Prospects and Challenges of Weather Derivatives in India

ABSTRACT

Introduction

Poor, small farmers are especially susceptible to income variability because of weather-related risks to their crops. In fact, even those rural poor who are not directly involved in agricultural production get affected because their incomes are often tied to the success of the agricultural production (Barnett and Mahul, 2007).

Traditionally, small farmers and the rural poor have used various types of mitigation techniques for weather-related risks to their income. These include savings, selling their assets, selling their livestock etc. However, the implied premium on these types of techniques was estimated by Rosenzweig and Biswanger (1993) to be as high as 35%.

Weather derivatives are a newer form of derivatives, which can be used for hedging the risks associated with weather. The first of such contracts was signed in 1997 in the United States of America.

The impact of weather on business activities is enormous and, obviously, varies with the business, the location and with climate change. In the agricultural sector, the amount of rainfall could make a significant difference to the yield patterns. This would be even more prominent in developing countries like India, where about 60% of the agricultural produce is dependent on the rainfall. The risk that is covered by weather derivatives includes the potential adverse impact of the weather on expected costs, revenues and cash flows. In India, most importantly, crop produce could be hedged against weather through weather derivatives.
Justification for the Study

There has been a prolonged debate on the use of weather derivatives in the Indian conditions. Weather derivatives could be an effective hedge against the vagaries of weather, which could result in a lower-than-expected agricultural output. And this would be true both, at an individual farmer level, or collectively at a larger level. Once again, the same argument would hold true for many other sectors where sales and revenues earned would be weather-dependant.

An interesting and required area of research is the potential need for weather derivative products. In the initial stages, for the market to grow, there would be need for a large number of market players. Taking the agricultural sector in India as the one which could benefit the most, this could be a good starting point for research. Research into the demand for weather derivatives and willingness to invest in such products would give an insight into the potential market and the manner in which they could be structured. Such a study has not been done in India, and this could possibly boost the market, while simultaneously be a feed into regulatory and policy issues which would have to be in place as the market takes off.

India has experimented with the crop insurance programme for many years. Whilst most of the schemes have been government programmes, a few private players have ventured into the field. However, the primary question has been of not just what an Indian farmer is able to pay, but also of what he is willing to pay. Unfortunately, most debates start with an assumption that a farmer would not be able to pay for hedging his yield, and so the government would necessarily have to subsidise any scheme that is floated.

An empirical study into farmers’ willingness to pay for a weather derivative would give the required insight into the structuring of such products, whether such products can be introduced without any government subsidy, as has been the case with all crop insurance thus-far, and the viability of private players coming up with innovative hedging products for farmers.

Literature Review

The review of literature has been done in two parts. The first is on the various crop insurance schemes which have been floated in India, and the lessons learnt from these. This also discusses the commodity derivative exchanges and commodity derivatives
trading in India, and the lessons learnt from these. Part two brings out the history of weather derivatives and structures commonly used. It also brings out methods which could be used for pricing weather derivatives and techniques for determining willingness to pay for such products. This sets the pace for the study on the prospects and challenges of introducing weather derivatives in India.

The Comprehensive Crop Insurance Scheme (CCIS) and the National Agricultural Insurance Scheme (NAIS) of the Government of India, as well as the Varsha Bima scheme of the Agriculture Insurance Company of India, have been studied in order to draw on the lessons learnt from crop insurance in the Indian context. What emerges is that the traditional crop insurance schemes in India have been plagued with many problems and have met with very limited success. Some of the predominant issues relate to moral hazard, adverse selection, delays in payouts and the very high payout to premium-receipt ratio. Crop insurance in India has become a sort of loan-insurance. The benefit actually goes to the providers of the loan, whilst the premium is paid by the farmer.

A study has also been done of the commodity markets in India. The Indian Commodity markets are far behind those in developed countries. This is mainly because of the long period of prohibition in forward trading in major commodities. There are a lot of lessons to be learnt from the process of introduction of derivatives trading in securities which have been to quite an extent extrapolated to trading in commodity derivatives. Lessons from both these experiments need to be kept in mind when the introduction to weather derivative trading takes place in India. Both, the LC Gupta committee report and the JR Varma group report, have been studied in detail, since these went into the regulatory issues prior to introduction of derivatives in India.

