

FIRST Initiative, UK

Technical Support for Weather Insurance Contract Design and Ratemaking and Portfolio Risk Management

Extended Executive Summary

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Weather Insurance Contract Design and Ratemaking

Executive Summary

1. India is a predominantly agriculture-based economy where an estimated 65% of the population is engaged in agriculture and associated activities which account for around 23% to GDP. The total number of landholders is more than 120 million of which 80% are small and marginal farmers owning less than 2 hectares of land. Given the scope of agricultural production in India, weather risk is of major concern to agricultural producers and agribusinesses alike. To further illustrate the point, it is estimated that rainfall variability accounts for more than 50% variability in crop yields (Source: AICI website; <http://aicofindia.nic.in/file14.htm>).
2. Weather risk impacts every part of the agricultural supply chain from land preparation up to sale and affects the selection of seed variety, time of sowing, transplantation, schedule of irrigation, timing of fertilizer application, usage of pesticide, harvesting, etc. Crop insurance is a proactive risk management tool. There are different categories of agricultural risks of which weather risks are among the most predominant. Traditional insurance claim settlement is based on the indemnity based insurance. An index based insurance scheme can be an alternative to traditional system. The (weather/rainfall/temperature) based insurance approach is in nascent stage and has huge potential. Against this backdrop, weather insurance products that provide protection against weather related risks are a valuable tool to farmers.
3. The scope and objectives of the study were agreed through extensive consultations with Agricultural Insurance Company of India (AICI) – an end beneficiary of this consulting work and the World Bank so as to arrive at eight (8) weather insurance pilots. These pilots were identified based on several criteria like geographical spread, agro climatic zones; availability of yield data and weather data; balance between Kharif & Rabi crops; balance between field crops, commercial crops and plantation crops; between rainfall based products and multiple weather parameter products. The main purpose of this assignment was to build a new product design and rating methodology which would go a long way in fulfilling the need of farmers and AICI by coming out with financially sustainable weather insurance products that do not require heavy government subsidies, and also to impart a basket of weather insurance products to AICI for pilot locations chosen under this assignment. Scope of this project was not limited to merely deliver these products but rather put together a generic and scalable methodology for developing contextually-relevant weather based contracts through which AICI can conduct pilots for identified agro climatic regions and other locations for mass coverage of farmers subsequently in other locations of India.
4. An overview of technical, operational and practical aspects of weather insurance in the developed countries (US, Canada), in middle income group countries (Mexico and Spain) and in developing countries (India) was carried out. This review provides useful insights and key guidelines for AICI's upcoming activities. A wide variety of index based insurance and weather insurance are available in the USA. The program based on rainfall index is available in some states for

pilots for the year 2007. The remote sensing based Normalized Difference Vegetation Index (NDVI) is another index in the practice. These are being used by the Pasture, Rangeland and Forest (PRF) group risk crop insurance contracts which cover rain as a single peril. In Saskatchewan, Canada several weather based insurance products are available since 2001. The precipitation and temperature during the growing season, forms the basis for coverage. The claim is triggered when precipitation fall below 70%. In Alberta, the coverage is based on the precipitation and soil moisture levels. It has also coverage based on the NDVI for some crops. Spain operates variety of insurance plans nearly for all crops. The coverage is based on the NDVI based weather index. It operates by establishing insurance guarantee based on the historical averages of NDVI. In Mexico, the catastrophe crop insurance uses the agronomic/crop process models that establish the relationship between the weather conditions and crop yields. The combined use of historical and simulated weather data is also of interest. In India ICICI Lombard product offered an incredible insight for local market to gauge farmer's aspiration through weather based products to meet their day to day livelihoods.

5. The US, Canada, Mexico, and Spain all have functioning weather based or remote sensing based crop insurance plans. However in India, AICI is the only insurance company to offer NDVI-based products using India Remote Sensing satellite which is becoming more effective on lines similar to NOAA AVHRR based NDVI index used in other parts of the world. Such an improvement stems primarily from the higher resolution of the satellite data used for developing NDVI based indices. With respect to weather based products the use of historical data in conjunction with kernel density estimation technique to derive the probabilistic measure of weather index risks is relevant. However, In the Indian context, burning costs are used to establish measures of risk and premium rates. This is fully analogous with other nonparametric approaches to estimating premium rates and is justified on the basis of a reasonably large sample from which to derive rates.
6. With regard to weather insurance AICI started offering weather insurance plans in 2004 for selected crops. The contracts were based on the sowing failure, seasonal rainfall volume and rainfall distribution index. Some of these were customized designed contracts for frontline agribusiness companies like ITC, Pioneer Hybrid International and JK seeds. In addition to the rainfall based products, AICI has underwritten weather contracts based on temperature and NDVI indices. The major challenge found in the NDVI based option was the cost of data. The current practices of AICI were studied to get inputs for the improved design. Issues pertaining to pricing require considerable attention. The other operational considerations for design of improved weather insurance products include marketing, contract design, loss estimation and adjustment etc. The review of weather insurance plans in four countries and current practices in India helped to understand the technical, operational and practical needs of the improved weather based insurance pilots. The study evolved an eight (8) step design process. The steps involved in the process are: desk research, analysis of compiled data, field research, contract design procedure, identification of delivery channels, field testing of pilot contracts, refinement of contract based on feedback and marketing of fine tuned products.

