to about half. Despite the large numbers of farmers covered, which makes NAIS the largest program worldwide (even though, as yet, a large proportion of farmers are not insured) several problems need to be addressed. The demand for crop insurance is concentrated in the states where crops grow under rain-fed conditions and natural risks are greater. These states include Andhra Pradesh, Gujarat, Karnataka, Orissa, Uttar Pradesh and Rajasthan. Two crops, paddy and groundnut, represent 40 percent of the total premium volume. See Figure 1.2 and Annex A.

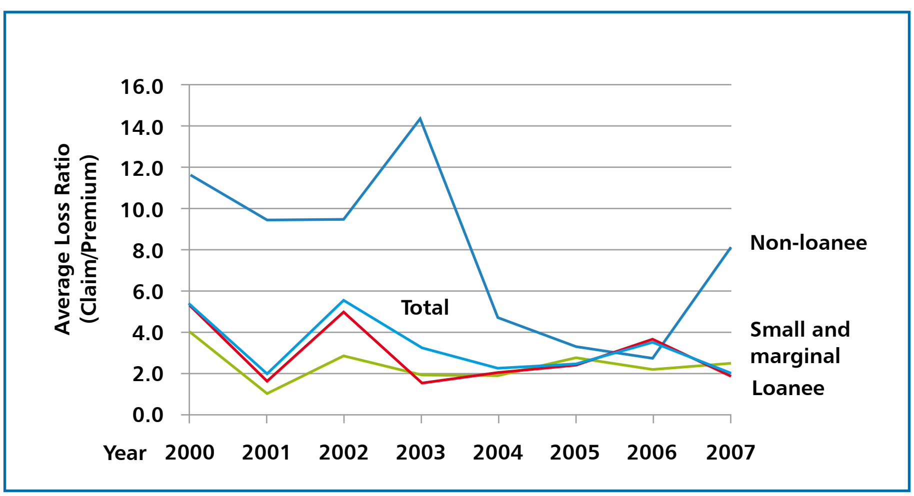
Figure 1.2: NAIS Premium Volume, 2000-2008



Source: Data from AICI

1.7 Since its inception, the annual loss ratio (claim/premium) has been always higher than 100 percent, i.e., the total indemnities 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: less than 1.5 percent and 3.5 percent, or the actuarial assessed rates, for food crops and oilseeds respectively. The loss ratio averaged 250 percent in 2007, but this hides a large disparity between non-borrowing farmers and borrowing farmers. This disparity illustrates the impact of adverse selection: non-borrowing farmers choose to insure their riskier crops. It should also be noted that the loss ratio of the small and marginal farmers tends to be less than the loss ratio of all farmers. See Figure 1.3 and Annex A.

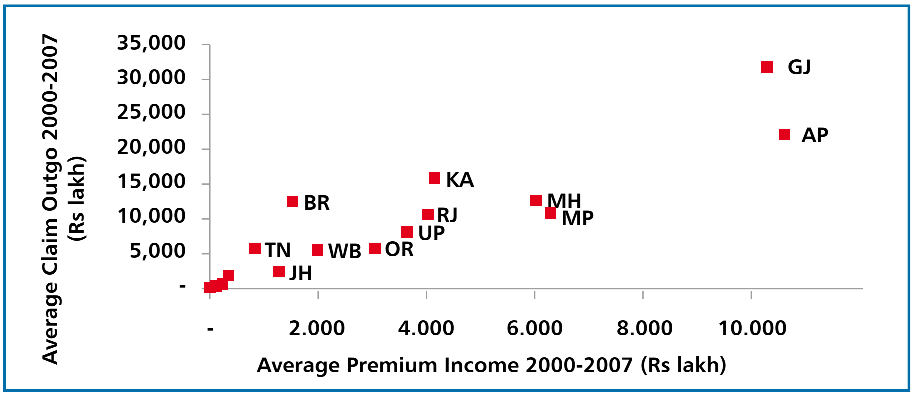
Figure 1.3: NAIS Loss Ratio (Indemnities/Premiums)



Source: Data from AICI

1.8 Some states, such as Andhra-Pradesh and Gujarat, collect even more claims in proportion to their premium contribution. See Figure 1.4 and Annex A.

Figure 1.4: NAIS Premium Income and Insurance Claims by State



Source: Data from AICI

1.9 Yet another critical problem has been the long delay in payment of indemnities. 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' inability to expeditiously contribute to claim settlements, since they have typically not budgeted adequately for such liabilities. Farmers not receiving claims payment on time may default on their bank loans and become ineligible for loans for the next crop cycle. This has also contributed to the relatively low take up of crop insurance, despite significant increase in outreach in recent years.

1.10 To address these issues, the Government of India (GOI) has reviewed the NAIS with dual objectives of making the scheme more attractive to farmers (especially in terms of timely payments) so as to increase the crop insurance penetration levels, and to place the scheme on actuarial regime. Premiums would be charged on a commercial basis and the Government's support, where necessary, would provide up-front premium subsidies differentiated by the economic category of farmer. AICI would receive up-front premium subsidies and would be responsible for all claims.

1.11 Properly functioning crop insurance could improve access to credit for farmers through reducing risk for lenders and timely payments of indemnities; improve resource allocation and improve fiscal management. With some careful attention, the Indian crop insurance program could more effectively contribute to the rural sector.

1.12 The Technical assistance (TA) was requested by AICI/Government in this context. This TA follows a first TA, whose findings and recommendations have been presented in the World

Bank report *India National Agricultural Insurance Scheme: Market-based solutions for better risk sharing* (Report No. 39353, February 2007).[3] The overall objective of the study and this report is to offer follow-up technical assistance to AICI in order to assist the insurance company in moving towards a market-based approach in the design of actuarially-sound area yield and weather-based crop insurance products. The TA aims at improving further the contract design of insurance products and suggesting a methodology to AICI to develop insurance products designed and rated with actuarially-sound actuarial techniques using lessons from international best practice. The main audience for this report is a technical audience. While the primary audience is AICI senior management, the methods and tools can also be of interest to policy makers and agricultural insurance practitioners in India and other emerging counties.

1.13 This market-based approach, relying on a sound actuarial regime, could help the government to (i) reduce its fiscal exposure as it can better forecast public financial support; and (ii) develop a more cost-effective agricultural subsidy program as subsidies can be better targeted, for example to catastrophic risks. It could also help the insurance company AICI to build up adequate technical reserves to cover their insurance risks, expand outreach amongst farmers and access reinsurance markets. Finally, it would benefit farmers because it would allow for a more timely payment system and, ultimately, a more equitable crop insurance subsidy scheme.

1.14 The main proposed modifications of the NAIS by the Joint Working Group (2004) and by World Bank are broadly consistent and highlight the need to follow actuarial and underwriting international standards to facilitate the shift to a market-based regime. However, there are important differences as well (see summary in Table 1.1 and detailed comparison in Annex B).

3 This report amongst other things describes the current NAIS program, the role of different stakeholders in agriculture insurance, suggested changes to the NAIS including on the ratemaking methodology.

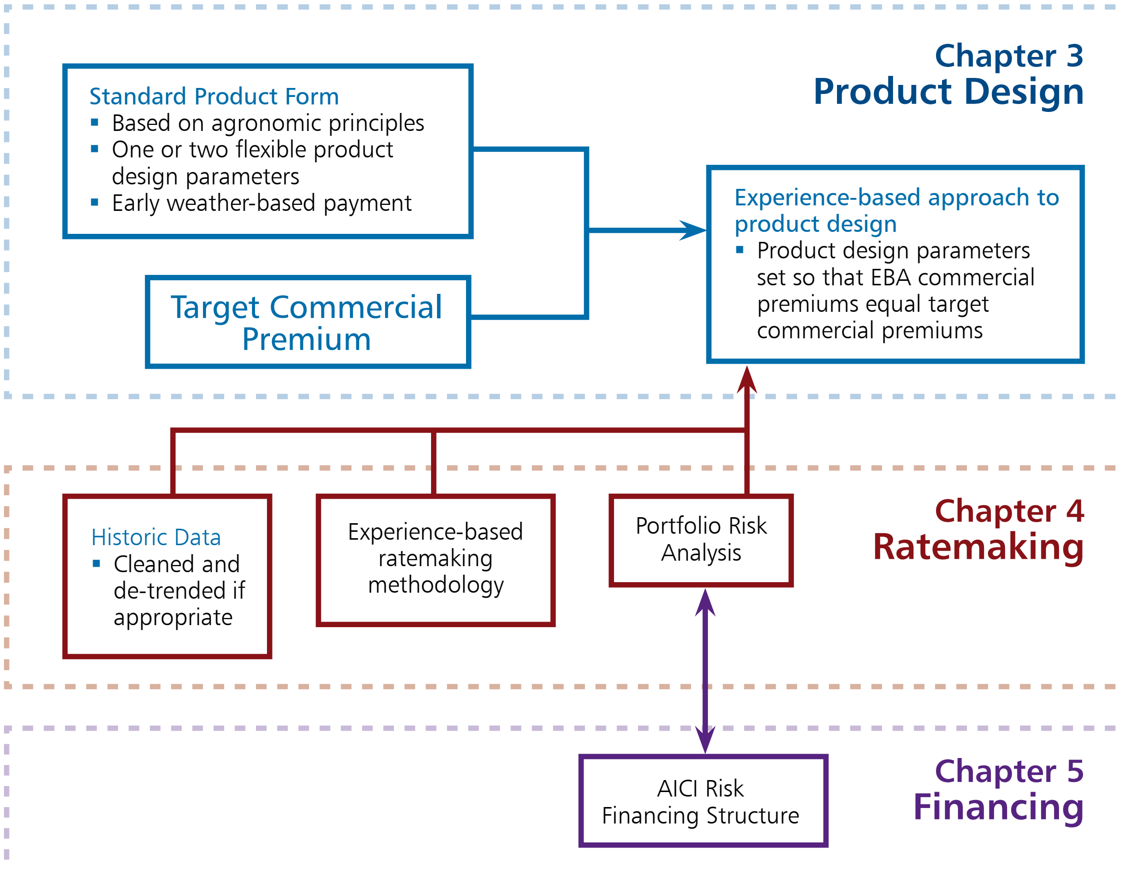
Table 1.1: Summary comparison between GOI and Bank suggestions for *MNAIS*

Key Issue	Proposed Modification by Joint Group (2004)	World Bank Suggestions (2007 and 2011)
Government financing	Entirely ex ante, in the form of upfront premium subsidies	GOI financing entirely ex ante. State government financing part ex ante, part ex post, transitioning to full ex ante in the medium term as the quality of CCE data is improved to a level that is acceptable to reinsurers.
Basis risk	Reduce Insurance Unit size to individual village Panchayat for major crops.	Reduction in Insurance Unit size would be a social benefit. Total claim payment from AICI determined using data for existing Insurance Units. Split of claim payment between new Insurance Units, and any additional social benefit from state government, could be determined by village Panchayat level data.
Quality of CCEs	No specific recommendations	Independent CCE audits. Development of a national NAIS CCE procedures manual and standardized training of loss adjusters.
Premium rates and coverage level/risk classification	Premium rates capped; Threshold Yields based on simple formula (best 5 out of last 7 years).	Premium rates set by government. Risk classification through a statistically robust approach to setting Threshold Yields, using 10 years of yield data.
Delayed settlement	Early payment based on crop condition reports, weather data and satellite imagery	Early non-repayable part-payment, based on weather index. More efficient CCE reporting.

1.15 GOI is piloting a modified NAIS (*mNAIS*) in up to 50 districts. This is a significant development and the technical and policy suggestions from this and earlier reports are directly relevant to such a move. The *mNAIS* is to operate on an actuarial regime, where the government's financial liability is predominantly in the form of upfront premium subsidies and farmer premium are risk-based. Other changes include the addition of an early part-payment to farmers based on weather indices, a reduction in insurance unit size from the Block level to the Village level for major crops, the enforcement of early purchase deadlines in advance of the crop season, and additional benefits for prevention of sowing, replanting, post harvest losses, and localized risk, such as hail losses or landslides. If well implemented, an improved program could result in increased benefits for millions of current farmer clients, and can be expected to lead to far greater coverage of the insurance program in the medium term.

1.16 The report consists of seven chapters, starting with this Introduction. Chapter 2 provides a review of the CCE process and suggests further improvements including the development of an improved monitoring framework. Chapters 3, 4 and 5 offer interrelated suggestions on technical aspects of product design, ratemaking and financing, respectively (see Figure 1.5). Chapter 6 presents estimates of the fiscal implications of alternative subsidy structures under an actuarial regime, and the potential impact of universalisation of NAIS. Chapter 7 contains the conclusions and suggestions. The report ends with eight annexes, which provide supplementary technical details referred to in the main text.

Figure 1.5: Overview of Chapters 3, 4 and 5



CHAPTER 2: STRENGTHENING CCES UNDER MODIFIED NAIS

2.1 The National Agricultural Insurance Scheme (NAIS) in India operates on the principle of area yield insurance. In area yield insurance, each year a set number of plots cultivated with the insured crop are sampled within a certain unit area, known as an insurance unit (IU). The IU can be as large as a Block/Taluka or as small as a group of 4-5 villages.

2.2 The claim payments from NAIS insurance products depend crucially on the results of Crop Cutting Experiments (CCEs), which ultimately form the basis for area yields. Insured farmers receive claim payments based upon the difference between the Threshold Yield and the area yield arrived on the basis of CCEs in their IU.

2.3 This chapter considers further improvements in CCEs to increase their accuracy, reliability and timeliness. It builds on and extends the 2007 World Bank report (2007a). These changes are particularly significant since – if NAIS moves to an actuarial regime – it would be essential to ensure that the CCEs are conducted in a manner consistent with the requirements of such a regime. In particular improvements in the CCE process – which is in the hands of the state governments which under the actuarial regime would make ex-ante contributions and hence would be capping their exposure upfront – are critical not just for better and more timely measurement, but also to ensure credibility with the insurer/s and re-insurers.

CURRENT METHODOLOGY OF YIELD ESTIMATION

2.4 The primary function of yield estimates is for the purposes of planning, policy formulation and implementation. The yield estimates of major crops are obtained through analysis of Crop Cutting Experiments (CCEs) conducted under scientifically designed General Crop Estimation Surveys (GCESs). At present over 95% of the production of food grains is estimated on the basis of yield rates obtained from the CCEs. The primary objective of GCESs is to obtain reliable estimates of actual yields of principal food and non-food crops for States and UTs which are important from the point of view of crop production.

2.5 Yields for principal crops are estimated across India using a statistical procedure chosen to provide unbiased efficient estimates of the mean yield in each IU. Experimental plots are selected for GCES and CCEs by stratified multi-stage random sampling, where tehsils/taluks/ revenue inspector circles/ CD blocks/anchals etc. are strata, revenue villages within a stratum are the first stage unit of sampling, survey numbers/fields within each selected village as sampling unit are the second stage and experimental plot of a specified shape and size are the ultimate unit of sampling.

2.6 Designated CCEs are also used for the purposes of crop insurance. These CCEs are conducted during the late stages of a crop preceding its harvest time (usually within a couple of week before harvest) and consist of identification and marking of experimental plots of a specified size and shape in a selected field on the principle of random sampling, harvesting and threshing the produce, and recording of the harvested produce for determining the percentage recovery of dry grains or the marketable form of the produce. A stylized workflow for NAIS CCEs is presented in Annex C. This workflow is followed by many states, with other states adopting slightly different procedures.

2.7 Field Operations Divisions (FOD) of the National Sample Survey Organization (NSSO) provides technical guidance to the States and Union territories for organizing and conducting Crop Estimation Surveys. In addition NSSO, in collaboration with States and UTs, implements sample check programs on area enumeration work, area aggregation and conduct of crop cutting experiments under the Scheme for Improvement of Crop Statistics (ICS). While executing the program of sample checks on crop cutting experiments, the FOD associates itself with the operational aspects of the conduct of crop cutting experiments. This includes selection of sample villages, training of field staff for supervision of field work and, in the process, gathering micro level information relating to conduct of crop cutting experiments for estimation of crop yield. The results of Crop Estimation Surveys are analyzed and presented in the annual publication entitled "Consolidated Results of Crop Estimation Surveys on Principal Crops" is brought out by the NSSO regularly.

2.8 The minimum number of CCEs conducted for insurance purposes within a given Insurance Unit (IU) varies with the size of the IU. If an IU is a district the minimum number of CCEs conducted is 24; if it is a Taluka / Tehsil / Block the minimum number is 16; if it is a Mandal / Phirka / Revenue Circle / Hobli, the minimum number is 10; and if it is a Village Panchayat the minimum number is 8 (AICI, 1999). In practice, due to limited staff and budget, the number of CCEs conducted for insurance purposes is often equal to the minimum number according to these guidelines.

2.9 The Central Statistical Organisation (CSO) reports substantial errors in the CCE process which they attribute both to field staff not strictly adhering to the prescribed procedures and to the inadequate level of training and supervision for those involved with the process (See Annex C).

2.10 Although other parties are involved in CCEs, the process is highly dependent on the assessment of a village-level Primary Worker. The operational work of CCEs is entrusted to the revenue/

land record/agricultural/statistical department official at the village-level, referred to as the Primary Worker. The economic importance of CCEs for crop insurance necessitates proper supervision and monitoring of CCEs. Senior officials from statistical, agriculture, revenue/land record departments are assigned specific CCEs to be physically inspected by them. However, the assessment of the village-level Primary Worker is rarely challenged due to their proximity, greater cognizance of key information, and operational conversance with CCEs. This makes the role of Primary Worker absolute and pivotal in the CCE process, rendering the supervision and monitoring process superficial to a considerable extent.

2.11 Primary workers typically have low levels of training in the conduct of CCEs for insurance purposes, reducing the accuracy and consistency of CCEs. These Primary Workers operate at the lowest tier of their organizational hierarchy and thus have very limited human resources under their command. Yield estimation through CCEs involves a physical process which requires significant amount of human labor and time. The multitude of duties to be fulfilled by the Primary Worker, particularly during the narrow time window near the crop harvest time, may prompt him or her to compromise the rigor with which the CCEs have to be conducted. These issues can become glaring for villages which are remote or poorly connected thus making monitoring of CCEs more difficult.

2.12 Primary Workers are assigned little or no specialist manpower and instead rely heavily on informal workers. Due to no full-time manpower at their command, the Primary Workers take physical assistance of local ad-hoc labor resources while conducting the CCEs. Involvement of local ad-hoc labor in CCE activities exposes the CCE computations to moral hazard or inaccuracies or both. The freshly harvested crop sample from the specified plot needs to be dried and threshed before the yields are computed. Due to logistic expediencies, there are possibilities that the Primary Worker may leave the harvest sample in the custody of local farmers/villagers. In certain cases the task of computation of yield for the harvested sample may also be left to these informal helpers.

2.13 CCE quality is likely to vary considerably between states. In many states, the responsibility for physically carrying out CCEs is divided between the revenue department and the agricultural department. The role of agricultural department is of supportive nature to the revenue department that is ultimately accountable for the CCEs. By virtue of their frequent involvement in crop estimation and other surveys as part of their routine work, the Primary Worker from the revenue department may be expected to demonstrate higher expertise in such exercises than their peers from agricultural department. Disparity in the levels of accountability and expertise may cause differences in the quality of performance of these agencies during CCEs.

2.14 A lack of accuracy in CCEs increases the basis risk experienced by farmers by increasing the non-sampling error. The basis risk arises from the difference between the policyholder's yield and the average yield calculated through CCEs, and arises from three sources. First, the *indexation error* is the difference between the farmer's yield and the average IU yield and is high when yields are heterogeneous within an IU. Second, the *sampling error* is the difference between the average yield of those plots selected for CCEs and the average yield of all plots in the IU, and is high when the plots selected for CCEs are not representative of the IU. Third, the *non-sampling error* is the difference between the true and the measured average yield of those plots selected for CCEs and is high when CCEs are inaccurate.

2.15 In an actuarial regime, the accuracy and reliability of CCEs becomes paramount for the sustainability of the program and particularly for seeking international reinsurance capacity. For AICI to be able to manage the NAIS insurance risk portfolio on behalf of GOI and States, all parties must be protected from the threat of moral hazard. It is therefore imperative to critically evaluate the process of CCEs and put necessary checks to obviate the possibility of moral hazard in reporting of the results of CCE.

2.16 Moral hazard would be present if fraudulent manipulation of CCE reports could occur without detection by AICI or States. Undetected manipulation of a CCE report could increase the insurance payout to farmers in a given Insurance Unit for a given year. Such fraudulent behavior would threaten the long term sustainability of NAIS, and make it impossible for AICI to purchase reinsurance for the NAIS portfolio at attractive rates in the long run. AICI would only be able to manage the NAIS insurance risk portfolio if the threat of systematic moral hazard could be eliminated. In the presence of moral hazard, states would have to partially or fully retain the insurance risk from the NAIS portfolio.

FURTHER IMPROVEMENTS

2.17 The CCE process is technically sound but farmers and government would benefit from improvements in some operational aspects: timeliness, accuracy and consistency of yield estimates. The following suggestions provide a template for improvements.

Standardized procedures and manual

2.18 A ***nationwide standardization of procedures*** for CCEs for insurance purposes could lead to a reduction in the non-sampling error of CCE reports, and an increase in equity across crops and regions. This could have substantial benefits for farmers by reducing basis risk. One particular area that benefit in particular from standardization is a nationally consistent approach to calculating the realized actual yield for a given IU from raw CCE reports. A method which allows for consistent treatment of outlier yields, such using a Windsorized mean of CCE yields to estimate area-yields by IU, could increase the robustness of actual yield calculations.[4]

2.19 A standardized procedure could be clarified thorough the ***development of a national procedures manual for CCEs*** for insurance purposes. One objective of such a manual could be to clarify the distinctions between CCEs conducted for insurance purposes and all other CCEs. For example, it is important that yield losses that cannot be attributed to an insured peril (i.e., it is due to an "uninsurable" cause of loss) are not being recorded for insurance purposes, although they can be for policy reasons. Also, only crops grown under farm management conditions that are normal for an area should be eligible to contribute to the area-yield-based estimate for insurance purposes. For example, crops seeded after an acceptable date or using technology that is not acceptable for a crop under local conditions should not be accepted into the pool of statistical information for the area-yield-based insurance scheme.

Ongoing training of loss adjusters

2.20 Establishing a national CCE procedures manual would only produce benefits if the prescribed procedure is then followed by personnel tasked with conducting CCEs for insurance purposes. A natural complement to the development of a standardized training manual would be a national system for ***ongoing training of specialized personnel tasked with conducting or overseeing the process of CCEs for insurance purposes***. The intent of such training would not be to duplicate the CCE workforce but in the medium to long term, to train a network of individuals in insurance principles so they can conduct the CCEs with an understanding of the difference between data for broad policy objectives and the data accuracy needed for insurance purposes. In Canada, the U.S., Mexico and other countries, there is an in-country network of such certified professionals, called loss adjusters. See Chapter 2 of World Bank (2007a) for more details of standardization and training of loss adjustment in Canada.

2.21 Trained or certified loss adjusters could fulfill various functions in India. One option would be for all Primary Workers conducting insurance CCEs to be trained loss adjusters. However, this would require a very large number of trained loss adjusters, and is unlikely to be feasible in the short or medium term. A second option would be for the loss adjusters to provide support and to serve as supervisors to Primary Workers. A final option would be a combination of the two, whereby in areas in which large claims are expected due to observable adverse agricultural conditions, some or all CCEs could be conducted by trained loss adjusters. In contrast, trained loss adjusters would take on a support/supervisory role in those areas in which large claims are not expected. Were a standardized procedures manual to be developed, trained loss adjusters

4 A Windsorized mean is a mean calculated after replacing the lowest value with the second lowest value and the highest value with the second highest value.

could be geographically mobile, able to conduct high quality insurance CCEs in key regions and for key crops.

Enhanced supervision and auditing of the CCE process

2.22 State Governments will already have in place some safeguards to ensure that CCE reports are protected from the possibility of fraud. Under an actuarial regime AICI would need to formally demonstrate to external reinsurers that such safeguards were robust. ***Increasing the robustness of safeguards*** would likely lower cost of reinsurance, and therefore the cost to State and Central Governments, or increase the benefit to farmers. To be able to demonstrate robustness, existing procedures and safeguards would need to be documented and, most likely, additional safeguards would need to be put in place.

2.23 NAIS ***already features partial protection*** against moral hazard by basing the Threshold Yield in an IU on the yield history of that IU. If fraud was to be committed in one year this would reduce the Threshold Yield in future years, reducing the future insurance payments to farmers.

2.24 One potential additional safeguard would be for AICI to commission a ***professional third-party agency to conduct a series of independent, random CCE audits***, and for reinsurers, states and AICI to commit to a well defined procedure for the event of suspected CCE manipulation. Independent audit of CCEs by professional, third-party agencies would not only act as a validity check for CCE data but could also provide an effective deterrent against the manipulation of CCE data.

2.25 AICI could entrust the task of CCE audits to a professional third-party after identifying the plots to be audited (see Appendix C for additional details). The respective state government agencies would furnish the complete list of CCE plots and the CCE calendar to AICI after finalizing them for the season. Based on this list and other supplementary information, AICI would choose the plots to be audited either randomly or through a pre-determined procedure. Audit of CCEs would be most useful if conducted after, but within ten days of, the official state CCEs on plots chosen to be adjacent to the official state CCE plot. 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.

2.26 Under an actuarial regime in which states transfer risk to AICI, an ***arbitrator*** would need to be appointed. The possibility of Insurance Regulatory and Development Authority as the arbitrator could be explored. In the event of suspected manipulation of CCEs, reinsurers, AICI or states could make a formal complaint to the arbitrator, prompting a set procedure. An arbitrator would need to have the power to settle any dispute. In the event of proven systematic manipulation of CCEs within a state, possible outcomes include the apportionment of claims liability between the state and AICI, penalties and possibly more stringent action depending on the degree of deviation.

2.27 AICI should also ***incorporate independent data sources in its validation of CCEs***, using robust statistical methods. AICI must verify both the average as well as the variability of yields reported in a State. By incorporating independent data sources, such as weather data, satellite images and crop intelligence reports, into its CCE validation procedure AICI could reduce the number of audits that would need to be conducted. AICI could also use remote sensing technologies to target its CCE audits in districts in which claim payouts are expected to be high.

2.28 The cost-effectiveness of technology opens the possibilities of ***video-recording the official CCEs***. Requiring the video recording of CCEs could increase AICI and State government's ability to better supervise the CCE process. The responsibility of arranging the video-recording could be left with the village-level official who may be paid a fixed allowance per video recording, which could be INR 200 per video recording or possibly lower is cell phone technology is used. AICI and State government 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.

Targeting IU size and the number of CCEs per IU

2.29 It is important that the claim payments to insured farmers reflect experienced shocks. One way of mitigating basis risk is to reduce the size of IUs, while keeping constant the number of CCEs to be conducted for each IU of a given size. This was one of the central recommendations of the Joint Working Group report (2004). However, for insurance payments to be representative of the smaller IUs many more CCEs would need to be conducted, even if fewer CCEs were to be conducted per IU. Moreover, a reduction in the size of the IU alongside a reduction in the number of CCEs per IU would not necessarily reduce basis risk unless the CCEs were of sufficient quality. Reducing the size of the IU acts to increase the homogeneity of yields within an IU, reducing indexation error. However, reducing the number of CCEs per IU acts to increase both sampling and non-sampling error. *If sampling and non-sampling error are high relative to indexation error then a reduction in the size of the IU, alongside a reduction in the number of CCEs conducted per IU, could lead to an increase in basis risk, rather than a decrease*.

