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# Crop production Sustainability in West Bengal: Risk proneness and crop insurance- A way forward

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## ABSTRACT

For estimating the risk and determining the suitable crop insurance plan, the time series district wise area, production and productivity data for considerable numbers of years (1983-84 to 2010-11) were used. The distribution of yield has been studied and it was observed that in almost all the crops grown in West Bengal, the crop yield follows normal distribution. However the yield of sugarcane did not follow normal distribution. On the basis of extent of short fall in yield the districts have been classified as low, medium and high risky for growing a particular crop with respective crop insurance premium rates.The study indicated that the district wise risk determination is more appropriate than the state wise risk determination. The crop insurance premium rate for all the crops under study have been determined for the crops having high and medium risk in the districts. In case of sugarcane MPD method for premium determination have been used as the yield did not followed normal distribution. The premium rate varied from 1.7% to 13.4% in rice crop and 1.9% to 3.6% for wheat crop depending upon districts and the type of crop at 90% indemnity level.

**Keywords**: Agriculture, crop insurance, risk, premium, West Bengal

## INTRODUCTION

Crops are grown in field under the umbrella of nature. To be more specific, in presence of natural factors such as varying soil conditions and weather factors (Singh *et al*., 2008). The soil conditions vary from place to place and the weather factors vary from year to year. Thus crop faces the risk from place to place and from year to year. In India, crop production is not merely an occupation, but a livelihood for farmers. Nearly 75% of the Indian population lives in rural areas where primary occupation is crop cultivation (Bharati *et al*., 2014b). Crops provide food for our growing population and the country utilizes crop products as raw materials for agro-based industries. During last four decades there is tremendous increase in food production from 74.23 million tons (1966-67), the period before green revolution to 264.38 million tones (2013-14). Era of food shortages has been left behind and the country has come to the stage of self-sufficiency with occasional surpluses in grain production (Singh *et al*., 2013).

However, there are many challenges ahead. The human population is rising. Our rich bio-diversity needs to be protected. Safeguard of farmers' right within the circumference of globalization is essential (Singh *et al*., 2008 and Kumar, 2003). International obligations due to agreement on agriculture need to be fulfilled. All these are posing serious threat to our agro-ecological system. Over 100 million farmers throughout the length and breadth of the country are engaged in this noble occupation. They need to be effectively and systematically assisted to adopt a demand-driven and cost effective mode of agriculture; making full use of the new technologies and strategies evolved by the research institutions. Frequent failures of crops especially in rain fed, drought and flood prone areas and the inability of the farmers to absorb the risks of instability in production-levels as well as price fluctuations are the reasons of poor levels of investments affecting the economic viability of financial institutions (Singh *et al*., 2008 and Singh *et al*., 2013). Crop insurance is one way of not only providing a positive and stabilizing influence on crop production

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and productivity, but also minimizing the risk (Bharati *et al*., 2014b and Kumar and Bharati, 2005).

Government of India has fixed flat rate of premium for different crops *viz* for bajara and oilseeds 3.5%, 2.5% for other *kharif* crops, 1.5% for wheat crop and 2% for other *rabi* crops. Premium rates should vary from crop to crop and area to area as the risk is different in different situations. It should be high for highly risk prone crops and low for low risk prone crops (Bharati *et al*., 2014a). In the present situation the farmers of low risk prone areas pay same premium as the farmers of highly risk prone areas. As a result the farmers of low risk prone areas are not happy from the prevailing crop insurance plan. It would be more logical if we could get different premium for different crops and different climatic conditions (Kumar and Bharati, 2005 and Bharati *et al*., 2014a).The literature lacks the study of risk proneness of different crops in different locations. Keeping this in view of the present study on risk proneness of major crops in West Bengal is undertaken.

## MATERIALS AND METHODS

West Bengal agriculture has occupied around 3 per cent of India's productive land. More than 8 per cent of India's foods are being generated by the agricultural sector of West Bengal. Small and marginal farmers rule over the West Bengal agriculture and cultivate more than 68 per cent of the total area. The agriculture in West Bengal is one of the most significant means to earn livelihood especially in the rural sectors. This has been enabled by various schemes of the Green Revolution and the land reforms (Bharati *et al*., 2014a). West Bengal comprises of 8 per cent of India's population and the majority of them are engaged in farming and other agricultural activities. The major food crops cultivated in West Bengal is rice (Aus, Aman and summer), wheat, pulse, oilseed, jute, sugar cane and potato. There has been a significant rise in the cropping intensity of West Bengal from 131 per cent to 162 per cent during the last 2 decades. The fifteen district of West Bengal were considered for risk proneness study for the major crops. These districts are Burdwan, Birbhum, Bankura, Purba Medinipur, Howrah, Hooghly, North 24-Parganas, Nadia, Murshidabad, Uttar Dinajpur, Maldah, Jalpaiguri, Darjeeling, Cooch Behar, Purulia. The productivity data of major crops for the period from 1983-84 to 2010-11 for all the districts have been collected from the Department of Statistics and programme implementation, Bureau of Applied Economic and Statistics, Govt. of West Bengal.

