

## CHAPTER 3: METHODOLOGY

The chapter focuses on the methodology that was adopted for the analysis performed in the thesis. This chapter has been divided into a few sections, viz., Weather Insurance Product Evaluation, Basis Risk, Weather Data Analysis and Climate Trends and Perspective of the Stakeholders.

### 3.1. WEATHER INSURANCE PRODUCT EVALUATION

WIBI products, on the basis of index definitions, can be designed in a number of ways with various combinations. This section deals with how to compare and evaluate different generic index based insurance product designs. In order to evaluate the effectiveness of various weather insurance products available in the market, four basic insurance design models were chosen for *Kharif* season (i.e. rainfall) and three basic insurance design models for *Rabi* season (i.e. temperature) as mentioned below

For *Kharif* season

1. Key factor index product
2. Aggregate rainfall product with dry spell
3. Market product with crop stage-wise volume and dry spell
4. INFOCROP based crop growth simulation model –Rainfall volume

For *Rabi* season

1. CRIDA Model
2. INFOCROP(IARI) based crop growth simulation model-Temperature deviation
3. Market product for temperature

#### 3.1.1. DATA

Three locations (Akola, Anantapur and Bijapur) were chosen for testing the index-based insurance product designed for the *Kharif* season and two locations (Hissar and Ludhiana) for testing insurance products for the *Rabi* season. The crops chosen for *Kharif* were Soybean in Akola, Groundnut in

Anantapur and Sorghum in Bijapur, and wheat for both the locations in *Rabi* season. The crops were chosen to test the different product design concepts, keeping in mind the importance of crops in the respective locations and their response to the important weather parameters during *Kharif / Rabi* season. The locations for *Kharif*-specific product have a high degree of variation in year-on-year rainfall, while for locations for *Rabi*-specific product are wheat-producing regions. To some extent, the selection was also influenced by the availability of historical weather and yield data.

The latest 15 years weather data and yield data ending 2010 were considered to study the effectiveness of WIBI products.

### 3.1.2. METHODOLOGY

#### 3.1.2.1. PRODUCT DESIGNS

A simple WIBI product design consists of three components. First is the index I based on weather parameter/s which has a significant impact over crop yield. Second, the Trigger point T and the adverse deviation from this trigger point will start payment from the contract. And finally, the payout function F which is a function of adverse deviation of index from Trigger. The payout function F is defined in such a way that it should indemnify the farmer for the yield loss due to adverse deviation of index. Claim payment from this design D is given by equation (3):

$$P(D)=F[\Delta(I,T)] \quad \dots\dots\dots (3)$$

Where,:

$\Delta(I,T)= \text{Max}(0,T-I)$  in the case of deficit cover, and

$\Delta(I,T)= \text{Max}(0,I-T)$  in the case of excess cover.

In a complex WIBI product design, there may be more than one index on single or multiple weather parameters. Say, a design D has indices  $I_1, I_2, \dots, I_n$ , and Trigger  $T_1, T_2, \dots, T_n$ , and Payout function  $F_1, F_2, \dots, F_n$ . Then Claim payment from this design D will be given by equation (4):

$$P(D) = \sum_{i=1}^n F_i(\Delta_i(I_i, T_i)) \quad \dots\dots\dots (4)$$

Where,

$\Delta_i(I_i, T_i) = \text{Max}(0, T_i - I_i)$  in the case of deficit cover, and

$\Delta_i(I_i, T_i) = \text{Max}(0, I_i - T_i)$  in the case of excess cover.

In a more complex design, Trigger,  $T_1, T_2, \dots, T_n$  and deviation Function  $\Delta_1, \Delta_2, \dots, \Delta_n$  will be vector valued.

Different rainfall index designs are given in Annexure-1

### **Rainfall Index Designs (*Kharif*)**

**D1. Key Factor Index Product:** Crop coefficients (Kc) are used with reference to evapotranspiration<sup>9</sup> for grass (ET<sub>o</sub>) to estimate specific crop evapotranspiration rates. The crop coefficient is defined as the ratio of the crop evapotranspiration to the reference evapotranspiration. The crop coefficient is a dimensionless number (usually between 0.1 and 1.2) that is multiplied by the ET<sub>o</sub> value to arrive at a crop ET (ET<sub>c</sub>) estimate. The resulting ET<sub>c</sub> can be used to judge when to irrigate and how much water should be put back into the soil to keep the crop healthy and obtain optimum yield. Crop coefficients vary by crop, stage of crop growth and some cultural practices.