2.30 IU size could instead be ***determined broadly using statistical principles***. World Bank (2007a) reported on a statistical investigation into the quality of CCEs. Table 2.1 displays the results of this CCE analysis for six states and crops. The explanation for a 22 percent radius value can be expressed as "we are 95 percent confident that the true yield for the IU is within 22 percent of the area yield estimated by the CCE process". See World Bank (2007a) for more details about the calculation procedure. The radii are driven both by actual variation in yield within an IU, and by measurement errors in CCEs. They do not capture systematic under or overestimation of yields and therefore may be seen as a lower bound for the basis risk in each product.

2.31 In the short to medium term, ***IU size could be reduced in those areas with heterogeneous yields and increased in those areas with homogenous yields***. If an IU is agriculturally homogenous, with low variation in yields, then decreasing IU size may not reduce basis risk. However, if an IU is agriculturally heterogeneous, with high variation in yields, then decreasing IU size could reduce basis risk. For example, the number of CCEs per IU could be set so that the 95% radius was no more than 30, that is, for each IU it would be possible to state that "we are 95 percent confident that the true yield for the IU is within 30 percent of the area yield estimated by the CCE process".

Table 2.1: Summary of Yield Radii at 95 Percent Confidence for Selected States, Crops, and Years

State	Crop	Year	Mean 95% radius for all IUs (%)	Number of IUs
Andhra Pradesh	Rice	2003–04	17.5	968
Gujarat	Cotton	2000–03	39.3	91
Gujarat	Groundnut	1992–03	33.2	91
Uttar Pradesh	Wheat	2003–04	17.6	20
Maharashtra	Pigeon pea	2000–04	30.6	44
Maharashtra	Sorgum	2000–04	41.2	46

Source : Data from AICI. Table from World Bank Report (2007a)

Using technology and reports to reduce basis risk

2.32 In the medium term it may be possible to use satellite data to improve the products or reduce the costs of providing insurance.

2.33 One option would be to use ***satellite predictions to target more intensive sampling where yields appear low***. This approach could be used in an ongoing fashion to reduce the cost of the CCE process. A satellite model, calibrated with mid-season data, would be used to estimate actual yields at the IU level, and additional CCEs would be conducted in those IUs in which yields were expected to trigger a payment. The satellite model could be improved over time by comparing modeled estimates with the yields reported from CCEs. This targeting of CCEs could also be used to target CCE audits.

2.34 In the medium term it may be possible to develop ***real time reporting of CCEs by requiring Primary Workers to send raw yield data by mobile phone*** immediately after a CCE has been conducted, with the full hard copy of the CCE data to be submitted at a later date. Were AICI to develop technical capabilities to process this raw CCE data sent by mobile phone, it may be possible to use these reports to dynamically improve monitoring and verification of CCEs. For example, these reports could be compared with the output from a satellite model to broadly verify their reasonableness in advance of harvest. This continuous reporting process could speed the data verification process and be used to notify channels within the claims payment function to increase resources if needed.

2.35 One final option would be for ***high resolution satellite imagery to be used to estimate the relative yields of village Panchayats within the IU***. The total payment to all farmers insured in an Insurance Unit would still be based on the yields estimated from CCEs across the IU but this payment would be split between farmers in different village Panchayats according to the high resolution satellite model.

Next steps

2.36 A ***state-level trial of some of these ideas could be used as a first step*** to full implementation across all states. Such a trial could be conducted during Rabi 2010-11 in suitable states. As part of the trial it would be useful for AICI and the state to collate raw yield data from individual NAIS CCEs conducted in previous years. This data could be analyzed to better understand how a decrease in IU size, or increase in the number of CCEs could be used to reduce basis risk.

2.37 To assist with the standardization and development of a manual and training it may be useful for AICI to commission independent, high quality CCEs to be conducted alongside, or as part of, the standard audits. These could be conducted in the same plots as the standard audits, or in different plots within selected IUs. This exercise could help in the identification of current gaps in the structure of CCEs and also facilitate a deeper analysis of the factors causing deviations from desired accuracy and consistency levels.

2.38 Considering the heavy involvement of the agricultural and revenue departments in the CCE process it might be prudent in the short term to involve personnel from these departments in the development of specialist loss adjustment training. It may also be useful to utilize experience from loss adjusters in Canada, the U.S., or Mexico.

2.39 In the ***short term, partly to address concerns of transparency in CCEs, till the time that the CCE process is improved, state governments could still be responsible for area yield index-based claims in excess of premiums***. The current CCE process may not offer the adequate accuracy and transparency that are essential for a sustainable actuarial crop insurance regime including from the perspective of reinsurers. As *mNAIS* is implemented, the quality, standardization and monitoring of CCEs would need to be improved. In the short term, while the insurability of CCE data is being improved, the state governments could be partially or fully responsible for the final area yield index-based claim payment (e.g., a proportion of such claims, or the excess of claims above a threshold). To keep the program broadly budget neutral for the state this would imply that the *ex-ante* state government premium subsidy would be relatively lower than the central government's to allow for the additional *ex-post* element of the state government subsidy. State government subsidies could transition from mixed ex-ante/ ex-post to fully ex-ante over the short to medium term, as the CCE process is enhanced

CHAPTER 3: IMPROVING AGRICULTURAL INSURANCE PRODUCT DESIGN

3.1 This chapter summarizes the technical assistance on crop insurance product design provided to AICI since 2008. It first discusses how the use of historic data in determining the *shape* of a product can lead to data mining and systematic under-pricing of products. NAIS products are not susceptible to this form of data mining, since they are of a standard shape, with historic data only used to determine one parameter: the Threshold Yield. However WBCIS products are not yet standardized for each crop, leading to the potential for data mining and systematic under-pricing. Sophisticated techniques are not able to correct for this form of data mining at the ratemaking stage without a significant reduction in efficiency. It is suggested that WBCIS and modified NAIS products be of a standard shape for each crop, varying only with one or two key *level* parameters.

3.2 It then discusses how the experience-based approach suggested for the ratemaking of the modified NAIS (World Bank 2007a) can be adjusted to allow AICI to set a flat premium rate across a state, and classify risks by varying the products sold across the state. The suggested approach would lead to better risk classification and lower variation in premium rates and products within risk collectives than the existing NAIS and WBCIS approaches. The methodology is illustrated for NAIS cotton products in Madhya Pradesh, with an illustrative target unloaded premium rate of 4%. The suggested experience-based approach gives Threshold Yields that have less variation within a district than current Threshold Yields, whilst allowing full risk classification.

3.3 Finally, this chapter discusses the design of double index crop insurance products, when the insurance payment depends on two separate indices, such as an area yield index and a weather index. Such products could combine the best features of area yield index and weather index. Two types of products are analyzed: first, where the weather index and area yield index payments are separate; and second where any early weather index payment is offset against any area yield index payment.

STANDARDIZATION OF PRODUCTS AS A PROTECTION AGAINST DATA MINING

3.4 AICI conducts product design for weather based crop insurance products with knowledge of the historic weather data series appropriate to the product. A product designer will typically add or remove cover until the historic burning cost, the average claim payment from the product calculated using historic weather data, is close to a target unloaded premium. Ratemaking is based on the same data as product design. Both the existing and suggested ratemaking methodologies use the same weather data series as used for product design.

3.5 Unlike the suggested experience-based approach, AICI's current WBCIS ratemaking procedure implicitly encourages a product design process that is heavily dependent on statistically insignificant features of historic data. For example, consider two deficit rainfall products that must be designed for nearby weather stations. Suppose that both rainfall histories are similar but that one station has had one year with very low rainfall and the other has not. Under a burning cost approach to ratemaking it would be difficult to offer the same product at the same price for both stations, even if the difference in rainfall histories was not statistically significant. This is because the burning cost approach does not give any indication as to whether differences in rainfall histories are statistically significant or not.

3.6 If individual products are designed to offer as much cover as possible for a target price, where the design process makes full use of historic weather data, then the current WBCIS design and ratemaking methodology may lead to the systematic under-pricing of products. This is because it is tempting for products to be designed which offer significant cover for events that have not occurred in the past and to leave out significant cover for events that have occurred in the past (see Box 3.1 for examples). If the same weather data is used for design and pricing then the resulting average historic loss cost for that product will be systematically lower than the true expected claim payment, leading to an underestimation of the fair premium. This is a form of data mining.

Box 3.1: Examples of data mining for weather based index insurance

> Suppose that you are a product designer with 30 years data and wish to offer cover for a one month period in two adjacent districts. The average rainfall for the month in question is 80mm in both districts and you want to develop a trigger below which you start making payouts. Your crop model says you should make payouts below 55mm.
>
> District 1: Of the worst ten historic years there are nine years with monthly rainfall of 52mm and one year with monthly rainfall of 45mm. You find you can significantly cheapen the product based on historic data by moving the trigger from 55mm to 51mm, excluding the nine years with 52mm rainfall from the payouts.
>
> District 2: Of the worst ten historic years there are nine years with monthly rainfall of 61mm and one year with monthly rainfall of 45mm. You find that you can increase the trigger from 55mm to 60mm without increasing the historic average payout from the product.
>
> Both of these are examples of data mining that would lead to the under-pricing of products.

3.7 Products cannot be rated on an actuarially sound basis with this form of data mining. One could reduce the bias in rates by calculating historic loss costs for a particular product using weather data series from all nearby weather stations, and then charging a premium based on the average of the average loss costs for this product. However, this would involve cumbersome calculations and would introduce significant inefficiency in estimation; that is to say that premiums would often be either too high or too low, even if they were fair on average.

3.8 The suggested ratemaking methodology would also be vulnerable to this form of data mining in product design (see Chapter 4). The weighted average Pure Premium Rate under the suggested methodology is constructed to be equal to the weighted average historic loss cost. If historic loss costs are universally biased downwards due to data mining in product design then average Pure Premium Rates will also be biased downwards.

3.9 A way to guard against this form of data mining is to require that all products for a particular crop in a particular season differ only by a limited number of parameters. For example, under the TA the Indian Agricultural Research Institute (IARI) developed models of the impact of rainfall deficiency on crop yields, based on the InfoCrop agronomic model. A standardized product could offer full cover for modeled crop loss above a specified deductible. The deductible parameter could be chosen by AICI for each product, based on statistical principles, while the shape of the product would be determined by the IARI agronomic model.

3.10 As another example, all Kharif jowar products sold across India might include four phases of deficit rainfall cover, one phase of consecutive dry day cover, and one phase of excess rainfall cover. All such products would have identical exits, rates, maximum payments, periods, and trigger days. However, triggers for deficit rainfall cover could be uniformly increased or decreased for each jowar product so that the calculated rate was within the required range. For example, if the triggers for the four phases of one jowar product were {50, 70, 80, 40} then the triggers for any other jowar product would be {50+X, 70+X, 80+X, 40+X} for some number of millimeters X, that could be positive or negative. X would be chosen for each product so that the Pure Premium Rate is within the target range. Such an approach would shield the design process from statistically insignificant features of historic weather data. Such dependence would not lead to data mining.

3.11 The suggested ratemaking procedure would allow AICI more flexibility in designing products based on agronomic principles. If the difference in rainfall for a group of weather stations in some Risk Collective was not statistically significant, then the same product could be sold in all stations at the same, or a very similar, price. This would have been difficult to justify under the existing ratemaking methodology.

3.12 Although the above discussion focuses on WBCIS, the importance of standardizing the shape of products, based on agronomic principles, and using historic data only to determine one or two key parameters is equally valid for any other types of products AICI offer. NAIS products are standardized, differing only in the Threshold Yield, and are therefore robust to this form of data mining. Were AICI to offer double index policies, where the claim payment depended on both an area yield index and a weather index, it is suggested that the shape of products is dependent only on agronomic principles, and that historic data is used only to determine one or two key parameters. For example, the actuarial premium rate and weather based component could be fixed across India or across states for each crop, with the Threshold Yield for the area yield component a flexible parameter for ratemaking.

3.13 AICI's ratemaking process and data should remain confidential, and not released to external product designers. This is to protect against an entrepreneurial external product designer designing a product with significant cover for events that have occurred less frequently than expected at that weather station. If ratemaking or data cannot be kept confidential, then AICI may wish to consider adding a loading to these premiums to protect against potential data mining.

AN EXPERIENCE-BASED APPROACH TO PRODUCT DESIGN

3.14 One uncontroversial objective for the design and pricing of NAIS insurance products is that the value of insurance for the same crop in the same state should not vary between Insurance Units (IUs). There are much broader questions of political economy as to the degree to which an NAIS insurance product should be the same for different farmers growing different crops in different states. These broader questions are not investigated in this report. Instead, the focus is on the technical issue of how products could be designed and priced so that, for example, the NAIS cotton product sold in one IU in Madhya Pradesh offers the same expected claim payment to farmers as the cotton product sold in another IU in Madhya Pradesh.

3.15 In addition to being equitable, such an objective would also protect the NAIS portfolio from the threat of adverse selection. If the value of insurance varies with IU, one might expect a higher uptake of insurance in IUs with better value insurance than in IUs with poorer value insurance. Adverse selection appears to be a serious problem faced by NAIS for uptake by non-loanee farmers and may also be a problem for loanee farmers.[5] Under adverse selection, the average cost of NAIS products would be higher and farmers who happened to live in IUs where the insurance was poorer value would likely obtain less protection.

3.16 Different IUs have different characteristics and so this objective could only be met if the insurance product or premium could vary between IUs within the same state. If the same product was sold for the same price in two IUs, one of which had very low average yields and one of which had very high average yields, then the value of the product would be much higher for farmers living in the IU with low average yields. To be able to offer the same value to both farmers either the premium rate would have to be higher in the IU with lower average yield or the product in the other IU would have to offer a lower Threshold Yield.

3.17 This section discusses risk classification in terms of NAIS products, but the principles extend to other products, such as weather index or double index products. The key requirement for this approach is that products for a given crop are standardized, with one free parameter, either the premium rate or a product design parameter, to be chosen based on the principles of risk classification. Products sold under the NAIS are of a standard form whereby the farmer pays an insurance premium, and receives a claim payment only if the Actual Yield for the insured crop in the farmer's IU falls short of the contractual Threshold Yield. In the context of the NAIS the free parameter could be either the premium rates or the Threshold Yield. Examples of standardized weather index and double index products are given in the previous and next sections, respectively.

5 See Figure 1.3 and 'A Study of Yield based Crop Insurance in India: A Performance Review' by P.C.James and Reshmy Nair. AICI report. 2009.

Options for Risk Classification under NAIS

3.18 The NAIS already engages in partial risk classification by setting Threshold Yields to differ across IUs. The Threshold Yield is calculated to be the moving average yield for the past three years in the case of rice and wheat and for the past five years for all other crops, multiplied by the Indemnity Level. The Indemnity Level is based on the Coefficient of Variation (CV) for the ten year yield history and is 60%, 80% or 90% depending on the CV. Indemnity levels and premium rates are typically chosen to be the same for a given crop in IUs across the state and so are typically not used as a tool for risk classification within a state.

3.19 However, this method of risk classification is not robust, since the three or five year Average Yield for an Insurance Unit may not be representative of the true long term average. From a statistical point of view, and in the absence of a trend, the three or five year Average Yield is not an efficient estimate of the 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. As an illustration, consider two IUs which are exposed to the same level of agronomic risk. One IU has suffered a serious crop loss in the last five years but the other has not. The Threshold Yield for the former IU would be much lower than the Threshold Yield for the latter IU, since the five year Average Yield would be much lower. However, this difference in Threshold Yields is not from a fundamental difference in the risk in each IU, just from one IU having been unlucky in the previous five years and the other having been lucky. The Joint Group Report (2004) agrees with this analysis: "The concept does not provide for adequate protection to farmers, especially in States / Areas where there have been consecutive adverse seasonal conditions, pulling down the average yield" (p34).

3.20 In practice it is difficult for AICI to classify risks by setting different Indemnity Levels or by charging different premiums for the same crop in different IUs within a state. Despite the legal flexibility, risk classification by Indemnity Levels or premiums is rarely done in practice both for operational and political reasons.

3.21 In contrast to NAIS, AICI has flexibility to classify risks under WBCIS by designing appropriate products. In theory AICI is able to classify risks under the Weather Based Crop Insurance Scheme (WBCIS) by designing products with a target expected claim payment. However, as discussed in the previous section of this chapter, WBCIS products are complex and risk classification is often done individually for each product, rather than on a systematic statistically robust basis.

3.22 If it is not possible for premium rates to vary for a given crop within a state, risk classification must be achieved by choice of the Threshold Yield (see Table 3.1). Note that the rationale for risk classification by adjusting the Threshold Yield is not driven by statistical concerns; it would be possible to achieve the same degree of statistical efficiency in risk classification through appropriate adjustment of Indemnity Levels, premium rates or Threshold Yields. However, since large potential gains from efficient risk classification cannot be achieved through premium rate adjustments for administrative and/or political economy reasons, it is suggested to achieve them through the adjustment of Threshold Yield. As shown in the remainder of this section, risk classification through setting Threshold Yields also has other attractive characteristics, such as achieving a lower variation in Threshold Yields within districts than under the current approach.

Table 3.1: Ability of AICI to classify risks under alternative schemes.

	Current NAIS	WBCIS	A proposal for Modified NAIS
Flexibility to differentiate premium rates within states	Not flexible	Limited flexibility	No flexibility
Flexibility to set an appropriate Threshold Yield	No flexibility to set appropriate Average Yields. Limited flexibility to vary Indemnity Level	Fully flexible	Fully flexible
Risk classification possible	Only partial, through Indemnity Level	Yes	Yes

3.23 Setting a flat premium rate for each crop across each state would not restrict the monetary amount of cover a farmer could purchase, either in terms of the premium or the sum insured; it would only restrict the ratio of the premium to the sum insured. For two farmers purchasing insurance for the same crop in the same state with the same Sum Insured, the premium would be the same. However, either farmer could choose to purchase additional cover for an additional premium.

An illustrative example of setting Threshold Yields for cotton products in Madhya Pradesh

3.24 An example of how AICI could determine Threshold Yields through a statistically robust methodology is given, using the illustrative case of cotton in Madhya Pradesh (MP). Calculations use ten years of yield data, from 1998-2007 inclusive, and data for area insured in 2008. All data was provided for AICI. In total data is used for 41 Insurance Units (IUs), spread over nine districts. Additional historic yield data was provided for six IUs for which the sum insured in 2008 was zero. These six IUs have been excluded from the analysis.

3.25 Threshold Yield calculations have been performed for 2008 for cotton in MP using five different methods, which are described in Box 3.2 below. For all methods the task is to design and rate 41 products to be sold in Kharif 2008, using yield data from 1998-2007 and expected portfolio composition for 2008. See Annex D for all figures. Methods 1 and 2 are based on the current NAIS approach. Methods 3 and 4 are similar to the current approach to product design under WBCIS, with Threshold Yields set at an IU and district level, respectively. Method 5 is a full experience-based approach where districts are used as risk collectives. Methods 3, 4 and 5 target a premium rate of 4%, as this is similar to the average historic claim payment from Method 2, and mathematical formulae are given in Annex D.

Box 3.2: Five Methods for calculating the Threshold Yield under NAIS

- **Method 1** is the current NAIS approach with 80% Indemnity Level and no de-trending. For each IU the Threshold Yield is calculated to be the Average Yield from 2003-2007 multiplied by 80%.
- **Method 2** is the current NAIS approach with 80% Indemnity Level using de-trended yields. The de-trending is based on ten years of data, from 1998-2007. However, in calculating the Threshold Yield only the de-trended data from 2003-2007 is used.
- In **Method 3** the Threshold Yield for each Insurance Unit is calculated separately, so that the 10 year historic claim rate equals 4% (with de-trending). For each IU the Threshold Yield is changed until the average historic claim rate (using de-trended data) is equal to the target rate.
- In **Method 4** the Threshold Yield is calculated at the district level for each of nine districts, so that the 10 year weighted average historic claim rate within each district equals 4% (with de-trending). This Threshold Yield, one for each district, is chosen so that the average historic claim rate in the district, weighted by sum insured and using de-trended data, is equal to the target rate.
- **Method 5** is an Experience Based Approach (EBA) where districts are used as Risk Collectives. The Threshold Yield is a weighted average of the Threshold Yields calculated in Methods 3 and 4, with the weight, the Threshold Yield Factor (TYF), constant for all IUs within a district and determined using credibility theory. The Method 5 TY = Method 3 TY x TYF + Method 4 TY x (1 – TYF).

3.26 Method 5 differs from the traditional EBA by setting a fixed target premium and using an experience-based approach to determine Threshold Yields (see Annex D for a detailed description of the method). Chapter 4 of World Bank (2007a) assumed that Threshold Yields were fixed and used an experience-based approach to determine premiums. This is the traditional approach. Instead, Method 5 assumes that premiums are fixed and uses an experience-based approach to determine Threshold Yields. Insurance Units are grouped into risk collectives, which in this worked example are assumed to be districts. Examples of other possible Risk Collective rules are given in Annex D. The rule that partitions Insurance Units into Risk Collectives should be based on sound spatial, agronomic or practical rationale and should not depend on historic yield data.

The Threshold Yield Factor (TYF) is chosen to be the largest factor such that the EBA-implied price of all products within each district is equal to the target rate of 4%. The TYF will be close to 1 if the historic yield distributions within a district are significantly different. In this case, using the formula above, the Method 5 Threshold Yield will be set to be close to the Method 3 Threshold Yield. The TYF will be close to 0 if differences in historic yield distributions within a district are not statistically significant. In this case, using the formula above, the Method 5 Threshold Yield will be set to be close to the Method 4 Threshold Yield.

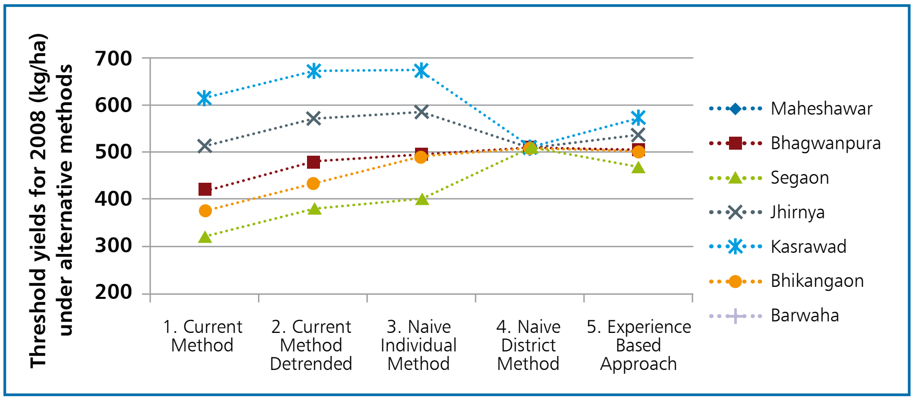
3.27 Table 3.2 compares the main features of the five different methods employed.

Table 3.2: Comparison of five methods for calculating the Threshold Yield under NAIS

	Method 1	Method 2	Method 3	Method 4	Method 5
Yield data is de-trended?	No	Yes	Yes	Yes	Yes
Actuarial premium rates are constant across the state?	No	No	Yes	Yes	Yes
Degree to which Threshold Yields vary within a district	High variation	High variation	High variation	No variation	Degree of variation automatically determined by the data
Degree of spatial homogeneity of yield distribution used to increase efficiency?	No	No	No	Risk assumed to be homogenous within district	Yes
Method currently employed by AICI	Yes: NAIS, no de-trending	Yes: NAIS, with de-trending	Yes: similar to WBCIS design	Yes: similar to WBCIS design	No

3.28 Figure 3.1 provides an illustration of the Threshold Yields calculated for one district in MP. See Annex D for full details of calculated Threshold Yields for all IUs in MP.

Figure 3.1: Threshold Yield Calculations for the district of Khargone, Madhya Pradesh



3.29 Method 1 gives Threshold Yields that are lower than Methods 2-5 because it does not correct for the trend in the data. The weighted average historic average claim rate under Method 1, using de-trended data for pricing, is 1.5%. This compares to 3.2% for Method 2 and 4% for Methods 3-5. There appears to have been a trend in cotton yields over the last ten years, most likely brought about by the increased adoption of Bt cotton (see Chapter 4). Cotton yields in MP appear to display a statistically significant trend of 36 kg/ha/yr with a P-value of 1.1%. This P-value is well below 5% and so the trend is statistically significant at the 5% level. As discussed in Annex F, Method 1 treats this trend as though it was uncertainty and so gives a Threshold Yield that is too low.

3.30 Methods 1-3 determine the Threshold Yield for each IU based only on historic data for that IU, and are only efficient if the distribution of yields in nearby IUs differ substantially. Weather is spatially correlated and so it is likely that the distribution of yields is similar in nearby IUs. Methods 1-3 do not make use of the spatial structure of yield distributions to increase efficiency. The three methods are all susceptible to the problem outlined above, that the Threshold Yield for an IU may be driven by unusually high or low yields. Method 3 uses ten years of data and is therefore more robust to this.

3.31 Method 4 is only appropriate if Insurance Units across a district are exposed to the same level of risk. This is an extreme example of incorporating information from nearby Insurance Units to improve efficiency and is appropriate only if the risk faced by all IUs within a district is the same.

3.32 Methods 3-5 allow AICI to design a product to target a particular premium rate, specified in advance. In this example, a target premium rate of 4% is used, before any allowance for expense or risk loading. In contrast, Methods 1-2 only target a specific premium rate in as much as AICI has flexibility in setting the Indemnity Levels.

3.33 Methods 4 and 5 use districts as Risk Collectives. Other specifications of Risk Collectives could be used. The rule that partitions Insurance Units into Risk Collectives should be based on sound spatial, agronomic or practical rationale. It should not depend on historic yield data. In this section Risk Collectives are chosen to be districts. Examples of other possible Risk Collective rules are given in Annex D.

3.34 Method 5 gives a Threshold Yield which is a weighted average of those calculated under Methods 3 and 4, where the weight (the Threshold Yield Factor) is chosen to be statistically efficient. The Threshold Yield Factor is chosen to be between zero and one and measures how similar insurance units within the same district are. A description for how this factor could be calculated, based on Bühlmann's Credibility Theory is given in Annex D.

3.35 For the seven IUs in the district of Khargone, Method 5 produces Threshold Yields that are closer than those of Methods 1-3 (see Figure 3.1). This is because an estimated 63% of the difference in Threshold Yields across Khargone from Methods 1-3 is not statistically significant. For example, Method 3 gives a Threshold Yields of 673 kg/ha for Kasrawad and 403 kg/ha for Segaon. Method 4 calculates them to be the same, at 511 kg/ha. Method 5 calculates that only 37% of the difference in average yields within the district is statistically significant and therefore calculates the Threshold Yield for Kasrawad to be kg/ha and that for Segaon to be kg/ha.

3.36 The Threshold Yield Factor of Method 5 varies between districts: from 12% in Ratlam to 69% in Chhindwara. Both of these districts have three IUs. Historic yields in Ratlam have been subject to high variation and the average historic yield for any IU is not likely to be close to the true mean (the *estimate* has a high *standard error*). However, the yield histories from each IU within Ratlam seem to be similar to each other. Since the difference in yield histories does not seem to be due to any statistically significant difference, the EBA Method 5 calculates the Threshold Yield to be 12% of the individual IU Threshold Yield from Method 3 plus 88% of the district Threshold Yield from Method 4. In comparison, historic yields in Chhindwara have had low variation, and the yield histories from each IU seem to be statistically different to each other. The EBA Method 5 calculates the Threshold Yield to be 69% of the individual IU Threshold Yield from Method 3 plus 31% of the district Threshold Yield from Method 4.

Conclusion

3.37 By using an average of 3-5 year yields as an estimate of Average Yields, and setting Indemnity Levels and premium rates to be fixed across a state, risk classification is currently poor under the NAIS. Annex D shows the Threshold Yields calculated under statistically efficient Method 5 and existing Methods 1 (no de-trending) or 2 (with de-trending).