### Assumptions for the assessment of risk proneness

If the yield of a particular crop in a district in a given year is less than the average of the previous three years yield, the year was considered as shortfall in yield. Mathematically, there is yield loss,

$$\text{If } y_t \langle \frac{y_{t-1} + y_{t-2} + y_{t-3}}{3}, \text{ t=1, 2, 3, …, n.}$$

Where,

$y_{t=}$ yield in year t,
$y_{t-1=}$ yield in previous year,
$y_{t-2=}$ yield in a year before previous year,
$y_{t-3=}$ yield in two years before previous year.

### Assessment of risk proneness

Probability of shortfall is the ratio of number of shortfall in yield and the number of years including shortfall and no-shortfall. The extent of shortfall is the difference of yield in the year of yield shortfall and the average of previous three years yield.

### Determination of premium rates

When yield follow normal distribution the premium rates are obtained through normal curve techniques, otherwise by mean per cent deviation method (Botts and Boles, 1958)

### Normal curve techniques

It the actual yields of a defined area are distributed normally with mean 'm' and variance '$\sigma^2$' and each insured farmer in the area receives indemnity 'c' then the value of the probability density function of normal distribution at 'c' is 'd' and value of the cumulative density function at c ie 'A'.

The pure premium is the expected value of the indemnity. The indemnity paid to the farmer as a function of the yield can be specified as follows:

$$I(x) = c - x \text{ if } x \leq c$$
$$= O, \text{ if otherwise.}$$

Thus, pure premium can be defined as E [I (X)]. The probability density function of X: $X \leq c$ can be specified as

$$= \frac{x}{A}, \; x \leq c \text{ ; X is distributed as } N(m, \sigma^2)$$
$$= O, \text{ it otherwise,}$$

Where,

$$A = \int_{-\infty}^{C} \frac{1}{\sqrt{2\pi}\sigma} \exp\left[ -\frac{1}{2} \left\{ \frac{x-m}{\sigma} \right\}^2 \right] dx$$

Hence, E [I (X)]= $E(c-x) = (c-m) + \frac{d}{A}\sigma^2$

Obtaining the value of 'A' and'd' from normal tables, the premium rates are computed.

### Mean per cent deviation method

If the threshold yield is denoted by 'c', the yield of the area by 'y' then the indemnity 'I' paid to the farmers in the insured area is given by

$$I = c - y \text{ , if } y \le c$$
$$= 0, \text{ if } y > c$$

It is seen that although the yield Y, is assumed to be a continuous random variable, since it has a positive probability of assuming zero (Dandekar, 1985). This implies that the distribution function of indemnities has a discontinuity at the point zero.

The average indemnity which is the mathematical expectation of I, is given by

$$E(I) = [C - E(y \mid y \le c)].\Pr(y \le c)$$

The expectation of indemnities depends on the probability of yields being below the threshold yield, the value of C and the 'conditional mean yield', E ( $y \mid y \le c$ ). The conditional mean yield is the expectation of the truncated distribution of yields below the threshold yield, c. Knowledge of the distribution function of yields is clearly crucial to the determination of suitable premiums for different values of c.

## RESULTS AND DISCUSSION

For determining the risk of various crops pertaining to the districts of West Bengal, the districts existing as on the base year, i.e., 1983-84 were considered and the subsequent bifurcated districts were clubbed in to the pre-existing districts. In other words the area and production of subsequent districts were clubbed to give a single area and production of pre-existing districts. To get the yield of a particular crop the yield were obtained by dividing the production with area. This yield data were subjected to the further statistical computation as per methodology mentioned in the methods and materials section of this paper (Kumar and Bharati, 2005). The computations consist of coefficient of variance studies, probability studies of getting lower yield in comparison to the previous three years average, extent of shot falls, classification of districts and determination of premium rates (Botts and Boles, 1958).