A limited amount of research has been done on weather derivatives the world over. This is especially so with regard to willingness-to-pay and with regard to valuation techniques. While various types of indices have been used to varying extents, the most common index used in the US and Europe is the temperature index. This is probably because one of the major factors for the growth of Weather Derivatives was the deregulation of the energy markets in the US (Alaton et al, 2002). Until a few years ago, 98-99% of Weather Derivatives traded were based on temperature (Garman et al, 2000).

In spite of the obvious need for universal pricing in the Weather Derivatives market, no standard pricing models are in place. Unlike other financial markets, there is no real common language in the weather market. Many market makers have developed their
own models which they use only for their purposes and which they rarely share with others.

Methods of evaluating willingness-to-pay have been studied. One of the methods, which has been used fairly extensively is the Contingent Valuation (CV) method. Contingent Valuation uses surveys to obtain responses to hypothetical situations and then determines preferences through respondents’ willingness to pay for a service which is proposed to be introduced or for an improvement in an existing service. The method is named so because it determines ‘willingness to pay’ values which are contingent upon a hypothetical situation or market which is described to the respondent.

**Research Objectives and Methodology**

There were three major objectives of this research:

- Theoretically estimate the amount that a typical farmer might be willing to pay for weather-risk hedging and the magnitude of the basis risk, which is considered an important limitation for these products. Thereafter, empirically evaluate the appeal of weather derivative products to farmers and their willingness to invest in these products in order to hedge weather related risks, through a survey.

- Study the policy and regulatory framework for derivative trading in India and see how these could be adapted for weather derivatives trading in the Indian context.

- Study existing models for pricing weather derivatives and to study how they could be adapted for Indian conditions.

The empirical framework of the study attempts to bring out farmers’ preferences vis-à-vis various services related to hedging of crop yield through stated preference techniques. It then uses the contingent valuation technique to value their willingness to pay for such products.

The questionnaire finally designed covered questions that concern:
- Demographics of the sample (age, education, family size, income etc.)
- Type of losses suffered, attributable to weather
- Awareness of weather risk issues
- Awareness of weather risk hedging methods
• Willingness to invest in weather derivatives to hedge weather risks
• Preferences for various types of weather derivative products

A bidding game is used in the questionnaire to determine yes or no responses to various bids for weather derivative pricing. A Random Utility model is used, and logit and probit estimations are done using LIMDEP software.

**Theoretical Analyses**

A theoretical framework is attempted which would be able to give an estimate of the ‘willingness to pay’ for hedging the weather risks. This is based on the expected utility for a farmer growing a crop. It builds in some simplifying assumptions and includes the cost of and the gain from a possible hedge on the portion of yield variability, which could be attributed to rainfall dependence. An empirical analysis based on the gross production of soyabean in the district of Jhalawar in the state of Rajasthan is done to give a rough estimate of what would be the aggregate willingness to pay in order to cover yield risk.

For a farmer growing a crop, his expected utility can be expressed as

\[ E(U) = E(S) - C - R \]

Where \( E(U) \) is the expected utility, \( E(S) \) is the expected sale price, \( C \) is the cost of inputs and \( R \) is a risk premium.

Utility is maximized with respect to planned production. Thereafter, the case where the farmer has an option to hedge the weather risk through purchase of weather derivatives is introduced. The cost of hedging, that is, the amount paid by the farmer as premium, is included in the cost of inputs. First order condition are got by differentiating expected utility at time \( t \), \( E(U_t) \), with respect to planned production \( q_t \) and the amount of hedging \( h \).

A dataset of soyabean production, inputs etc for the 23 years 1982 to 2004 at Jhalawar district in the southern part of the state of Rajasthan, is used for the empirical study. The study indicates that the demand for weather derivatives as a shield against volumetric risk in the case of soyabean in the district of Jhalawar in Rajasthan exists and would be of the order of around 5.47% of the sale price that a farmer would get from his produce.
One of the major challenges of weather derivatives is that climatic variability occurs on spatial and temporal scales. This is not too evident in the case of temperature, but could have significant effects on derivatives based on rainfall.