3.38 Were AICI to be given the flexibility to classify risks by setting Threshold Yields, the variation of Threshold Yields within a risk collective would be lower than it currently is. This is because only some of the variation in Average Yields between nearby IUs is statistically significant. If risk collectives are chosen to be districts, the variation in average Threshold Yields could be higher between some districts than it currently is, if some districts appear to be higher risk than other districts. However, the variation in Threshold Yields within each district would be lower.

3.39 So long as Threshold Yields could be determined using an Experience Based Approach, products could be designed to target fixed actuarial and commercial premium. For example, all cotton products could be designed to give an actuarial premium rate of 4%. Target premiums could be determined by AICI or defined in rules.

3.40 The EBA to setting Threshold Yields (Method 5) is more equitable, efficient and robust to adverse selection than the existing approach. For area yield index, weather index and double index products with one flexible parameter, full risk classification could be implemented using an experience-based approach to product design without the need for variation in premium rates within a state.

DOUBLE INDEX PRODUCT DESIGN

3.41 AICI is currently offering area yield index insurance through NAIS to some farmers and weather based index insurance through WBCIS to other farmers. Both WBCIS and NAIS suffer from basis risk: the insurance claim payment made to a policyholder does not always reflect the true loss incurred by that policyholder. For an insurance product to have zero basis risk, a trained loss adjuster would need to be sent to every plot of land where a loss has been incurred. This would be uneconomical in a country like India with so many small and marginal farmers.

3.42 The basis risk from area yield index insurance is usually considered to be lower than that from weather index insurance. 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. It is an open question as to whether weather based schemes can deliver basis risk that is as low as that under area yield schemes in an Indian context.

3.43 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.

3.44 Offering an insurance product that depends on both an area yield index and weather indices could combine the strengths of NAIS and WBCIS. In theory such a product could reduce basis risk relative to both NAIS and WBCIS, in addition to offering an early weather index payment. Moreover, such a product would not have to be more complex than existing WBCIS products, as discussed below.

Comparison of Double Index Products

3.45 Basic analyses for two different types of double index products have been performed. Full definitions of the product types considered are given in Annex E. Under the first type of product the weather index and area yield payments are separate, with no offsetting. Under the second type of product, any early weather index payment is offset against any area yield index payment. Both product types would allow AICI to use any functional form for the weather based payment.

3.46 Both product types would allow AICI to design products so that the weather component comprised a certain proportion of the expected claim payment and the area yield component comprised the remainder. For example, AICI might want the weather based element to comprise 75% of the expected claim payment. Using the notation of Annex E, this would be possible under both product types, by setting and, or and .

3.47 Products without offsetting would be able to offer full cover for weather-based perils, but only partial cover for other perils. This is because a claim payment of 100% of the Sum Insured would only be possible if both the weather was bad and the Actual Yield was low. In comparison products with offsetting could be designed to make a claim payment of 100% of the Sum Insured if *either* the weather was bad *or* the Actual Yield was low.

3.48 In designing the weather element for products without offsetting the aim would be to minimize the basis risk. In contrast, the weather element for products with offsetting should not include cover for perils which are only weakly correlated with weather. As noted in the previous paragraph, for products without offsetting full cover can only be offered for perils that are offered under both the weather and area yield elements of the product. As in WBCIS, there would therefore be a desire to cover as many perils as possible in the weather based element. In comparison, under a product with offsetting it is perhaps unlikely that major losses would be incurred across an IU without either weather or area yield indices being triggered. For products with offsetting it is more important that there is only a small probability that a claim payment is made despite losses not having been incurred. This means that the weather element would only include cover for perils for which weather is an excellent measure, such as deficit rainfall.

3.49 For products with offsetting the weather based payment could be of a simple functional form, focused on capturing one or two key weather-based perils. Current WBCIS products are complex, often offering cover for more than three perils. This is driven by a desire to design products that minimize basis risk by providing cover for many perils. However, complex products are very difficult for policyholders and other stakeholders to understand. Moreover, weather indices can offer protection from some perils better than others. By offering area yield gap insurance, AICI need not be concerned with designing a weather based element that covers all possible perils, since all insurable perils would be covered under the area yield component. The weather based payment could instead be focused on key perils, such as deficit rainfall, for which basis risk is low.

3.50 A summary of the features of both double index policy types is presented in Table 3.3.

Table 3.3: Features of double index policies

Double index policy type	Products with no offsetting of weather index payments	Products with offsetting of weather index payments
Freedom to specify functional form of weather index component?	Yes	Yes
Freedom to weight product towards weather or area yield index cover?	Yes	Yes
Ability to offer full cover for non-weather perils	No	Yes
Weather index element to include perils for which weather is only weakly correlated?	Perhaps	No
Residual basis risk	Moderate to Low	Low
Product simplicity for policyholders	High if weather index element is complex	Low if weather index element is simple
Design and ratemaking simplicity for AICI	As simple as existing products	More complex than existing products

3.51 Due to data limitations it has only been possible to demonstrate the product types using hypothetical data (Annex E). It is suggested that the product types are compared using real historic yield and weather data, using real historic yield and weather data acquired for the same Insurance Units. The numerical example given in the Annex E is based on generated data for one Insurance Unit. A similar exercise could be conducted using real historic data for multiple insurance units in the same state. Threshold Yields would not be set on an individual basis, but rather using an experience-based approach as suggested in the previous section.

Photo: Comstock

CHAPTER 4: REVISING AGRICULTURAL INSURANCE RATEMAKING

4.1 This chapter summarized the technical assistance on crop insurance ratemaking provided to AICI since 2008. It explicitly builds on the ratemaking methodology outlined in World Bank (2007a), which suggested that a robust de-trending methodology be applied to yield data at the start of the ratemaking procedure.

4.2 This chapter offers a detailed presentation of the suggested yield de-trending methodology to be used under the current rating methodology (Normal Theory Method), with an illustrative example for Cotton in Gujarat. A prototype actuarial software was developed and tested by AICI in Gujarat, Madhya Pradesh and Maharashtra for cotton in Kharif 2009, leading to lower premium rates and an increased uptake from 180,000 farmers in Kharif 2008 to almost 300,000 farmers in Kharif 2009. In the medium-term the Experience-Based Approach (as presented in the 2007 World Bank report) should replace the Normal Theory Method, as it would lead to an increase in robustness and statistical efficiency of ratemaking.

4.3 This chapter also applies the experience-based approach to ratemaking to weather based crop insurance products. This builds on the exposition of the experience-based approach to ratemaking for use with area yield index crop insurance in World Bank (2007a). It applies sound actuarial principles and builds on a portfolio approach to estimate the catastrophe load. A prototype actuarial software was developed and tested by AICI in Kharif 2010 in selected states. It builds on an integrated macro-spreadsheet that allows for a more efficient management of the product design and rating, thus mitigating the risk of errors due to the use of multiple independent spreadsheets.

4.4 Finally, this chapter presents the suggested methodology to determine the catastrophe load in the weather based crop insurance rating methodology, with reference to a formal risk analysis for the entire weather based crop insurance portfolio. It is illustrated using the 2008 Kharif weather based crop insurance portfolio.

NAIS RATEMAKING WITH DE-TRENDING

4.5 In 2008 the NAIS premium rate for cotton in Gujarat was perceived to be high compared to the likely claim payment, and insured acreage had fallen dramatically over the last few years. The NAIS premium rate for cotton in Gujarat state had risen from 11.85% in 2003 to 17.2% in

2008. Over the same period cotton claims had been very low, with an average claim between 2003 and 2007 of Rs. 10.58 lakh. Insured acreage for cotton in Gujarat state had fallen from 5.67 lakh ha in Kharif 2000 to 0.2 lakh ha in Kharif 2008 – a fall of 96%. Premium income had fallen to Rs. 7.33 crore[6] in Kharif 2007.

4.6 A possible explanation for the difference between the estimated high premium rates and the actual low claim payments may be the rapid uptake of Bt cotton, which appears to have increased the expected yield from cotton and may have affected the variability. The agricultural statistics collected under the crop cutting experiments (CCEs) do not distinguish traditional cotton and Bt cotton, although Bt cotton occupied 66 percent of the cultivable area under cotton in 2009. The area occupied in India by Bt cotton hybrids in India is estimated to have increased from around 50,000 ha in 2002 to 7.6 million ha in 2008.[7]

4.7 The existing NAIS ratemaking procedure is not robust under such technological trends. The current NAIS pricing methodology, based on the Normal Theory Method (NTM), is not robust in its responsiveness to significant technological changes that cause a shift or trend in the probability distribution of yields. Annex F includes a detailed technical discussion of this point.

Revisiting cotton price

4.8 AICI considered various approaches to adapting the ratemaking methodology for cotton in Gujarat state. An AICI internal document 'Draft note on NAIS - Review of Premium rate in Gujarat state', dated September 17, 2008 suggested a number of alternative approaches discussed in this section.

4.9 Any immediate change to the current ratemaking procedure should be sustainable, actuarially sound, and feasible in the short term. In the future there are likely to be agricultural innovations that lead to changes in the yield distribution for other crops. Decisions made for Bt cotton may set a precedent for the approach to ratemaking in the future and so any changes should lead to a sustainable ratemaking methodology. Ratemaking should also be based on well-defined principles that can be defended using statistical or other actuarially sound arguments.

4.10 In the long term, treating Bt and non-Bt cotton as separate crops may be the most attractive option but is not feasible in the short term. Ignoring the additional cost and complication of conducting additional crop cutting experiments, the preferred approach would be to offer separate insurance products for Bt and non-Bt cotton. However, this is not feasible in the short term due to data limitations. In particular, the current agricultural data collection procedure, based on CCEs, does not allow for the distinction between traditional cotton and Bt cotton.

6 Rs. 1 crore is equal to Rs.10,000,000.

7 Figures from Business Standard, 25 March 2009

4.11 Reducing the administrative loading factor, introducing a bonus, treating cotton as a food crop, or requesting an additional subsidy may not be sustainable. Any such treatment does not address the core issue of the underlying risk assessment of cotton and could set an unhelpful precedent for other states and other crops.

4.12 The introduction of Bt cotton is a technological trend that appears to have led to a marked increase in expected cotton yields and may have affected the variability. The ratemaking methodology could be amended to approximately allow for this. The current ratemaking methodology mistakes an upward trend in yields for uncertainty, leading to high premiums (see Annex F). If the technological trend has been substantial, as it appears to have been for cotton in Gujarat due to the adoption of Bt cotton, the calculated premium is unlikely to fully reflect the current risks faced by farmers. The introduction of Bt cotton appears to have reduced the variability of yields, but this effect is not yet statistically significant and there are credible agronomic reasons for why such a reduction may not continue. In this section we have not made any adjustments to correct for any possible change in variability in yields.

4.13 In the immediate term, as an interim measure, it is suggested that the current Normal Theory Method (NTM) approach to ratemaking could be enhanced by the removal of any statistically significant trends in yield data before pricing calculations are performed. This recommendation is consistent with World Bank (2007a). This is not a first-best solution. However, it does appear to be the most appropriate short term solution. In the longer term, it is suggested that AICI could move to an Experience Based Approach to ratemaking with an integrated de-trending methodology, as suggested in World Bank (2007a).

De-trending

4.14 De-trending should aim to remove technological trends, such as the adoption of a high yielding crop variety, without removing natural variation in experience. For example, if the most recent three years were exceptionally good for farmers due to unusually good weather, an insurer may not want to treat this increase in yields as a technological trend, but rather to treat it as the historic realization of uncertainty. Particular care needs to be taken with the Normal Theory Method, which is not particularly well suited to an integrated de-trending methodology.

4.15 A de-trending methodology should incorporate both statistics and judgment to determine whether any apparent trend is an actual structural trend or just a series of increasingly favorable or unfavorable events. With only ten years of data, it may be difficult to identify a true trend separately for each Insurance Unit. When there has been no underlying trend in the data, a trend that is statistically significant at the 5% level will be observed on average once every twenty tests. There would be evidence for a statistically significant trend for a particular crop in a particular state if substantially many more than 5% of the individual yield histories displayed a trend that was statistically significant at the 5% level of significance, or if the weighted average yield for that crop in that state displayed a statistically significant trend. If there was such statistical evidence for a trend then a decision should be made as to whether any statistically significant trends for that crop are plausible, based on a strong rationale. In the case of cotton, the adoption of Bt cotton leads to a plausible explanation for an upward trend in yields. However, in other cases there may be a statistically significant trend that has occurred 'by accident'. Any trends that are considered to have occurred by accident should be left in the data; that is, no de-trending should be performed for this data.

4.16 When unsure about whether a pattern in yields is pure uncertainty or a structural trend, actuarial prudence suggests that an insurer should assume whichever gives the higher premium. Under the Normal Theory Method and in the case of an upward trend in yield data, the prudent approach would be not to de-trend yield data. In this section, yield data are only de-trended with a trend that is significant at the 5% level of significance.

4.17 State-wise linear de-trending has been considered. If there is a statistically significant upward trend in the area-weighted average yields in a state, yield data has been increased for each unit using this trend.[8]

4.18 Alternative approaches to de-trending would include linear de-trending by insurance unit and stepwise aggregate de-trending. By calculating a trend for each insurance unit and then removing any statistically significant trend for that unit, it is possible to statistically differentiate between units where Bt cotton has been widely adopted, leading to a large increase in expected yields, and units where Bt cotton has not been adopted, leading to no change in expected yields. However, in addition to removing any trends, it is likely that such a procedure would remove much of the natural variation in the data. For example, for an IU that suffered poor weather for the first few years but very good weather for the final few years, de-trending would remove this natural variation and underestimate the CV, even if it was not caused by a trend that was expected to continue over time. Aggregate stepwise de-trending might be appropriate if take-up of a technology is known to have occurred over a very small period of time. However, in the case of Bt cotton it appears to have been adopted gradually, with the success of early adopters encouraging more farmers to switch to Bt cotton. Linear de-trending therefore appears to be more appropriate in this case.

8 For example, for Gujarat cotton the best estimate area sown-weighted trend is 111 kg/ha/year and this trend is statistically significant at the 5% level. For insurance unit Viramgam, the 1998 Kharif yield of 712 kg/ha/year has been increased by 9 x 111 kg/ha/year to give a de-trended yield of 1,707 kg/ha/year. The 1999 Kharif yield of 570 kg/ha/year has been increased by 8 x 111 kg/ha/year to give a de-trended yield of 1,454 kg/ha/year.

4.19 Cotton yields for all four states considered display statistically significant trends, supporting the argument that the adoption of Bt cotton has led to an increase in expected yields and providing justification for the de-trending of historic yields (see Table 4.1). Gujarat, Maharashtra, Karnataka and Andhra-Pradesh have all experienced statistically significant upward trends in cotton yields. The effect of de-trending on Gujarat cotton yields is displayed in Annex F.

4.20 De-trending cotton yields can reduce the calculated premium by more than half. The estimated premium rate with de-trended yields is reduced by 64% for cotton in Gujarat (see Table 4.1). Such a high premium reduction can also be observed for cotton in Maharashtra, Karnataka and Andhra Pradesh. It should be noted that neither Groundnut nor Pearl Millet yields exhibit a statistically significant linear trend in Gujarat. This tends to confirm that the adoption of Bt cotton has led to a technological trend in yields but there has been no equivalent trend in other crops (for example, due to weather patterns).

Table 4.1: Statistical investigation of aggregate linear trends for six products

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

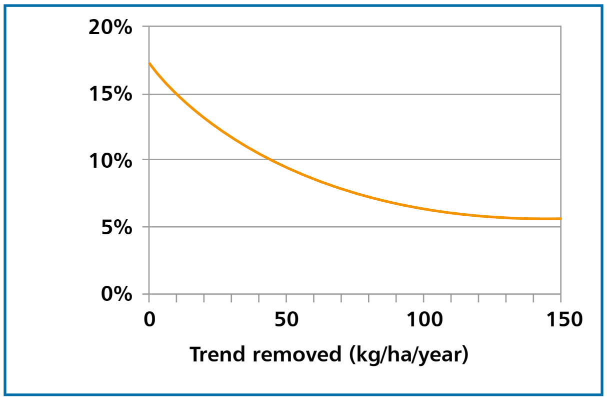
Notes: 1. Premiums are NTM commercial premiums rates (i.e. after addition of 41% loading factor for cash crop s and 16% for food crops), based on indemnification level of 60% and weighted by 2007 area sown.

2. A procedure for calculating an appropriate p-value in MS Excel is given in Annex F.

3. Statistical significance is at the 5% level.

4.21 Premiums are indicative and should be subject to expert judgment. The statistical method employed tests whether the data exhibit a statistically significant trend, not what the true trend is. The trend to be removed is partly a matter of expert judgment. For example, the very low p-value for Andhra Pradesh cotton suggests that there has been a statistically significant trend in yields, but it does not tell that the true trend is equal to the best estimate trend of 80. By removing an annual trend of 40kg/ha instead of 80kg/ha, the indicative commercial premium is 3.6%, instead of 1.6%. Figure 4.1 illustrates how the indicative commercial premium for Gujarat varies with the amount of trend that is removed.

Figure 4.1: Cotton in Gujarat: Indicative Commercial Premium after De-trending



4.22 The cotton premiums quoted above are likely to be conservative as currently no de-trending is applied to the average yield used to calculate claim payments. NAIS deploys a three-year moving average for rice and wheat and a five-year moving average for all other crops to calculate the probable yield, upon which the threshold yield is based. As yields have, on average, increased over the last three to five years the probable yield is likely to underestimate the true expected yield for the coming year. The actual expected claim payments are therefore likely to be lower than those suggested in Table 4.1. See Annex F.

4.23 A universal de-trending methodology would be more robust and statistically efficient within an Experience Based Approach (EBA). The NTM approach relies on strong parametric assumptions about the data, notably the normality assumption of the underlying yield distribution functions. De-trending in an NTM approach requires additional strong parametric assumptions to be made, notably that the CV is constant over time, even as the mean is increasing. If the assumptions are not satisfied the approach can perform poorly. In contrast, an EBA approach is robust under a larger range of assumptions. It is also more efficient, under a wide range of statistical assumptions.

Portfolio weighting

4.24 Weighting average premiums by area sown gives a lower premium than when weighting by area insured. Table 4.2 shows that the estimated premiums before de-trending increase when they are weighted by the area insured. This is the direct consequence of adverse selection: high risk farmers are more likely to purchase insurance than low risk farmers. This adverse selection problem is exacerbated under the NAIS because premium rates are set at the state level, while claim payments are made at the insurance unit level.

4.25 Adverse selection of high risk farmers under NAIS has increased as the premium has increased. The 2009 commercial premium when weighting by area insured in Kharif 2002 is 20.2%,whereas when weighting by area insured in Kharif 2008 is 25.9%. Farmers purchasing NAIS cotton insurance in Gujarat in 2008 are in higher risk IUs, on average, than those purchasing NAIS cotton insurance in 2002. See Table 4.2.

Table 4.2: Commercial premiums for Gujarat cotton using different weightings

Weight in premium calculation	Estimated premium for Gujarat cotton
Area sown Kharif 2007	17.4%
Area insured Kharif 2002	20.2%
Area insured Kharif 2004	25.3%
Area insured Kharif 2006	22.0%
Area insured Kharif 2008	25.9%

Note: Premiums are NTM commercial premiums rates (i.e. after addition of 41% loading factor), without any de-trending, and based on indemnification level of 60% and weighted by 2007 area sown.

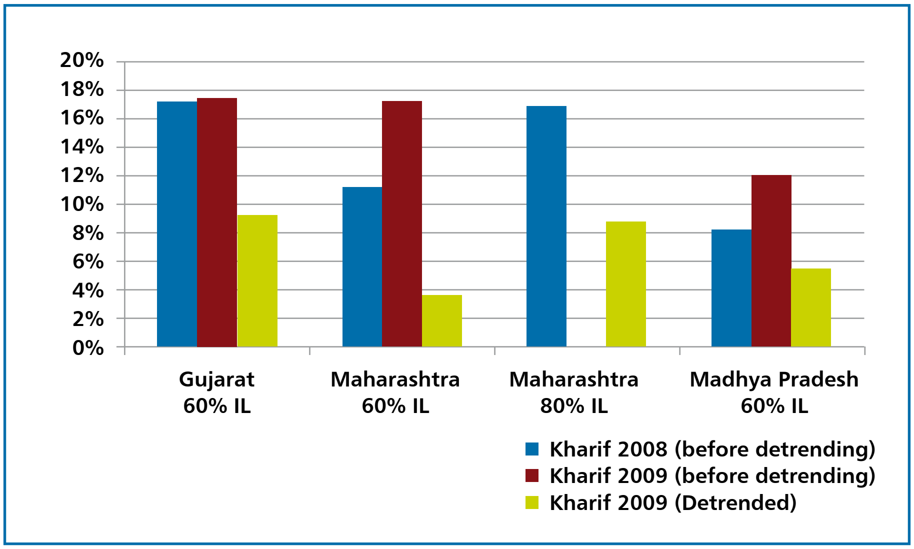
4.26 It is suggested that premium rates could be computed using the estimated portfolio of the coming season. Rates would thus better reflect the expected claim payments. AICI could calculate premiums using a portfolio weighting expected to be appropriate for the coming season. Where data is available, weighting should be based on most recent area insured, or a weighted average of historic areas insured, instead of area sown.

Conclusion

4.27 The suggested methodology was implemented by AICI during Kharif 2009 for selected crops. The NAIS premium rate for cotton in Gujarat (at 60% indemnity level) was reduced from 17.4% to 9.25%, i.e., a 47% premium reduction. The NAIS premium rate for cotton in Maharashtra decreased from 11.3% (at 60% Indemnity Level) to 7.3% (at 80% Indemnity Level); farmers are offered a cheaper product with a better coverage. Therefore, the proposed revisions of the NAIS ratemaking, which allows for yield de-trending, has allowed AICI to offer products that are less expensive and with a better coverage, without affecting the actuarial soundness of the crop insurance program.

4.28 Figure 4.2 presents the revised NAIS premium rates for cotton, as implemented by AICI in Kharif 2009. The rates were reduced by almost half in all three states, without affecting the long-term actuarial soundness of the products. If systematically applied across the entire NAIS portfolio, as recommended in World Bank (2007a), a robust detrending methodology would protect the NAIS portfolio from future trends such as changes in agricultural technology or agro-climatic conditions (including climate change).

Figure 4.2: Revised NAIS Premium Rates for Cotton, Kharif 2009



Source: AICI. Premium rate for Maharashtra 80% IL in Kharif 2009 (before de-trending) is not available.

REVISED RATEMAKING FOR WEATHER BASED CROP INSURANCE

4.29 The current weather-based crop insurance ratemaking methodology implemented by AICI was appropriate as long as AICI's weather-based portfolio was at a pilot stage. The methodology was suggested by World Bank (2007b). Under this methodology each insurance product was priced separately, with one loading factor to account for missing data (the *Data Uncertainty Factor*) and a second loading factor to account for the catastrophic load (the *Return on Risk* factor). This approach was based on international weather market practices, and was appropriate while the number of products sold by AICI was small.

4.30 AICI's weather based crop insurance portfolio is now larger and better diversified. In the 2008-09 agricultural year over 1,000 weather different based products were offered over 14 States. Approximately 310,000 policies were purchased with an estimated total premium income of Rs66 Crores (approximately USD13.2 million) and Total Sum Insured of Rs725 Crores (approximately USD145 million).

4.31 A portfolio-based approach to ratemaking is likely to be substantially more efficient than a stand-alone approach, whilst allowing AICI more flexibility to offer standardized products based on agronomic principles. Premium calculations would be more robust to statistical outliers, and so commercial premiums would be a better reflection of the true expected cost to AICI. Both the existing and proposed ratemaking methodologies involve calculation of an estimate of the future claim payments from products: the Historic Burn Rate (HBR) and the Pure Premium Rate (PPR), respectively. Both estimates are unbiased but the PPR is likely to be closer than the HBR to the actual expected future claim payment. The increase in efficiency comes from exploiting the spatial and agronomic structure of weather patterns.

4.32 AICI ratemaking is likely to also benefit from a portfolio approach to risk loading. The catastrophe risk loading should be based on peak losses at the portfolio level rather than at the product level in order to take advantage of any risk diversification benefits. Given the size of the current weather based crop insurance portfolio, with more than 1,000 products offered in 14 states, the overall weather based crop insurance portfolio should be better diversified and hence the catastrophe risk load is likely be lower.

4.33 The suggested ratemaking procedure would allow AICI more flexibility in designing products based on agronomic principles. If the difference in rainfall for a group of weather stations in some Risk Collective was not statistically significant, then the same product could be sold in all stations at the same, or a very similar, price. This would have been difficult to justify under the existing ratemaking methodology.

4.34 The suggested ratemaking methodology is depicted as a flow chart in Figure 4.3 and described, with justification, throughout this section. This procedure outlined in this flow chart is coded up in MS Excel for the purpose of illustration in an accompanying spreadsheet (shared with AICI).

Efficient Estimation of Expected Loss

4.35 A procedure for calculating a statistically efficient estimate of the expected loss from each weather insurance product is suggested. This is called the Pure Premium Rate (PPR), and the calculation involves several steps. The PPR is the equivalent of the Historic Burn Rate (HBR) under the existing methodology. The PPR does not increase or decrease rates relative to the HBR; the total weighted average PPR is the same as the total weighted average HBR. Rather, the PPR involves a re-spreading of rates between products where any difference in rates is statistically insignificant. The PPR can only be calculated for a group of products at a time. This is different to the approach currently taken by AICI, where each product is priced on a stand-alone basis.

Calculate Historic Loss Costs

4.36 Insurance products must first be grouped into Balance Back Collectives (BBCs) and Risk Collectives (RCs). A BBC should contain products for which extreme claim events are expected to be similar in nature. A RC should contain similar products that are based on different sources of weather data. A BBC could be the same as a RC, or could include more than one RC. The grouping of products into collectives requires both expert judgment and practical considerations (See Annex G for further description).