7. Various analyses were carried to establish linkages between rainfall and crop yield. Regression between cumulative rainfall during the crop growing season and crop yield is often unable to capture the correspondence between the two variables primarily due to lack of requisite rainfall during crop phenophases. A number of analyses for determining the impact of weather (rainfall) deviations on crop yield losses were carried out during the assignment. Comparisons were made using weather contract design used in this product development process covering important phenophases of the crop such as vegetative growth, flowering stage, grain-filling stage and maturity stage of crop growing cycle. The sensitivity of crop yields under different weather scenarios has been evaluated by comparing deviations in crop yields with deviations in rainfall for different crop stages. For groundnut crop in Singanamala mandal, Anantapur, Andhra Pradesh, insignificant correlation was found between the crop yield deviation and rainfall deviation in Flowering and Pod Formation stage, while it is highest in the Pod Filling and Maturity stage. For cotton crop in the Jadcherla Mandal of Mahabubnagar in Andhra Pradesh, little correlation was observed between crop yield and rainfall deviation for all the stages of crops. The cotton crop in Akola, Maharashtra showed moderate correlation for Boll Formation and Boll Development stage while it was negative for Vegetative and Flowering stage. The soybean crop in the same region had the highest correlation for Pod Filling and Maturity stage, while it was negative or negligible for other two crop stages. At Gorakhpur, UP, the maize crop showed the little or negative correlation between crop yield deviation and rainfall deviation.
8. The data analysis on cumulative rainfall distribution in the adjacent IMD stations showed that the district level rainfall is not suitable to develop the rainfall based indices for entire district based on one rain-gauge and/or weather station. This results from basis risk which is extremely high for weather parameters like rainfall, wind etc. In case of the temperature based indices the district level information can be used as the spatial variation of temperature is quite gradual and low. The spatial distribution of weather stations monitored by IMD is, on an average one per district, which is not sufficient to account for the basic risk involved in settlement of rainfall-based contracts. It has been found that among the Indian states, Andhra Pradesh has the potential to offer crop weather insurance contracts with the least basis risk for contract pricing as well as settlement by virtue of its enviable repository of Mandal level rainfall data.
9. In order to derive an early payment schedule for NAIS based weather insurance product payouts, it can be said that two of the proposed weather insurance pilots follow a similar trend as the NAIS schemes, while the others showed mixed results. In cases of Anantapur (Groundnut) and Mahabubnagar (Cotton), the exercise for examining the feasibility of an early payment schedule yielded highly encouraging results. However it cannot be vouched with complete surety that an early payment schedule for even these locations will always give reliable outcomes as the issue of predicting area-yields using station-level rainfall data is fraught with extreme uncertainty as has been established in innumerable previous studies. The feasibility of NAIS early payment schedule is inconclusive in cases of Gorakhpur (Maize) and Akola (Cotton). It may however be concluded that the early payment schedule should at best be a highly calculated gamble wherein the insurance company should restrict its downside by resorting to a low level of interim payout. Therefore, the decision of setting up an early payment schedule

has to be taken by AICI with a clear view of the risks and returns associated with such a mechanism.

10. Design of weather insurance products involved focus group discussion and individual interactions with various stakeholders', consultations at RMSI and among international consultants to evolve essential design steps. The risk perceptions of farmers and their demands pertaining to weather risk played an extremely important role during the contract design process. Issues like weather data availability, missing data, basis risk are other crucial factors in the design of the contracts. For illustration, details of a cotton pilot developed for Mahabubnagar district in Andhra Pradesh have been presented in detail to exhibit different aspects of a weather contract developed for a pilot location. The contract design utilized all the information gathered from the initial three stages of the pilot program development. Contracts were designed such that the contract(s) being offered best met the risks as defined through the initial field work. Additionally, there was a focus on simplicity in the contracts as it would help avoid confusion among farmers both at the time of purchase and at the time of settlement. The contract structure reflected:

- The critical crop growth periods
- The weather parameters being indexed and the corresponding period for the consideration (weekly, decade-wise or biweekly)
- Thresholds/critical values/strikes for each contract
- Necessary capping or floors for daily or weekly data values in order to count only significant values in the index
- Suitable basis of indemnification for each cover chosen based on a synthesis of field inputs and scientific literature moderated by the contract developer.

Following this, the thresholds and/or strikes and associated parameters were then inserted in the contract design structure wherein these strikes were adjusted back and forth to optimize the premium and risk coverage.

11. Apart from the weather pilots, study also included blended/combined satellite and weather insurance pilots for potato, wheat, and tea crops. It has been realized that the blended products for tea and rubber plantations requires better insight into crop response to relative humidity (RH) in addition to rainfall and temperature, and also there is a need to further investigate how these weather indices can be tied with derivatives from satellite imagery. Hence the procedural steps were limited up to step 4 in the design of these blended/combined pilots. It was felt that the procedure could be further reviewed case by case at a later date by AICI to roll out the final products by underwriting the remaining steps.

12. International ratemaking procedures have been adapted to price weather products. It is recommended that AICI should calculate the premium as given below:

$$\text{Premium} = \text{AEL} + \alpha * (\text{PML (1-in-100)} - \text{AEL}) + \text{Administrative \& Business Expenses}$$

Where, AEL is the Adjusted Expected Loss, the expected loss adjusted by a data uncertainty factor; PML (1-in-100) is the 1-in-100 year Probable Maximum Loss and α is the target AICI Return-on-Risk (RoR), assuming AICI is required to reserve capital against its portfolio at the 1-in-100 year PML level.