The crop's water use can be determined by multiplying the reference ET<sub>o</sub> by a crop coefficient (Kc). The crop coefficient adjusts the calculated reference ET<sub>o</sub> to obtain the crop evapotranspiration ET<sub>c</sub>. Different crops will have a different crop coefficients and resulting water use. The key factor index based product is designed on the basis of Kc estimated based on the standard practices. For details on Kc refer to Annexure-2

**D2. Aggregate Rainfall Product with Dry Spell:** In this design there are two indices, one is aggregate rainfall over risk period from sowing to maturity and the other is consecutive dry days during the critical crop period to take care of rainfall distribution during the important stage of the crop.

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<sup>9</sup>Evapotranspiration (ET) is the sum of evaporation and plant transpiration from the Earth's land surface to atmosphere. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and water bodies.

**D3. Market Product with Crop Stage-Wise Volume and Dry Spell:** This product, by and large, has evolved by the market practices over the past five years. The aggregate rainfall is divided into a number of sub-phases corresponding to crop phenological phases. Sum insured is allocated and triggers and payout rates are fixed for each pheno-phase in such a way that the total sum insured is distributed across the crop cycle.

**D4. INFOCROP-based Crop Growth Simulation model:** This weather insurance product has been designed keeping in mind how a crop responds to moisture stress at different stages in the context of soil type, the dominant crop variety, cultural practices, etc. as modeled by ‘INFO CROP’- an output worked out by Indian Agriculture Research Institute (IARI) on crop growth simulation model platform. IARI provides both fortnightly and monthly responses. However, for the sake of comparison, fortnightly outputs are used in designing the weather insurance product.

#### **Temperature Index Designs (*Rabi*)**

**D1.CRIDA Model:** The basis of this product design has been taken from a research paper published by Central Research Institute for Dryland Agriculture (CRIDA). The model uses not only the heat based on the temperature but also the duration of the heat. In this paper an attempt has been made “to quantify the combined effect of high temperature, above the normal range, and continuous exposure duration to such temperature stress that causes a significant amount of yield loss.” The total cover period under this product design has been divided into two sub-phases, viz. vegetative phase and reproductive phase. Here the temperature  $T_i$  taken under consideration is the mean temperature for the  $i^{\text{th}}$  day during phase and  $T$  is the trigger temperature for the phase. Trigger temperature is usually the long-term average of daily mean temperature over respective phases.

**D2. INFOCROP Growth Simulation Model-Temperature Deviation:** This weather insurance product has been designed keeping in mind how a crop responds to adverse deviation of mean temperature at different stages as modeled based on ‘INFOCROP’, which uses inputs as discussed under D4 - an output worked out by IARI. The model estimates the potential yield loss arising from adverse deviation in temperature at different crop stages. IARI provides both fortnightly and monthly responses. However, for the sake of convenience, fortnightly outputs are used in designing the weather insurance product.

**D3.Market Product for Temperature:** The third product, by and large, evolved by the market practices over the past five years, wherein the adverse deviations in temperature (from the standard temperature) during the reproductive and maturity stages of the crop, cumulated at fortnightly intervals is used as a proxy for estimating crop losses.

**3.1.2.2. PROCEDURE**

To compare the various product designs at the same level, the products are adjusted in a manner that the frequency of payouts is equal. Also for comparison, the historical payouts are adjusted to give a uniform pure risk premium rate (burn cost) without any change in frequency of payouts. Further, the product designs are analyzed by:

1. Comparing the ‘maximum payout’ from each product designs
2. Historical payouts from each design can be compared with historical yield loss and can be analyzed using following statistical techniques:
  - a) Assessment of scatter plot - To check the comparative performance of each of the product designs against yield losses, first yield loss was plotted on X-axis and corresponding adjusted payouts from each WIBI product design on Y-axis. Then claim payment pattern from product design against yield loss was observed.
  - b) Calculation of the Pearson product-moment correlation coefficient and Spearman rank correlation coefficient: Pearson’s product moment correlation coefficient is given by equation (5):

$$r = \frac{\sum_{i=1}^n (X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^n (X_i - \bar{X})^2} \sqrt{\sum_{i=1}^n (Y_i - \bar{Y})^2}} \dots\dots\dots(5)$$

where  $X_i$  and  $Y_i$  denote yield loss and claim payments from index based insurance products, respectively.

To calculate Spearman’s rank correlation coefficient first ranks are given to the observations. Suppose ranks for yield loss are  $X_i(i=1,2\dots n)$  and ranks for payout from WIBI are  $Y_i(i=1,2\dots n)$ .if some of the individuals receive the same rank in a ranking of merit, they are said to be tied. Let ‘m’ number of observations, say  $(K+1)^{th}$ ,  $(K+2)^{th}$ , .....