### Crop wise coefficient of variance studies

The coefficient of variance of the crops under study as presented in table 1 revealed that the summer rice in each district has least coefficient of variance and the sugarcane having highest in comparison to other crops under study(Kumar and Bharati, 2005). It is due to the

**Table 1: Coefficient of variation (%) of yield of different crops in different districts of West Bengal**

| Districts | Aus Rice | Summer rice | Aman Rice | Wheat | Pulse | Oilseed | Jute | Sugar cane | Potato |
|---|---|---|---|---|---|---|---|---|---|
| Burdwan | 18 | 13 | 20 | 13 | 25 | 13 | 17 | 84 | 18 |
| Birbhum | 18 | 12 | 24 | 18 | 23 | 20 | 19 | 93 | 23 |
| Bankura | 24 | 18 | 25 | 15 | 22 | 23 | 21 | 91 | 16 |
| E. Medinipur | 32 | 9 | 27 | 14 | 44 | 36 | 20 | 87 | 19 |
| Howrah | 22 | 13 | 24 | 29 | 22 | 35 | 27 | 93 | 19 |
| Hooghly | 13 | 9 | 20 | 15 | 20 | 18 | 18 | 89 | 20 |
| North 24 Parg | 17 | 8 | 28 | 13 | 13 | 13 | 21 | 94 | 31 |
| Nadia | 27 | 10 | 25 | 15 | 16 | 8 | 16 | 87 | 23 |
| Murshidabad | 30 | 12 | 26 | 14 | 16 | 13 | 19 | 101 | 22 |
| N. Dinajpur | 29 | 17 | 27 | 14 | 37 | 18 | 28 | 95 | 52 |
| Maldah | 41 | 10 | 31 | 15 | 22 | 26 | 29 | 91 | 40 |
| Jalpaiguri | 29 | 18 | 20 | 17 | 17 | 22 | 24 | 89 | 48 |
| Darjeeling | 38 | 13 | 20 | 24 | 18 | 17 | 24 | 84 | 28 |
| CoochBehar | 30 | 8 | 18 | 14 | 15 | 16 | 22 | 93 | 48 |
| Purulia | 40 | 13 | 27 | 20 | 23 | 28 | 9 | 91 | 27 |
| West Bengal | 26 | 12 | 23 | 12 | 12 | 10 | 17 | 87 | 14 |

fact that the summer rice receives only artificial irrigation and does not vary from year to year. Contrary to this the sugar crop having highest coefficient of variance is mainly due to the fact that this crop if annual in nature and receives both type of irrigation natural as well as artificial. The natural irrigation has more variability due to climate change. The rabi crops such as wheat, potato some of the oilseed ad and pulses showed moderate variability whereas the kharif crops showed considerable variations mainly due to rain dependency in nature (Bharati *et al*., 2014a). The variations give lower value for the state as a whole as the yield variability of the districts gets neutralized.

### Lower yield probabilities studies

Data presented in table 2 depicts the probability of lower crop yield in comparison to previous three years average yield. It was observed that except oilseed crops the low yield is expected in every two to three years. Where as in oilseed crops low yield is expected to occur for two years in every three years. There are certain crops in certain districts such as Aus Rice in East Medinipur, Murshidabad and Aman rice in Burdwan and Maldah, Jute in North 24 Pargana and and Purulia, in which low yield is expected to occur in every four or more years (Bharati *et al*., 2014a).

### Yield shortfall (%) in different districts of West Bengal

Frequency of low yield indicates only the low yield not the magnitude of yield. For studying the extent of shortfall defined as the difference of yield in the year of shortfall yield and the average of previous three years yield, table 3 is used. In the present studythe shortfall up to 10 % has been considered as minor shortfall and there is no need for crop insurance as insurance protection involves cost which will neutralize the protected amount. The shortfall from 11% to 20% has been considered as medium loss and the farmers growing the respective crop in respective districts may be encouraged to adopt crop insurance plan. Similarly the shortfall from 20 % and more has been considered as high loss and the farmers should be advised to go for crop insurance for the protection of their crop loss. The table 3 revealed that per cent extent of shortfall in sugarcane, potato, pulse and wheat in all the districts is medium to high indicating need for crop insurance plan in all the districts for these crops. For jute and oilseed crops some of the districts fall under low risk category while others need crop insurance like oilseed crop in Birbhum, Bankura, Howrah, Hoogle, North Dinapur, Maldah, Jalpaiguri, Darjeeling, Cooach Behar and Purulia as well as Jute in East medinipur, Howrah, Maldah, Jalpaiguri, Cooach Behar and Purulia districts of the state. So far as rice crop is concerned, summer rice is almost in safe zone in all the districts except Bankura and Jalpaiguri, in which slight medium short fall is observed. Six districts East Medinipur, Hawrah, Nadia, Murshidabad, Maldah and Darjeeling observed medium short fall percentage with repect to Aman rice and the rest districts have low shortfalls in yield. In case of Aus rice only six districts Burdwan, Birbhum,