Geographic basis risk in the case of weather derivatives can be defined as the risk that the payout does not correspond with the deviation in the underlying weather parameter at the location at which hedging is desired. This, typically comes in when the weather station, data from which is used for deriving the index, is located at a distance away from the location at which hedging is desired.

In order to establish the intensity of the issue, data was used from two weather stations located close to each other and the correlations in rainfall were studied. Daily rainfall data from the India Meteorological Department for the 30 year period from 1975 to 2005 was used for the study.

It could be concluded that for short term rainfall-index based weather derivative contracts, the location of the weather station vis-à-vis the contract location assumes special significance. For longer term contracts, the use of proxy weather stations could be justified to a certain extent.

The Survey

The questionnaire-based survey was conducted with a broad objective of overall assessment of floated crop insurance schemes, appeal of weather derivative products and farmers’ willingness to pay for such schemes. It was conducted in two districts viz., Jhalawar and Tonk of Rajasthan where the AIC has launched crop insurance schemes. These districts were chosen based on the district-wise number of policies sold in the Varsha Bima-2006 scheme and the Rabi Weather Insurance scheme 2006-07.

Various elicitation methods were studied, and the bidding-game method was considered the one with the maximum advantages in the scenario. Considering the level of the presently charged premiums for crop weather insurance, it was decided to start the bid at 10% of the value of the maximum payout of the weather derivative, i.e., the farmer would be willing to pay Rs 100 for a possible payout of Rs 1000 from the weather derivative. Subsequent steps of the bidding game were kept at 8%, 5%, 3% and finally at 2%. Thus there were five steps designed into the bidding game.
Prior to the survey, a focus group discussion was held in one of the villages. This was followed by pilot testing of the questionnaire. The final questionnaire included a script which was used to describe the concept of the proposed weather derivatives. This script was tried out during the pre-testing, and was subsequently modified, taking into account the learnings from the responses.

A sample size of just over 500 was used; this gave a confidence interval of 0.042 ie. 4.2% with a confidence level of 95%.

**Findings of the Survey**

Expectedly, 98% of the respondents indicated that they go through mental stress, worrying about abnormal rainfall and how it would affect their crops. While 68% said that worries about abnormal rainfall stresses them to a very large extent, 31% said that it stresses them somewhat. (Figure 1).

![Figure 1 Mental stress - rainfall uncertainty](image)

Satisfaction levels were found to be fairly high (85%) with the two schemes launched by AIC in the recent past – Varsha Bima and Rabi Crop insurance. Between the two districts, satisfaction levels were much higher in Tonk. In Jhalawar, most of those who had reservations about their satisfaction with the schemes, attributed these to time taken in and difficulties related to the receipt of the claim amount.
Surprisingly, only 36% felt that the procedures of the schemes were very clear and transparent. This could very well indicate that a large number of farmers are going in for the schemes only because others are opting for them, without being fully aware of the nuances. This might not be a sustainable situation in the long-run and indicates a need for more branding, awareness building of procedures and larger inputs for training the villagers about the schemes.

Before going on to the section on weather derivatives in the questionnaire, each respondent was individually explained the concept behind the derivative products. The proposed weather derivative schemes were received fairly enthusiastically by the respondents. 92% of them felt that the schemes could help them either to a very large extent or to a fair extent.

About 40% of the respondents would prefer to hedge when rainfall will be below 20 percent from the normal. Slightly more than one fifth of the respondents wouldn’t mind risking a 30% variation in rainfall before hedging. A mean of the responses indicates that the respondents are willing to take a chance with rainfall being 24.9% below normal before they would want to hedge their risk.

Similarly, farmers would want to go in for a hedge against high temperatures only when the temperature levels go to between 5 to 10% above normal. A mean of the responses indicates that farmers are willing to take a chance with temperature being 7.1% above normal before they would want to hedge their risk.

Close to 90% of the respondents expressed that they would have a better sense of comfort with government controlled and manned weather recording stations than with privately manned stations. Also, an extremely large number of respondents preferred to go in for weather derivative schemes offered by the government, as against those offered by private agencies.