$K+m)^{\text{th}}$  are tied. Then each of these ‘m’ observations is assigned a common rank, which is the arithmetic mean of the rank  $K+1, K+2, \dots, K+m$ . Spearman’s rank correlation coefficient is given by equation (6)

$$\rho = 1 - \frac{6(T_x + T_y + \sum_n d_i^2)}{n(n^2 - 1)} \quad \dots\dots\dots (6)$$

$$\text{where } T_x = \frac{1}{12} \sum_{i=1}^s m_i (m_i^2 - 1) \quad \text{and} \quad T_y = \frac{1}{12} \sum_{i=1}^t m_i (m_i^2 - 1)$$

Here, ‘s’ and ‘t’ are number of sets of rank to be tied in the X-series and Y-series, respectively.

A higher Pearson’s product-moment correlation coefficient or Spearman’s rank correlation coefficient suggests that an increase in shortfall (increase in rank of Yield) is accompanied with increased payouts from WIBI products (increase in rank of payouts from WIBI products). One can check significance of Pearson product-moment correlation coefficient and Spearman’s rank correlation coefficient using t-test.

- c) Plotting of nonparametric best fit lines for probability of positive claim from index against yield loss: Let  $X_i$  s and  $Y_i$  s denote yield loss (%) and payout (%) due to indexed based insurance for  $(i=1, 2, \dots, n)$ . Define  $Z_i$ ’s such that

$$Z_i = \begin{cases} 1, & Y_i > 0 \\ 0, & Y_i \leq 0 \end{cases}$$

Now the best line of fit for ‘Z’ against ‘X’ using principles of least square method is arrived as:

$$Z = a + bX$$

The non-parametric best fit lines may not depict the best relationship between yield loss and probability of positive claims due to indexed based insurance, because sometimes the probabilities may result in values greater than 1. However, they are easy to understand and make comparisons of the behavior of probability of positive claims due to indexed based

insurance against yield loss simple. Thus, a product design is considered to be better for which intercept term is lower or at best equal to zero. There is an intuition that the higher the yield loss, the higher should be the probability of positive payout from index, so product design will be better if the slope is higher.

## **3.2. BASIS RISK**

The most significant challenge with the WIBI products is *basis risk*, the risk that an insured farmer might not receive a claim payment when he or she most deserves it due to an imperfect correlation between the insurance product and farmer's production. An index that captures the vast majority of bad years is likely to be more attractive to farmers, but an index that does not trigger claim payments in very bad years will be unattractive to farmers, particularly the most vulnerable ones. Indian farmers have experienced basis risk in WIBI products, and this has prompted innovations in product design. However, despite its key role in driving client value, there has been surprisingly little statistical analysis of basis risk for WIBI products in India.

This section of the chapter deals with the methodology adopted for the statistical analysis of the basis risk in a WIBI product. The analysis has been done in the following two parts:

1. **Product Basis Risk**: It deals with the risk of mismatch in claim payments due to product design, product choice, policy decisions and regulatory functions.
2. **Spatial Basis Risk**: It deals with the risk of mismatch in claim payments due to the differences in the geographical locations between the reference weather station and the insured farmer's field site.

### **3.2.1. PRODUCT BASIS RISK**

#### **3.2.1.1. DATA**

With a large number of small sized farm-holdings it would be highly challenging to collect farm level yields. In view of this the tehsil (sub-district) level yields estimated through General Crop Estimation Surveys (GCES) were used as a proxy for farm level yields. Perhaps this is most appropriate setting to

discuss the product basis risk by comparing the area-average yields (not individual farmer yields) for a group of farmers in each tehsil.

The yield data used for the analysis were generated as part of GCES and were based on multi-stage stratified random sampling. Despite structured methodology, there might have been limitations with yield data on account of sampling, manipulation risk, inaccuracies in the sub-plot selection, lack of skilled personnel in conducting the surveys, etc.

So far as weather (rainfall) data is concerned, it is a 'point' data of a particular location in a tehsil, and not the weighted average rainfall of many points within tehsil. To this extent, there may be a degree of inconsistency in comparing the point based rainfall data and sample based yield data.

The products analyzed for 2011 and 2012 were the real WIBI products offered as part of WBCIS by the select insurance providers. While the products of 2012 were largely dictated by the state government, the product in 2011 was originally submitted by the insurance providers and subsequently fine-tuned with inputs from the state government.