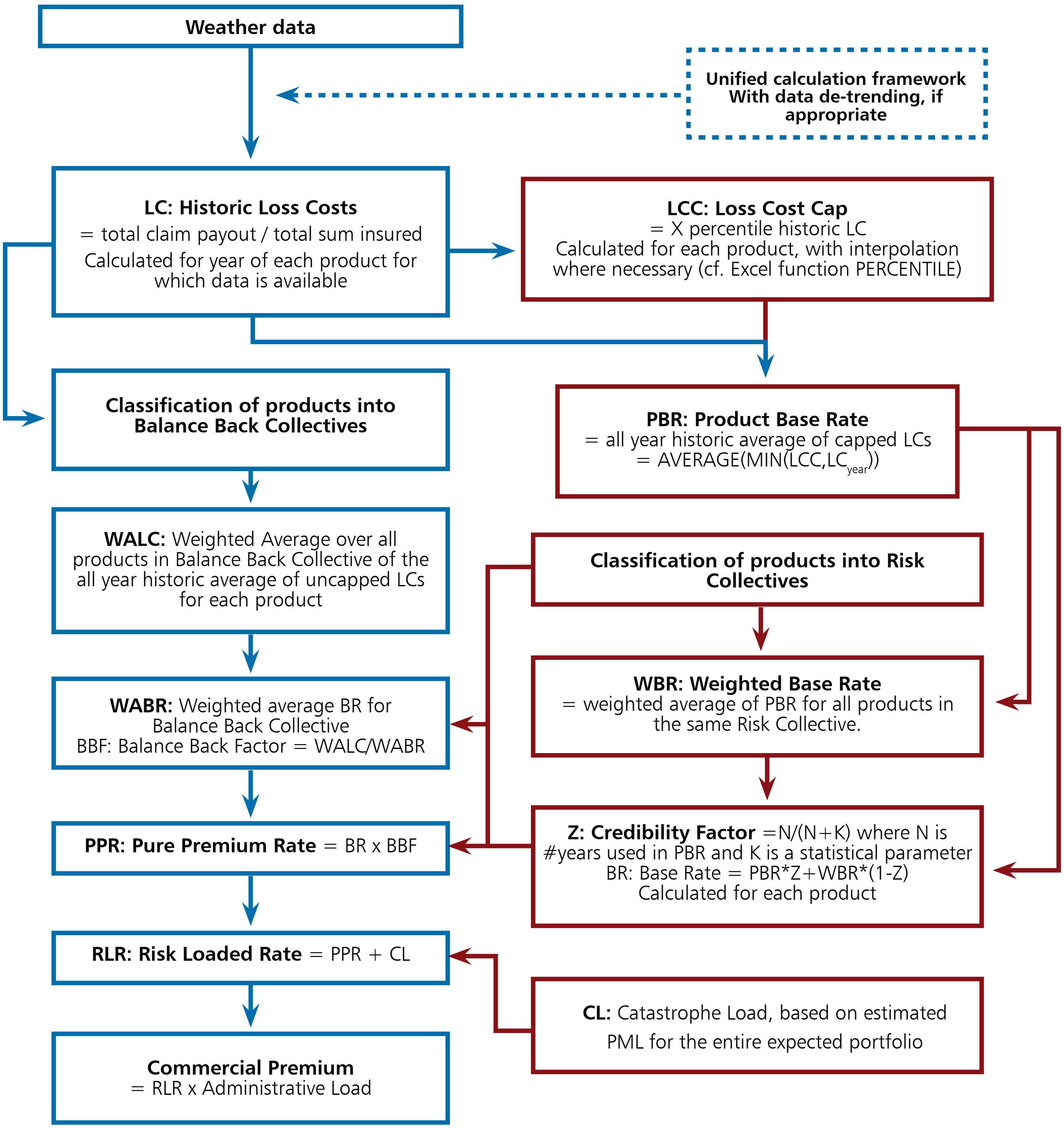
4.37 Historic loss costs should be calculated for all products in the same BBC and RC. For each year for which historic weather data is available for a particular insurance product, the loss that would have been incurred in that year for that product should be calculated. The historic loss cost for that year is then the loss divided by the Total Sum Insured for the product. Historic loss cost calculations should be based on cleaned historic data, not simulated data.

4.38 Loss cost histories should be de-trended, if necessary. The historic loss cost data analyzed under this study (620 products sold in Kharif 2008) did not appear to display statistically significant trends. Trends were identified for some individual products but these trends were not statistically significant, considering the large number of products offered. Analyzing the trend for each crop or state generated no statistically significant trends. As no statistically significant trend was identified, no loss cost de-trending was deemed to be necessary.

4.39 AICI may want to develop a streamlined loss cost calculation process to facilitate robust products design and ratemaking. In particular, AICI may wish to move from a process whereby calculations for each product are conducted in separate spreadsheets to a process whereby a small number of master spreadsheets perform standardized calculations for all products[9].

9 This point was the subject of an afternoon workshop titled 'Enhancing Software Design', discussed on 12 May 2009 by the World Bank Team.

Figure 4.3: Weather-Based Crop Insurance: Flow Chart of the Suggested Experience-Based Ratemaking Methodology



Cap and Balance Back Factor

4.40 A cap is applied to each loss cost history to remove statistical outliers. Bühlmann's Credibility Theory is a linear process, and thus extreme outliers can present difficulties requiring special attention. A technique commonly used in conjunction with credibility weighting is to cap large losses before the application of Credibility Theory. Capping large losses can reduce the variance of observed incurred losses allowing more credibility to be assigned to the capped observations. A properly chosen cap may not only add stability, but may even make the methodology more accurate by eliminating extremes. For each loss cost history, the Loss Cost Cap (LCC) is calculated to be the Xth percentile loss cost, where X is a number between 0 and 100 chosen by AICI. The choice of X is discussed in Annex G.

4.41 The Product Base Rate (PBR) is defined as the average capped loss cost for that product. The PBR is the average of capped loss costs, where the cap is applied to individual historic loss costs.

4.42 Outlier losses are spread back over each Balance Back Collective. The Weighted Average Loss Cost (WALC) is such that if products within the Balance Back Collective are purchased according to their expected weightings, then the total premium income from charging the WALC for all products would be the same as the total premium income from charging a rate equal to the average historic loss cost for each product. After Credibility Theory has been applied to the capped loss costs to derive a Base Rate (BR) for each product, every rate within a Balance Back Collective is multiplied by WALC / WABR, where WABR is the Weighted Average Base Rate for all products in the same Balance Back Collective. Any outlier losses removed through capping are therefore spread back over each Balance Back Collective.

4.43 Capping loss costs then adding back a Balance Back Factor is actuarially sound as infrequent events lack statistically credibility. Since extreme losses have been removed from each product's experience, it is appropriate to add them back in at a broader level, so that rates are not underestimated. These losses could be added directly to Base Rates or incorporated proportionately by way of a multiplying factor. The two approaches will be similar if the Balance Back Collectives are homogenous. In Figure 4.3 and the attached Excel spreadsheet, it has been assumed that the entire excess losses are to be incorporated proportionately by multiplying Base Rates with a Balance Back Factor.

Credibility Theory

4.44 Credibility refers to the degree of belief in a particular source of data. Credibility is a relative concept and is greater the more relevant the data source, and the greater the number of observations in the data source.

4.45 The PBR may be a poor estimate of future capped loss costs for a particular product. The expected accuracy of this estimate is a function of the variability in historic capped loss costs. If historic loss costs can be calculated for a large number of years and these loss costs have low variability, then the PBR is likely to provide a good estimate of future loss costs for that product. If, however, historic loss costs can only be calculated for a few years and/or the variability in historic loss costs is high then the PBR may provide a poor estimate of future loss costs for that product. From a statistical point of view, the standard errors, or confidence intervals, of the PBR as an estimator of the true expected capped loss cost would be large.

4.46 The Weighted Base Rate (WBR) is defined as the weighted average of PBRs for all products in the same Risk Collective. The weights are taken to be equal to estimates of insurance purchase in the coming season.

4.47 Rather than relying solely on the PBR to determine rates, statistical efficiency can be increased if the WBR is also given an appropriate weight in ratemaking. If products are similar and weather is spatially correlated then loss cost histories may be used from other similar products to increase efficiency of estimates of the desired product.

4.48 The credibility formula for the Base Rate (BR) is given by: $BR = PBR*Z+WBR*(1-Z)$, where BR is the Base Rate, PBR is the Product Base Rate, that is the average capped loss cost for that product, WBR is the weighted average PBR for all the products in the Risk Collective, and Z is the Credibility Factor. The Base Rate is therefore a weighted average of the PBR and the WBR, where the weight is the credibility factor Z.

4.49 Credibility Factor Z can range from 100% (full credibility assigned to loss cost history for individual product) to 0% (no credibility assigned to loss cost history for individual product). Z should be 100% when the Risk Collective provides no statistically useful information for ratemaking. Correspondingly, Z should be 0% when the individual loss cost history is statistically uninformative, compared with the history for the full Risk Collective.

4.50 The Credibility Factor Z is suggested to be calculated according to Bühlmann's Credibility Factor Formula. This Credibility Factor satisfies intuitive properties and is robust in a range of scenarios. Z increases if there is more data for the product itself, the variation of loss costs for each product history decreases, or the variation of PBRs between products increases. See Annex G. Alternative approaches could also be considered (see Annex G).

4.51 The Pure Premium Rate (PPR) is the unloaded estimate of the expected loss from a particular product, and equals Base Rate x Balance Back Factor. This corresponds to the Burning Cost currently calculated for each product on a standalone basis.

Example: Ratemaking for maize products in Rajasthan

4.52 Table 4.4 illustrates PPR calculations for two maize products sold in Rajasthan. The Risk Collective is assumed to equal the Balance Back Collective and includes all maize products sold in Rajasthan. Loss cost histories for the 21 Rajasthan maize products are available. Notice that some of the difference between PBR and WBR is deemed to be not statistically significant and so both BRs are drawn towards the WBR.

Table 4.4: Example PPR calculations for two maize products in Rajasthan

Tehsil	Devli	Pratapgarh
Risk Collective	All maize RJ products	All maize RJ products
Balance Back Collective	All maize RJ products	All maize RJ products
Average uncapped loss cost	7.1%	2.9%
Loss Cost Cap (LCC)	17%	8%
Product Base Rate (PBR)	6.0%	1.9%
Weighted Base Rate (WBR)	3.5%	
Credibility Factor Z	61%	65%
Base Rate (BR)	5.0%	2.4%
Balance Back Factor (BBR)	1.32	
Pure Premium Rate (PPR)	6.6%	3.2%

Catastrophe Load

4.53 The suggested approach to catastrophe loading is based on an aggregate portfolio approach. This means that the total additional premium income from the Catastrophe Load should equal the total cost to AICI of bearing the risk of the entire portfolio.

4.54 AICI could conduct a portfolio risk analysis to determine the total amount of risk capital required, based on an aggregate Probable Maximum Loss (PML) approach. Were AICI to choose a return period of between 100 and 150 years, preliminary analysis of the AICI weather based crop insurance portfolio shows that the total aggregate probable maximum loss cost would be between 10% and 13%, depending on the distribution used to extrapolate estimated aggregate historical loss costs and the precise return period chosen (see following section).

4.55 AICI could estimate the cost of securing this risk capital, allowing for the internal cost of capital to AICI and the cost of any reinsurance purchased. Where AICI must quote premiums for products before the entire portfolio is finalized, judgment must be applied in assessing the level of diversification in the forthcoming weather based crop insurance portfolio. The more diversified the portfolio, the lower the Probable Maximum loss cost will be. If there is some uncertainty surrounding the level of diversification in the forthcoming portfolio AICI may wish to estimate the Probable Maximum loss cost on a prudent, or cautious, basis.

4.56 The aggregate portfolio catastrophe load can be spread between products based on their contribution to the premium income or their contribution to the Total Sum Insured. The former would lead to a loading factor to be multiplied by the PPR; the latter would lead to a load being added to the PPR. The latter, additive, approach is suggested as it allows AICI flexibility to rate groups of products in advance of knowing the full portfolio.

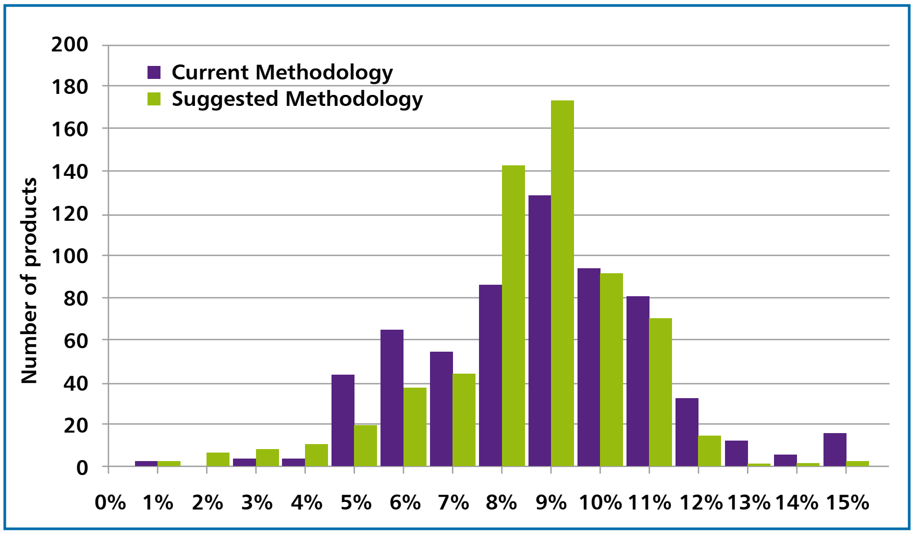
4.57 A Catastrophe Load (CL) suggested is added to the PPR for each product. For example, if AICI wished to accumulate capital of 16% of the aggregate Total Sum Insured, the cost of securing risk capital were 7%, the Catastrophe Load would be 16% x 7% = 1.1%.

Comparison of selected insurance rates

4.58 The historic loss costs were used to estimate commercial premiums under the existing and the suggested methodologies for 620 products sold in Kharif 2008. The results are illustrated in Figure 4.4.

4.59 Commercial premium rates derived from the suggested methodology are slightly lower than the current commercial premium rates, due to a slightly lower catastrophe load. Assuming an administrative loading of 30% and a Catastrophe Load of 1.12 the average commercial premium under the suggested methodology would be 9.1%, compared with an average commercial premium under the existing methodology of 9.4%. Estimated commercial premium rates under the revised rating methodology are more concentrated around the mean and are less skewed to the right. In particular, some products with higher premium rates under the current rating approach may have been influenced by "outliers" that are not statistically significant and, therefore, under the revised methodology, these products have lower premium rates. Were the administrative load to remain at 15%, the average premium under the suggested methodology would be 8.1%. It has been assumed that Risk Collectives and Balance Back Collectives are constructed to include all products in the same state for the same crop. A Catastrophe Load of 1.12 corresponds to an opportunity cost of capital of 7%. Loss Cost Cap Percentage is 90%. These figures are purely illustrative.

Figure 4.4: Distributions of Calculated Commercial Premiums Using Existing and Suggested Methodology



Moving towards implementation

4.60 The suggested ratemaking methodology is based on international best practice and customized to reflect the national situation. A prototype Excel spreadsheet was developed to illustrate this methodology. However, some steps may require some more time to be fully implemented. In this context, should AICI want to implement the suggested ratemaking methodology in the short term, this section suggests some possible simplifications in the rating methodology that should facilitate its implementation without affecting its actuarial soundness.

4.61 Balance Back Collectives could be chosen to be the same as Risk Collectives. There is a feedback loop between ratemaking and product design. By choosing BBCs to be the same as RCs, all products in a Risk Collective could be designed and rated together. Over time, AICI may wish to experiment with different definitions of Balance Back Collectives.

4.62 Risk and Balance Back Collectives could be defined to include products sold for the same crop in the same state. For example, one such Risk Collective would include all maize products sold in Rajasthan. Each product could be rated without having to rate products in other states. Risk collectives would automatically not include multiple products with claim payments based on the same weather data.

4.63 As discussed in Chapter 3, product design should be mainly based on agronomic fundamentals. AICI should ensure that product design is kept separate from the data used for ratemaking purposes. One might think of a weather insurance product as comprising a *shape* of cover in addition to a *level* of cover. The shape of cover should not be driven by individual weather data histories because, otherwise, products are likely to be underpriced. It might seem natural for the shape of cover to depend on agronomic fundamentals. In contrast, it is perfectly reasonable for the level of cover to depend on the individual weather data history. Such dependence would not lead to data mining.

4.64 In Kharif 2009 the suggested ratemaking methodology was trialed for one state, but was not combined with a standardized product design methodology based on agronomic fundamentals. Products were chosen to be almost identical to Kharif 2008 products, which had each been designed so that the average historic payout using historic weather data was equal to the target rate. These products may not have been robust to the data mining concerns of the first section of Chapter 3. Moreover, by design the Product Base Rate was automatically equal to the Weighted Base Rate, and therefore the power of Bühlmann's Credibility Theory was not utilized. Had a standardized product design methodology been implemented, as suggested in the first section of Chapter 3, it is likely that AICI would have been able to justify selling similar products for the same price in different Insurance Units.

WEATHER BASED CROP INSURANCE PORTFOLIO ANALYSIS

4.65 Under the suggested ratemaking methodology, it is suggested to conduct a portfolio risk analysis to determine the total amount of risk capital required, based on an aggregate Probable Maximum Loss (PML) approach. First, one should calculate the historic losses that would have been incurred if the current portfolio had been sold in previous years. Second, one should estimate the portfolio PML for a given return period. For the suggested ratemaking methodology the PML should be expressed as a proportion of Total Sum Insured, called the Probable Maximum Loss Cost (PMLC).

4.66 The Catastrophe Load is then calculated with reference to the PMLC, AICI's cost of capital, and AICI's risk financing strategy. The calculation of the Catastrophe Load is described in the previous section and is used in the ratemaking calculation as follows:
Commercial Premium = (Pure Premium Rate + Catastrophe Load) x Administrative Load.

4.67 AICI may wish to calculate separate Catastrophe Loads for the Kharif and Rabi seasons to allow for any difference in catastrophic risk borne. This section ignores any reduction in the Catastrophe Load to account for diversification between the Kharif and Rabi seasons. By underestimating the benefits of diversification, this approach may be considered prudent for the products analyzed.

Data

4.68 AICI provided appropriate details for 687 weather-based crop insurance products sold in Kharif 2008 season. For each product the following information was supplied: State the product was sold in, crop for which the product was designed, Total Sum Insured, and calculated historic losses based on historic weather data. The average number of years for which historic losses had been provided, was 21. Area insured information was provided for 475 products.

4.69 Weather products designed for paddy crop accounted for 72% of the portfolio by Total Sum Insured, and weather products sold in Bihar accounted for 55%. See Annex G for the composition of the portfolio considered split by state and crop, respectively.

llustrative Portfolio Risk Analysis for Kharif 2008 Portfolio

4.70 For each historic year, the total premium income, total sum insured and total claim payment are calculated in respect of the 2008 Kharif portfolio for which data is available for that year (see Annex G). Products have been weighted according to their estimated weight in the 2008 portfolio. Where loss data is missing for a particular product for a particular year that product is excluded from the total premium income, total sum insured and total loss for that year. For states with no area insured information it is assumed that each product sold in that state was bought in equal numbers such that the total area insured matched with the figures in Annex G. Calculations have been based on real, not simulated, data to more accurately reflect the benefit of diversification within the portfolio.

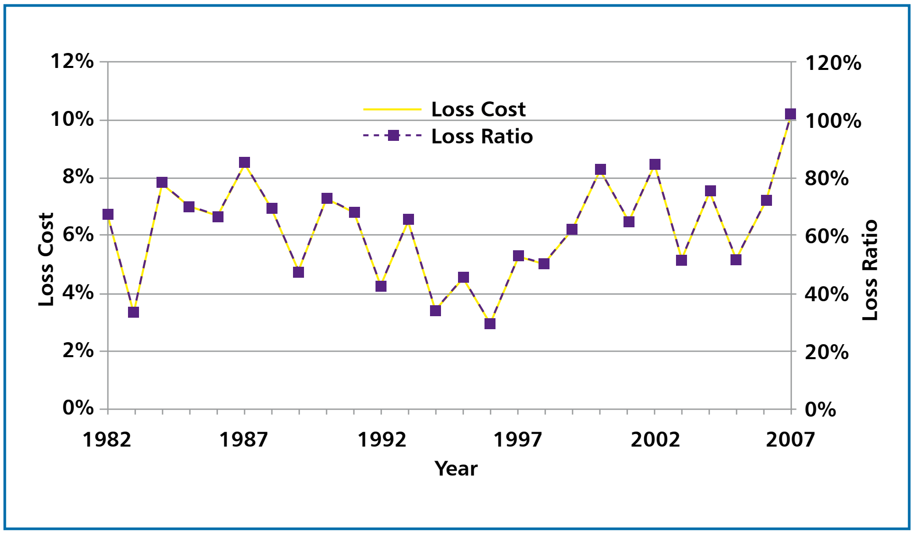
4.71 For each year between 1982 and 2007 loss information for over 25% of the 2008 portfolio was provided by sum insured. There are many gaps in historic weather data series leading to gaps in the historic calculated loss information for a particular product. For years before 1982, data for less than 26% of the total Kharif 2008 portfolio are considered by sum insured. These years have been excluded from the analysis, as the calculated loss ratio and loss costs in these years are likely to be overestimates due to the lack of diversification within the portfolio for which data is available.

4.72 Because the present historic portfolio, for which data is available, is less diversified than the true 2008 portfolio, these PMLCs are likely to be over-estimated: The estimated PMLCs are likely to be higher than the true PMLCs due to the relative lack of diversification in our historic portfolio.

4.73 The average calculated loss ratio and loss cost are 62% and 6.2% respectively (full histories displayed in Figure 4.5 and in Annex G). Since smoothed premiums are equal to 10% of the

Total Sum Insured for the majority of products, historic Loss Ratios and historic loss costs are of a very similar shape, and hence the two lines in Figure 4.5 overlap.

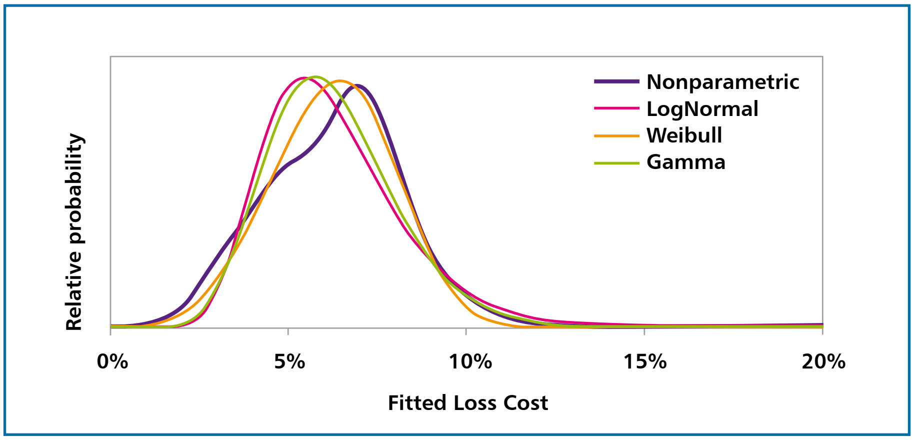
Figure 4.5: Aggregate Estimated Historic Loss Ratio and Loss Cost



Note: Weighting is by 2008 portfolio as far as historic data is available

4.74 To estimate the portfolio Probable Maximum Loss Cost, historic loss costs must be fitted to a distribution (see Figure 4.6). Loss costs for 26 years are only calculated (see Annex G) but estimating 100+ year PMLCs is of interest. This is done by extrapolating past loss cost values, under a certain assumption about the true shape of the distribution. The analysis is conducted using a range of different distributional assumptions.

Figure 4.6: Fitted Probability Density Functions of Aggregate Portfolio Loss Costs



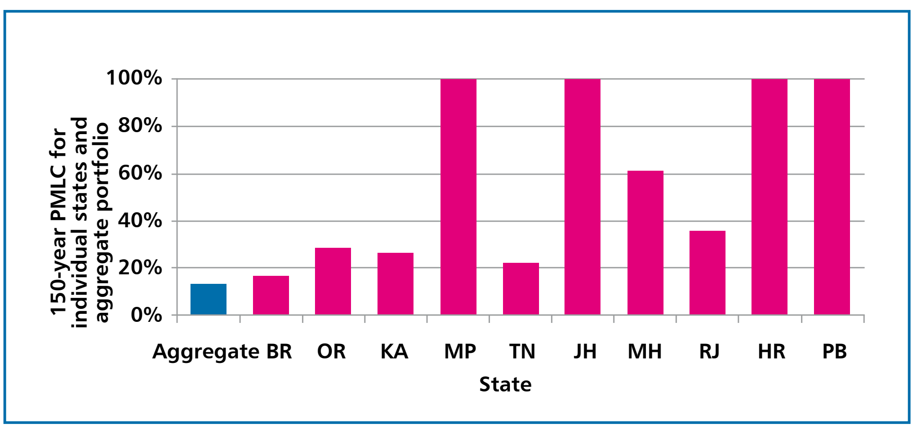
4.75 The 150 year PMLC ranges from 10.2% to 12.8%, depending on the assumption made about the distribution (see Table 4.5). As would be expected, assuming the conservative LogNormal distribution yields the highest PMLC whereas Weibull and Nonparametric distributions yield the lowest PMLCs. However, as noted above these estimates are likely to be biased upwards due to the lack of diversification in our historic portfolio.

Table 4.5: Estimates of the Probable Maximum Loss Cost

PMLC return period	10 years	20 years	50 years	100 years	150 years	Mean loss cost
Nonparametric	8.5%	9.2%	10.0%	10.5%	10.8%	6.2%
LogNormal	8.9%	9.9%	11.2%	12.2%	12.8%	6.3%
Weibull	8.4%	9.0%	9.6%	10.0%	10.2%	6.3%
Gamma	8.6%	9.5%	10.5%	11.2%	11.6%	6.2%

4.76 The PMLC decreases as the number of states increase, reflecting the increased diversification within the weather-insurance portfolio. The aggregate historic portfolio loss cost is more stable than the historic loss cost for any given state. This is because of the benefits of diversification within AICI's weather based crop insurance portfolio. Therefore, as AICI's portfolio becomes more diversified, the Catastrophe Load would be expected to reduce. See Figure 4.7.

Figure 4.7: Risk Pooling Benefits from Diversification over States



Note: PMLCs have been calculated assuming that loss costs follow a LogNormal distribution.

Effect of portfolio risk analysis on technical premiums

4.77 Under AICI's existing ratemaking methodology for WBCIS, risk adjusted premium rates are on average 37% higher than the average historic claim rates. The weighted average Technical premium comprises the weighted average Expected Loss (6.1%), the weighted average Data Uncertainty Factor (1.0%) and the weighted average charge for risk capital (1.3%) and is therefore given by 6.1%+1.0%+1.3%=8.4%. 8.4% is equal to 6.1% x 1.37. A further administrative multiple of 1.15 is applied to the Technical Premium giving Commercial Premiums that are on average equal to the Expected Loss multiplied by 1.57. All averages are weighted by 2008 Kharif portfolio.

4.78 Under the proposed ratemaking methodology, ignoring any reinsurance and without changing any assumptions underlying the calculation, this catastrophe loading would be reduced from 37% to 10% (see Table 4.6). The weighted average Expected Loss for the portfolio is calculated to be 6.1%. The loading for risk capital would add a further 12.8%x5%=0.6% assuming a LogNormal distribution and 150 year PMLC (see Table 4.5). This is equivalent to a multiple of 1.10 being applied to the Expected Loss. The Cost of Capital is usually calculated as the Hurdle Rate of Return minus the rate of interest earned on reserves. Were AICI to purchase reinsurance for the WBCIS portfolio, the reinsurance premium net of any refund should be used for rating ceded benefits. The above PML based approach would then be applied to the residual risk borne by AICI.

Table 4.6: Weighted Average Loading for Kharif 2008 portfolio on different bases

Pricing Methodology	PMLC return period (years)	Assumed loss cost Distribution	Cost of Capital	Administrative Load	Risk Loading	Total Loading
Current	150	LogNormal	5%	1.15	1.37	1.57
Proposed	150	Weibull	5%	1.15	1.08	1.24
	150	LogNormal	5%	1.15	1.10	1.27
	150	LogNormal	5%	1.30	1.10	1.44
	150	LogNormal	10%	1.15	1.21	1.39

Notes: 1. The Risk or Catastrophe Loading equals the total premium before allowance for expenses, that is the Technical Premium, divided by the Expected Loss.
2. The Total Loading is the Commercial Premium divided by the Annual Expected Loss.

4.79 The reduction in risk loading is due to the portfolio approach to risk loading and the removal of the Data Uncertainty Factor. The charge for risk capital under the existing ratemaking method was approximately 20% of the Expected Loss. However, the loading for each product was calculated separately, and no allowance was made for the diversified nature of the WBCIS. By conducting historic burn analysis for the entire WBCIS Kharif 2008 portfolio it has been possible to demonstrate that WBCIS benefits from significant diversification. The cost of holding reserves equal to the portfolio 150 year PML is much lower than the cost of holding reserves for each policy.

4.80 The Data Uncertainty Factor (DUF) was appropriate while WBCIS was at a pilot stage, and was based on methods employed in markets for weather derivatives. However, for a large personal lines insurance portfolio like that of the WBCIS it is appropriate to allow for any statistical censoring of data at a portfolio level, rather than separately loading each product based on an individual DUF. If missing data is believed to be missing at random then no adjustment to the Catastrophe Load would be necessary; calculated Pure Premium Rates would be unbiased estimates of the true expected loss ratios and the Catastrophe Load would adequately allow for any aggregate data uncertainty. If it is believed that, across the portfolio, years with bad rainfall are less likely to have been recorded than years with good rainfall then Pure Premium Rates could be biased downwards and the portfolio Catastrophe Load should be increased to reflect this bias. Correspondingly, if it is believed that, across the portfolio, years with bad rainfall are *more* likely to have been recorded than years with good rainfall then Pure Premium Rates could be biased upwards and the portfolio Catastrophe Load should be *decreased* to reflect this.