**Table 2: Probability of occurrence of lower yield than average yield of previous three years in different districts of West Bengal**

| Districts | Aus Rice | Summer rice | Aman Rice | Wheat | Pulse | Oilseed | Jute | Sugar cane | Potato |
|---|---|---|---|---|---|---|---|---|---|
| Burdwan | 0.32 | 0.44 | 0.23 | 0.41 | 0.56 | 0.71 | 0.44 | 0.36 | 0.44 |
| Birbhum | 0.28 | 0.36 | 0.38 | 0.33 | 0.44 | 0.53 | 0.48 | 0.52 | 0.36 |
| Bankura | 0.28 | 0.32 | 0.31 | 0.33 | 0.5 | 0.53 | 0.4 | 0.48 | 0.4 |
| E. Medinipur | 0.24 | 0.4 | 0.27 | 0.41 | 0.5 | 0.35 | 0.32 | 0.28 | 0.44 |
| Howrah | 0.44 | 0.44 | 0.38 | 0.48 | 0.33 | 0.41 | 0.36 | 0.4 | 0.48 |
| Hooghly | 0.48 | 0.32 | 0.31 | 0.33 | 0.56 | 0.47 | 0.36 | 0.48 | 0.4 |
| North 24 Parg | 0.32 | 0.6 | 0.35 | 0.41 | 0.44 | 0.53 | 0.16 | 0.4 | 0.52 |
| Nadia | 0.28 | 0.4 | 0.42 | 0.44 | 0.39 | 0.47 | 0.48 | 0.4 | 0.48 |
| Murshidabad | 0.24 | 0.36 | 0.38 | 0.44 | 0.33 | 0.65 | 0.28 | 0.28 | 0.28 |
| N. Dinajpur | 0.44 | 0.44 | 0.31 | 0.41 | 0.5 | 0.71 | 0.32 | 0.32 | 0.32 |
| Maldah | 0.44 | 0.28 | 0.23 | 0.44 | 0.44 | 0.41 | 0.28 | 0.44 | 0.36 |
| Jalpaiguri | 0.36 | 0.52 | 0.38 | 0.41 | 0.56 | 0.47 | 0.4 | 0.28 | 0.4 |
| Darjeeling | 0.32 | 0.52 | 0.35 | 0.48 | 0.39 | 0.59 | 0.32 | 0.36 | 0.32 |
| CoochBehar | 0.32 | 0.4 | 0.35 | 0.41 | 0.56 | 0.65 | 0.32 | 0.52 | 0.28 |
| Purulia | 0.4 | 0.44 | 0.31 | 0.41 | 0.5 | 0.65 | 0.08 | 0.48 | 0.64 |
| West Bengal | 0.24 | 0.36 | 0.35 | 0.44 | 0.44 | 0.59 | 0.24 | 0.28 | 0.4 |

**Table 3: Extent of shortfall (%) in different districts of West Bengal**

| Districts | Aus Rice | Summer rice | Aman Rice | Wheat | Pulse | Oilseed | Jute | Sugar cane | Potato |
|---|---|---|---|---|---|---|---|---|---|
| Burdwan | 8 | 6 | 9 | 11 | 19 | 8 | 10 | 13 | 17 |
| Birbhum | 9 | 7 | 7 | 10 | 12 | 12 | 5 | 16 | 15 |
| Bankura | 4 | 12 | 3 | 16 | 13 | 19 | 5 | 19 | 13 |
| E. Medinipur | 16 | 7 | 22 | 10 | 21 | 9 | 17 | 18 | 15 |
| Howrah | 20 | 7 | 18 | 22 | 21 | 13 | 16 | 11 | 15 |
| Hooghly | 5 | 9 | 5 | 19 | 15 | 12 | 6 | 16 | 20 |
| North 24 Parg | 9 | 3 | 8 | 10 | 12 | 8 | 8 | 19 | 14 |
| Nadia | 8 | 6 | 13 | 12 | 13 | 8 | 4 | 20 | 13 |
| Murshidabad | 17 | 4 | 12 | 10 | 14 | 8 | 10 | 12 | 14 |
| N. Dinajpur | 16 | 9 | 9 | 12 | 22 | 12 | 9 | 15 | 18 |
| Maldah | 18 | 9 | 15 | 10 | 17 | 16 | 14 | 14 | 11 |
| Jalpaiguri | 12 | 13 | 9 | 12 | 15 | 17 | 13 | 16 | 18 |
| Darjeeling | 27 | - | 11 | 22 | 15 | 13 | 8 | 15 | 13 |
| CoochBehar | 13 | 9 | 5 | 12 | 12 | 11 | 13 | 14 | 20 |
| Purulia | 25 | - | 10 | 19 | 24 | 20 | 12 | 17 | 15 |
| West Bengal | 3 | 4 | 4 | 8 | 6 | 4 | 5 | 13 | 12 |