The product offered in 2011 and 2012 has generally two types of coverage: one is deficit rainfall cover and the other is excess rainfall cover. Deficit rainfall cover has been further bifurcated in two covers: rainfall deficit (volume) cover and rainfall distribution cover. The major differences in 2011 and 2012 products are described below:-

- i. In 2012 product, deficit volume cover and excess rainfall cover have been covered on either/or basis with an equal amount of the sum insured, for the entire cover period. In 2011 product, the excess rainfall is covered independently from deficit volume cover and for the period where excess rainfall event may reduce yield production. In 2011 product some crops and locations, where excess rainfall is not a major risk, have not been covered, as suggested by the state government.
- ii. Deficit volume cover is indexed by phase-wise aggregate rainfall and compensated according to defined bilinear pay-out function. In 2011 product, component of bilinear pay-out function has been judged to be best according to agronomic principles and premium constraint. While in 2012 product, Strike1 and Exit points are provided by the state government and except for five districts of Northern and Western Rajasthan, Strike 2 is set



- at the midpoint of Strike1 and Exit. Rate1 and Rate 2 were determined by the rule such that 1/3 of the maximum pay-out is to be paid between Strike1 and Strike 2 at a uniform rate and the rest 2/3 of maximum pay-out is to be paid between Strike 2 and exit at a uniform rate.
- iii. In 2011 product, rainfall distribution cover is indexed by the number of days in a spell of consecutive dry days and compensated according to defined pay-out table. While in 2012 product, rainfall distribution cover is indexed by longest spell of consecutive dry days and compensated according to defined linear pay-out function.
  - iv. In both the products, excess rainfall has been indexed by supremum (the least upper bound) of a set consisting of any three consecutive days rainfall during respective phase but in 2011 product compensated through linear pay-out function while in 2012 product compensated through bilinear pay-out function.

A product structure (term-sheet), corresponding to each year has been kept in Annexure-3.

### **3.2.1.2. METHODOLOGY**

The approach used is to analyse each WIBI product separately. However, the drawback is the loss of statistical power due to very small sample size. In such cases, statistical analysis alone should not be relied upon as the basis for product design or policy decisions. However, by analysing collection of WIBI products, one can increase the accuracy of statistical analysis of basis risk by increasing the number of data points in an analysis.

Operationally, there are two fundamental steps to perform basis risk analysis for a collection of WIBI products: first, one must adjust the data from different products so that the data can be combined into a single consistent dataset; second the statistical analysis can be performed using this dataset. Some additional details of these steps are given below.

The first step involved adjustment raw yield and burn cost<sup>10</sup> data, so that the marginal distributions of adjusted yields and adjusted burn costs were expressed in common units across different products. Here, yields were adjusted by expressing them as a percentage of the average historical yield for that crop in that insurance unit. This was adjusted for differences between insurance units for area average

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<sup>10</sup>The burn cost for a particular product in a particular year is the claim payment that would have been made had that product been in force at the time, calculated by applying historical weather data to product terms and conditions.

yields. Similarly, burn costs were adjusted by expressing them as a percentage of average of the historical burn cost for that product. The output for the first step resulted in a combined dataset with two columns; one of adjusted yields and the other of adjusted burn costs, for all products and all years.

Once the combined dataset were generated, it was possible to analyse the dataset using statistical techniques, such as:

1. Assessment of scatter plots: This enables one to understand the relationship between the adjusted yields and burn costs.
2. Calculation of the Pearson product-moment correlation coefficient and Spearman rank correlation coefficient: These specify the movement of the adjusted yields and the burn costs with each other. The formula of the Pearson's product moment correlation coefficient is given in equation (6).

Ideally, one assumes that as the adjusted yields increase, the adjusted burn costs would decrease. Thus, a highly negative correlation between the two variables would exhibit the best relationship.

3. Plotting of non-parametric best fit lines and confidence intervals: The best fit lines exhibit the behaviour of the two variables with each other without any constraints. The confidence intervals specify how far the range of the best fit lines extends that enables one to perform an in-depth analysis.

According to the economic theory (e.g. Clarke, 2011), the correlation between rainfall and the pay-outs in the bad years is the most important method for analysing basis risk.

Another analysis that has been carried out corresponds to the calculation of the probability of pay-outs corresponding to different levels of yield losses.