4.81 Under the proposed ratemaking methodology, AICI could increase loading for administrative expenses from 15% to 30% and still reduce average premium rates. Current weighted average premium rates are Expected Loss x 1.57. Under the proposed ratemaking methodology, and with an increase in administrative expenses from 15% to 30%, the current weighted average premium rate would be Expected Loss x 1.44.

Conclusion

4.82 It is suggested that AICI calculates the loading for risk capital on a portfolio basis, not individual product basis. Loading on an individual basis was appropriate while the WBCIS was small and undiversified. However, it is no longer appropriate now that WBCIS consists of a large geographically diversified portfolio.

4.83 It is suggested that AICI conducts a full portfolio risk analysis at the start of each agricultural year for the estimated portfolio, to feed into management decisions on the Catastrophic Load and reinsurance purchase decisions. The WBCIS risk profile is sensitive to the portfolio composition. This portfolio composition is not yet stable and the calculations in the current section are only appropriate for the WBCIS Kharif 2008 portfolio.

CHAPTER 5: AICI RISK FINANCING UNDER MODIFIED NAIS

CONTEXT

5.1 Government is considering a proposal to move to an actuarial regime under the modified National Agricultural Insurance Scheme (NAIS). Premiums would be charged by AICI on a commercial basis and governments, where necessary, would provide "up-front" contributions for premium subsidies. AICI would receive premium subsidies and be liable for all claims (unlike currently where claims in excess of premiums collected are paid ex-post by state and central governments). This will help reduce the contingent liability of state and central governments, smooth their fiscal contribution over time, and address the issue of delayed indemnity payments to farmers since government contribution would be made up-front. Through actuarially sound premium rates, the risk exposure of every crop can be assessed and governments can determine their premium subsidy contribution ex ante based on the premium rates and estimated outreach, and also use the premium rates for broader agriculture policy signaling.

5.2 A key challenge for AICI would be to secure its claims paying capacity, that is, its ability to quickly pay all valid claims in full, through a cost-effective risk financing strategy. Actuarially based premiums will allow AICI to build up technical reserves (and possibly multi-year equalization reserves) to cover recurrent NAIS losses, while AICI may have to purchase additional capacity on the reinsurance market to cover excess claims. GOI may also act as a re-insurer/lender of last resort to cover catastrophic losses, as is the case in many countries (e.g., USA, Mexico and Spain).

5.3 The World Bank policy note (2010) accompanying this report suggests that in the short term, while the insurability of CCE data is being increased, state government support could be transitioned gradually from ex-post towards up-front premium subsidies. This transition would be completed in the medium term, once the CCE process has been sufficiently enhanced (see Chapter 2). For the sake of illustration, this chapter explicitly considers only the case in which the transition has been completed and AICI is responsible for the entire NAIS risk profile, except for catastrophic losses. However, the principles discussed in this section apply equally to risk financing in the transition period.

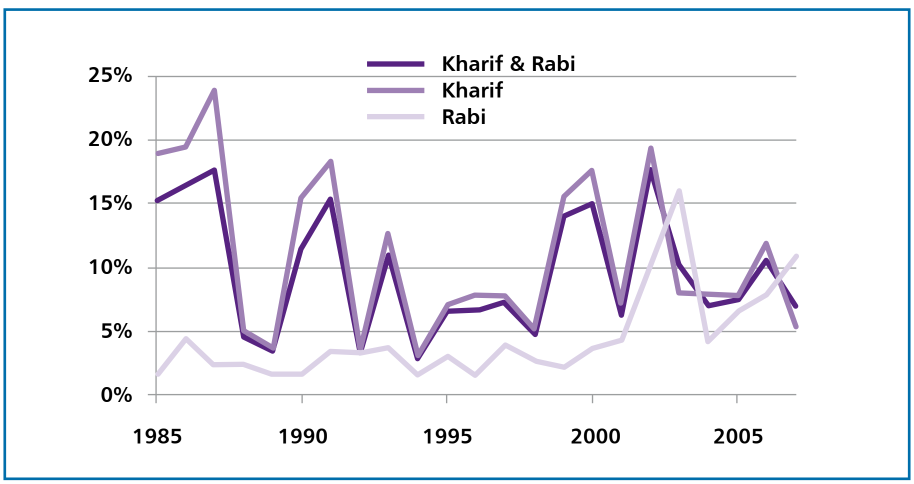
5.4 This chapter presents the key findings of the NAIS portfolio risk assessment and discusses potential risk financing strategies, including reinsurance and contingent debt funding for AICI combined with some funding to address systems and capacity enhancement needs. A contingent debt facility would allow AICI to increase its risk retention within a sound financial framework. Although retention would expose AICI to some portfolio risk, the savings in reinsurance costs would help AICI building up reserves in the medium term.[10]

5.5 A similar approach is also valid for the financing of the AICI weather based crop insurance portfolio. While this section uses the NAIS portfolio as an illustration, the same approach could be used to design a cost-effective risk financing strategy for the AICI weather based crop insurance portfolio.

RISK PROFILE OF THE NAIS PORTFOLIO

5.6 The NAIS portfolio is exposed to major losses. The historic annual loss cost (defined as the annual claims paid divided by the total sum insured) computed for each season (Kharif and Rabi) over the least 23 years indicates that the Kharif season is more risky than the Rabi season. The annual loss cost for Kharif reached almost 25 percent in 1987 (under the former CCIS) and almost 20 percent during the 2002 drought year (see Figure 5.1). The long term average loss cost is estimated at 10.0 percent for Kharif and 7.8 percent for Rabi. The long term weighted average loss cost of both seasons together is 9.5 percent (see Table 5.1). Based on international experience, this loss cost is very high for an area-based crop yield shortfall program and if this program were to operate on a commercial basis, this would translate into minimum commercial premiums in the order of 12.5 percent.

Figure 5.1: Annual Historic Loss Costs (all crops)



10 The World Bank has offered such a contingent facility to several of its client countries, including Turkey, Mongolia, Colombia, Costa Rica and Guatemala.

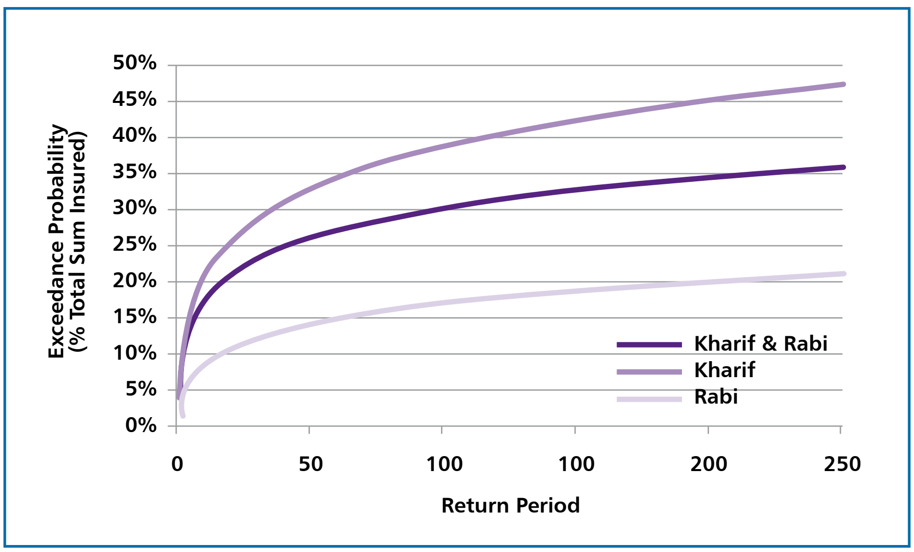
Table 5.1: Loss cost for the NAIS portfolio, by season (1985-2007)

	Kharif	Rabi	Kharif + Rabi
Average loss cost	10.0%	7.8%	9.5%
Standard deviation	6.3%	3.6%	4.9%

Note: Long term weighted average over 23 years.Loss cost = Paid claims/Total sum insured
Source: AICI, 2010.

5.7 The risk profile of the NAIS portfolio is depicted by the loss exceedance curve on Figure 5.2.[11] The Kharif portfolio is much riskier than the Rabi portfolio. For instance, a 1-in-50 year event (50 year return period) is estimated to cause losses of 14 percent of the total sum insured (TSI) during Rabi and 33 percent of TSI during Kharif. A 1-in-100 year disaster (100 year return period) could cause losses on the combined NAIS portfolio of 31 percent of TSI.

Figure 5.2: NAIS portfolio, Loss exceedance curve.



11 The historical loss cost is fitted with a Log-normal distribution, which is widely used by agricultural reinsurers. The implied 1-in-50 or 1-in-100 year disasters are sensitive to the distribution used. Most other distributions commonly used for claims modeling may lead to slightly smaller 1-in-50 or 1-in-100 year losses than those quoted in this note.

5.8 Based on international experience on crop insurance, it would be prudent if AICI could design a risk financing strategy which would allow them to sustain a 1-in-100 year disaster. This corresponds to 31 percent of TSI of the whole NAIS portfolio estimated at US$5.7 billion, i.e., approximately, US$1.8 billion. If AICI were to charge actuarially based insurance premiums (averaged at 12.4 percent), its annual premium income would be US$707 million (including public premium subsidies).

INSURANCE PORTFOLIO RISK FINANCING

5.9 A cost-effective risk financing strategy combines self-retention, reinsurance and contingent debt. Financing could involve quota-share (QS) reinsurance with the residual risk capital requirements structured into layers, where each layer is financed by retention or risk transfer. The bottom layer, characterized by high probability/low severity events, could be financed through reserves, the next layer could be funded through a contingent loan, and other layers could be financed through risk transfer (Excess of Loss reinsurance and/or insurance linked securities such as cat bonds).

5.10 Figure 5.3 illustrates a hypothetical catastrophic risk financing strategy. It is assumed that a 20 percent quota share is ceded to the reinsurance market (10 percent to GIC on a compulsory basis and 10 percent on a voluntary basis) and the remaining 80 percent is structured as follows. AICI would retain the first losses up to 12.4 percent TSI (i.e., 100 percent loss ratio assuming a 30 percent loading factor). The contingent loan could cover losses up to US$176 million in excess of US$706 million.[12] A first stop loss reinsurance protection could be purchased for losses up to US$388 million in excess of US$882 million. A second stop loss reinsurance could be purchased for loss up to US$141 million in excess of US$1,270 million. Finally, a third stop loss reinsurance could cover losses up to US$324 million in excess US$1,411 million. Under this risk financing strategy, AICI would finance their claims paying capacity of US$1.7 billion through their own reserves (US$564 million), proportional reinsurance (US$347 million), non-proportional reinsurance (US$682 million) and contingent credit (US$141 million).

12 Principles of actuarial risk management suggest that AICI might wish to leverage the contingent debt facility for both medium-term and short-term self-insurance. Following such a strategy, AICI would acquire more than US$141 million of contingent debt, but only draw down a maximum of US$141 million in any one year. Contingent debt would then fulfill the purpose of both technical and multi-year equalization reserve; it would be triggered in the event of abnormally high claims and insufficient reserves, but the maximum loan would be triggered only in the event of multiple years with abnormally high claims.

Figure 5.3: Hypothetical NAIS risk financing strategy

Return Period (years)	Layer Excess Point (US$ m)	Loss Cost	Loss Ratio	Layer Limit (US$ m)		Layer	Annual Expected Loss (US$ m)	Probability of First Loss	Loss-on-line	Indicative rate-on-line	Indicative cost (US$ m)	Indicative Multiple
107	1,735	30.5%	245.9%									
					259	5	4.01	2%	1.5%	3.9%	10	2.5
41	1,411	24.8%	200%									
					113	4	3.42	4%	3.0%	6.1%	7	2.0
				Quota share								
27	1,270	22.3%	180%									
					310	3	23.28	13%	7.5%	11.2%	35	1.5
				20%								
8	882	15.5%	125%									
				347	141	2	25.67	24%	18.2%	25.5%	36	1.4
4	706	12.4%	100%									
					564	1	387.46	100%	68.6%	82.4%	465	1.2

5.11 Contingent debt is an alternative risk transfer instrument. It allows the buyer to secure access to credit when it is the most needed. Contingent debt can efficiently finance frequent losses in the working layer where reinsurance is expensive, thus allowing the buyer to build up reserves quickly and retain more premium in the country. A financial model was developed to assess the expected annualized cost of a contingent credit and compare it with the cost of reinsurance. See Box 5.1.

5.12 A contingent loan facility is estimated to be at least 20 percent less expensive than stop loss reinsurance.[13] Under realistic but conservative assumptions, the overall expected cost of a contingent debt is estimated at 1.2 times the loan amount. In insurance terms, this means that the implicit multiple of the contingent debt (i.e., the ratio between the expected Net Present Value (NPV) and the loan amount) is 1.2. Based on reinsurance market practice, the multiple for excess of loss reinsurance is estimated to be at least equal to 1.4. This means that a contingent loan is at least 20 percent less expensive than reinsurance. Note that some assumptions, like the

13 For illustration purposes, the terms and conditions (interest rates, grace period, duration, front end fee, etc.) used in this example are broadly based on those of the World Bank contingent loan (e.g., DPL with CAT DDO).

discount rate, are very conservative. A higher discount rate would further reduce the cost of a contingent loan, while leaving the cost of reinsurance unchanged.

5.13 A contingent loan is less expensive than quota share reinsurance. Assuming a 40 percent loading factor in the insurance premiums and a 15 percent reinsurance commission, it can be shown that the implicit multiple is still higher than the multiple of the contingent loan.

Box 5.1: Annualized cost of contingent debt

The annualized cost of a loan is calculated under the following assumptions

- Final maturity: 30 years
- Grace period (on principal repayment): 5 years
- Front end fee: 0.5% of total loan volume
- Renewal fee: 0.25% of total loan volume, payable at the end of every three years
- No commitment fee
- Interest rate: 6 month LIBOR plus 0.5% markup. Average interest rate = 5.5%
- Discount factor (annualized): 4.50%

The net present value (NPV) of a loan is computed based on these assumptions. The cost of contingent capital is defined as the net present value of the loan to be borrowed to cover the annual expected loss.

Box 5.2. Illustrations of World Bank DPL with CAT DDO

The Development Policy Loan (DPL) with Catastrophe Risk Deferred Drawdown Option, DPL with CAT DDO, is a development policy loan that offers IBRD-eligible countries immediate liquidity up to USD$500 million or 0.25 percent of GDP (whichever is less) if they suffer a natural disaster (OP/BP 8.60). The instrument was designed to provide affected countries with bridge financing while other sources of funding are being mobilized. Eligible borrowers must have an adequate macroeconomic framework in place at inception of the program, and a disaster risk management program that is monitored by the World Bank.

The DPL with CAT DDO has the same lending base rate as regular IBRD loans, making it an extremely competitive risk financing instrument. The front-end-fee, payable upon effectiveness, is 0.5% and there is no commitment fee. The draw down period is for three years, renewable up to four times (with a renewal fee of 0.25%). Repayment terms may be determined either upon commitment, or upon drawdown within prevailing maturity policy limits. Repayment schedule would commence from date of drawdown.

The first DPL with CAT DDO was approved in September 2008 by the World Bank's Board of Executive Directors. The US$65 million contingent loan to aims the Government of Costa Rica aims to enhance its capacity to "implement a Disaster Risk Management Program for natural disasters." This program is described in the loan document and agreed upon before signing. Following the 6.2 magnitude earthquake that hit Costa Rica on January 8, 2009, the Government of Costa drew down approximately US$15 million. DPLs with CAT DDO have since been negotiated with Colombia and Guatemala and are currently under preparation in various other countries.

Source: World Bank Catastrophe Risk Insurance Working Group (2009)

CHAPTER 6: FISCAL IMPLICATIONS OF MODIFIED NAIS

6.1 A comprehensive NAIS portfolio model (including crop, states and farmer types) has been developed. This model allows for the analysis of the economic and fiscal impact of various scenarios, such as the level of penetration and the government-sponsored crop insurance subsidy program. This chapter describes the key features of this model and discusses some selected scenarios. They should be seen as illustrations, as the model allows for many more scenarios to be analyzed.

6.2 Most agricultural insurance programs have some forms of public support, usually in the form of upfront premium subsidies. The World Bank survey of 65 countries shows that the (upfront) cost of premium subsidies is about 44 percent of the original gross premium; including operating and claims subsidies, the total cost to governments of providing agricultural insurance is estimated to be as high as 68 percent of the original gross premium (Mahul and Stutley 2010). Other forms of public support, such as data collection and management, research and development, and legal and regulatory framework, can also greatly contribute to the sustainable development of agricultural insurance.

MOVING FROM POST-DISASTER FINANCING TO EX ANTE FINANCING

6.3 The existing subsidy structure, primarily in the form of ex post disaster financing, leads to an open ended fiscal exposure for Central and State Governments with high variability in annual payments (see Table 6.1) and delay in claims settlement.

Table 6.1: Risk profile of existing subsidy structure by state, based on 2006-7 NAIS portfolio

State	Premium income from farmers (Rs. Crore)	Total combined subsidy required by central and respective state government (Rs. Crore)			
		Average	1 in 10 year event	1 in 20 year event	1 in 30 year event
Gujarat	80	405	1,766	2,188	2,188
Andhra Pradesh	112	290	1,079	1,824	2,393
Bihar	23	233	495	672	790
Rajasthan	68	186	736	1,229	1,604
Karnataka	43	193	510	783	980
Madhya Pradesh	69	147	489	811	1,052
Uttar Pradesh	53	97	194	244	275
Maharashtra	37	84	192	256	296
Orissa	30	80	210	357	470
West Bengal	23	71	214	358	468
Tamil Nadu	10	82	282	477	516
Chattisgarh	16	49	137	469	631
Jharkhand	7	27	111	232	290
All states	577	2,134	3.149	3,632	3.912

Notes: All figures are based on the 2006-7 NAIS portfolio.
Total subsidy includes ex ante premium subsidy and claims liability.
'All states' includes states not listed in the table.
State and Aggregate losses are each assumed to follow a LogNormal distribution, with coefficients estimated from NAIS experience between Kharif 2000 and Rabi 2007-8. This leads to conservative loss estimates of extreme events (one in 20 years and above).
Administrative load is assumed to be 30% of the expected loss

6.4 Under the proposed modified NAIS, insured losses would be financed under an "actuarial regime" in which central and state government's financial liabilities would be predominantly in the form of ex ante premium subsidies, and AICI would be responsible for managing the risk portfolio. In the extreme case in which the entire financial support from government was in the form of ex-ante premium subsidies, the liability of the government would not be subject to any risk. This liability would be equal to the average total subsidies (third column of Table 6.1), with a load to allow for the additional expense of placing risk on private capital markets.

6.5 Due to the high cost of reinsurance for extreme events, the government may want to act as the reinsurer of last resort, offering coverage for extreme excess losses caused by, for example, 1-in-50 year events. In most years government liability would be fixed but in the event of extreme losses being incurred by NAIS, government liability would be higher. Such a public-private catastrophe risk financing arrangement is standard in many developed and developing countries (e.g., USA, Mexico, Spain).

6.6 Social benefits that cannot be actuarially priced due to a lack of data, such as additional benefits due to a reduction in IU size, could be funded by government under an ex post subsidy structure.

A CROP-BLIND SUBSIDY STRUCTURE

6.7 Using the NAIS portfolio model developed under this NLTA, it is possible to estimate the cost structure of alternative subsidy programs under an actuarial regime (see Box 6.1 and Table 6.2). For example, if one were to assume a shift from the current NAIS to a regime where small and marginal farmers pay 10% of the commercial premium (that is, 90 percent upfront subsidy) and other farmers pay 25% of the commercial premium (that is, 75 percent upfront subsidy), this would lead to (i) a decrease of the gross premium income by 14 percent (ii) an increase of public (from both central and state governments) subsidies by 4 percent. Note that that a move to an actuarial regime can be budget-neutral for GoI, as shown by Scenarios 5 and 6. Scenario 6 has been designed so that both the total subsidy for GoI and the split of the subsidy into small/marginal and other farmers are unchanged. Such a scheme would offer the same upfront premium subsidy of 21 percent to small/marginal farmers. This confirms the observation displayed in Figure 1.3 that the average loss cost for small and marginal farmers has been a little lower than that for other farmers between 2000 and 2007. Combined with the premium subsidies for small and marginal farmers, the total realized subsidy has been approximately the same for small and marginal farmers as for other farmers.

Box 6.1: Hypothetical Scenarios of Public Support under ***mNAIS***

Scenario 1:

- S/M farmers receive 10% premium subsidy
- AIC maximum liability is 100% times Premiums in respect of FCOS and 150% times Premiums in respect of ACH;
- Total subsidy has been estimated as (historic loss cost x sum insured x loading factor of 1.3) - estimated premium income from farmers.
- States and GOI pay 50%-50% of the excess losses

Scenarios 2 to 6:

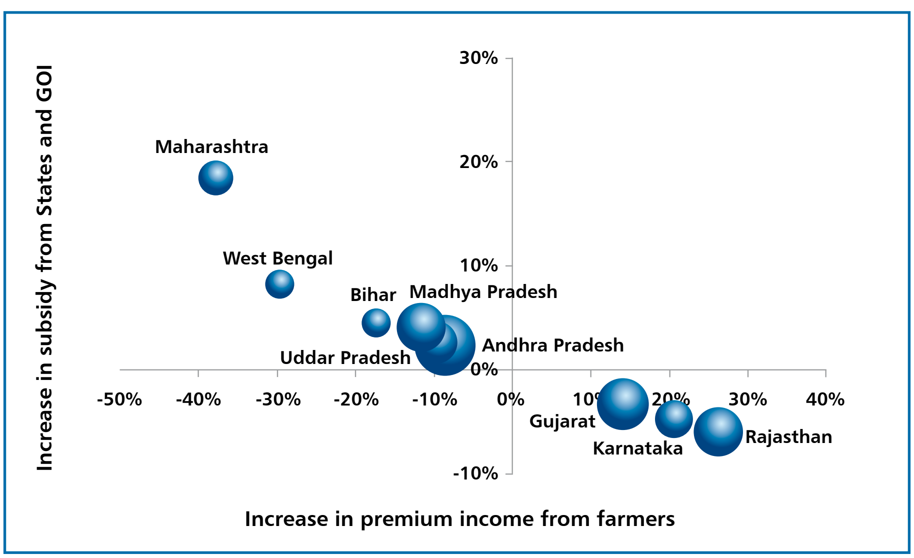
- Farmer contributions expressed as percentage of total cost of cover
- GOI and States split the premium not covered by farmers according to the given ratios, for all crops (FCOS and ACH);
- Administrative loading on premiums: 30%

Table 6.2: Comparison of budgetary impact under different regimes, 2006-7 NAIS Portfolio

Scenario	S/M farmer contribution	Other farmer contribution	Ratio of subsidy GOI:States	Estimated premium income from farmers (Rs. Crore)	Estimated average subsidy from GOI (Rs. Crore)	Estimated average subsidy from states (Rs. Crore)
1		Existing regime		577	1,067	1,067
2	10%	25%	2:1	496	1,477	739
3	10%	25%	1:1	496	1,108	1,108
4	15%	25%	1:1	557	1,078	1,078
5	10%	30%	1:1	572	1,070	1,070
6	21%	21%	1:1	570	1,071	1,071

6.8 Were NAIS to move to a budget-neutral crop-blind premium subsidy structure with the same premium subsidy for all farmers (Scenario 6), the structure of subsidies split by state would not change considerably. However, were NAIS to move to a budget-neutral crop-blind premium subsidy structure with higher premium subsidies for small and marginal farmers, the GOI subsidy to Rajasthan, Karnataka and Gujarat would decrease and the subsidy to other states would increase (Figure 6.1). This is because Rajasthan, Gujarat and Karnataka all have relatively low proportions of small and marginal farmers, and therefore would receive lower subsidies relative to under the current scenario. The difference in subsidy between scenarios 1 and 4 is modeled using the assumptions of Box 6.1.

Figure 6.1: Illustrative budgetary effect of change in subsidy structure from existing regime (Scenario 1) to crop-blind scenario 4



Note: Bubble area is proportional to total NAIS Sum Insured in that state in the 2006-07 agricultural year.

NAIS PORTFOLIO UNDER UNIVERSALISATION

6.9 *Universalisation* means a significant increase in NAIS penetration rates. This consists of both an increase in the level of overall penetration and a rebalancing, so that penetration rates are increased to a greater degree for crops in states where current penetration is low than when current penetration is high.

Composition of Portfolio under Universalisation

6.10 The first step of estimating the possible effects of universalisation is to estimate what the Sum Insured for each crop in each state would be under universalisation. We estimate the effect of universalisation on the 2006-7 NAIS portfolio. Three alternative assumptions are considered that could be made to estimate the Sum Insured under universalisation for a particular crop in a particular state:

A. Estimated total production value in Quintals x MSP/MP in Rs/Quintals[14];

B. Estimated total production cost in Quintals x MSP/MP in Rs/Quintals;

C. Current Sum Insured x Total Area Sown / Current Area Insured.

6.11 Estimates of the Sums Insured under full Universalisation, split by State and Crop are given in Annex H. For Assumption B the total production cost is estimated to be 70% of the total production value for every crop in every state. This is a strong assumption, but it is difficult to come up with an objective measure of the ratio of production cost to production value for each crop. Data from the GOI Department of Agriculture and Cooperation are used for estimates of Total Area Sown. All other data was provided by AICI.

6.12 Assumptions A, B and C imply that under full *universalisation*, the Total Sum Insured by AICI would increase by a factor of 18, 13 and 6, respectively. Assumption A presumes that every farmer in India will insure their entire production value. This is implausible, particularly considering that NAIS is designed to insure only production costs. Assumption B relies heavily on an assumption that the ratio of production cost to production value is 70% for all crops in all states. Data is not available to be able to accurately assess whether this is a reasonable assumption. Assumption C is equivalent to assuming that as the number of insured farmers increases, the sum insured per acre remains constant for each crop in each state.

6.13 Universalisation Assumption C is considered to be the most appropriate for quantifying the effects of a significant increase in penetration rates. For the remainder of this section, Assumption C is adopted when estimating the Sum Insured under universalisation. Moreover,

14 MSP: Minimum Support Price; MP: Minimum Price.

in all the figures that follow 100% universalisation is assumed; that is to say it is assumed that the area insured under universalisation equals Current Sum Insured x 100% of Total Area Sown / Current Area Insured

6.14 The estimated effect of Universalisation on the composition of the NAIS portfolio is displayed in Figures 6.2 and 6.3. Currently Andhra Pradesh and Paddy have high NAIS insurance penetration. Under universalisation they would account for a reduced proportion of the total portfolio, with Uttar Pradesh, Maharashtra, Sugarcane and Groundnut accounting for an increased proportion of the NAIS portfolio.