About a quarter of the respondents indicated a preference for going in for village level schemes; however, most either preferred to go it alone or to go in for schemes which would permit small, self-formed groups (Figure 2).
The valuation section of the survey comprised a bidding game, where respondents were asked to indicate with a YES or NO answer whether they would be willing to pay a certain amount for a weather derivative which would provide a maximum payout of Rs 1000. At the end of the bidding game, the respondents were also asked the amount that they would be willing to set aside in a month solely for the purpose of hedging their weather related risks through purchasing weather derivatives or insurance.

With the largest number of farmers, the game stopped at a bid of 5%, with a very small number taking the game to a bid below that. In fact the number of respondents who indicated a Yes at a bid value less than Rs 50 was only 8.7%.

Expectedly, it was seen that those who indicated a higher amount that they were able to save in a month out of their total income, also indicated a Yes at a higher bid value (Figure 3).

Figure 2  Respondents' preference to buy weather derivatives as individuals or in groups
Since the CV responses were either Yes or No to a particular bid, the response could be taken as a binary variable and a statistical model appropriate for a discrete dependant variable could be used. The intention was to be able to analyse covariate effects on responses eg. the effect of education, age, awareness of insurance schemes etc on the willingness to pay.

The basic concept used is that of the Random Utility Model (RUM) devised by Hanemann (1984), where a respondent answers ‘Yes’ to a payment if he perceives that the benefits which would accrue by paying that amount are greater than the cost of paying for it. Preferences for Willingness to Pay would differ across individuals based on their social-demographic characteristics, and their preferences on the type of structuring that the weather derivatives should have.

In order to understand the determinants of respondents’ willingness to pay for weather derivatives which would be consistent with intuition and with economic demand theory, a series of multivariate regression analyses were performed with the survey data. Those variables having little effect on the dependant variable were left out from the final model. These included source of income, landholding, type of crop grown, total produce, source of worry in terms of yield/price risk, satisfaction levels with previous schemes, whether the farmer had taken loans in the past, and whether he had any outstanding loans.

In our final model, 9 variables viz., education, age, monthly savings, livestock holding, perceptions on surety of yield, awareness of crop insurance schemes, preference of
weather factor to hedge, preference for time period of contract and preference for individual vs group schemes were taken as independent variables.

Linear random utility probit and logit models are fitted with the model:

\[
Pr(\text{Yes}) = Pr \left[ \theta < (\alpha_1 \text{edu} + \alpha_2 \text{age} + \alpha_3 \text{mon_sav} + \alpha_4 \text{live} + \alpha_5 \text{ysrty} \\
+ \alpha_6 \text{iawar} + \alpha_7 \text{hpref} + \alpha_8 \text{ctim} + \alpha_9 \text{gpref} - \beta t)/\sigma \right]
\]

\[Haab \ and \ McConnel, \ 2002\ explain \ WTP \ in \ a \ random \ utility \ model \ as:\]

\[\alpha_i z_j + \beta(y_j - WTP_j) + \varepsilon_{ij} = \alpha_0 z_j + \beta y_j + \varepsilon_{ij}\]

where \( y_j \) = income of \( j \)th respondent
\( z_j \) = vector of attributes and characteristics
\( \varepsilon_{ij} \) = Non observable (inherent to the respondent) component of preferences

So,

\[WTP_j = \alpha z_j / \beta + \varepsilon_{ij} / \beta\]

Uncertainty from randomness of preferences \( \varepsilon_{ij} / \beta \) has mean zero; so the expectation of willingness to pay with respect to preference uncertainty \( \varepsilon \) is:

\[E_{\varepsilon} (WTP_j | \alpha, \beta, z_j) = \alpha z_j / \beta\]

Both, the Probit and Logit models give close to identical results of willingness to pay, as can be seen from tables 1 and 2. These values are Rs 87.994 and Rs 87.993 respectively.