### **3.2.2. SPATIAL BASIS RISK**

#### **3.2.2.1. DATA**

The data were taken from the website of the Water Resources Department of the Government of Rajasthan, [http://waterresources.rajasthan.gov.in/Daily\\_Rainfall\\_Data/Rainfall\\_Index.htm](http://waterresources.rajasthan.gov.in/Daily_Rainfall_Data/Rainfall_Index.htm). The rainfall data corresponded to the Jaipur district for the past 11 years, i.e. 2001 - 2011. For this district,

the rainfall data were available for 14 rain gauges operated from tehsil headquarters, viz., Amber, Bairath, Bassi, Chaksu, Chomu, Dudu, Jamwa Ramgarh, Kotputli, Naraina, Paota, Phagi, Phulera, Sambhar, Sanganer (*see map below*). The study was done for the *Kharif* season which constituted the period of Jun-1 to Sep-30 (*further referred as period*).

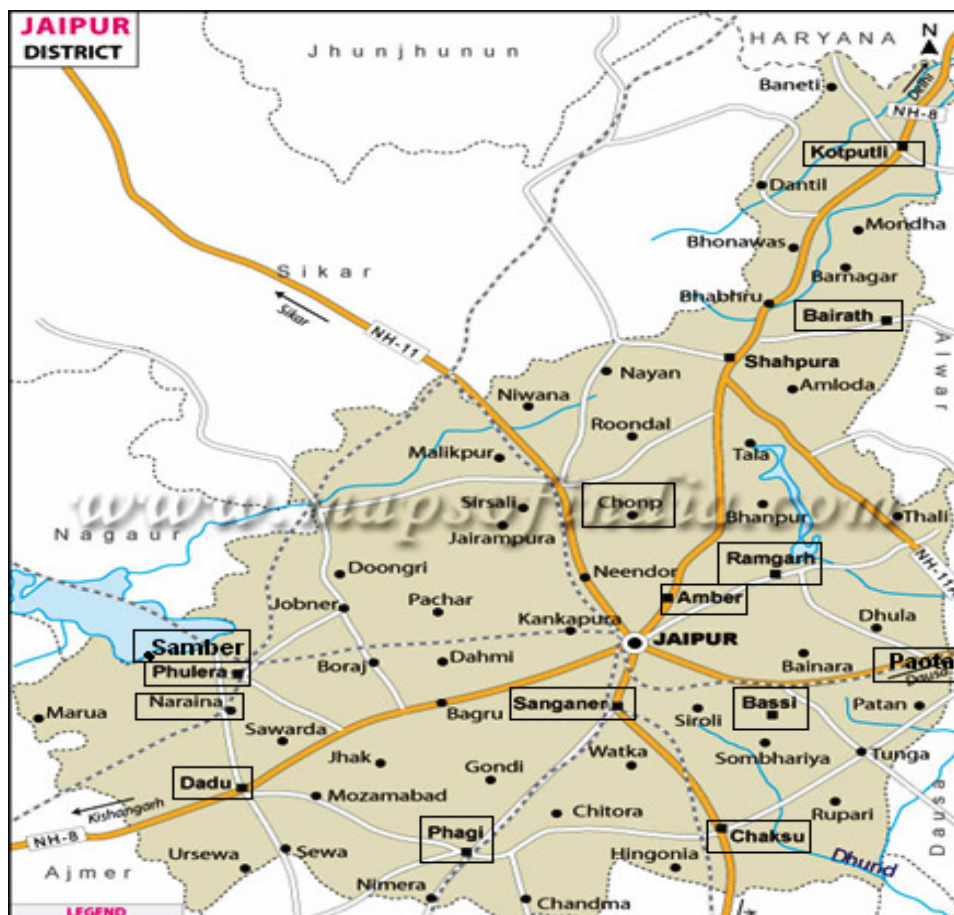


FIGURE 1: MAP SHOWING SPATIAL DISTRIBUTION OF SELECTED WEATHER STATIONS IN JAIPUR DISTRICT

Further, 91 ( $^{14}C_2$ ) combinations of the stations were used in the analysis. The latitude and the longitudes of all the stations were obtained to determine the distances between each pair of rain gauges. The distances between the stations are given in Table A9.1 of Annexure-9

For the analysis of spatial basis risk for the product, the Jaipur term sheet for the crop Bajra (pearl millet) for the year 2011 (under WBCIS) was used. It is given in the Annexure-4.

### 3.2.2.2. METHODOLOGY

Spatial basis risk depends on the locations of the reference weather station (or rain gauge) and the insurance unit. These locations are recognized geographically by the information on their latitudes and longitudes, which can be converted into distances. Thus, the basis risk analysis expresses different scenarios in relation to the distances.

Again, there are two fundamental steps to performing spatial basis risk analysis for a range of rainfall events and the actual product payouts. First, one must prepare data from the given raw rainfall data into various events to be analyzed; second, perform statistical analysis using this dataset. The additional details of these steps are given below.