Regarding the length of data, 20 years preferably 30 years or over continuous daily data with less than 5 % missing datasets is minimally acceptable in international weather market. Data not satisfying these criteria will be subjected to higher premium rates.

13. A software tool has been developed for Agricultural Insurance Company of India (AICI) under this assignment with a view to not only estimate the premium and payout parameters but also to help develop weather insurance contracts on fly. The software has the capability to estimate payout based on predefined contract parameters and triggers for three different covers namely Sowing and Germination Cover, Deficient Rainfall Cover and Excess Rainfall Cover. The durations and the sub-stages can be chosen based on agronomic and agrometeorological information for various crops. The software has the capability to work on both simulated and historical data, which lends enormous flexibility to the insurance company to use the weather data best suited to the requirements. A ratemaking module has also been added to the same application with the help of which standalone and bundled commercial pricing (for both simulated and historical weather data) can be determined for each product. Ratemaking module of this application provides an option for AICI to use/change various loading factors and parameters associated with the data uncertainty factor to derive optimum premium which covers the underlying risk adequately. This software application automates the various statistical processes that are part of contract design and pricing. The outcome in turn is a drastic reduction in the time required to develop a product from scratch.
14. The stakeholders operational manual for each of eight pilot crops have been developed which would help AICI in summarizing the key policies and procedures for implementation. It gives details of eligibility criteria, contract features and results, underwriting process used, pricing (applicable for both historical and simulated weather data), enrollment and claim settlement process. For the purpose of monitor the contract performance in current year and to ensure that program is being run efficiently, an MS excel based support application has been developed for AICI to enable it to monitor contract and settle the claims as promptly as possible.
15. This is to highlight that overall design of weather contract and pricing of weather insurance products developed under this assignment is flexible enough to be replicated by AICI in same as well as other agro climatic areas operationally. However, while scaling up this program AICI may have to seek services from agricultural risk management companies to ensure that weather data used by them are clean enough for replication. Also to expand current weather portfolio by selecting more crops and region – similar study leading to development of new pilot products are required so as to upgrade and update the basic weather insurance product developed under this assignment.

16. Under this assignment, the eight pilots delivered cover three states and seven crops in various locations in these three states. The table below provides a quick snapshot and summary of weather based products developed.

Table: Summary of Weather Insurance Products

List of pilots	Frequency of payouts (out of 100 yrs)	Pure premium rate (simulated)	Commercial premium rate	Is this product commercially viable
Andhra Pradesh				
Jadcherla – Cotton	23	5.2%	9.0%	YES
Koilkonda - Rice	16	4.9%	11.9%	YES
Anantapur - Groundnut	56	13.2%	19.0%	NO
Maharashtra				
Akola - Cotton	23	4.9%	8.3%	YES
Akola - Soybean	20	5.3%	9.5%	YES
Nasik - Grape				
Uttar Pradesh				
Gorakhpur - Rice	18	3.8%	8.3%	YES
Gorakhpur – Maize	26	4.8%	9.0%	YES

17. While marketing of these products will be carried out by AICI, list of delivery channels identified during product development process will help AICI in increasing the outreach of weather insurance products in these states. However, before moving ahead with this, AICI needs to build a package including roles, responsibilities and rewards that would be shared between AIC and its prospective marketing partners.

Portfolio Risk Management

Executive Summary

AICI is an exclusive organization set up for implementing and shifting National Agricultural Insurance Scheme (NAIS) to an actuarial regime. NAIS was until FY 2002 – 03 implemented by General Insurance Corporation of India. AICI also transacts other insurance businesses directly or indirectly concerning agriculture and its allied activities.

The NAIS is being implemented from Rabi 1999-2000 with the objective of providing insurance coverage and financial support to the farmers in the event of failure of any of the notified crops as a result of natural calamities, pests and disease, and to help to stabilize farm incomes, particularly in disaster years. The scheme is available to all the farmers (both loanee and non-loanee) irrespective of their size of holding and is currently the largest crop insurance scheme in the world in terms of the number of farmers covered. Before this the crop area yield insurance scheme implemented by GIC since April 1, 1985 and was termed as CCIS which covered only the loanee farmers.

AICI targeted to cover under NAIS 25% of all farmers, sum insured of INR 25,000 crores and commercial premium of INR 3,000 crores by 2007 – 08 and 50% of all farmers, sum insured of INR 60,000 crores and commercial premium of INR 6,500 crores by 2011–12 from a sum insured of INR 18,540 crores in 2005 - 06. Along with the targeted insurance penetration, AICI also planned to move NAIS onto an actuarial regime by switching government financial support from claims subsidy to upfront premium subsidy when the project started in October 2006.

To move into an actuarial regime with such a level of liability and insurance penetration, AICI would require an in-depth analysis of the risk of their portfolio and a good risk management and transfer strategy. It was also discussed that the first phase towards actuarial regime would be to move only 100 districts nationwide to an actuarial regime.

Currently, actuarial rates are being charged in case of annual commercial / horticultural crops. Small and marginal farmers were entitled to a subsidy of 50 per cent of the premium, which was shared on 50:50 bases by the Central and State Governments. The subsidy on premium has gradually been phased out and at present only 10 per cent subsidy is available to small and marginal farmers.