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**Table 1 Calculation of mean WTP with normal utility function**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient</th>
<th>Mean</th>
<th>Coeff*Mean (( \alpha z_j ))</th>
<th>Mean WTP (( \alpha z_j / \beta ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDU</td>
<td>0.1276</td>
<td>2.652985</td>
<td>0.33852055</td>
<td></td>
</tr>
<tr>
<td>AGE</td>
<td>0.060084</td>
<td>3.264925</td>
<td>0.196169188</td>
<td></td>
</tr>
<tr>
<td>MON_SAV</td>
<td>0.054596</td>
<td>4.035448</td>
<td>0.220317329</td>
<td></td>
</tr>
<tr>
<td>LIVE</td>
<td>0.246784</td>
<td>1.899254</td>
<td>0.468706154</td>
<td></td>
</tr>
<tr>
<td>YSRITY</td>
<td>0.054495</td>
<td>3.235075</td>
<td>0.17629481</td>
<td></td>
</tr>
</tbody>
</table>
Given that in our questionnaire, when posed with a certain bid amount, the farmers were asked to respond with a simple ‘Yes’ or ‘No’ response, the probability that they would say ‘Yes’ at a particular bid amount is given by:

\[
\text{Probability (Yes)} = 1 - \left( 1 + \exp \left[ \alpha z_j - \beta (\text{bid amount}) \right] \right)^{-1}
\]

The probabilities of getting a ‘Yes’ response at various bid levels are indicated in figure 4.

The results make intuitive sense – the probability of a ‘Yes’ response increases as the bid amount decreases.
Regulatory Issues

It has been recognised by most users of weather derivatives (Bates, 2004) that the two obvious benefits of a regulatory framework for them would be:

(i) barriers to cross-border business in weather derivatives can be overcome easily
(ii) it would make sure that these instruments do not get inappropriately treated as insurance contracts and get subjected to insurance regulation.

As for any other derivatives, for the introduction of weather derivatives trading in India, there is a need for a regulatory framework. However, the aim needs to be to form broad, overall regulations. If the regulatory framework is too prescriptive and too narrow, it could curb the development of the weather derivative market, which is already late in India, as compared to the USA or Europe.

The existing legal framework for derivatives trading in India has been studied, both to draw out the lessons learnt and to be able to identify initiatives required for weather derivative trading in the country. The Forward Contract (Regulation) Act (FCRA) was passed by the Indian parliament and came into being in 1952. Although 56 years old, this act still governs futures trading in commodities in India. The Securities Contracts
(Regulation) Act (SCRA), 1956, the Securities Laws (amendment) Ordinance, 1995, The Securities Contracts (Regulation) Bill, 1998 and the Securities Laws (Amendment) Act, 1999 have been studied with the specific intent to bring out their relevance to weather derivatives in India.

Some of the regulatory initiatives required for weather derivatives suggested are:

- Regulatory framework for other derivatives can easily be extended for weather derivatives
- Exchange traded and OTC trades must both be catered for
- FII investments would increase depth of market
- Necessity of conducting research and disseminating education on weather derivatives needs to be built into the regulatory framework
- Need for easy and readily available weather data
- Accuracy of weather data and its cost
- Dissemination, on a real-time basis, of weather forecasts
- Regulation on advisors
- Should be introduced in existing commodity exchanges
- Re-channeling of government subsidies
- Bare-minimum’ approach to regulation till the market takes off
- Tax treatment of weather derivatives, especially for small farmer

It is also brought out that as there is a build-up of the availability of high quality meteorological data and weather forecasts, there will have to be directives for the re-use and sale of information generated by the public sector. These would include equitable availability of information, clarity and transparency in conditions for as well as charges for re-use of information, methods for fixing of charges as well as upper limits for these charges etc.

The Regulatory scope, while being defined, should include a reference to geological variables, which might later come into the ambit of innovative weather derivative products. As an example, volume of river flow might be a derivative product in future.

A survey would be the best method of determining the kind of weather derivative contracts required. However, a-priori, a large number of contracts with various underlying indices and expiry periods, will be useful.
Valuation

While the scope of weather derivatives is enormous, there are the accompanying challenges of valuing and pricing the derivatives to not only be financially viable instruments, but also be instruments with appeal to the financially weaker sections of society, viz. the farmers.

Whilst the methods of valuing equity options are fairly well defined, this is not so in the case of weather derivatives. The major reason is that, unlike as in equity options, we cannot assign a monetary value to the underlying ie. the weather, in the case of weather derivatives. Thus a no-arbitrage option pricing model such as the Black-Scholes model (Black and Scholes, 1973) is not a practical pricing tool for weather derivatives.