The first step involved preparation of data for various rainfall events; the chance of rain, the risk of rather heavy rainfall, the risk of dry spell<sup>11</sup> and its length and the distribution of aggregate rainfall over a period, for different weather stations over the years. This included calculation of conditional probabilities, i.e. the probability of the occurrence of the event at a weather station given that it occurs at the reference weather station, with respect to the rainy days, rather heavy rainfall events and dry spells, calculation of the Pearson product-moment correlation coefficient between weather stations with respect to the aggregate rainfall. The formulae are given below:

$$P(\text{Event at station } i | \text{Event at station } j) = \frac{P(\text{Event at stations } i \text{ and } j)}{P(\text{Event at station } j)}$$

The formula of the Pearson's product moment correlation coefficient is given in equation (6).

Similarly, burn costs for the different weather stations and years were calculated. This included the calculation of standard deviations of the absolute differences in burn costs of the weather stations. Further, the distances between the weather stations were also obtained.

The next step was carried out with the help of regression analysis. Here, all the calculated statistical quantities were regressed on the distances between the weather stations. The method of least squares was used to perform the regression analysis. Various models such as linear, exponential, quadratic etc. were used for the regression analysis. These are given below:

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<sup>11</sup>A continuous period of days experiencing rainfall less than 2.5 mm

Linear regression model:  $Y = a + b * d + \varepsilon$

Exponential regression model:  $Y = a * e^{b * d} + \varepsilon$

where,

Y = Statistical quantities (probability, correlation, standard deviation, etc.) corresponding to various rainfall events or the pay-outs,

d = Distance between the weather stations

a = Constant to be determined.

b = Slope of the regression, and

$\varepsilon$  = Error-term.

The underlying assumption for the analysis was that as the distance from the reference weather station increases the conditional probabilities and correlations decrease. This monotonically decreasing behaviour can be linear or exponential depending upon the event under consideration. However, when considering the standard deviations they behave in a manner opposite to that of the conditional probabilities and the correlations. As the distances between the weather stations increase, one assumes that the standard deviations of the absolute differences in the burn costs between the weather stations also increase.

### **3.3. WEATHER DATA ANALYSIS AND CLIMATE TRENDS**

Weather uncertainties are more frequent now-a-days, and are a threat to agricultural production. Extreme weather conditions (e.g., droughts, dry-spells, intense rainfalls, floods, freeze, extreme heat, etc.) are expected to become more frequent and of greater severity under the projected climate change scenario. The climate change affects the mean and variability of weather conditions, and the variance and covariance of weather events, including increase in the frequency and scope of extreme events. Climate change may not be all grim news, though these trends imply changes in yields, their averages and distribution of their more extreme values, and they affect the appropriateness of different risk management tools (Antón *et al.*, 2012). While the studies have documented the broad trends as

observed and forecast in terms of long-term climate changes, but have not specifically looked at the way WIBI products look at the weather in its short and medium term impact. The analysis, therefore, has focused on studying the weather trends in the medium-term with particular reference to the dimensions used in WIBI products.

### 3.3.1. DATA

The data have been taken from the All India Coordinated Research Project (AICRPAM) Central Research Institute for Dryland Agriculture (CRIDA) is used for analyzing the trends. Trends in rainfall, temperature and relative humidity have been analyzed for 21 well distributed representative meteorological observatories located across various parts of India for the period from 1986 to 2010 (25 years). The State / Region-wise selected locations across the Country for the study are listed in Table 2, and the spatial distribution is shown in Figure 2.

TABLE 2: STATE/REGION-WISE SELECTED METEOROLOGICAL OBSERVATORY STATIONS IN THE COUNTRY

S. No.	Zone	Location	State	Latitude (N)	Longitude (E)	Altitude (m)
1	West Coast	Thrissur	Kerala	10° 31'	76° 13'	25
2		Dapoli	Maharashtra	17° 46'	73° 12'	250
3	West	Udaipur (Arjia)	Rajasthan	25° 21'	74° 38'	433
4		Anand	Gujarat	22° 33'	72° 58'	45
5		Parbhani	Maharashtra	19° 08'	76° 50'	423
6	South	Bijapur	Karnataka	16° 49'	75° 43'	594
7		Anantapur	Andhra Pradesh	14° 41'	77° 37'	350
8		Benguluru	Karnataka	12° 58'	77° 35'	930
9		Kovilpatti	Tamil Nadu	09° 10'	77° 52'	90
10	Central	Jabalpur	Madhya Pradesh	23° 09'	79° 58'	393
11		Raipur	Chattisgarh	21° 14'	81° 39'	298
12	East	Bhubaneswar	Odisha	20° 15'	85° 50'	25
13		Ranchi	Jharkhand	23° 17'	85° 19'	625
14		Mohanpur	West Bengal	22° 10'	88° 06'	170
15		Jorhat	Assam	26° 47'	94° 12'	86
16	North	Rakhdiansar	Jammu & Kashmir	32°39'	74°58'	332
17		Ludhiana	Punjab	30° 56'	75° 52'	247
18		Kanpur	Uttar Pradesh	26° 26'	80° 22'	126
19		Faizabad	Uttar Pradesh	26° 47'	82° 08'	133
20	Hill Station	Palampur	Himachal Pradesh	32° 07'	76° 03'	1291