Figure 6.2: Proportion of Total Sum Insured by Crop before and after Universalisation

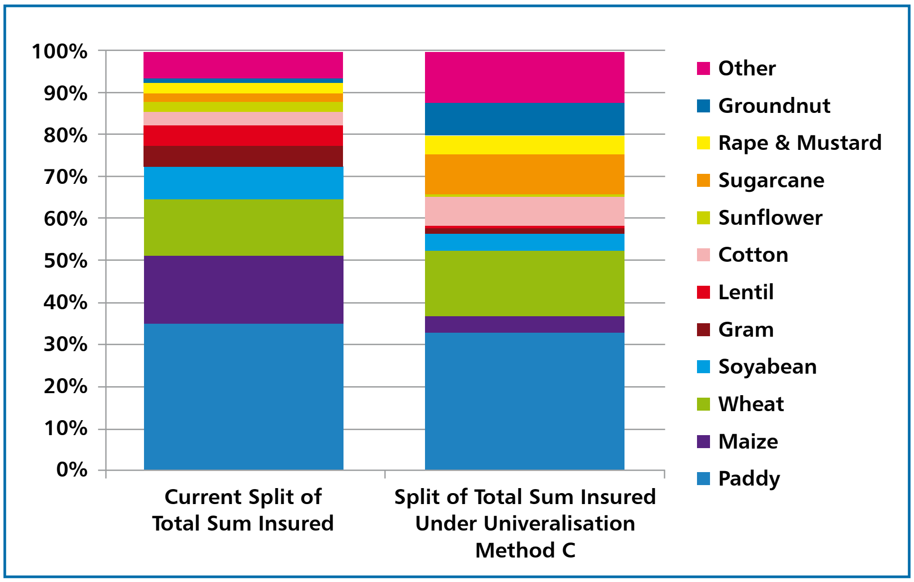
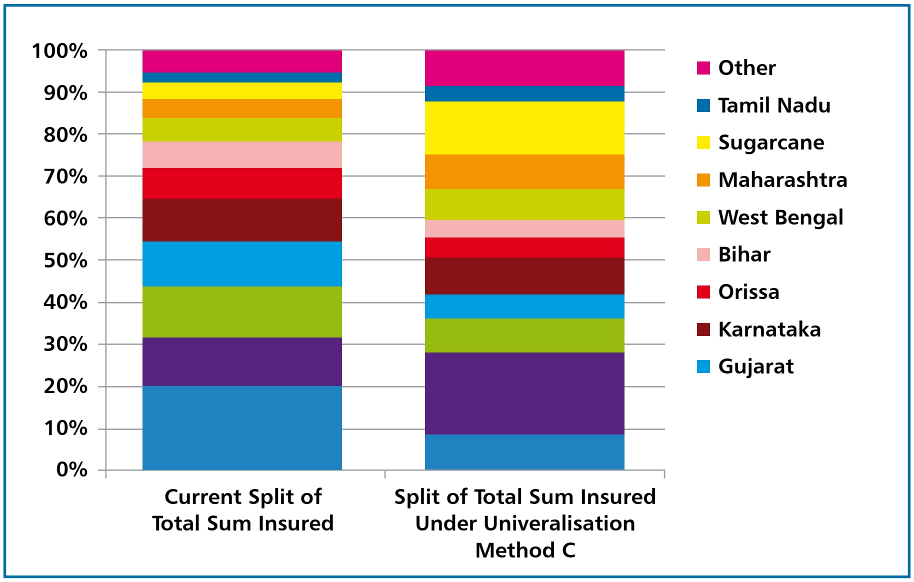


Figure 6.3: Proportion of Total Sum Insured by State before and after Universalisation



6.15 It is further assumed that the proportion of Sum Insured attributable to small and marginal farmers remains the same under universalisation for each crop and each state (see Annex H). As the sum insured for a particular crop in a particular state increases, it is implicitly assumed that the Sum Insured attributable to small and marginal farmers increases at the same rate as the total Sum Insured.

6.16 The loss cost might be expected to reduce under universalisation, as a result of no adverse selection and high risk diversification. However, the magnitude of this effect is uncertain and difficult to quantify. In the extreme case with 100% insurance coverage, there is no adverse selection. In the extreme case with 1% insurance coverage, insurance purchase is likely to be in Insurance Units (IUs) where rates are perceived to be good value. This may cause adverse selection. As a conservative assumption, it is assumed that there is no decrease in the portfolio loss cost following an increased take-up.

Analysis of the fiscal impact of universalisation

6.17 Under the current NAIS, full universalisation would increase the premium income from 577 Rs. Crore to 3,990 Rs. Crore (US$130 million to US$899 million), and the average total subsidy from Central and State Governments from 2,134 Rs. Crore to 12,032 Rs. Crore (US$0.5 to US$2.7 billion). These figures are based on an estimate for the total sum insured under universalisation, calculated using Universalisation Assumption C (see Annex H) and use loss cost estimates for each crop derived from NAIS experience between Kharif 2000 and Rabi 2007-8.

CHAPTER 7: CONCLUSIONS AND SUGGESTIONS

7.1 GOI is transitioning the NAIS into modified NAIS (*mNAIS*) under an actuarial regime on a pilot basis from Rabi 2010-11. This report has offered a number of specific implementable technical recommendations for *mNAIS*. A detailed summary of the recommendations in this report and World Bank (2007a) has been compiled as Table B.1 in Annex B, alongside the corresponding Joint Group recommendations.

7.2 In the medium term, enhancing the crop yield estimation process is essential for the sustainability of the agricultural insurance in India. While in the short term risks of inaccurate computation of yields can be controlled through making state governments pay the area yield "correction factor" claims, in the medium term there is a need to address CCE quality through other achievable measures. Considering the heavy involvement of the agricultural and revenue departments in the CCE process it might be prudent in the short term to involve personnel from these departments in the development of specialist loss adjustment training. It may also be useful to review experience from loss adjusters in Canada, the U.S., or Mexico.

7.3 Both the double index products and the suggested approach to product design and ratemaking suggested in this report are more complex than either the existing NAIS or the existing WBCIS. It is suggested that during the pilot of *mNAIS*, AICI invests time in developing specialized software that implements the suggested actuarial methodology in a robust and efficient sense. With standardized products for each crop, it should be possible to create one design and ratemaking model for each crop, which draws on raw weather and area yield data to jointly design and rate all products for that crop. During the course of this NLTA the World Bank has provided illustrative models, with prototype software coded in MS Excel, that implement the suggested methodology, and AICI has developed their own internal versions of two of these models (de-trending and experience based approach to ratemaking). It is suggested that AICI continue to develop their capacity to perform appropriate actuarial calculations in a robust way.

7.4 In parallel with a move to an actuarial regime, AICI would need to increase its institutional capacity and devise a cost-effective risk financing strategy. Under the modified NAIS, crop yield losses would be borne by AICI. The company should devise a cost-effective risk financing strategy, relying on an optimal combination of reserves, contingent credit and reinsurance. A contingent credit would allow AICI to build up additional reserves quickly to increase its retention capacity and retain more premium volume within the country, while transferring excess risk to the reinsurance market when it is most efficient. Contingent debt has proved to be a useful instrument for financing catastrophe loss exposures, particularly in the first years of operations, when rapid build-up of surplus is required. The contingent loan facility could help AICI to deal effectively with the over-dependence on reinsurance and with the fluctuations and cycles of the reinsurance market. Contingent credit could supplement AICI reserves for the financing of the working layer, i.e., the financing of recurrent claims with a return period of less than 10 years, where reinsurance is very expensive (because the expected loss is high). It could also finance the upper layer, i.e., very infrequent but catastrophic losses, where reinsurance is also expensive (because the catastrophe load is high).

7.5 This report suggests a combination of weather and area-yield index as an optimal solution for crop insurance in India, as opposed to a solution that uses either only area yield insurance or only weather indexed insurance. One way to do this is to develop NAIS into a modified NAIS.[15]

7.6 Under *mNAIS*, weather based crop insurance payouts would be "corrected" by an end-of-season correction factor based on the area-yield index (as estimated by the crop cutting experiments), with intermediate payments being made based on a weather index. The correction factor could take several forms. For example, an area yield index payout could be offset against any weather index payout already made, or there could be no offsetting. Subsidies for the weather based cover could be made upfront but state government subsidies for the area-yield based cover could remain entirely ex-post.

7.7 Given the technical and operational challenges associated with the implementation of either the *mNAIS*, it is suggested that implementation begins with a pilot in selected states. This would also allow AICI to strengthen its technical and operational capacity. Table 7.1 presents a suggested action plan for *mNAIS*, incorporating many of the technical suggestions in this report. It describes the action steps including those pertaining to improvements in product design, refinement including differentiating risk between farmers and states and allowing greater choice to states, and bringing in the private sector.

15 The possible other way would be to add an area yield indexed element to the WBCIS to create an enhanced WBCIS (eWBCIS). Were the implementation of *mNAIS* to be delayed for any reason, it would be still be possible to pilot many of the ideas underlying *mNAIS* through and eWBCIS.

Table 7.1: Summary of all short and medium term suggested actions under modified NAIS (***mNAIS***)[16]

Type of actions		Short term actions (less than 1 year)	Medium term actions (1 to 5 years)
Summary		Announce and implement *mNAIS* on a pilot basis (selected state or states)	Expand *mNAIS* to all states, factoring any lessons from pilot.
1. Financing	State and Central Government subsidy structure	Central and state governments to fund ex ante premium subsidies and could provide catastrophic Stop Loss reinsurance coverage (selected states). State governments to be partially responsible for area yield index payments.	Expand to all states. Transition to full ex-ante subsidies from state governments.
	AICI risk financing strategy	AICI to conduct portfolio risk analysis for its portfolio in advance of each season. AICI to develop and introduce a risk financing strategy for its portfolio, exploring options such as reinsurance and contingent/ direct credit.	
2. Quality of CCEs	Standardization	Develop a draft national NAIS CCE procedures manual, with additional technical assistance.	
		Standardize CCE process (selected states)	Expand to all states.
	Personnel and training	Develop standardized training for loss adjusters, certified to conduct or supervise insurance CCEs (selected states)	Expand to all states.
	Monitoring and auditing	Commission randomized, independent, high quality CCE audits to be conducted alongside the standard CCEs (selected states).	Expand to all states.
		Investigate the potential for remote sensing technologies (e.g. satellites) for monitoring CCE reports (selected states). Investigate the potential of video recording to mitigate the potential for manipulation of CCE reports (selected states).	Expand to all states.

16 A similar set of actions could be used if *eWBCIS* were to be implemented instead of or in addition to *mNAIS*.

2. Quality of CCEs	Speed of reporting	Primary Workers to be required to share raw yield data with AICI by mobile phone immediately after an NAIS CCE has been conducted. Full paperwork to follow later. (selected states)	Expand to all states.
	Statistical treatment of raw CCE data	Review and standardize the process for calculating the Actual Yield for an Insurance Unit from the raw yields for each CCE conducted within the Insurance Unit.	
	Assess the quality of CCEs	Acquire historic raw yield data from individual NAIS CCEs conducted in the state to assess whether more CCEs should be conducted and whether Insurance Unit sizes should be decreased (selected states).	
3. Delays in claims settlements	Timeliness of CCE reports	State Governments release CCE reports to AICI earlier (all states).	
	Double trigger policies with early weather-based payment	Introduce early part claim based on weather index into *mNAIS* such that either: The weather index payment is offset against any final area yield payment The weather index payment is not offset against any final area yield payment	GoI provides market infrastructure support (e.g., weather stations)
	Timeliness of claim settlement	Upfront premium subsidies by Central and State Governments (in selected states).	
4. Actuarial risk classification	Yield histories	All area yield calculations to be based on 10 year yield history (in selected states)	Expand to all states.
	Yield de-trending	Robust yield de-trending methodology to be applied for all crops with a statistically significant trend in yields or weather (in all states). [Already piloted in selected states for selected crops.]	
	Premium Rates	Premium rates paid by farmers and subsidy rates paid by Central and State Governments to be set by Central and State Governments (in selected states).	Expand to all states.
	Threshold Yields	Experience-Based Approach to designing products to be operationalized and streamlined (in selected states)	Expand to all states.

5. Basis risk	Reducing size of Insurance Unit	Could be introduced as a social benefit with the objective of commercial viability when data is available for actuarial pricing.	
6. Adverse selection	Sales cut-off dates	Move back cut-off dates (could consider premium discount for early purchase)	
7. Incomplete benefits	Coverage for prevention of sowing, replanting, post harvest losses and localized risks		Could be introduced as a social benefit since data for actuarial pricing does not currently exist.
8. Private sector involvement	Open aspects of *mNAIS* to private sector	AICI to investigate the purchase of reinsurance for the weather and area yield based elements of *mNAIS*.	Encourage private sector participation in risk capital provision, product delivery and innovative product design.
9. Institutional capacity building	Develop capacity for actuarial calculations	Develop a set of spreadsheets, one for each crop, which jointly design and rate all *mNAIS* products for that crop. These tools should be designed to be efficient to use, easy to check and scrutinize by other members of the team, and clearly documented.	

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GLOSSARY

Actual yield	Estimate of the realized average crop yield in an Insurance Unit
Actuarially pure premium rate	Premium rate worked out considering the frequency and severity of past events.
Adverse selection	Selective participation observed under voluntary crop insurance program: increasing participation when insurance is considered to be particularly good value and decreasing participation when insurance is considered to be less good value. Selection can occur over seasons or between insurance units.
Annual crop	A crop that generally has a life cycle up to one year.
Area yield based insurance	Insurance scheme under which insurance payments are based on an area yield estimate determined by harvest production measurements taken at a series of randomly chosen Crop Cutting Experiments locations
Basis risk	The risk that the claim payment from an insurance contract does not match the loss incurred by a policyholder. In the case of area yield based insurance, it may be considered to be the risk that the yield loss observed in the insurance unit does not exactly match an individual's loss experience and may be decomposed into the indexation error, the sampling error and the non-sampling error.
Block/mandal	Administrative sub-division of the district, which in turn is a sub-division of the state.
Claim ratio	Claims expressed as percentage of premiums collected.
Crop Cutting Experiment (CCE)	Process by which the crop yield in a plot is estimated from a dried and threshed sample of harvested crop.
Government	Unless otherwise specified, government refers to the combination of Central and State Governments.
Guaranteed yield	See Threshold yield.
Indemnity level	Limits, in percentage, applied on probable yield to produce threshold yield. Indemnity Levels available under NAIS are 60%, 80% and 90%.
Indexation error	An element of basis risk, equal to the difference between a policyholder's yield and the average yield in the Insurance Unit.
Insurance unit	Administrative level (e.g., Block, Tehsil) where the crop yields are estimated through the crop cutting experiment process.

Loaded premium rate	Actuarially pure premium rate loaded for administrative costs, profit and contingency.
Loss adjuster	A representative of the insurer or an independent person employed by the insurer to assess and determine the extent of the insurer's liability for loss or damage claimed by the insurer.
Loss cost	Claims expressed as percentage of sum insured.
Loss ratio	Claims expressed as a percentage of premium income.
Moral hazard	Under area yield insurance, moral hazard occurs when plot selection, behavior of owners of plots for which a CCE is to be conducted, or CCE reports are altered so as to increase the potential likelihood or magnitude of a loss.
Non-sampling error	An element of basis risk, equal to the difference between the true and the measured average yield of those plots selected for CCEs.
Probable yield	Moving average of seasonal area yields.
Primary Worker	Village-level department official entrusted with the operational work of CCEs
Sum insured	Amount of risk coverage on which the premium is paid. It is also the maximum value of the claim.
Sampling error	An element of basis risk, equal to the difference between the average yield of those plots selected for CCEs and the average yield of all plots in the IU.
Threshold yield	Probable yield multiplied by indemnity level.

ANNEX A: GRAPHICAL OVERVIEW OF THE HISTORY OF THE NAIS PORTFOLIO

Figure A.1: Average premium by farmer type, 2000-2008

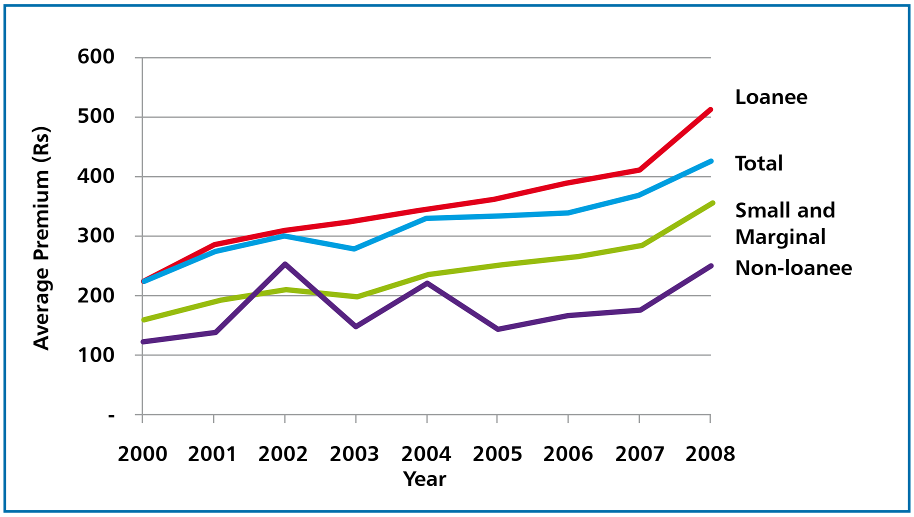


Figure A.2: Average area insured by farmer type, 2000-2008

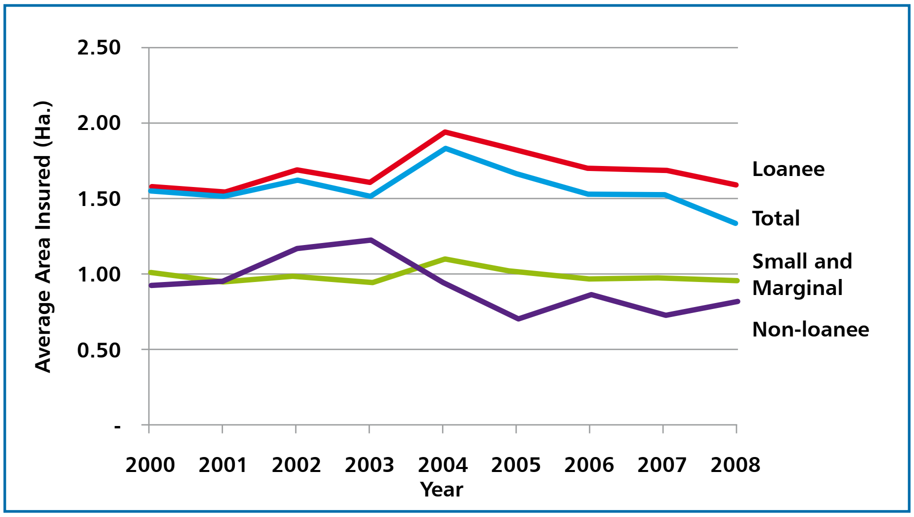


Figure A.3: NAIS premium volumes by State, 2000-2008

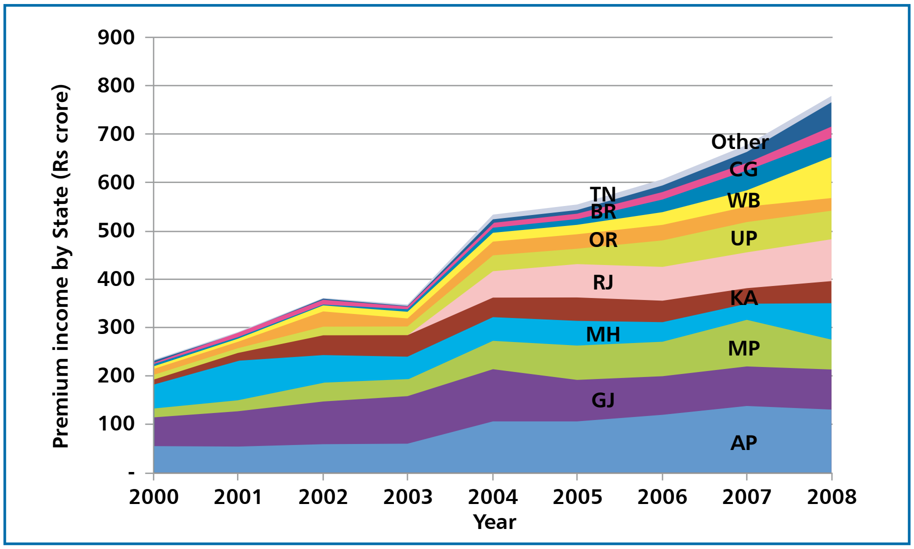


Figure A.4: NAIS premium composition by State, 2000-2008

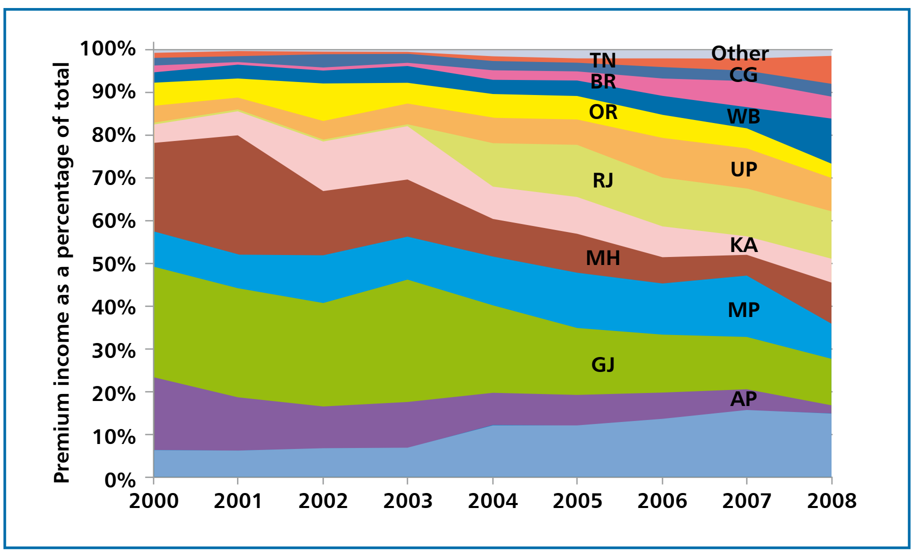


Figure A.5: NAIS premium composition by crop, 2000-2008

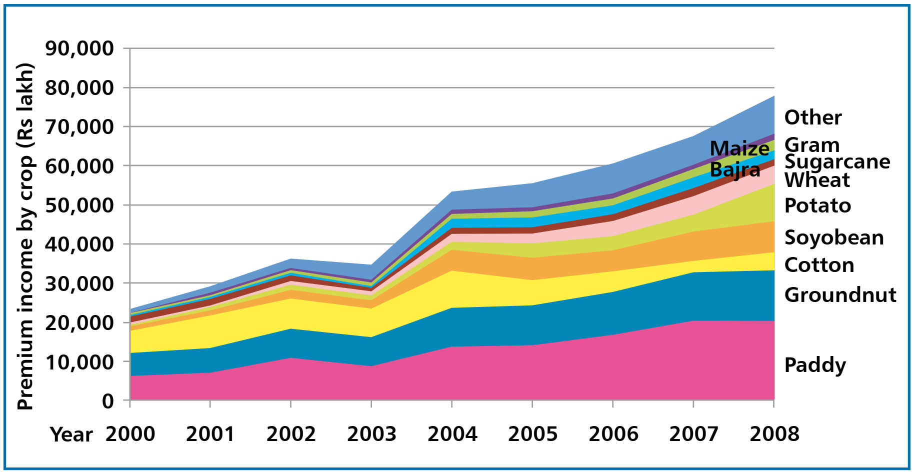


Figure A.6: NAIS claim payment history, 2000-2007

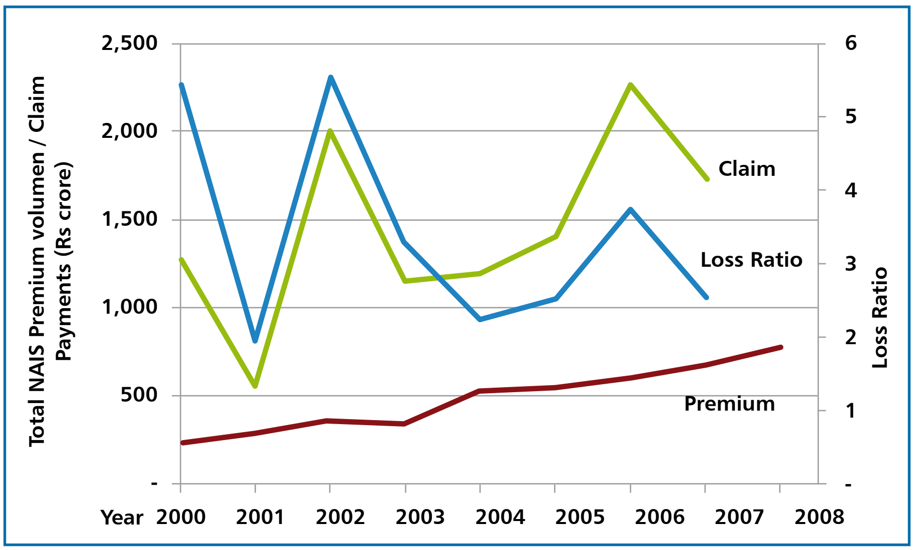
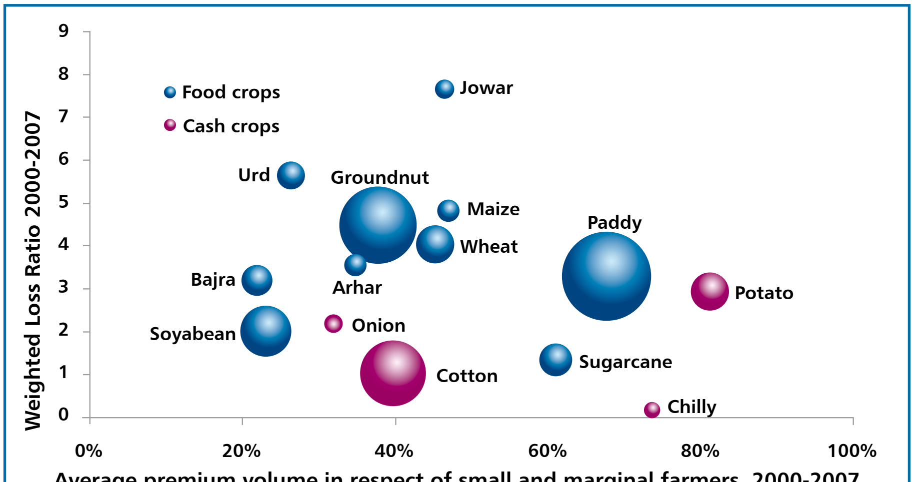
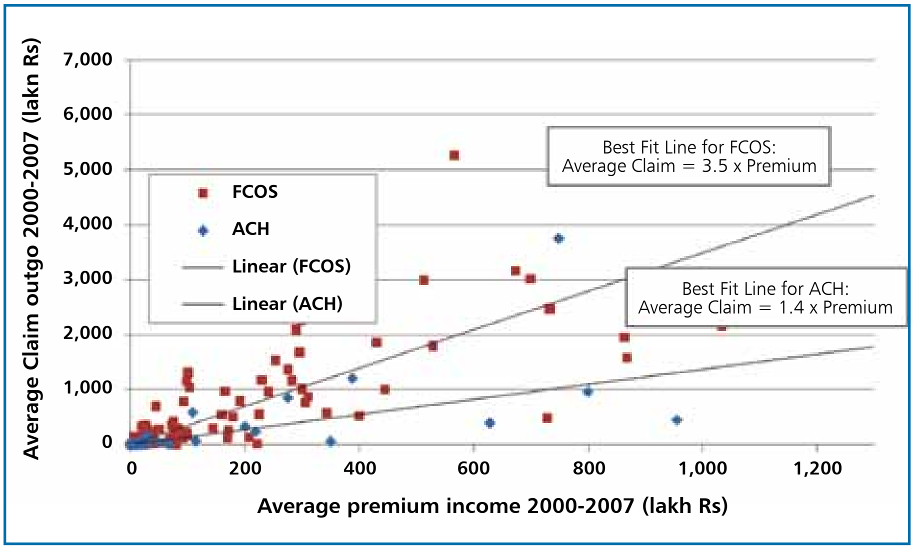


Figure A.7: Loss Ratio for major crops, 2000-2007



Note: Bubble area is proportional to average premium volume for crop, 2000-2007

Figure A.8: Average Premium Income and Claim Outgo for each Crop and State, 2000-2007



ANNEX B: SUMMARY OF MAIN PROPOSED MODIFICATIONS TO NAIS

Table B.1: Summary of main proposed modifications to NAIS

Key Issue	Proposed Modification by Joint Group (2004)	World Bank Suggestions
1. Financing Ex post subsidy structure leads to open ended fiscal exposure, high variability in annual payments and delay in claims settlement	The NAIS scheme would be put on an "actuarial regime" in which government's financial liability would be restricted to premium subsidies and government would no longer pay for excess losses. The rates paid by farmers would be capped at 8%. The premium subsidy paid by government would range from 40% to a maximum of 75% of the full premium rate. It is also suggested that the lending banks would bear 1% of the crop insurance premium costs. This measure is aimed at inducing financial discipline and proper budgeting for the government (it is much easier for government to budget premium subsidies than it is to estimate expected claims in any season) and professionalism and accountability on behalf of the insurer.	The NAIS scheme would be put on an "actuarial regime" in which government's financial liability would be predominantly in the form of ex ante premium subsidies. Social benefits, such as a reduction in Insurance Unit size could be funded by government under an ex post subsidy structure, and extreme excess losses caused by 1-in-100 year events could be covered by government. Both the ex ante premium subsidy paid by government and premium rates paid by farmers could be set by government for each crop. For example, premium rates and subsidies could be set at 8% and 4%, respectively, for all crops, or rates and subsidies could vary by crop. Threshold Yields for each product could then be determined under a statistically robust Experience-Based Approach, so that the actuarial premium rate for each product is equal to the premium rate from farmers plus the premium subsidy from government. In the short term, while the insurability of CCE data is being increased, one option would be for state governments to be partially or fully responsible for the final area yield index-based claim payment. For example, state governments could be responsible for paying a proportion of such claims, or the excess of claims above a threshold. To keep the program broadly budget neutral this would imply that the ex-ante state government premium subsidy would be relatively lower than the central government's, to allow for the additional expected ex-post element of the state government subsidy. State government subsidies could transition from mixed ex-ante/ ex-post to fully ex-ante over the short to medium term, as the CCE process was enhanced.