Through the component 2 of this project we have come up with an interactive tool that would provide users at AICI with the ability to evaluate the risk profile of their entire insurance portfolio (or any components thereof). The tool was developed on the basis of discussions and interactions with World Bank and AICI personnel, especially those occurring during January and March 2007 meetings in Delhi.

In addition to the above a desire was expressed to allow users of this portfolio tool to consider any range of “what-ifs” that would apply to changes in underwriting or actuarial parameters of the insurance programs and in turn show as an output its impact on the underwriting and financial results. The structure and implementation of

the process in the tool can be broadly divided into the following three models: **Macro, Micro and DFA Model.**

Macro Model

The macro portfolio model is based upon a detailed analysis of the accumulated AICI's experience data over the 1985-2005 periods. Loss experience data for these 21 years of history is used in conjunction with information about total premium and sum insured to evaluate the entire portfolio or subsets of the history. This data is aggregated to the season-state-district-crop level from the information provided by AICI and are presented on an annual basis. Each of the following features and functionalities of the tool are built keeping mind the requirements of AICI as per the terms of reference.

- A wide variety of statistical indicators are presented for the portfolio considered. These include averages and measures of dispersion for important variables such as the loss cost and loss ratios as well as downside risk measures such as the PML and value at risk (VaR). The PML/VaR statistics are based upon the assumption of log-normality for the distribution of loss-costs. Various other summary statistics and diagrams are also presented.
- An analysis is based upon the existing experience. For example, a possible underwriting change might involve elimination of a crop, state or district from eligibility for coverage. One can go back and use the historical experience data to see how the portfolio would have performed over time had that particular crop not been in the portfolio.
- This type of “as-if” analysis considers the performance of the portfolio as if the current (2005) mix of sum-insured and premium had characterized the history. In other words, historical loss-costs are used to simulate the performance of the current portfolio. Two variants of this analysis are considered.
 - First, we use the actual 2005 sum insured matches to each year of history. A shortcoming of this approach pertains to the fact that the mix of districts and crops has changed considerably over time—resulting in a degree of difficulty in matching recent experience with historical losses.
 - In a second approach, we use a set of proxy measures of the missing loss-costs (based on similar crops, regions, etc.).
 - Finally, we evaluate the existing historical experience using weights that reflect the degree to which current (2005) experience is able to be matched back in time. These weights fall to as low as 30% as one moves back into the 1990s.
- The tool also gives the option of analyzing the portfolio with new set of rates. Thus, providing the user flexibility to analyze any portfolio mix both at the existing rates as well as with actuarial rates. This performance analysis of any portfolio mix is also taken forward to the Dynamic Financial Analysis to study the implications of these changes on solvency margin, capital allocation and reinsurance.
- An important component of the macro model involves the ability to consider exogenous underwriting changes. Slider bars provided in the tool allow users to make adjustments to the expected loss-cost and the sum-insured. These adjustments can be used to assess the effects of underwriting changes that alter the risk and penetration levels represented by the portfolio. The micro model (discussed below) is used to inform these adjustments for a number of possible

underwriting changes that could be considered (e.g., eliminating certain coverage levels and changing the determinants of insurance guarantees). This linkage is not direct in the sense that the software tools are not directly linked, but rather both can be run concurrently and the user can manually enter risk changes and can explore the sensitivity of the changes to assumptions and inferences derived from the micro model.

- The macro model also includes an option to add weather products to the portfolio. At present, the weather products are defined only for three states: Andhra Pradesh, Maharashtra, and Kerala. The performance of the weather products is simulated using loss-cost information constructed using actual and simulated weather data for the three states. Users are able to input levels of sum insured and premium rates and can consider the weather products individually or in combinations with other states and crops.
- The macro model also produces a number of outputs that are used as inputs into the DFA model. This includes summary statistics regarding financial performance measures as well as measures of the correlations and covariance among different components of the portfolio.
- Following the requirements specified by the potential users of the tool, the software is written using only Excel and freely-available software. In particular, the computational platform for the tool is the R language. To run this tool a users' guides that describing installation and setup of the tool is provided to help execute basics of its operation.

In summary, a few caveats associated with the macro model should be emphasized here.

- First, it is based only on 21 years of data.
- Second, many of the analyses are based upon assumptions of log-normality for the distribution of loss-costs. This is very standard. However, this does impose a specific shape on the distribution which may not always be supported by specific portfolio mixes.
- Finally, a segment of the analysis is based upon proxy measures of missing loss-cost experience. This necessarily involves replacing missing data with informed estimates and thus any resulting inferences should be conditioned on the assumptions underlying the proxy measures.

Micro Model

The basic purpose of micro analysis is to measure the impact of possible changes in the underwriting practices in the coming years: (i) Change in the methodology of determining the guaranteed yield either based on 5 best years out of 7 preceding years moving average method or preceding 10 years moving average; (ii) Keeping the indemnity levels at 80% and 90% only (removing 60%). Since the underwriting is done at the insurance unit i.e. mandal/block level the micro model is based on the insurance unit level data. Impact of these changes was measured on the loss costs and variance (portfolio risk) of the selected crop portfolio at various insurance unit levels (Mandals / Blocks / Districts / States), and also at different indemnity levels.