FIGURE 2: MAP SHOWING SPATIAL DISTRIBUTION OF SELECTED METEOROLOGICAL OBSERVATORIES IN THE COUNTRY

(SOURCE: AICRPAM CENTRAL RESEARCH INSTITUTE FOR DRYLAND AGRICULTURE)

Weather parameters like rainfall, temperature and relative humidity have been categorized under 12 sections. Out of these 12 sections, six belong to rainfall, three to temperature and three to relative humidity (Table 3).

TABLE 3: PERIOD-WISE SELECTED PARAMETERS OF RAINFALL, TEMPERATURE AND RELATIVE HUMIDITY

S. No.	Parameter	Period
1	Rainfall during Southwest monsoon	June – September

2	Number of rainy days <sup>12</sup>	June – September
3	Single day maximum rainfall	June – September
4	Two day maximum rainfall	June – September
5	Length of dry spell	June – September
6	Length of wet spell	June – September
7	Relative humidity between 70 and 80 percent	January – December
8	Relative humidity between 80 and 90 percent	January – December
9	Relative humidity more than 90 percent	January – December
10	Minimum of daily minimum temperature	January – December
11	Maximum of daily maximum temperature	January – December
12	Average of daily temperature range	January – December

### 3.3.2. METHODOLOGY

Linear trend and moving average trend in various weather parameters pertaining to rainfall, temperature and relative humidity for the 25-year period (1986-2010) have been analyzed for 21 well-distributed representative locations across the country, identified and monitored by CRIDA. Usually, trend analysis of rainfall data is done for the total rainfall quantity or rainfall quantity of different seasons/periods. This study has presented trend analysis on various weather parameters which have a significant relationship with agriculture (Table 3). Not only amount of rainfall, but also the number of rainy days, the length of dry spell, length of wet spell and maximum rainfall on a single day and consecutive days have a considerable effect on crop growth, production and productivity. These parameters also have an indirect effect on crop production by creating congenial environment of pest or disease outbreak. The brief methodology used is discussed below:

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<sup>12</sup> A day is considered as a rainy day when the rainfall received is 2.5 mm or more



Linear Trend Analysis: Let  $y(t)$  be a time series of annual (or monthly for a specific month, etc.) values of a meteorological variable that consists of two independent components, then viz. trend plus noise:

$$y(t) = a + bt + e_t \quad \dots\dots(1)$$

where, 't' is the time in years ranging from 1 to 25, 'a' is the intercept of the linear relationship between weather data  $y(t)$  and time  $t$ ,  $b$  is the slope of that relationship and  $e_t$  is a random noise sequence with variance  $\sigma^2$ .

Moving Average Trend Analysis: Simple moving average (SMA) is the un-weighted mean of the previous  $n$  datum points. Let  $y_1, y_2, \dots, y_n$  be values of the meteorological variables up to time  $n$ . Then the moving average is given by equation (2):

$$MA_n = \frac{y_1 + y_2 + \dots + y_n}{n} \quad \dots\dots (2)$$

For all  $n = 1, 2, 3, \dots, t$ .

The moving average trend analysis is done for eight key weather parameters viz. number of rainy days, (i.e. rainfall of 2.5 mm or more), single day maximum rainfall during June to September, length of dry spell and number of dry spells for more than 15 days during June to September, minimum of daily minimum temperature during January to December, maximum of daily maximum temperature during January to May, average of daily temperature range and relative humidity greater than 90 percent during the year.

Regional grouping of weather stations is done to examine the spatial differences in the trends in rainfall, temperature and relative humidity. Weather stations are also grouped based on altitude to discuss the results of trend in temperature parameters. Five-year moving average of weather parameters is taken to analyze the Moving Average Trend.

