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RESEARCH PAPER

Estimation of Economic Losses in Farming due to Climatic Aberrations in East Champaran, Bihar

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ABSTRACT

Farmers in East Champaran, Bihar are frequently exposed to unexpected climatic events that affect crop yields and income. Climatic aberrations adversely affects rainfed *rabi* crop performance. This study attempted to assess the loss in productivity and monetary losses incurred by farmers due to climatic aberrations. Data was collected from four villages covering randomly selected 332 farmers using a pre-tested structured interview schedule. Occurrence of floods and heavy rains reduced yields of paddy and maize crops by 50%, while deficit or delayed rainfall led to a yield decline of 26% in paddy, 24% in maize and 18% in wheat. The occurrence of frost, reported to be a regular feature by 26% of the respondents led to a yield decline of 18% in wheat and 21% in winter maize and potato. Due to these unforeseen events, annual income (from all sources) of INR 1.46 lakhs/year declined to just INR 1.0 lakhs/year, which gets further aggravated due to a lack of non-farm activities during adverse situations. The study revealed that farmers incur significant losses due to unexpected climatic events and it is necessary to popularize in-situ soil moisture conservation practices for the post-monsoon season to ensure satisfactory yields from rainfed *rabi* crops.

HIGHLIGHTS

- Aberrant climatic conditions like drought, flood, frost etc may cause heavy losses to agricultural crops resulting in reduction in income of farming community.
- Present study assessed that climatic aberration caused loss in productivity of various crops like paddy, wheat, maize and sugarcane varying from 18-50%.
- Net monetary loss in paddy crop due to untimely or delayed rain and flood was INR 9000 to 21000/ha while in wheat, monetary loss due to untimely rain or frost caused monetary loss up to INR 8000/ha.

Keywords: Aberrations, Agricultural drought, Floods, Income, Small and marginal farmers, Adaptation

Research on the impact of unexpected climatic events and exposure of farmers to such events has become increasingly important in India and other developing countries and has begun to receive attention from policymakers. In a study of vulnerability of farmers at the district level in the state of Karnataka, nearly 51% of the state's geographical area and 42% of the human population were in the highly vulnerable category (Kumar *et al.* 2016). Udmale *et al.*, 2014 reported the impact of drought on local adaptation measures and the

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need for administrative measures in Maharashtra, India. Another study from the drought-prone western district of Odisha, India reported that higher adaptive capacity did not necessarily reduce their vulnerability to climate variability and that diversified livelihoods were important to reduce the risk associated with unexpected climatic events (Panda, 2016).

Agriculture is the mainstay in Bihar state with 75% of the population dependent on it for their livelihood. Bihar is India's most flood prone state with 76% of the population in North Bihar and 68800 sq. Kms affected by floods, causing loss to life and property and rendering thousands of hectares of fertile land unfit for sowing. Besides floods, the state is also affected by unseasonal droughts due to long breaks in the rainy season and there are pronounced variations in rainfall distribution (Nath *et al.* 2017). Ghosh and Mukhopadhyay (2014) reported that annual rainfall received in different areas is not uniform every year and areas which received low rainfall in 2009 received high rainfall in 2011. In another study by Singh *et al.* (2014) carried out in Bihar, significant variations were reported during June and September which varied by 23% and directly affected the production of rice. In recent times, the occurrence of unseasonal rains, long gaps between spells or unexpected rains during periods of crop maturity have begun to occur with increased frequency, with cloud development and downpour within a period of 1-2 days, leaving no time for the farmers to protect his standing or harvested crops. While one or two showers or a moderate downpour during the *rabi* season (Dec. - April) is beneficial to crops like wheat and maize, unseasonal rains accompanied with hailstones and squalls have led to extensive damage in recent years. In 2014, unseasonal rains affected six states of India in which over 5.5 m ha crop area worth INR 5000 crores were damaged. In *rabi* season of 2015, a total of 15 states, covering 70% of India's geographical area producing 81% of food grains, were severely affected by hailstones and squalls which damaged standing wheat crop in 122.6 lakh ha. The monetary loss was estimated to be INR 20453 crores and food grain production was affected by 5.2%. In Bihar alone, about 14.58 lakh ha was affected (Bhushan *et al.* 2015). A paper covering the eastern states of India by using empirical methods for analysis, reported that the estimated yield gap is 10-30% in case of paddy and 2-15% in wheat. They attributed this to sub-optimal resource use (fertilizers and mechanization) but also to low seed replacement rate along with frequent floods and drought (Jha *et al.* 2018). Singh *et al.* (2019) reported upon the positive impact of the introduction of improved varieties of major crops on yields in the East Champaran region of Bihar.