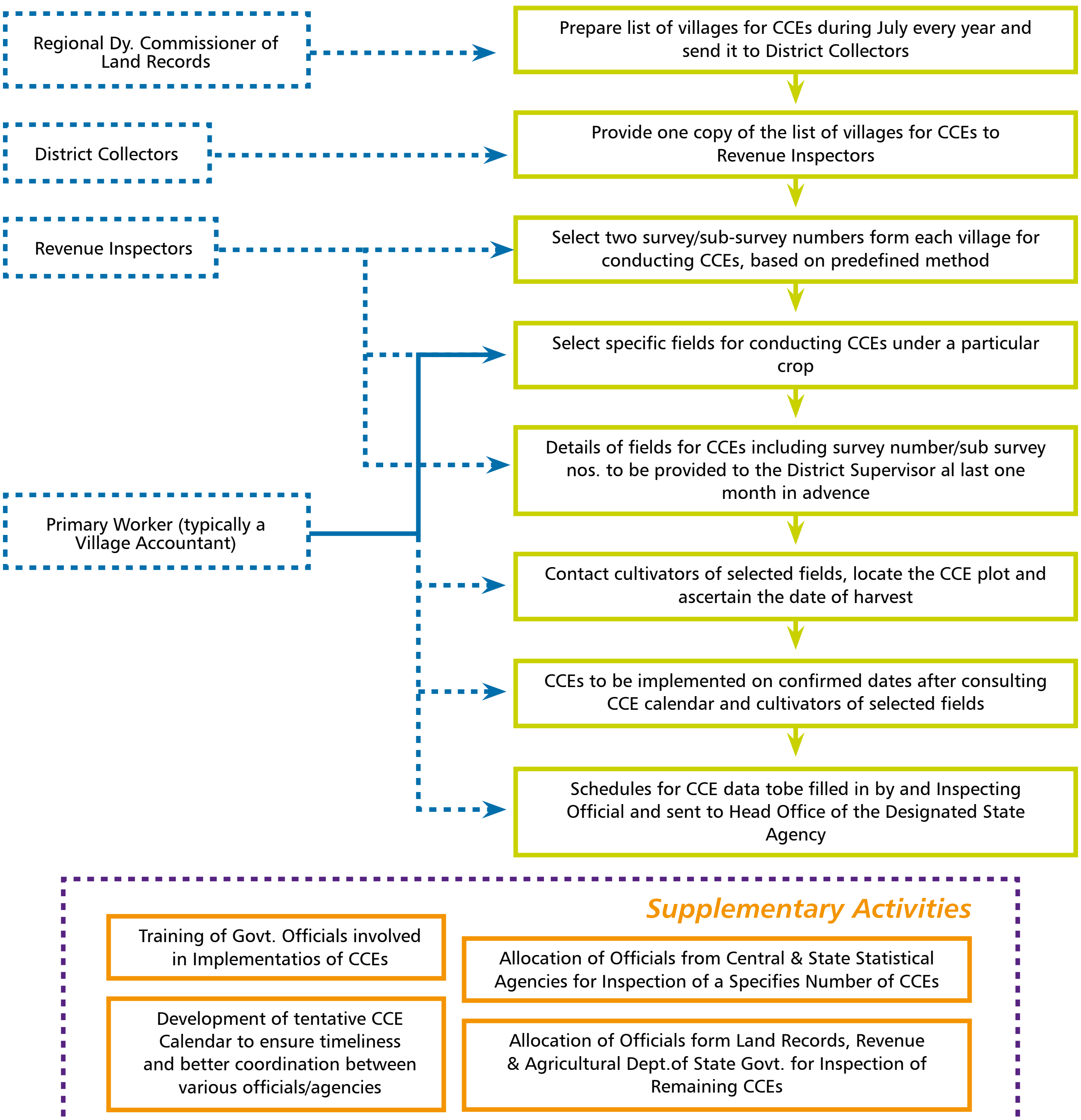
Key Issue	Proposed Modification by Joint Group (2004)	World Bank Suggestions
2. Quality of CCEs A lack of standardization, trained personnel, and monitoring for CCEs increases basis risk in NAIS and the potential for manipulation of CCEs.	No specific recommendations	First, the process could be standardized and documented in a national NAIS CCE procedures manual, with associated standardization of training for Primary Workers and CCE supervisors. The process for calculating the Actual Yield for an Insurance Unit from the raw yields for each CCE conducted within the Insurance Unit could be clarified and standardized across states. Second, randomized, independent, high quality CCE audits could be commissioned alongside the standard CCEs. Third, technology could be utilized to improve monitoring. Remote sensing technologies (e.g. satellites) could be used to improve monitoring of CCEs and video recording could mitigate the potential for manipulation of CCEs by Primary Workers. In addition, Primary Workers could be required to share raw yield data with AICI by mobile phone immediately after an NAIS CCE has been conducted, in advance of the full paperwork being supplied.
3. Delays in claims settlements Delay in NAIS indemnity payments due to the time taken to process CCEs	Compensation of up to 50% of likely claims could be released during the season, which would finally be adjusted against claims according to the CCE results. Parameters such as crop condition reports, weather data and satellite imagery would be used to release an interim claims settlement.	To facilitate prompt payment of final claims, Government could contribute to ex ante premium subsidies, rather than ex post claim subsidies. State Governments could also ensure that CCE reports are delivered to AICI earlier. It is estimated that such measures could reduce delays in claim settlement by four to five months, thereby reducing the overall settlement time by as much as about 50 percent. Advanced indemnity payments even prior to harvest could be made based on weather indices. This approach will enable reaping the benefits drawn from combining the best features of both area-yield (e.g., more accurate loss estimates and more comprehensive coverage) and weather-based insurance (e.g., faster claim settlement).
4. Actuarial risk classification Incomplete risk classification, leading to wide variation in the value of NAIS products within a State	The Threshold Yield (TY) will be established as the average of the best 5 out of 7 preceding 7 years.	It is suggested that AICI use a statistically robust Experience-Based Approach to determine Threshold Yields. The methodology has been chosen to achieve actuarially-sound Threshold Yields that are stable yet reflective of regional differences and responsive to changes in risk over time. To achieve this, the Threshold Yield for an Insurance Unit is set to be equal to a weighted average of the actuarial Threshold Yield for that Insurance Unit and the actuarial Threshold Yield for the district. The suggested approach uses 10 years of yield data to determine Threshold Yields, with a technology adjustment for yield trending. Under the suggested methodology there will be lower variation in Threshold Yields within a district than under the current methodology and lower variation over time. Such a measure could bring more stability in the participation, as non-borrowing farmers would not be able to adversely select against the insurance program by participating when coverage is high or not insuring when coverage is low.

Key Issue	Proposed Modification by Joint Group (2004)	World Bank Suggestions
5. 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 Block level to the individual Village Panchayat for major crops.	Statistical analysis could be conducted to quantify the relative benefits to farmers from a reduction in basis risk from increasing the number of CCEs per Insurance Unit, decreasing the Insurance Unit size, and increasing the quality of audits. An analysis of the first two would require historic raw yield data from individual CCEs conducted for insurance purposes in one or more states. An analysis of the quality of audits would require independent, high quality CCEs to be conducted and documented alongside the standard audits. If Government priorities lead to lowering the unit before actuarially-sound premium rates are developed, a useful approach may be to blend market-based insurance objectives and social objectives. AICI could retain claims assessed on an actuarially-sound basis at the existing IU level, while residual claims (i.e., the difference between claims reported at the smaller IU level and the claims reported at the current IU level) could be covered by the Government as a social benefit. Under the IU size reduction the number of CCE's would have to be increased by an average of 3.75 times, representing an increase in the cost of CCE's from Rs. 210 million to Rs 788 million.
6. Adverse selection Adverse selection caused by non-loanee 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 loanee and non-loanee farmers. For Kharif crops, sales cut-off dates to be from 15th June to 15th July (based on the onset of the South-west Monsoon) and 31st December for Rabi crops.	The Government could institute a purchase deadline for crop insurance in advance of the crop season, for both borrowing and non-borrowing farmers. For example for the Kharif season, it is suggested to move back the cut-off date from September to July. This early deadline for insurance purchase would reduce adverse selection among non-borrowing farmers. However, the reduced time for purchasing insurance could also result in a trade-off with the outreach of the program. AICI could address this through improved communication and this might also get addressed through the likely increased use of the Kisan Credit Card. The Government could also encourage an earlier insurance sign-up through premium discounts. AICI could introduce a premium discount within a certain period well in advance of the growing season. This discount could extend to state and central governments in order to encourage their early premium payment to match the farmers' premium.

Key Issue	Proposed Modification by Joint Group (2004)	World Bank Suggestions
Incomplete benefits Incomplete coverage of NAIS, where cover is not offered for prevention of sowing, replanting, post harvest losses and localized risk, such as hail losses or landslide.	Pre-sowing risk, particularly prevention of sowing due to adverse climatic risks to be covered with 25% of sum insured paid as compensation covering input costs incurred up to that state. Post-harvest losses on account of cyclonic rains to be covered for up to 2 weeks after harvesting when losses would be assessed on an individual farmer basis The localized risks of hailstorm, landslide, and damage by wild animals could be assessed and settled on an individual farmer basis.	The Government could extend coverage for planting and post-harvest risks, but only when a proper data management system is established. These benefits could be built into the basic crop insurance program or added as endorsements for additional premium. However, adding additional enhancements to a scheme that is missing some of the basic support instruments may complicate the process to an extent that an actuarially-sustainable scheme and other key objectives are jeopardized over the long term in order to accomplish relatively smaller short term objectives. If GOI wants to offer these benefits before the development of a proper data management system, since these benefits would not be actuarially rated (for lack of data), the Government could consider them as social benefits and thus bear the associated costs. The costs of individual grower loss assessment will have to be budgeted for and if AICI has to cover the costs, included in their revised actuarial pricing. Otherwise, it could be offered as a social benefit.

ANNEX C: CROP CUTTING EXPERIMENTS

Figure C.1: Stylized workflow of Crop Cutting Experiments



Source: Adapted from a) Guidelines for Crop Cutting Experiments issued by the Department of Land Records, Madhya Pradesh b) Manual on Area and Crop Production Statistics prepared by Central Statistics Organization in association with Indian Agricultural Statistical Research Institute (IASRI).

Major Issues Emerging from Improvement of Crop Statistics (ICS) Scheme

"GCES carries out around 500,000 experiments every year; but these are not still adequate to provide usable estimates below the district level. With the introduction of National Agricultural Insurance Scheme (NAIS) in several States a need is felt for assessment of yields of insured crops at the lower level such as tehsil or C.D. Block and even at the panchayat level. NAIS has, therefore, prescribed for additional crop cutting experiments for this purpose at the rate of 16 per block or 8 per panchayat for insured crops. Some of the states have already implemented this scheme of crop-cutting experiments. This imposes an enormous additional burden on the field agency and increases the non-sampling errors considerably resulting in further deterioration of the production statistics.

Some major problems of yield statistics are as follows:

1. It has been observed that field staff appointed by the State Governments do not strictly adhere to the prescribed procedures and thereby the survey estimates are subject to a variety of non-sampling errors.

2. The errors are introduced mainly due to wrong selection of fields and deviation of selected experimental plots. The use of defective instruments such as weighing machine introduces considerable amount of measurement errors.

3. The state departments of revenue and agriculture, which are responsible for carrying out the survey, keep these programmes on low priority and there is inadequate higher level of supervision and control of field operations. The "High Level Coordination Committee (HLCC) on Agricultural Statistics" in the states have also not shown much impact in improving the quality of data.

4. In order to meet the requirements of getting estimates at block/village panchayat levels especially for crop insurance purposes some of the State increased the number of crop cutting experiments considerably. This imposes an enormous burden on the field agency, increases considerably the non-sampling errors, which results in further deterioration of quality of data collected through GCES. There is possibility of under estimation of yield rates in case of crop insurance due to local pressure from insured farmers where interest lies in depressing the crop yield.

5. It has been observed that inadequate training is provided to the field staff for conducting the crop cutting experiments.

6. Another important factor, which has bearing on the quality of production data is, the late time schedule fixed for certain crops in Kharif season in some states. In this case crop-cutting experiments are to be conducted before completion of the season due to early harvesting. Such situations have been arising in respect of Kharif crops like maize, jowar, bajra, groundnut, cotton, soybean etc. in States like Gujarat, Haryana, Karnataka and M.P. Due to early harvesting of these crops, area under crop is generally under reported."

Source: Central Statistical Organisation. (2004) Manual on Area and Crop Production Statistics, Indian Agricultural Statistical Research Institute (IASRI), 42, 1-111

Suggested procedure for independent CCE audits

Basis of Audit

The CCE audit will be based on the list of sample plots for CCEs finalized by the respective state government agency. Plots for CCE audits to be identified by AICI thorough stratified random sampling from the CCE list provided by state agencies. AICI would then hand over this secondary list of CCE plots to the professional third-party audit agencies for audit within ten days of the official state CCEs.

Targeting of Audits

Audits could be targeted at particular crops, particular agronomic regions or particular states. AICI may wish to make use of remote sensing technologies to target auditing. The sampling procedure should remain private.

Size and Location of Sample Plot

A sample plot located adjacent to the CCE plot would be employed for audit. Plot size could be 5-metre x 5-metre, or smaller if deemed appropriate.

Timing of Audit

The maximum permissible delay between CCE conducted by the state agencies and the CCE audit would be 10 days. In addition to the CCE calendar provided by the respective state agencies, AICI would have to put in place a proper mechanism to ensure coordination with the state agency conducting CCE. Based on the information received from the state agencies, AICI has to guide the third-party audit agencies on their audit schedule. Daily progress reports from the respective state agencies during the designated time window for CCEs can be useful in keeping track of official CCEs. Such requirement from state agencies would also help to streamline the physical implementation of CCEs by bringing the process under daily monitoring of AICI.

The cost of auditing one plot may range from INR 600 per plot (US$ 12 per plot) to INR 900 per plot (US$ 18 per plot) as per the prevailing costs. The Joint Group Report 2004 quotes INR 300 as the cost per CCE. However, this is based on the current cost of CCEs, to be conducted by local administrators. The cost of hiring a professional private organization to conduct high quality external audits would be higher than the cost of standard CCEs.

ANNEX D: NAIS EXPERIENCE BASED APPROACHED TO SETTING THRESHOLD YIELDS

Table D.1: Calculations of Threshold Yields for Cotton in M.P. using five methods

		Threshold Yields					Threshold Yield Factor for Method 5
District	Tehsil	Method 1	Method 2	Method 3	Method 4	Method 5	
Chhindwara	Sausar	622	681	869	837	859	69%
Chhindwara	Bichhua	412	470	554	837	641	69%
Chhindwara	Pandhurna.	525	583	727	837	761	69%
Dewas	Bagli	740	798	665	712	701	23%
Dewas	Kannod	618	676	725	712	715	23%
Dewas	Khategaon	445	503	634	712	694	23%
Dhar	Badnawar	364	422	379	538	442	60%
Dhar	Sardarpur	490	548	510	538	521	60%
Dhar	Kukshi	559	617	566	538	555	60%
Dhar	Dharampuri.	757	816	628	538	592	60%
Dhar	Gandhwani.	369	428	520	538	527	60%
Dhar	Manawar	594	652	723	538	649	60%
Khandwa	Khandwa	410	468	481	473	476	40%
Khandwa	Harsud	345	403	443	473	461	40%
Khandwa	Pandhana	455	513	513	473	489	40%
Jhabua	Alirajpur	614	672	784	534	631	39%
Jhabua	Jhabua	634	693	794	534	635	39%
Jhabua	Thandla	484	542	517	534	528	39%
Jhabua	Jobat	705	763	774	534	627	39%
Jhabua	Petlawad	603	661	537	534	535	39%
Jhabua	Ranapur.	579	637	639	534	575	39%
Jhabua	Meghnagar	466	524	469	534	509	39%
Ratlam	Ratlam	721	779	631	619	620	12%
Ratlam	Bajna.	698	756	538	619	610	12%
Ratlam	Sailana	791	849	720	619	631	12%
Khargone	Maheshwar	513	572	513	511	512	37%
Khargone	Bhagwanpura.	421	480	498	511	506	37%
Khargone	Segaon	322	380	403	511	470	37%
Khargone	Jhirnya	516	574	588	511	540	37%
Khargone	Kasrawad	614	672	673	511	572	37%
Khargone	Bhikangaon	377	435	492	511	504	37%
Khargone	Barwaha	521	580	512	511	511	37%

District	Tehsil	Threshold Yields					Threshold Yield Factor for Method 5
		Method 1	Method 2	Method 3	Method 4	Method 5	
Barwani	Theekri	259	317	386	408	399	41%
Barwani	Rajpur	396	454	516	408	453	41%
Barwani	Barwani	307	365	371	408	393	41%
Barwani	Pansemal	401	459	557	408	470	41%
Barwani	Niwali.	401	459	454	408	427	41%
Barwani	Sendhwa.	433	491	545	408	465	41%
Burhanpur	Burhanpur	620	678	741	431	602	55%
Burhanpur	Nepanagar	330	388	420	431	425	55%
Burhanpur	Khaknar	301	360	401	431	415	55%

An Experience Based Approach to setting Threshold Yields

World Bank (2007a) described an Experience Based Approach to ratemaking. In that approach, the Threshold Yields were taken as given and the technical problem was to determine efficient premium rates. The approach in Chapter 3 of this report is an extension of that approach.

Consider the following definitions:

- N = the number of Insurance Units (IUs) in the Risk Collective (RC) to be considered
- i = the ith IU in the RC
- n_i = the number of years of yield history for product (10 or fewer)
- DY_{ij} = the de-trended historic yield in IU i in year j.
- TPR = the Target Premium Rate, before any risk or expense loading
- ITY_i = the Method 3 Threshold Yield for Product i
- $RCTY$ = the Method 4 Threshold Yield for the Risk Collective
- TY_i = the Method 5 Threshold Yield for Product i

The Method 3 Threshold Yield for product i is defined as the ITY_i which solves the following equation:

$$\frac{\sum_{j=1}^{n_i} \max[ITY_i - DY_{ij}, 0]}{n_i \times ITY_i} = TPR$$

The Method 4 Threshold Yield for the Risk Collective is defined as the $RCTY$ which solves the following equation:

$$\sum_{i=1}^{N} \frac{\sum_{j=1}^{n_i} \max[RCTY_i - DY_{ij}, 0]}{n_i \times RCTY} = TPR$$

The Method 5, or EBA, Threshold Yield for Product i and for a given Threshold Yield Factor (TYF) is given by the following equation:

$$TY_i(TYF) = TYF \text{ x } ITY_i + (1 - TYF) \text{ x } RCTY$$

For a given set of Threshold Yields defined by the above equation for some TYF, the Final Pure Rate for product i $FPR_i(TYF)$ is the Final Pure Rate as defined in the World Bank Report 2007.

The problem now is to make an efficient choice for the TYF. Bühlmann's Credibility Theory suggests that an efficient choice for the TYF is the largest number between 0 and 1 such that $FPR_i(TYF) = TPR$ for all i. That is to say the Final Pure Rates, as calculated using the EBA approach of the World Bank Report 2007, are equal to the Target Premium Rates.

If the Credibility Factor used in calculation of the Final Premium Rate is calculated according to Bühlmann's Credibility Factor Formula then the efficient Threshold Yield Factor will be such that the Bühlmann's Credibility Factor is zero. Equivalently, $\frac{1}{K}$, the inverse of the Credibility Parameter K should be set to be as close to zero as possible.

The choice of Risk Collectives

Classifying products into Risk Collectives requires expert judgment.

Products in a Risk Collective should be chosen based on a sound spatial, agronomic or practical rationale and should not be overly influenced by historic yield data for individual Insurance Units. Although different Risk Collective specifications could be considered with the intention of lowering the resulting credibility factor for Risk Collectives, any specifications should contain a conceptually contiguous group of products. Products should not be included or excluded from an Risk Collective based on their historic yields.

- Examples of possible rules for generating Risk Collectives include:
- All products sold in the same district, based on the same crop
- All products sold in the same district, based on the same crop. However, if any Risk Collective contains fewer than five Insurance Units it should be merged with an adjacent Risk Collective.
- All products sold in the same state, based on the same crop
- All products sold in the same agronomic region, based on the same crop
- All products sold in the same state and the same agronomic region, based on the same crop

ANNEX E: DOUBLE INDEX CROP INSURANCE

Definition of products with no offsetting of weather index payments

A double index product could offer a claim payment that is a weighted average of a payment based on the weather index and a payment based on the area yield index. The total claim payment from such a product could be written as:

$$\lambda_w \times f(l_w) + \lambda_y \times \frac{\max[TY - AY, 0]}{TY}$$

where: λ_w and λ_y are the weights for the weather based and area yield based components, respectively with $\lambda_w + \lambda_y = 1$; the indexed payment is a multiple of some function f of weather index l_w; and the area yield based component offer protection when Actual Yields (AY) are below some Threshold Yield (TY).

This type of policy would allow both an early weather-based payment of $\lambda_w \text{ x } f(l_w) = 1$ and a later area yield-based payment of . $\lambda_y \times \frac{\max[TY - AY, 0]}{TY}$

The Sum Insured for a product without offsetting would be equal to the Sum Insured for the weather component plus the Sum Insured for the area yield component. A claim payment of 100% of the Sum Insured would only be possible if both the weather was bad and the Actual Yield was low.

An example of such a product would be if the total claim payment was 50% of a WBCIS policy plus 50% of an NAIS policy. Using the notation above, λ_w and λ_y would both be set to 50%, $f(l_w)$ would be the WBCIS claim payment function and TY would be defined as for NAIS Threshold Yields.

Definition of products with offsetting of weather index payments

A second type of double index product is one that offers an early non-repayable weather index payment and a later area yield index payment, where any weather index payment is offset against the area yield index payment. Denoting the early non-repayable weather payment as $\lambda_w f(l_w)$ and the gross area yield index payment as $\lambda_y \frac{\max[TY - AY, 0]}{TY}$, the total top up, or gap insurance, payment from the area yield element would be given by $\max\left[\lambda_y \frac{\max[TY - AY, 0]}{TY} - \lambda_w f(l_w), 0\right]$.

The total payment from such an insurance product is given by:

$$\lambda_w f(l_w) + \max\left[\lambda_y \frac{\max[TY - AY, 0]}{TY} - \lambda_w f(l_w), 0\right]$$

This may be rewritten as the following expression, where the total payment from the insurance product is the maximum of a weather index element and an area yield index element:

$$\max\left[\lambda_w f(l_w), \lambda_y \frac{\max[TY - AY, 0]}{TY}, 0\right]$$

The Sum Insured for a product with offsetting would be equal to the maximum of the Sum Insured for the weather component and the Sum Insured for the area yield component. Such products could be designed so that the Sum Insured for each component was the same, and so a claim payment of 100% of the Sum Insured could be made if either the observed weather was very bad or the Actual Yield was very low.

An example of such a product would be if the total claim payment was equal to the maximum of the claim payment from 75% of a WBCIS policy and the claim payment from 50% of an NAIS policy. Using the notation above, λ_w would be set to 75%, λ_y would be 50%, $f(l_w)$ would be the WBCIS claim payment function and TY would be defined as for NAIS Threshold Yields.

Example of designing double index insurance policies

Four products are designed based on the following hypothetical ten years of historic data (Table E.1). Two of the products do not and the other two do allow the offsetting against the weather index payment. For each type of product we design one product with 75% of the historic claims mass arising from the weather based component and 25% arising from the area yield component, and the second product with 25% of the historic claims mass arising from the weather based component and 75% arising from the area yield component.

Suppose further that the target unloaded historic loss cost for this product is 8%. Chapters 3 and 4 suggest that products are designed and priced together. The example below designs one product individually, and is therefore purely for illustration. The method may be compared with Method 3 of Chapter 3.

Assume that an agronomist has estimated a function that gives the expected yield, given weather data. Further suppose that AICI has calculated the values of this weather index function for each of the last ten years, using historic weather data. Let the historic Actual Yield based on Crop Cutting Experiments and historic weather indexed losses be as follows:

Table E.1: Hypothetical data for double index insurance policy worked example

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Actual Yield from CCEs, AY (kg/ha)	442	480	827	483	209	189	259	106	346	317
Weather Indexed Yield, IY	897	600	562	347	157	140	396	378	529	293

Product without offsetting with 75% weather index and 25% area yield index cover

Consider a product with claim payment given by: $\max[0,194 - IY] + \max[0,258 - AY]$. The maximum claim payment is 194+258=452. The historic claim payment from the weather element is 27 and that from the area yield element is 9. The total historic loss cost is 8% as required.

Product without offsetting with 25% weather index and 75% area yield index cover

Consider a product with claim payment given by: $\max[0,295 - IY] + \max[0,197 - AY]$. The maximum claim payment is 295+197=493. The historic claim payment from the weather element is 9.8 and that from the area yield element is 29.5. The total historic loss cost is 8% as required.

Product with offsetting with 75% weather index and 25% area yield gap index cover

Consider a product with claim payment given by: $\max[0,298 - IY, 207 - AY]$. The maximum claim payment is 298. The historic claim payment from the weather element is 30.3 and that from the area yield gap element is 10.1. The total historic loss cost is 8% as required.

Product with offsetting with 25% weather index and 75% area yield gap index cover

Consider a product with claim payment given by: $\max[0,197 - IY, 288 - AY]$. The maximum claim payment is 288. The historic claim payment from the weather element is 9.7 and that from the area yield element is 29.1. The total historic loss cost is 8% as required.