In the case of weather derivatives, two methods of valuation can be perceived. The first is to determine the value based on the probabilities of possible outcomes. This is called actuarial pricing. The second is to use market price as the value. Obviously the second method would only be possible if an observable market for weather options exists. This not being the case in India at present, weather options pricing based on actuarial techniques is probably the way forward.

In the absence of a market in the Indian context, a hypothetical market is discussed, and how a contract could be structured when weather derivative trading is introduced, is suggested.

One of the main reasons for the upsurge in volumes in the financial derivatives market in the 1980s was the general acceptance of the Black-Scholes model for pricing of options. Such a common model is still not in place in the case of weather derivatives, which has an acceptance across all prospective players.

This highlights the need for a simple method for pricing weather derivatives, so that it can be universally applied and is transparent enough for the players in the market to comprehend it.

Once again, data is considered from the point of view of farmers growing Soyabean in district Jhalawar in the state of Rajasthan. The crop is usually harvested in end October/November. A hypothetical situation is considered, with the availability of rainfall options on an index which is the aggregate rainfall in the period 16 June to 15 October, and where the farmer has been long in one put option every year in the past.
The fair price of the option would be the mean of the payout against the sale of the option in the period considered. In the method of determining the price of the option used, a sensitivity analysis is done on the variation of the tick size, and a tick size is determined, which gives the maximum reduction in the average deviation of the farmer’s income. In other words, we are striving for a situation where the intention is to steady the farmer’s income to the largest extent possible by hedging the weather risk to his crop yield.

With this social welfare target in mind, an attempt is made to see whether the amount of premium determined through using the willingness to pay figures, determined through the survey in Jhalawar, would make the put option financially viable from the point of view of the seller of the option.

The incomes of a farmer at Jhalawar, growing soyabean on one hectare of land, in the 12 years considered in the past, without hedging, and with hedging through being long on one put option, are indicated in fig 5. Also indicated on the same graph are the gain/loss in each of the years which the farmer would have had.

![Figure 5 Income of the farmer with and without hedging](image)

Since the amount of data available (12 years) is small, a monte-carlo simulation was done to generate values for the payout from the option with random values for the actual
rainfall. This was done on EXCEL, using the RISKSIM add-in. A total of 500 simulations were done.

The mean value of the payout to the put option over 500 simulations was determined to be Rs 161.07 when the strike value is fixed as the mean of the rainfall in the 12 years considered.

This implies that the seller of the option has a surplus of 14.05% over the mean payout, if he collects a premium of 8.8%, which is the maximum willingness-to-pay indicated by the farmers in Jhalawar for hedging weather risks to yield. This amount is likely to be adequate to cover administrative and other costs.

The figures derived indicate the feasibility of introducing weather derivatives as an investment option for small farmers to hedge the weather related yield risk which they face.

**Summary and Conclusions**

This thesis looks at the opportunities and the challenges that will be thrown up as we adopt weather derivatives as a form of risk management of crop yield, in the country.

A summary of the important findings in the thesis are enumerated below:

1. An empirical estimation of the willingness-to-pay by farmers growing soyabean in the Jhalawar district of Rajasthan, based on a theoretical model, yields a figure of 5.5% of the average MSP for soyabean.

2. Basis risk is an important consideration in weather derivatives. Based on a study of rainfall patterns at two weather stations, located close to each other, it was concluded that for short-term rainfall-index based weather derivative contracts, the location of the weather station assumes significance. For longer term contracts, the use of proxy weather stations could be justified to an extent.

3. 98% of farmers go through mental stress, worrying about the affect of abnormal rainfall on their crops.

4. Awareness levels of existing crop insurance schemes are low.

5. The proposed weather derivatives schemes were received enthusiastically by the farmers; 92% farmers feel that weather derivative schemes would help them in mitigating weather-related risks.

6. A very large proportion of farmers prefer to go in for weather derivative schemes offered by the government.
7. Willingness-to-pay for weather derivatives is determined to be approximately 8.8% of the maximum payout of the weather derivative contract.

8. Especially in the initial stages of introduction of weather derivatives in India, pricing of weather derivatives needs to be done through actuarial techniques, keeping in mind the social welfare aspect of stabilising the farmers’ income against the vagaries of weather.