The micro model was developed using the sample data measured at mandal or block (insurance unit) level, for major crops covering Kharif (Paddy, Cotton, Tur & Ground Nut) and Rabi crops (Wheat). To ensure that the sample data is illustrative and adequate,

reasonably good sample size of block or mandal level yield data were used for each of the selected crops: for instance the total number of mandals / blocks (unit of insurance) used were almost 2000 units covering the historical period of 21 years from 1985 to 2005.

Sample results based on above explained kharif crops - micro analysis have been summarized below:

- i) Moving from the present method (3 / 5 years method) of guaranteed yield calculation to 5 best years out of preceding 7 years method increases the loss cost as high as 32% at 100% indemnity level, 36% at 90% indemnity level, 41% at 80% level and 57% at 60% indemnity level for the kharif crops. The loss cost variations are very high for rabi crops it is almost 70% for rabi crops, while the combined (kharif + rabi) impact is 36% at 100% indemnity, 39% at 90% indemnity, 43% at 80% indemnity and 57% at 60% indemnity level respectively.
- ii) Similarly moving to preceding 10 years method of guaranteed yield calculation increases the loss cost, over all, by 5 – 10%.
- iii) Further, moving from 60% indemnity level to 80% level impacts the loss cost by almost 2 times and it is 4 times at 90% indemnity level for the kharif crops, while it has a significant impact of 8 to 10 times to 80% and more than 10 times to 90% for rabi crops. The combined effect seems to be at average increase of 3 times for 60% to 80% level, and 5 times for 60% to 90% indemnity level.
- iv) Similar trends have been observed to almost all the selected crops (paddy, Groundnut, Cotton, Tur, Wheat).

Portfolio Risk Assessment: The portfolio risks were measured by taking into account the variance of the insurance units and the observed covariance's among the units, weighted by sum assured of the insurance units. The portfolio risks were estimated at various insurance units (mandals / blocks / districts / state) as given below: (i) first, the portfolio risk for the selected crop was measured at mandal or blocks level by multiplying the covariance matrix measuring the underlying relationships among the insurance units, by assigning equal weights across all the insurance units of the selected districts. (ii) Portfolio risks at district level were estimated measuring the underlying risks observed at mandal or blocks level, (iii) then, the state level portfolio risks were estimated using the district risks.

A brief summary of the results are given below:

- The result of this analysis also corroborates with our loss cost analysis indicating that wheat crop is the most stable crop with low risk. The values of risk for all the insurance units are quite low; interestingly it is low even for high-risk zones like Gujarat.
- For Cotton and Groundnut also, the results are significantly correlated with loss cost results, suggesting that Groundnut & Cotton are one of the high-risk crops with high loss cost with greater variations. It is also interesting to observe that the value at risk is very high at the lowest insurance unit level (mandal / blocks) and the risk reduces when we move to the higher level of aggregation i.e. state or nation.
- The analysis is also helpful in identifying high-risk districts in each state for each crop, as we observe that Nalanda of Bihar and Siddharth Nagar of Uttar Pradesh

- for Paddy, Guntur, Krishna, Adilabad in Andhra Pradesh and Akola and Washim in Maharashtra for Cotton, are observed to be high-risk districts.
- As expected, the portfolio risks for kharif crops are comparatively higher than rabi. It is a well-known fact that rabi crops are less risky than kharif crops, and secondly the risk values are quite low for combined portfolio of kharif and rabi together. It is also interesting to observe that the risk becomes quite low for the portfolio underwriting multi-crops covering more regions as compared to portfolio having large size of individual crops

This tool is robust enough in capturing the underlying risks from the lowest insurance unit (mandals / blocks) to district / state / national level, by taking into account variations in the payouts over the historical years and the underlying relationships between the crops and insurance units. It was observed that the risk value at lowest insurance unit (mandal / blocks) is higher and reduces significantly when we move to the higher aggregation level i.e. state or nation.

Finally, since the tool has been build using the sample data, the results are indicative of the selected insurance units only, therefore, it is difficult to draw general conclusions. However, the tool is flexible enough to assess the portfolio risk for any crop / insurance units.

Dynamic Financial Analysis

The primary purpose of Dynamic Financial Analysis (DFA) is to measure underwriting performance and check how the underwriting activities are impacting the financial performance of the company under various scenarios, such as Reinsurance, Investment, etc. The key inputs used in the DFA are the sum assured premium income, claims, capital, reserves and surplus, investment income, operating & management expenses, etc. The DFA tool uses mean and standard deviation of loss cost information coming from the macro model. Then it calculates underwriting performance measurement parameters such as Loss Ratio, Combined Ratio etc and financial measures such as Solvency Capital requirement, probability of ruin etc. for various scenarios. The DFA model provides the flexibility to select the basis of analysis i.e. historical loss cost based analysis or projected for the next Financial Year.

State/Crop Level – Tail VaR Analysis

The State / Crop level analysis gives the underwriting results i.e. Underwriting Results and Combined ratio for each state and crop covered under NAIS and Weather Index Insurance. The DFA tool is connected to the Macro Model and if the macro model is run of the basis of actuarial rates, the underwriting results shown the DFA analysis will reflect the loss and combined ratio as per the new rates.