It is a paradox that despite the availability of large underground water resources and poor stage of ground water development (Kumar *et al.* 2017; Chandra *et al.* 2018), small and marginal farmers are unable to obtain assured water resources to save their crops under stressed situations. Present study attempts to find out exposure level of small and marginal farmers in the East Champaran region of Bihar, India to climatic aberration and economic losses caused to them in the form of yield reduction and monetary loss.

METHODOLOGY

Study area

The study was carried out in four villages of selected blocks namely, Jasauli Patti (Kotwa block), Chandrahiya (Motihari block), Chintamanpur and Khairimal Jamunia (Chakia block) of East Champaran district of Bihar, India which lies along the Dhanauti, a seasonal river which carries water during the monsoons and also receives water as runoff from a large area with agriculture as a major land use. The selection of the villages was based on data available on population of small and marginal farmers, personal observations of difficulties faced during erratic rainfall situations, and discussions with farmers and staff of the state agriculture department.

Data collection and analysis

A structured interview schedule was developed using an earlier perception study on drought carried out in Bangladesh (Habiba *et al.* 2012), tested and data were collected from 332 randomly selected farmers from the four villages. In order to assess the threat perception or exposure to climatic events faced by land owners, information was gathered on the occurrence of floods, low-intensity droughts, frost and those related to rainfall like untimely rains,

delayed rains or long gaps in rainfall occurrence. Responses were grouped into four categories *viz*., occur regularly, occur once in 2-3 years, rarely occur and no response.

In order to assess the monetary losses incurred by cultivators due to climatic events, information was gathered on crop yields (q/ha) during normal years and during the year when there were climatic disturbances like floods, agricultural drought, very cold winters or erratic rainfall distribution. This data from each village was then tabulated category-wise for each climate event and a per cent decline over yields obtained during normal years was calculated. Using the minimum support price (MSP) for 2017 (https://www.nabard.org) the cost of crops produced under both the situations (normal year and affected year) was estimated and a per cent decline in income was calculated. Data collected was tabulated and descriptive statistics like frequency and percentage were calculated on the responses received. For other responses dealing with exposure and coping strategies, the mean weighted score was calculated by assigning weights to responses with a score of 3 for regular occurrence, 2 for occurrence in 2-3 years, 1 for rare occurrence and 0 for no response.

RESULTS AND DISCUSSION

Exposure to different climatic events

Information gathered from 332 respondents across the four villages (Table 1), indicated that >75% of farmers were affected by rainfall events in general, with 88.8% reporting that untimely rains were a serious problem followed by 87% of farmers who reported that poor rainfall leading to moderate level of drought was a problem. Delayed arrival of monsoons during *'kharif'* was reported by 75.6% of respondents as a problem.

The occurrence of floods was a problem reported by 80.4% of farmers although it occurs only once in 5-7 years but causes loss of agricultural land and severe monetary losses which can take up to 3-4 years for recovery, provided climatic conditions remain conducive. While considering the exposure levels at each village individually, 56% and 26% of farmers from Chintamanpur and Khairimal Jamunia respectively, reported floods as a regular feature. This can be attributed to the location of the farm lands in close vicinity to the Dhanauti river which carries high flows during the monsoons and inundates large areas all along its banks. But in villages like Chandrahiya and Jassaulipatti flood occurrence was a rare occurrence but, moderate levels of drought were reported to be a serious problem and >80% of respondents reported this to be a regular feature. The scores obtained also indicated that the occurrence of untimely rains (at sensitive stages of crop growth) had the highest score (2.21) followed by delayed rains (1.93) and low rainfall (1.83). Similarly, the occurrence of frost (score 1.39) which led to damage in *rabi* maize, potato and wheat was reported to be a problem by 26% of the respondents.