Bankura, Hoogle, North 24 Pargana and Nadia fall under low risk category, while Purulia and Darjeeling were observed to be high shortfall in yield and the rest are under medium category. Computation of State as a whole, sugarcane and potato falls under medium risk category and the rest are under low risk category. As it was seen that the computation of shortfall fall all the crops tells that the no crops go under crop insurance plan, whereas the district wise computation reveled the proper risk with respect to location for each crop (Kumar and Bharati, 2005).

## Premium rates for crop protection

Crop insurance premium rate for each crop in different districts of West Bengal, in which the extent of shortfall is medium or high; have been computed and presented in

**Table 4: Crop insurance Premium for different districts of West Bengal at 90% IL using NCT method by MPD method in sugarcane**

| Districts | Aus Rice | Summer rice | Aman Rice | Wheat | Pulse | Oilseed | Jute | Sugar cane | Potato |
|---|---|---|---|---|---|---|---|---|---|
| Burdwan | | | | 2.1 | 2.3 | | | 5.2 | 2.3 |
| Birbhum | | | | | 2.2 | 8.5 | | 4.3 | 2.3 |
| Bankura | | 2.7 | | 3 | 2.5 | 8 | | 3.6 | 2.7 |
| E. Medinipur | 4.8 | | 5.2 | | 4.7 | | 4.1 | 4.8 | 2.4 |
| Howrah | 3.2 | | 4.9 | 5.3 | 5 | 7.2 | 3.1 | 3.2 | 2.1 |
| Hooghly | | | | 2.1 | 4.5 | 3.6 | | 7.2 | 1.9 |
| North 24 Parg | | | | | 3.2 | | | 5.6 | 2.3 |
| Nadia | | | 4.1 | 2.7 | 2.2 | | | 3.9 | 1.8 |
| Murshidabad | 6.3 | | 5.1 | | 2.6 | | | 6.3 | 3.1 |
| N. Dinajpur | 6.9 | | | 1.9 | 2.1 | 5.2 | | 6.9 | 2.5 |
| Maldah | 13.4 | | 8.9 | | 6.8 | 6.5 | 9.1 | 13.4 | 3.2 |
| Jalpaiguri | 7.9 | 2.8 | | 2.6 | 5.1 | 4.3 | 11.5 | 7.9 | 2.3 |
| Darjeeling | 10.2 | | 3.3 | 3.3 | 3.2 | 3.2 | | 10.2 | 2.5 |
| CoochBehar | 6.4 | | | 2.3 | 5 | 7.6 | 12.9 | 6.4 | 1.9 |
| Purulia | 10.6 | | | 3.5 | 3.5 | 8.6 | 6.6 | 10.6 | 1.9 |
| West Bengal | 4.2 | 1.7 | 4.3 | 2 | 3.2 | 8.2 | 1.6 | 4.2 | 1.7 |

table 4. In premium determination for crops in districts of low risk has been ignored due to uneconomic strategy. The data presented in table 4 revealed that out of fifteen districts of West Bengal, the Aus rice cultivators of only ten districts, Summer rice cultivators of only two districts, Aman rice cultivators of only 6 districts should go for crop insurance plan with a premium rate ranging from 2.7 to 10.7 % depending on the location and type of crops. The wheat growers of Burdwan, Birbhum, Bankura, North 24 Pargana, Murshidabad and Maldah are not required to go for crop insurance plan and the rest can be insured with premium rates ranging from 1.9 to 5.3 % premium. Except few district, the oilseed and jute growers can be insured with a premium ranging from 1.6 to 12.9 %. The pulse, sugarcane and potato growers in all the districts should go for insurance plan ranging from 1.9 to 13.4 % (Bharati *et al*., 2014a).

## CONCLUSION

Based on the time series data from 1983-84 to 2010-11 of all the district of west Bengal, for estimating the risk and determining the suitable crop insurance plan for all the districts it was concluded that rice wheat, pulse, oilseed, jute and potato followed normal distribution. Darjeeling and Purulia district were categorised as high risk zone for aus rice, Purba Medinipur district for aman rice. Similarly Howrah and Darjeeling for wheat and in case of pulses in Purb Medinipur, Howrah, Uttar Dinapur and Purulia was group high risk zone. Hoogle and Coach Behar were classified as high risk zone for Potato cultivation in West Bengal.

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