This analysis also estimates the Marginal Value at Risk (VaR) for each of the participating states and crops. The Marginal VaR gives the probable loss the crop or state is going to incur and the maximum capital which is required to be allocated in the next year. Some of the observations from the analysis is shared below:

- Tail VaR analysis suggests maximum capital allocation (to support losses) to Gujarat (45%) followed by Karnataka (16%) and Andhra Pradesh (13%). Based

- on this analysis, Gujarat, Jharkhand and Bihar are identified as high Risk zones for underwriting.
- Along with a high capital allocation Gujarat also has a high combined ratio which implies that it's a high risk zone and should be taken into consideration soon.

State / Crop Correlation Analysis

The correlation analysis gets input from the Macro model. Correlation here refers to NAIS (&CCIS) loss cost correlation calculated based on 21-year annual loss costs information. When there is a negative claim correlation between two states/crops we can say that, the loss cost for the selected states/crops are moving in opposite direction. High negative correlation is not rare but very unlikely. When there is a positive claim correlation between two states/crops, we can infer that, loss cost of the selected states/crops move together in the same direction. Hence there is loss accumulation problem. Crop correlation analysis mainly helps in designing insurance products for the individual crops. Similar insurance scheme can be designed if the crops are positively correlated. This will reduce underwriting risk substantially and reduce accumulation of losses.

Underwriting and Financial Results

The tool enables the users to analyze AICI's underwriting results, probability of ruin and solvency margin for various reinsurance arrangements. It also takes into consideration the solvency norms laid down by Insurance Regulatory and Development Authority of India. Please note that the tool takes as a default an input from Macro Model the mean and standard deviation of the loss cost. Thus it also provides a flexibility to see the results for any desired portfolio mix.

Event Loss Analysis

The tool provides Event loss analysis. The Macro Model provides necessary underwriting and event loss information for this analysis. The Event loss analysis has identified Drought as the most detrimental event for AICI's business. The tool predicts cyclone once in every 20 years, Drought and Flood in every 10 years.

Reinsurance Strategy

1. It summarizes RMSI recommendations to First Initiative and the Agricultural Insurance Company of India, AICI, for the **2007- 08 reinsurance strategy** of (a) AICI's pilot Crop Weather Index program which has been implemented with commercial reinsurance protection since 2004 and (b) the National Agricultural Insurance Scheme, NAIS, which has operated for 21-years with excess of loss protection provided by Government of India, GOI, and the participating State Governments.

Government of India Objectives for Crop Insurance

2. The GOI's objectives for NAIS are two-fold (a) to make the programme more attractive to Indian farmers with a view to increasing uptake levels from about

15% of all farms in 2005-06 to 50% of all farmers in 2012 and (b) to move the NAIS scheme onto a sound commercial insurance basis by adopting actuarially determined premium rates and by switching government financial support from settlement of excess claims to the provision of up-front premium subsidies. This will mean that beginning in 2007-08, or date to be agreed, AICI will need to put in place a formal risk management and risk transfer (reinsurance) strategy for the NAIS scheme. The NAIS is a major crop insurance program with 2007-08 total liability estimated at Rs. 244 billion (US\$ 5.4 billion). AICI will therefore potentially be seeking major international reinsurance capacity support in 2007/08 or future date to be agreed.

The GOI has also signalled its support for the expansion of crop weather index insurance in India, and at the time of finalizing this report, GOI has just announced its intention in 2007-08 to make available Rs. 100 Crore (US\$ 22 million) for premium subsidies on crop weather index products with a view to scaling-up this programme in 2 or 3 states in 2007-08.

RMSI Technical Assistance

3. In October 2006 RMSI was appointed by First Initiative to assess the risk exposure on the AICI book of business including both NAIS and crop weather index covers and to develop a sound risk retention and risk transfer strategy for the company based on reinsurance and/or alternative risk transfer mechanisms.
4. This report deals specifically with (a) a review of the international agricultural reinsurance markets and implications for AICI's reinsurance strategy in 2007/08, (b) an examination of the role of government in agricultural insurance drawing on international experience and to relate this GOI's financial support to agricultural insurance in India, and (c) RMSI's recommendations to AICI for their risk retention and risk transfer (reinsurance) strategies for the NAIS and Crop Weather Index Programmes in 2007-08.
5. The final results of RMSI's work on developing Portfolio Risk Assessment and Portfolio Risk Modelling Tools for AICI are presented in a separate report.
6. In 2006-07, RMSI was also contracted by First Initiative to assist AICI in the design and rating and pilot implementation of a series of new crop weather index products. The outputs and results of this design work are reported separately.

NAIS and Crop Weather Index Programs: Key features and results

7. Section 2 of this report provides a review of AICI's traditional NAIS crop insurance program and the new weather index pilot projects.

(a) NAIS Crop Insurance

8. The NAIS is an Area-Index Multi-peril, MPCl, Yield shortfall program, which has operated in one form or another for 21 years. In 2005-06 the scheme insured 16.7 million farmers or 14.4% of India's 116 farm holdings. In 2005-06 Total Sum Insured, TSI, amounted to a substantial Rs. 186 billion (US\$ 4.1 billion) with

premium income of Rs. 5.6 billion (US\$ 124 million). In terms of numbers of insured farmers, the NAIS is by far the world's largest crop insurance scheme.