Climatic aberrations and crop performance

The impact of unexpected climatic events for which landowners have no protection was estimated and is graphically presented in Fig. 1. As indicated, the highest losses occur due to flood which leads to a yield decline of >50% in the case of paddy and sugarcane and about 43% in the case of *kharif* maize. These losses were the highest in case of Khairimal Jamunia where > 80% of maize and paddy washed

Table 1: Pooled responses for climate related problems from the four villages (N = 332)

Climatic problems	Frequency of occurrence				Overall frequency	%	Weighted mean score*
	Regular	Once in 2-3 years	Rare	No response			
Flood	7	52	208	65	267	80.42	1.00
Drought	45	230	14	43	289	87.05	1.83
Untimely rains	162	114	19	37	295	88.86	2.21
Delayed rains	148	93	10	81	251	75.60	1.93
Long gaps in rainfall	84	55	30	163	169	50.9	1.18
Frost	86	100	4	142	190	57.23	1.39

*N= 332; *Weightage – Regular = 3; Once in 2-3 years - 2; Rare – 1; No response - 0.*

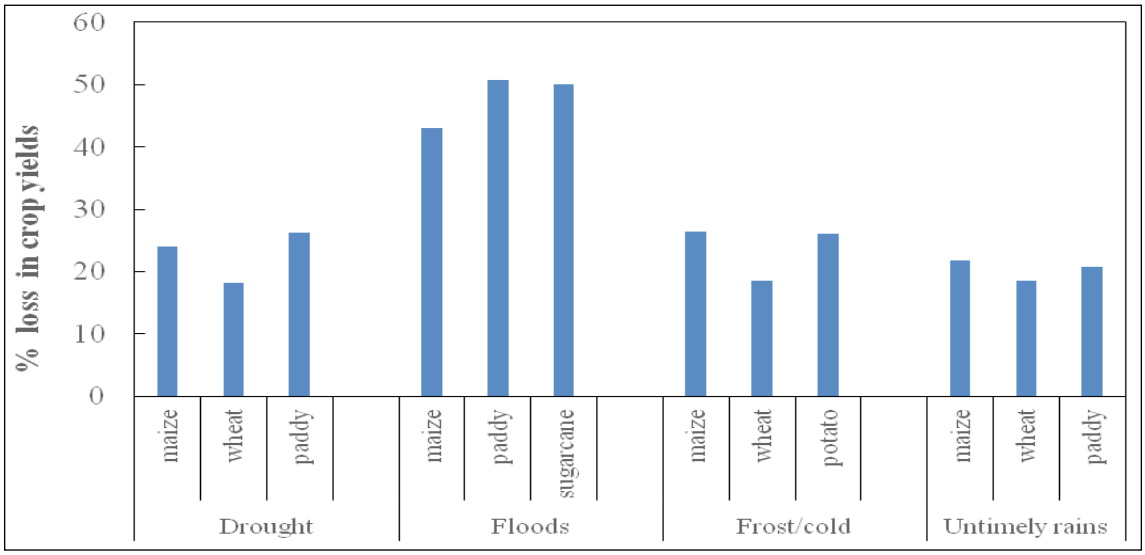

Fig. 1: Percentage loss in productivity of major crops due to climatic aberration

away, whereas 53.5 and 41% of paddy are lost in case of Jassaulipatti and Chintamanpur, respectively. This can be attributed to the location of the fields and the high volume of flood water in the *Dhanauti* river which flows along Khairimal Jamunia and Chintamanpur, while in case of Jassaulipatti flood water inundate large areas under paddy but due to its topographical features the flood water is unable to flow out and reduces only by the end of September or early October, leading to significant losses of the standing paddy crop.

Leaving aside the occurrence of floods which occur once in 5-7 years or so, deficit and delayed rainfall led to average losses of 26% in paddy and 24% in maize covering the villages of Jassaulipatti, Khairimal Jamunia and Chintamanpur. The deficit in *rabi* rains led to a loss of 18% in wheat yields which was nearly similar in all four villages. Untimely rains led to losses of nearly 22% in maize, 21% in paddy and 18% in wheat. In this situation, farmers have to wait for the water to recede and the field to dry for easy harvesting of the crops. The occurrence of frost during December and January was reported to occur on a regular basis by 26% of the respondents leading to a yield reduction of 21% in the case of potato and *rabi* maize and about 18.6% in wheat.