ANNEX F: CROP YIELD DE-TRENDING

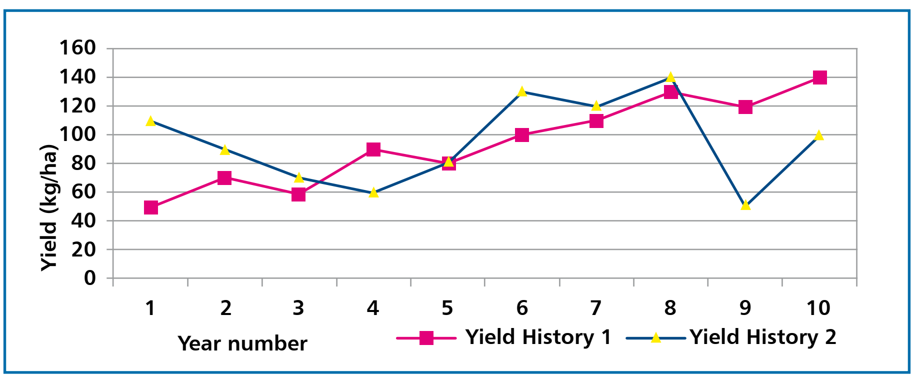
De-trending and the Normal Theory Method: a theoretical example

Current NAIS ratemaking methodology is based on the assumption that the yield in each of the last ten years is independent and identically normally distributed. The premium is based on the coefficient of variation of the most recent ten yields.

In the absence of any de-trending, a trend in the data will be automatically interpreted as natural variation. For example, consider Figure F.1 below. The first yield history suggests an upward trend in yields but very little uncertainty. The second yield history suggests no trend and much more uncertainty. However, AICI's current ratemaking methodology would treat both histories the same, charging both crops the same premium for the same indemnity level. Both crops would be treated as though the mean yield was 100 kg/ha and the CV was 32.

Were AICI to apply the de-trending methodology suggested in this paper, crop 1 would be found to have a highly significant trend of 9.6 kg/ha/year (p-value of 0.001%) and crop 2 would be found to have a statistically insignificant trend (p-value of 73%). After de-trending, crop 1 would be treated as having a CV of 6, much lower than the CV of 32 calculated before de-trending.

Figure F.1: Example of two yield histories with the same Coefficient of Variation



This appears to be what has happened for cotton in recent years. Cotton yields have displayed a significant upward trend, and that trend has been interpreted by the NTM methodology as being uncertainty.

One additional point is that when there is a clear trend in the data, AICI must also make a decision about the average yield to use when specifying claim payments. For example, in the case of yield history 1 above, AICI could assume an average yield in year 10 of 100 kg/ha, 150 kg/ha or something in between. 100kg/hg would almost certainly be too cautious, offering very poor value to farmers. On the other hand 150 kg/ha would leave AICI vulnerable to the possibility that the trend would not continue. Actuarial prudence would suggest an average yield assumption for year 11 between these two extremes.

Checking whether a trend is statistically significant using MS Excel functions

Suppose cells A1:A10 contained ten yield data years (e.g. the numbers 1998, 1999, … , 2007) and cells B1:B10 contained weighted average yields from year 1 to year 10.[17] The linear trend, which we assume is calculated in cell C1, is given by the formula:

=SLOPE(B1:B10, A1:A10)

The one sided t-value, which we assume is calculated in cell D1, is then given by:

=INDEX(LINEST(B1:B10, A1:A10,,TRUE),2)/C1

Finally, the p-value is given by:

=TDIST(ABS(D1),8,2)

In this paper we have used a 5% level of significance; that is we have assumed that a trend with p-value greater than 5% is not statistically significant but a trend with a p-value less than or equal to 5% is statistically significant. A low p-value means that it is unlikely that the trend could have occurred 'by chance' and therefore it is more plausible that there has in fact been a technological trend in yields. Choice of significance level is a matter of judgment: a lower (higher) level leads to less (more) de-trending.

17 Average yields should be weighted by area sown or area insured. The weighted average yield in a given year is given by the sum over IUs of [area sown in IU x yield in IU] divided by the total area sown.

Yield histories by Insurance Unit, before and after de-trending.

Figure F.2: Cotton yields in Gujarat by IU, Kharif 1998-2007, no de-trending
Weighted average CV=52%, NTM premium = 17.4%

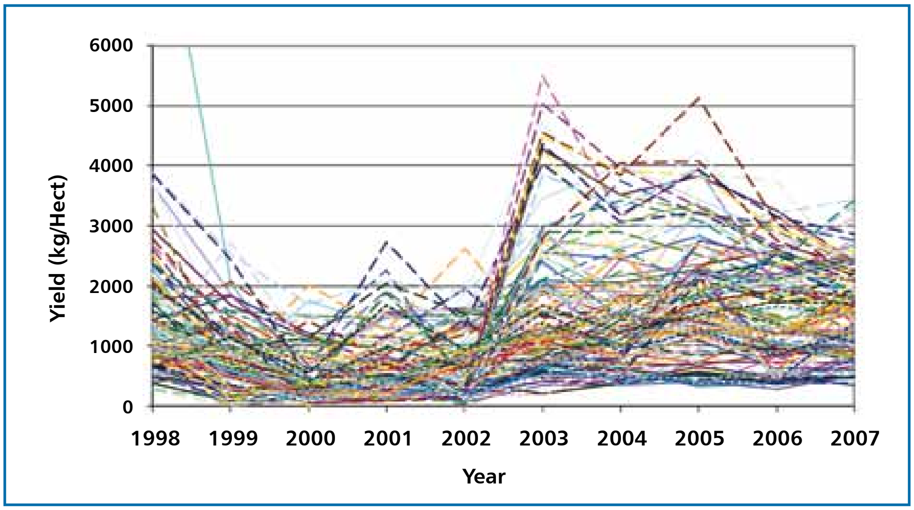
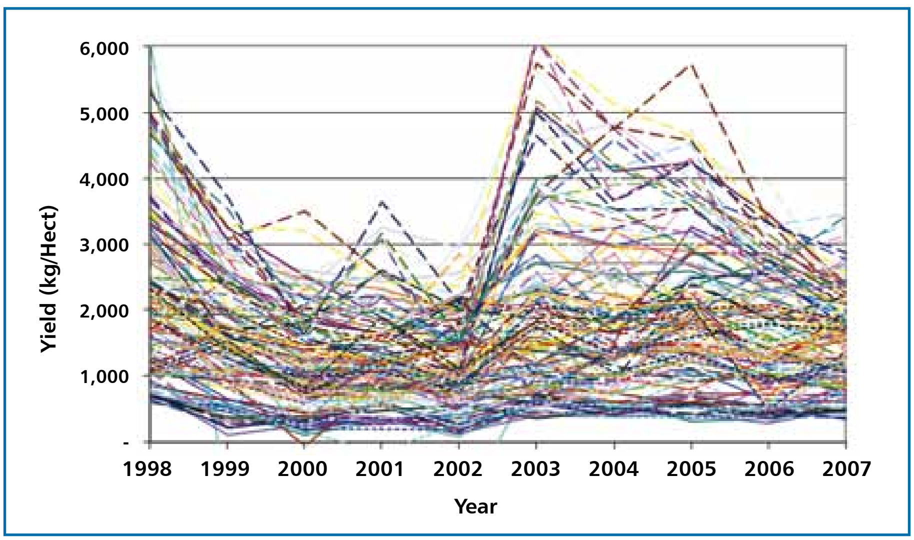


Figure F.3: Cotton yields in Gujarat by IU, Kharif 1998-2007, aggregate linear de-trending
Weighted average CV=33%, NTM premium = 6.2%



ANNEX G: REVISED RATEMAKING METHODOLOGY FOR WEATHER BASED CROP INSURANCE SCHEME

The choice of Balance Back Collectives and Risk Collectives

Classifying products into Risk Collectives and Balance Back Collectives requires expert judgment.

Products in a Risk Collective for weather indexed products should satisfy the following properties:

1. Risk Collectives (RCs) should be chosen based on a sound spatial, agronomic or practical rationale and should not be overly influenced by historic loss cost data for individual products. Although different RC specifications could be considered with the intention of lowering the resulting credibility factor for RCs, any specifications should contain a conceptually contiguous group of products. Products should not be included or excluded from an RC based on their historic loss costs.

2. Claim payments should be based on different, but similar, data sources. There should not be two products in the same RC with payments based on the same data source, or the assumptions underlying Credibility Theory will be violated. However, Credibility Theory is likely to be more effective at increasing efficiency if the weather patterns for products within the same risk collective are similar in nature. This does not mean, for example, that average rainfall or the variance of rainfall has to be the same. It does mean that the weather data underlying payments should be similar in an agronomic or spatial sense.

3. Products should feature similar designs. For example, products primarily offering deficit rainfall cover should not be in the same collective as products primarily offering excess rainfall cover.

4. RCs may reflect practical considerations. To rate a particular product, one needs to calculate historic loss costs for all other products in the RC. If ratemaking is to be undertaken sequentially by state it may be impractical for RCs to span multiple states.

Examples of possible rules for generating Risk Collectives include:

- All products sold in the same state, based on the same crop
- All products sold in the same agronomic region, based on the same crop
- All products sold in the same state and same agronomic region, based on the same group of crops

Products in a Balance Back Collective (BBC) should satisfy the following properties:

1. A BBC should contain products for which extreme claim events are expected to be similar in nature. BBC should typically be at least as large as RCs. A BBC could be the same as a RC, or could include more than one RC.

2. A BBC can contain multiple products based on the same data source. Such a specification would not invalidate any assumptions.

3. If the Balance Back Factor is to be multiplied by the BR to generate the PPR, and AICI designs products with a target premium in mind, then BBCs should contain products with similar target premiums. If not, products with low target premiums might be universally underpriced and products with high target premiums might be universally overpriced.

4. BBCs may reflect practical considerations. To rate a particular product, one needs to calculate historic loss costs for all other products in the BBC. If ratemaking is to be undertaken sequentially by state it may be impractical for BBCs to span multiple states.

Examples of possible rules for generating Risk Collectives include:

- All products sold in the same state
- All products sold in the same agronomic region
- All products based on the same group of crops
- Any rule as suggested above for Risk Collectives

Bühlmann's Credibility Factor Formula

For a detailed discussion of Bühlmann's Credibility Theory, see 'Introduction to credibility theory' By Thomas Herzog, 'A course in credibility theory and its applications' by Hans Bühlmann and Alois Gisler or 'Credibility' by Mahler and Dean (available at http://www.casact.org/admissions/syllabus/ch8.pdf).

To define Bühlmann's Credibility Factor Formula we will need to introduce some notation. Let us index products by i and years with loss cost histories by j. Then we define:

- N = the number of products in the Risk Collective to be considered
- n_i = the number of years of loss cost history for product i
- LC_{ij} = the loss cost for product i and observation j
- $\overline{n} = \frac{1}{N}\sum_{i=1}^{N} n_i =$ the average number of years of loss cost history within the Risk Collective

- $\overline{LC}_i = \frac{1}{n_i} \sum_{j=1}^{n_i} LC_{ij}$ = the average historic loss cost for product i
- $\overline{LC} = \frac{1}{N} \sum_{i=1}^{N} \overline{LC}_i$ = the average of average historic loss costs within the Risk Collective
- $VAR_j(i) = \frac{1}{n_i - 1} \sum_{j=1}^{n_i} [(LC_{ij}] - LC_{ij})^2$
- $VAR_i = \frac{1}{N-1} \sum_{i=1}^{N} [(\overline{LC}_i] - \overline{LC})^2$
- $E[s^2(\Theta)] = \frac{1}{N} \sum_{i=1}^{N} VAR_j(i)$ = an estimator for the expected variance of loss cost histories within the Risk Collective. This measures the variance 'within' products in the risk collective.
- $VAR[m(\Theta)] = max\left(VAR_i - \frac{E[s^2(\Theta)]}{\overline{n}}, 0\right)$ = an estimator for the variance of average loss costs between products in the Risk Collective. This measures the variance 'between' products within the same Risk Collective.

Bühlmann's Credibility Factor Z for a particular product is then given by the following formula:[18]

$$Z = \frac{n_i}{n_i + \frac{E[s^2(\Theta)]}{VAR[m(\Theta)]}}$$

The choice of Loss Cost Cap (LCC) and LCC percentile (X)

The purpose of the LCC is to remove significant outliers from the loss cost histories, prior to the application of Bühlmann's Credibility Theory. A properly chosen cap may not only add stability, but may even make the credibility methodology more accurate by eliminating extremes. The intention of the cap and Balance Back Factor is to spread statistically insignificant large losses over a large base so that pricing is robust to outliers.

18 Most textbooks assume that the number of historic LCs is the same for all products within a Risk Collective. The formulae suggested in this note allow for the fact that different products within the same Risk Collective may have different LC history lengths.

Expert judgment is required for in the choice of cap percentile. If the LCC percentile is set to be too high, the presence of outliers may lead to a low credibility factor Z. If the LCC percentile is set to be too low, the LCC could be 0% for a large number of products. Based on the loss cost histories provided to us we would suggest a LCC percentile X between 80% and 95%, although this may depend on the specific historic data and historic claim payment frequency. X could be chosen to be different for different BBCs.

The Excel PERCENTILE function can be used to calculate the LCC. For example, PERCENTILE(A1:T1,90%) would return the linearly interpolated 90th percentile loss cost, for loss costs listed in the range A1:T1.

Alternative approaches to increasing efficiency of premiums

In this report we have suggested the application of Bühlmann's Credibility Factor Formula to historic claims, alongside a cap and balance back procedure. The intention of this procedure is to increase the statistical efficiency of premiums, and therefore make the ratemaking procedure more robust to outliers. We believe that the suggested approach would lead to a significant increase in the efficiency of ratemaking without substantially increasing the complexity.

However, there are many other potential approaches that could have been taken. We will briefly describe some of them in this section.

1. Credibility Theory could be separately applied to frequency of claims and claim amounts. With twenty years of data the probability that a positive loss is incurred is likely predicted fairly accurately for each product. However, for many products there have only been around 5 years with positive historic loss costs. The claim amount, conditional on their being a claim, is therefore likely to be predicted much less accurately. By applying Credibility Theory to the frequency of loss separately to the loss amount, one may be able to increase the efficiency of estimates beyond what is suggested in this report. However, the calculation procedure would be somewhat more complicated. Such a procedure could be implemented by AICI at a later date, once AICI are more comfortable with Credibility Theory.

2. Limited Fluctuation Credibility Theory is a predecessor of Bühlmann's Greatest Accuracy Credibility Theory suggested in this report. Limited Fluctuation Credibility Theory would use the same credibility formula as above, BR = PBR*Z+WBR*(1-Z). However the Credibility Factor Z would be calculated differently.

3. There are a multitude of advanced statistical techniques that are similar in principal to Credibility Theory, although the rationale for their adoption is based on different statistical assumptions. These include Bayesian Networks, Hierarchical Bayes Models and Random Effects Linear Estimators.

These procedures would be more complex to understand, implement in MS Excel, and scrutinize. Bühlmann's Credibility Factor Z is an intuitive intermediate calculation that helps those conducting the ratemaking to understand the calculations. Moreover, Bühlmann Credibility is the least squares linear approximation to Bayesian Analysis.

Table G.1: Total Sum Insured and total premium income for 2008-9 weather based crop insurance portfolio

State	Season	Analyzed for ratemaking in Chapter 4	Total Sum Insured		Premium (lakh Rs.)	
			(lakh Rs.)	(US$ million)	(lakh Rs.)	(US$ million)
Bihar	Kharif	✓	17,331	36.1	1,733	3.6
Haryana	Kharif	✓	30	0.1	3	0.0
Jharkhand	Kharif	✓	1,421	3.0	142	0.3
Karnataka	Kharif	✓	3,211	6.7	296	0.7
Madhya Pradesh	Kharif	✓	2,059	4.3	232	0.5
Maharashtra	Kharif	✓	616	1.3	74	0.2
Orissa	Kharif	✓	4,456	9.3	446	0.9
Punjab	Kharif	✓	19	0.0	2	0.0
Rajasthan	Kharif	✓	385	0.8	39	0.1
Tamil Nadu	Kharif	✓	1,785	3.7	174	0.4
Bihar	Rabi	×	31,251	65.1	2,619	5.5
Chattisgarh	Rabi	×	65	0.1	5	0.0
Haryana	Rabi	×	156	0.3	13	0.0
Himachal Pradesh	Rabi	×	6	0.0	1	0.0
Jharkhand	Rabi	×	46	0.1	4	0.0
Karnataka	Rabi	×	1,201	2.5	120	0.2
Kerala	Rabi	×	383	0.8	40	0.1
Rajasthan	Rabi	×	5,588	11.6	449	0.9
Tamil Nadu	Rabi	×	2,243	4.7	202	0.4
West Bengal	Rabi	×	289	0.6	23	0.0
Total	Kharif and Rabi	-	72,541	151.1	6,644	13.8
Total analysed for ratemaking in Chapter 4	Kharif	-	31,313	65.3	3,169	6.7

Table G.2: Total Sum Insured by crop for portfolio

Crop	TSI (Lakh Rs.)	Crop	TSI (Lakh Rs.)
Paddy	22,419	Green gram	279
Black gram	1,504	Jowar	191
Cotton	1,452	Pulses	134
Groundnut	1,148	Chilly	82
Millets	928	Onion	22
Soyabean	550	Guar	9
Tur	510	Sesame	5
Maize	1,051	Other	616
Sunflower	413		
Total	31,313		

Note: Crop information was not provided for products sold in Maharashtra and so crop has been listed as 'Other'.

Table G.3: Historic Loss Cost and Loss Ratio for Kharif 2008 portfolio (1975-2007)

Year	Total Sum Insured in Kharif 2008 for which data has been supplied for this year (lakh Rupees)	Total Premium income in Kharif 2008 for which data has been supplied for this year (lakh Rupees)	Percentage of 2008 TSI for which we have data	Total Claim Payment from Kharif 2008 portfolio for which data has been supplied for this year (lakh Rupees)	Loss Cost (Total Claim Payment/ TSI)	Loss Ratio (Total Claim Payment / Total Premium)
1982	12,055	1,207	38%	815	7%	68%
1983	12,115	1,212	39%	405	3%	33%
1984	12,196	1,220	39%	949	8%	78%
1985	11,859	1,186	38%	835	7%	70%
1986	11,592	1,157	37%	778	7%	67%
1987	12,696	1,269	41%	1,076	8%	85%
1988	12,703	1,271	41%	883	7%	70%
1989	15,996	1,606	51%	778	5%	48%
1990	15,846	1,569	51%	1,148	7%	73%
1991	18,284	1,827	58%	1,247	7%	68%
1992	17,909	1,793	57%	759	4%	42%
1993	15,127	1,499	48%	979	6%	65%
1994	29,773	2,965	95%	1,032	3%	35%
1995	26,820	2,684	86%	1,227	5%	46%
1996	28,761	2,880	92%	863	3%	30%
1997	28,548	2,842	91%	1,514	5%	53%
1998	28,435	2,831	91%	1,424	5%	50%
1999	21,273	2,115	68%	1,310	6%	62%
2000	25,118	2,514	80%	2,083	8%	83%
2001	25,929	2,579	83%	1,692	7%	66%
2002	28,851	2,886	92%	2,430	8%	84%
2003	25,827	2,569	82%	1,346	5%	52%
2004	25,334	2,518	81%	1,889	7%	75%
2005	22,571	2,241	72%	1,153	5%	51%
2006	24,127	2,394	77%	1,730	7%	72%
2007	8,343	820	27%	839	10%	102%

Historic Loss Ratio for 2008 portfolio by crop and state (1975-2007)

Figure G.1: Aggregate Estimated Historic Loss Cost By Crop

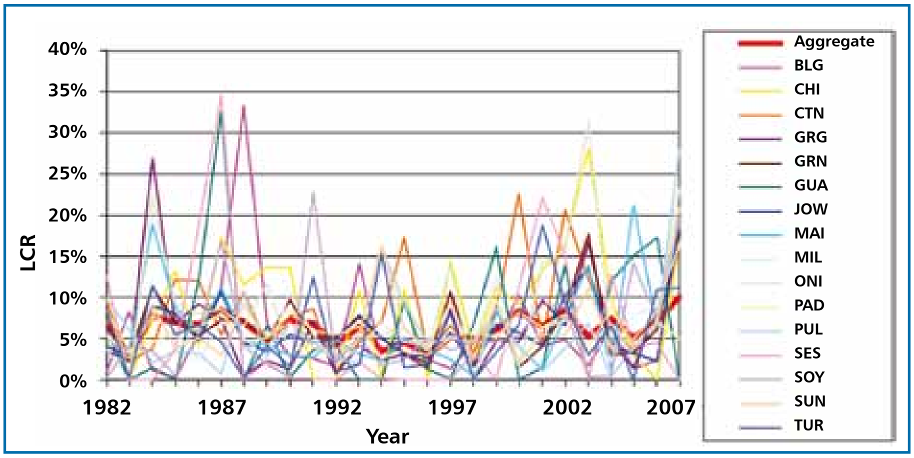
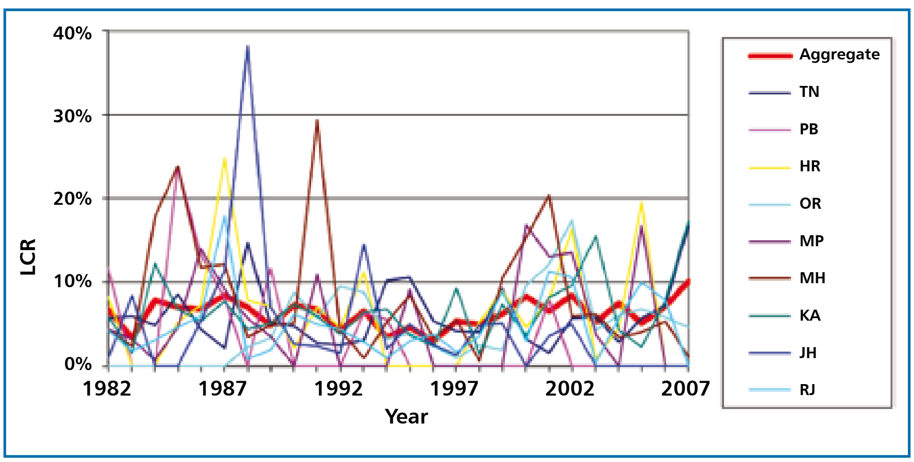


Figure G.2: Aggregate Estimated Historic Loss Cost By State



ANNEX H: FISCAL IMPACT OF MODIFIED NAIS

Table H.1: Sum Insured under universalisation, by Crop

Crop	Total SI in 2006-7 (Rs. Lakh)	Universalisation Assumption A: SI based on production value (Rs. Lakh)	Universalisation Assumption B: SI based on production cost (Rs. Lakh) [Approximate]	Universalisation Assumption C: SI based on ratio of areas (Rs. Lakh)
Paddy	699,143	10,884,902	7,619,431	4,118,483
Wheat	266,511	7,840,000	5,488,000	1,884,463
Sugarcane	47,621	2,764,666	1,935,266	1,171,650
Groundnut	19,699	1,450,800	1,015,560	1,027,386
Cotton	63,932	840,245	588,171	862,364
Maize	319,625	1,196,600	837,620	553,291
Rape & Mustard	40,473	1,044,000	730,800	523,144
Soyabean	155,527	979,020	685,314	495,335
Potato	25,201	1,396,088	977,262	417,869
Bajra	32,852	587,400	411,180	373,860
Jowar	45,912	517,370	362,159	346,396
Tur	3,810	491,310	343,917	199,149
Gram	103,075	1,105,600	773,920	139,941
Sunflower	50,817	217,440	152,208	90,568
Lentil	93,172	154,700	108,290	70,902
Onion	7,248	731,036	511,725	68,488
Banana	3,477	2,179,845	1,525,892	30,809
Chillies	6,478	370,230	259,161	28,712
Tapioca	1,842	472,867	331,007	16,196
Coriander	34	98,177	68,724	8,349
Ginger	186	260,247	182,173	1,979
Garlic	1,283	40,322	28,225	309
Turmeric	22	186,400	130,480	274
Total	1,987,941 (2,130,068*)	35,809,264	25,066,485	12,429,919 (13,454,365*)

**Numbers in brackets include estimates for all crops, not just the 23 major crops listed above*

Table H.2: Sum Insured under universalisation, by State

State	Total SI in 2006-7 (Rs. Lakh)	Universalisation Assumption C: SI based on ratio of areas (Rs. Lakh)
Uttar Pradesh	254,699	2,600,124
Maharashtra	85,046	1,698,119
Gujarat	215,601	1,183,579
Andhra Pradesh	421,743	1,159,074
Rajasthan	252,354	1,091,547
West Bengal	95,878	1,090,570
Bihar	118,442	994,307
Madhya Pradesh	233,232	782,037
Karnataka	153,640	637,834
Orissa	133,983	571,227
Tamil Nadu	50,437	499,882
Assam	1,961	391,093
Haryana	7,542	192,058
Chattisgarh	63,263	177,359
Jharkhand	28,952	109,824
Uttarakhand	4,241	89,995
Himachal Pradesh	2,002	79,020
Kerala	5,187	59,802
Jammu & Kashmir	509	38,418
Puducherry	603	3,166
Tripura	299	2,954
Meghalaya	418	2,247
Goa	12	61
Andaman & Nicobar	10	54
Sikkim	12	12
Total	2,130,068	13,454,365

Table H.3: Composition of 2006-7 portfolio by farmer type

Crop	Number of Small and Marginal farmers under NAIS in 2006 / Total number of farmers under NAIS in 2006	Sum Insured by Small and Marginal farmers under NAIS in 2006 / Total Sum Insured under NAIS in 2006
Paddy	76%	69%
Wheat	65%	48%
Maize	63%	51%
Jowar	41%	32%
Bajra	37%	18%
Groundnut	59%	38%
Rape & Mustard	35%	19%
Soyabean	51%	24%
Sunflower	21%	42%
Gram	11%	9%
Tur	51%	35%
Lentil	52%	42%
Sugarcane	81%	67%
Cotton	65%	49%
Potato	95%	83%
Onion	28%	19%
Banana	84%	63%
Chillies	88%	78%
Coriander	26%	9%
Garlic	35%	22%
Ginger	92%	95%
Tapioca	81%	69%
Turmeric	90%	74%

Table H.4: Budgetary impact of universalisation on current regime

	Estimated premium income from farmers (Rs. Lakh)	Estimated subsidy from GOI (Rs. Lakh)	Estimated subsidy from states (Rs. Lakh)
Uttar Pradesh	47,301	94,140	94,140
Maharashtra	75,121	71,388	71,388
Andhra Pradesh	35,870	66,758	66,758
Rajasthan	28,636	61,557	61,557
Gujarat	70,534	53,239	53,239
West Bengal	23,027	43,910	43,910
Bihar	22,051	39,677	39,677
Karnataka	20,612	39,109	39,109
Madhya Pradesh	22,124	37,656	37,656
Tamil Nadu	12,373	27,027	27,027
Orissa	12,918	24,457	24,457
Assam	8,843	14,194	14,194
Chattisgarh	4,605	7,113	7,113
Haryana	7,141	5,046	5,046
Jharkhand	2,889	4,899	4,899
Himachal Pradesh	1,546	4,370	4,370
Uttarakhand	1,351	2,718	2,718
Kerala	1,137	2,132	2,132
Jammu & Kashmir	677	1,828	1,828
Tripura	99	124	124
Puducherry	56	122	122
Meghalaya	111	82	82
Goa	1	2	2
Andaman & Nicobar	1	2	2

Assumptions:

- S/M farmers receive 10% premium subsidy
- AIC maximum liability is 100% x Premiums in respect of FCOS + 150% x Premiums in respect of ACH
- Total subsidy has been estimated as (historic loss cost x sum insured x loading factor of 1.3) - estimated premium income from farmers.
- Proportion of S/M farmers remains constant
- States and GOI pay 50%-50% of the excess losses

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