9. The NAIS has traditionally been targeted at small and marginal farmers and is mandatory for farmers utilizing seasonal credit. Since inception the NAIS has offered cover to farmers at highly subsidised premium rates which are currently capped at 2.5% for food crops and 3.5% for oilseeds, while actuarial rates are applied to horticultural and commercial crops.
10. NAIS is currently being implemented in 23 Indian states and 2 union territories. It is predominantly marketed through the agricultural lending banks which assume responsibility for policy issuance, premium collection and payment to NAIS and for settling claims. NAIS uses the results of the All India crop cutting experiments to adjust yield shortfall at an area level and to indemnity losses accordingly.
11. Over the past 21-years the NAIS program has operated at a financial loss as evidenced by the long-term average loss cost of 9.9% and long-term average loss ratio of 359%. For the past 21-years the GOI and State governments have settled AICI's excess losses on a 50:50 basis.

(b) Crop Weather Index Insurance

12. AICI began underwriting crop weather index insurance on a pilot basis in the Kharif 2004. Between 2005 and 2006 AICI have considerably expanded their weather index operations into new states and for different crop types and weather perils.
13. A key feature of the crop weather index programme is that to date this has operated on a strictly commercial basis with no subsidy support from GOI or the state governments. AICI has therefore adopted full actuarial rates on the weather index programme.
14. In the Kharif 2005 season or second year of implementation, the Crop Weather Index pilot program achieved very impressive levels of acceptance by Indian farmers with sales in 79 locations of 10 states, total policy sales of 125,000, premium income of Rs. 31.7 million (US\$ 0.7 million) and loss ratio of only 6.3%.

Government of India Support to Crop Insurance in India and International Experience

15. Section 3 of this report presents a review of major international agricultural insurance programs and the role of public sector support in territories including USA, Canada, Spain, Mexico and Portugal. In all countries, governments provide premium subsidy support to farmers, the justification being (i) that without these subsidies farmers would not be able to afford crop insurance and (ii) that subsidies enable insurers to charge the actuarially correct and often high rates associated with a risky class of insurance. The experience of these programs shows, however, that crop premium subsidies generally benefit larger farmers than smaller ones, and may not be the most cost-effective way of supporting agricultural insurance programs. The second most popular form of government financial support is to risk financing and where this is provided for the

reinsurance of catastrophe losses this is often a very cost-effective alternative to or addition too, commercial reinsurance.

16. Traditionally the GOI and the State governments have provided very high levels of financial support to **NAIS** (and its predecessor, the Comprehensive Crop Insurance Scheme, CCIS, which operated between 1985 and 1999). This support has been provided on a 50:50 basis by GOI and the participating states and has taken the following forms:
 - (a) Premium subsidy support for small and marginal farmers cultivating less than 2 hectares of land. In 1999, a 50% premium subsidy was provided, but this was reduced by 10% in each subsequent year to the current level of 10%;
 - (b) Subsidies on AICI's operating and administration expenses
 - (c) Settlement of claims exceeding 100% loss ratio (food crops) and 150% loss ratio (horticultural and commercial crops).
17. In 2005-06 government's financial subsidies to AICI on the NAIS programme amounted to Rs. 8 billion (US\$ 177.8 million), divided into: settlement of excess claims (93%); premium subsidies (6%); and subsidies on operating expenses (1%). Due to the very high levels of financial support provided by government on the NAIS especially in reinsuring excess claims, AICI is able to operate at a near break-even position on this programme and indeed the company has generated an operating surplus in three of the past four years on their crop business.
18. Conversely, between 2004 and to date, AICI have implemented the Crop Weather Index programme on a strictly commercial basis with no premium subsidy support or other financial support from government.
19. In 2007-08, or date to be agreed, GOI has signalled its intentions to commence withdrawal of financial support from NAIS's excess of loss (reinsurance) programme and to replace this by direct (up front) subsidies on the costs of actuarially determined crop insurance premiums paid by farmers. Using AICI's estimates of 2007-08 TSI and premium income on NAIS, the costs of a 65% premium subsidy would amount to about Rs. 20.2 billion (US\$ 418 million) to government against a saving in excess claims costs estimated at about Rs. 18.8 billion (US\$ 452 million) under the assumption of an average claims year. In other words the switch to premium subsidies would be almost cost-neutral to government.
20. In February 2007, GOI announced a major expansion of the Crop Weather index program and for the first time government will support this program with Rs. 100 Crore (US\$ 22 million) for premium subsidies. The participating state governments will match GOI's premium subsidies by a further Rs. 100 Crore (US\$ 22 million).

Review of International Reinsurance Markets and relevance to India

21. Section 3 also presents a review of the Traditional and Non-Traditional Crop Reinsurance and Weather Reinsurance markets and the reinsurance arrangements in key territories such as the USA, Mexico and Spain.