9. Some initiatives required while introducing weather derivatives are listed below:

(i) **Infrastructure.** One of the important requirements for the spread of weather derivatives in India would be the availability and reliability of weather data. Infrastructure, in the form of computerized mini-weather stations at village level, will need to come up in the form of public goods, providing real-time weather data. The government could play a major role in this and one suggestion is to divert the money going into subsidies for crop insurance schemes to providing weather station infrastructure and letting private players come up with innovative weather derivative products.

(ii) **Payment facilities.** With the spread of ICT kiosks at the village level, farmers could be encouraged to trade in weather derivatives and make payments/receive money through the internet. This would require a fair amount of awareness generation and training, but it could considerably lower transaction costs of the weather derivatives.

(iii) **Pilots.** The regulatory agency for weather derivatives would need to encourage providers to carry out a large number of pilot projects in weather derivative products in order to understand the needs, to assess the kinds of products structuring required and to address the challenges.

(iv) **Pricing.** There are two issues in pricing. Firstly, the market makers, or the agencies which decide to, as an example, be short in put options on rainfall, would need to be convinced that the pricing of the options is such that their risk is either covered, or can be reinsured in some other market. Secondly, the pricing has to be such that it is within the amount that buyers of the put option, say farmers, are willing to pay.

(v) **Experimentation.** The regulatory and policy environment should be such that experimentation in innovative products is not discouraged.

(vi) **Dissemination.** Results and recommendations from academic studies and learning’s from pilot projects would need to be actively disseminated. This could be done through stakeholder workshops.
(vii) **Government role.** The government would need to move away from an “intervention” role, (for example government intervention takes place through subsidizing crop insurance), to that of a “facilitator” for weather derivatives. Similarly, subsidies provided by the government would need to be re-channeled. Directly subsidizing financial services would discourage innovations by providers, in product designs and pilot testing. As an example, the various crop insurance products subsidized by the Central/State government have dissuaded private players from participating by coming up with their own products.

(viii) **Information sharing.** Credit information sharing between various players could help in reducing risks and costs. This aspect needs to be studied further for implementation.

### Limitations of the Study

A significant number of farmers are either illiterate or unaware of possibilities of weather risk hedging. Issues surrounding the provision of a hedge against weather could be complex in the face of heterogeneity of opinion on the efficacy of a scheme like weather derivatives trading. A lack of awareness of the possible benefits of such instruments, itself, might influence the willingness of a farmer to opt for them. Although a very serious attempt was made to educate the farmers on weather derivatives, prior to their answering the questionnaire, this might not be adequate to give them a comprehensive understanding. As such, a study of willingness to invest might be affected by factors other than socio-economic factors.

Regulatory and Policy recommendations suggested would have considerably large monetary and fiscal implications, which would have to be borne in mind.

The Contingent Valuation study to determine willingness-to-pay may have the following limitations:

1. The answers to the valuation questions may actually bring out feelings that the farmer may have on the issue at hand, rather than his actual willingness to pay.
2. There may be a fundamental difference in the manner in which the respondent makes a hypothetical decision as compared to an actual
decision which he may need to take later, when weather derivatives are actually introduced.

iii. Respondents might not have taken the willingness to pay questions seriously, since they do not have to pay the stated amount.

iv. The starting bid may have had an effect on the respondents’ answers

v. Respondents might have given strategic answers ie. they may have answered in a way which they feel might influence the outcome of the study to their benefit.

Scope for Future Research

The scope for future research in weather derivatives is enormous. Some of the areas in which research can be done are:

i. the appeal, the demand and the willingness-to-pay for weather derivatives in different businesses. This would help in structuring weather derivative products which would be demand across businesses.

ii. the possibility and the scope of building a composite index of rainfall and temperature. This would be useful for weather derivatives for hedging weather risk in some crops, whose growth is highly dependant on both rainfall and temperature.

iii. the costs of setting-up a large network of reliable weather stations.

iv. the effect of meteorological forecasts on the prices of weather derivative products. This could be done after a market for these products is in place.

v. portfolio effects of weather derivatives.

vi. correlations between weather derivative contracts and commodity futures prices.