### **3.4. PERSPECTIVES FROM STAKEHOLDERS AND THEIR RESPONSE**

#### **3.4.1. STATE**

The Government of India organized a capacity building workshop for the officials of the state governments during January 2012<sup>13</sup>, keeping in mind the multiple insurance companies and insurance products. The Workshop presented an opportunity to comprehend the perceptions of States on different key elements of three important index based crop insurance products (NAIS, MNAIS and WBCIS) being presently implemented in the country, and also to find their comfort level in implementing these products. The responses of the state government officials were elicited on the following key elements:

1. Preference for insurance schemes among NAIS, MNAIS and WBCIS
2. Strong and weak aspects of these three insurance schemes
3. Priority areas for improvements in MNAIS and WBCIS
4. Involvement of multiple insurance providers
5. Need for introducing double trigger (weather and yield index) insurance products
6. Comfort level of using weather data from private weather data providers
7. Need for creating a ‘technical support unit’ at the Centre to hand-hold and guide the states.

The questionnaire, given in the Annexure-5, was administered to all workshop participants. In addition, the questionnaires were also sent to representatives from other important states, which could not attend the capacity building workshop. In all, the responses were collected from 16 States (more than one participant from a few states), including Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Haryana, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal. Besides, a representative from the Government of India who attended the workshop also responded to the questionnaire.

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<sup>13</sup> The Workshop was organized at Administrative Staff College of India (ASCI), Hyderabad

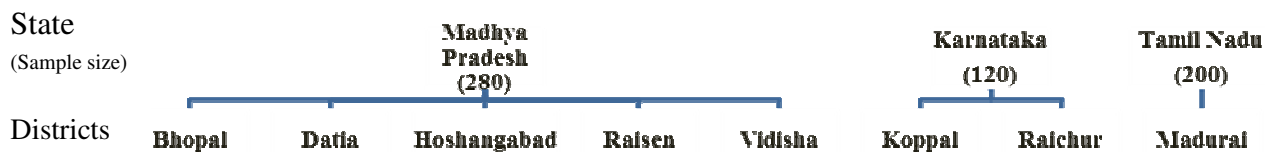
However, care should be taken while interpreting the results as they were drawn from a small sample size (20). Moreover, the representatives were also asked to express the views of the farmers, besides their own, and hence there is a chance of bias.

Simple percentage analysis, ranking techniques, bar charts, pie charts and radar charts were used to analyse and represent the results of the survey conducted on crop insurance.

### 3.4.2. FARMERS SURVEY

A farmers’ survey on crop insurance was conducted in three states (Madhya Pradesh, Karnataka and Tamil Nadu) to understand the key weather perils as perceived by farmers; influence of weather on farming decisions; perceived need for crop insurance; required weather variables to be covered under crop insurance under irrigated and conditions; awareness and adoption rate of crop insurance; barriers to purchase of crop insurance; satisfaction with the present crop insurance policy; farmer’s management of weather risk; various aspects of weather advisories and changes in weather variables as perceived by farmers. The total sample size was of 600 farmers, selected from across the different districts of the three sample States.

#### Sampling Design



Simple percentage analyses, ranking techniques, bar charts, pie charts and radar charts were used to analyze and represent the results of the survey conducted on crop insurance.

A logistic regression analysis was conducted to predict awareness about agriculture insurance program using age, education, size of land holding and type of farming (irrigated versus) as predictors.

Here the dependent variable is dichotomous, i.e. equal to 1 if a farmer is aware of agriculture insurance program, 0 otherwise.

The model specified was:

$$\text{logit}(Y) = \ln \left( \frac{\pi}{1 - \pi} \right) = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$$

logit (Y) is the log of the odds ratio or likelihood ratio that the dependent variable is 1.

where,

Y= Aware of Agriculture Insurance Program,

X<sub>1</sub>= Age of the farmer (years)

X<sub>2</sub> = Education level of the farmer (Illiterate, Primary Level, High Schooling, Intermediate (10+2) and Graduation & above),

X<sub>3</sub> = Size of landholding (in acres),

X<sub>4</sub> = Type of farming (, both irrigated & and irrigated),

β<sub>i</sub>= Coefficients of predictor variables (i=1 to 4),

π = Probability that the farmer is aware of agriculture insurance program, and can be calculated with the following formula:

$$\pi = P(Y = \text{Aware of Agriculture Insurance Program} / X_1 = x_1, X_2 = x_2, X_3 = x_3, X_4 = x_4)$$

$$= \frac{e^{\alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4}}{1 + e^{\alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4}}$$

(The logistic regression analysis was carried out by the LOGISTIC REGRESSION command in SPSS@version 11.5)

The farmer's questionnaire is given in Annexure-6. Apart from the logit analysis, the concomitant information that was available from the questionnaire was also recorded.