22. In 2005, market estimates suggest that total global agricultural (crop, livestock and forestry) insurance premiums were in the order of US\$ 8 billion of which nearly 70% were accounted for by North American crop hail and multiple peril crop insurance. India was ranked 7th with 2005 crop premiums of about US\$ 130 million and a further US\$ 95 million of livestock insurance. It is estimated that global agricultural reinsurance premiums amounted to about US\$ 1.3 billion in 2005, divided mainly between proportional (quota share) reinsurance treaties and non-proportional reinsurance treaties. The volume of facultative reinsurance is low in agriculture. The traditional agricultural reinsurance market is dominated by a small group of European and US commercial reinsurers.
23. The crop (& livestock) weather index market is only about 5 years old and at a pilot programme stage in key territories such as India, Mexico, parts of central and South America, Ukraine, Africa and Mongolia. The crop weather reinsurance market is very new and is dominated by the same group of mainstream commercial agricultural reinsurers. Currently most reinsurance is conducted on a traditional proportional or non-proportional treaty basis, and alternative risk transfer reinsurance mechanisms are not well developed for the agricultural sector. (This is in contrast to the energy sector which has over a decade of experience with weather derivative reinsurance and is now a major market).
24. On the basis of our review of the international reinsurance market and AICI's reinsurance requirements and options for 2007/08 on the NAIS and Crop weather Index programs, RMSI recommended that this year the company should seek to place their reinsurance requirements with traditional proportional and non-proportional agricultural reinsurers.

RMSI Recommended Reinsurance Strategy for NAIS in 2007/08

25. On the basis of our review RMSI have recommended that in 2007-08 AICI consider placing a combination of Quota Share Treaty reinsurance with the General Insurance Corporation, GIC, of India under the compulsory cessions, and then to purchase **Stop Loss Reinsurance Treaty protection on AICI's retention**. Chapter 4 of this report provides a detailed analysis of the NAIS (& CCIS) 21-year results on which basis we have suggested Indicative Stop Loss layering for losses excess of 15% of 2007-08 total sum insured, TSI, up to about 30% to 35% of TSI which represents the estimated probable maximum loss which could be expected on this program 1 in 100 years. This structure could be developed further if GOI were willing to provide AICI with additional stop loss reinsurance protection excess of 25% to 30% of TSI. RMSI's financial analysis of this reinsurance structuring option shows that if full actuarial rate increases are introduced the NAIS scheme would be able to operate profitably and on a self-sustained basis under the proposed combination of Quota Share and Stop Loss Treaty reinsurance protection.
26. At the time of submission of our final report to AICI, the GOI has announced for the Kharif and Rabi seasons 2007-08, that the NAIS program will remain unchanged, or in other words that actuarial rate increases will not be introduced this year and that government will continue to settle excess claims. This means that in 2007-08 AICI will not need to seek formal reinsurance protection from GIC

and international reinsurers. As such RMSI's proposed risk transfer and reinsurance strategy for NAIS will be put on hold in 2007-08.

Crop Weather Index Reinsurance Strategy 2007-08

27. Since inception, AICI has reinsured their crop weather index program partly through compulsory proportional cessions to GIC and facultative placements with GIC. In addition, for the past 2 years, AICI has placed a 20% quota share reinsurance treaty for the Varsha Bima policies with ParisRe (formerly AxaRe) which is a leading crop weather index reinsurer. In the Rabi 2006-07 AICI concluded a new 30% Quota Share Treaty for Rabi crops with ParisRe.
28. Under their 2007-08 Business Plan, AICI had previously projected a modest expansion of their crop weather index underwriting with a 400% increase in TSI to Rs. 4.0 billion (US\$ 89 million) and with expected premium income of about Rs. 254 million (US\$ 5.6 million). The company was therefore seeking to increase its Crop Weather Index Quota Share reinsurance cession from about 55% in 2006-07 to between 65% to 70% in 2007-08. The company had therefore planned to visit European reinsurers in April 2007 with a view to bringing new proportional reinsurance capacity for a modest 10% to 15% share, onto their crop weather index programme. In addition, AICI was also considering the need or otherwise for non-proportional stop loss protection on its 30% to 35% net retention in 2007-08. RMSI's financial analysis shows that average rates in the order of 10% will be required on the crop weather index programme in order to cover the operating costs on this class of business and to generate the level of profitability required by underwriters and their reinsurers.
29. There has been a significant development in late February 2007 namely, that GOI has announced its intention to promote a major scaling-up of AICI's crop weather index program by the provision of Rs. 100 Crore (US\$ 22 million) premium subsidy support to the program. Three states have provisionally been selected for the expanded crop weather index programme, Maharashtra, Karnataka and Jharkhand. The participating State government's will contribute a further Rs. 100 Crore (US\$ 22 million) for crop weather index premium subsidies. These states will suspend the NAIC Area-based yield index scheme in those districts where the scaled-up crop weather index programme is offered in 2007-08.
30. This represents a very significant development for AICI. It is anticipated that under the scaled-up and subsidised crop weather index programme in the 3 states, coverage and therefore total scheme liability may be 5 to 10 times higher than previously budgeted for by AICI or TSI of between Rs. 20 billion (US\$ 500 million) and Rs. 40 billion (US\$ 1 billion). This increased TSI liability will imply a need to re-assess AICI's crop weather index risk retention and reinsurance strategy for 2007-08 and the company will require very much higher quota share treaty and or stop loss treaty reinsurance support than previously anticipated. AICI is currently establishing a new 2007-08 crop weather index business plan and portfolio projections in conjunction with the state governments and which they will then present to Guy Carpenter, their appointed international reinsurance broker, in order for the broker to seek quotations for the 2007/08 reinsurance programme.

31. AICI, accompanied by Guy Carpenter, is planning to visit European reinsurers in the week starting 23 April 2007, in order to brief these reinsurers on the recent developments in their Crop weather Index and NAIS programmes and also to seek reinsurers' preliminary indication of support for the expanded crop weather index programme in 2007-08.