Reduction of crop yields and monetary losses due to climatic events

The impact of unfavourable climatic events on the production of two major crops in the four villages - rainfed wheat and rice is presented in Tables 2 & 3, respectively. The yield reduction in wheat was on average 18% lower than that obtained in normal years which is 29.35q/ha. The highest decline has been estimated in the villages of Jassaulipatti and Chintamanpur where yields lowered by 38% and 35% in comparison to yields obtained in Khairimal Jamunia. The net monetary loss averaged over all four villages is INR 8060/- per ha.

The occurrence of frost damaged wheat crop when it was in the pre-heading or flowering stage while delayed or poor *rabi* rains specially during the grain setting stage and led to poor yields (Table 3). In comparison to wheat, losses in paddy were significantly higher due to erratic rainfall distribution and floods. During years with normal climatic situations yields are about 30.48 q/ha but this declines by 26% with Jassaulipatti being the worst affected where yields decline by 40.3% in comparison to Khairimal Jamunia with monetary losses average over the four villages being about INR 11174.00 per ha. Untimely rains (at the crop ripening stage or harvesting stage) led to an average decline of 21% in crop yields and a monetary loss of INR 9190.00 per ha. The most serious damage was caused by floods which led to an average decline in yields by 50.7% and monetary loss of INR 21195.00 per ha with Jassaulipatti being the hardest hit. Losses in yields of different crops, which indicates that if losses due to floods are excluded, then yield reduction due to drought, frost and untimely rains is about 20-30%. Low temperatures cause losses

Table 2: Reduction in yield (q/ha) of wheat and cost (INR in thousands)

Climatic event	% yield decline	Yield (q/ha)	Sampled villages				Average (INR)
			Jassaulipatti	Chandrahiya	Khairimal Jamunia	Chintamanpur	
Normal condition	—	Normal conditions	22.15	35.7	36.21	23.36	29.35
		Cost* (INR)	33779	54442.5	55220	35624	44766
Poor rabi season rains	18	Affected conditions	18.15	29.27	29.7	19.16	24.07
		Cost* (INR)	27678	44634	45292	29219	36705
		Net loss per ha (INR)	6101	9808	9928	6405	8060
Frost & untimely rains	18.6	Affected conditions	18.03	29.06	29.48	19.02	23.90
		Cost* (INR)	27495	44316	44957	29005	36443
		Net loss per ha (INR)	6284	10126	10263	6619	8323

**Cost per hectare at the MSP of INR 1525/- per quintal.*

Table 3: Reduction in yield (q/ha) of paddy and cost (INR)

Climatic event	% yield decline	Yield (q/ha)	Sampled villages				Average (INR)
			Jassaulipatti	Chandrahiya	Khairimal	Chintamanpur	
Normal conditions	—	Normal conditions	20.6	33.7	34.5	33.15	30.48
		Cost* (INR)	29046	47517	48645	46741	42987
Delayed and deficient rains	26	Affected conditions	15.25	24.94	25.53	24.53	22.56
		Cost* (INR)	21502	35165	35997	34587	31812
		Net loss per ha (INR)	7544	12352	12648	12154	11174
Floods	50.7	Affected conditions	10.44	17.08	17.49	16.80	15.45
		Cost* (INR)	14720	24083	24675	23688	21791
		Net loss per ha (INR)	14326	23434	23970	23053	21195
Untimely rains	21	Affected conditions	16.27	26.62	27.26	26.19	24.08
		Cost* (INR)	22941	37534	38436	36278	33797
		Net loss per ha (INR)	6105	9983	10209	10463	9190

**Cost per hectare at the MSP of INR 1410/- per quintal.*

of nearly 30% in winter maize and potato while untimely rains cause an average loss of about 20% in summer maize, paddy and wheat.

Loss in annual income of farm household

While summarizing the net monetary loss incurred by land owners from all measurable sources of income (farm income, off-farm income earned as labourers, temporary employment) the average income during normal years of the four villages is INR 1.46 lakhs with Khairimal Jamunia having the highest income (INR 2.03 lakhs per year) and Chandrahiya the least (INR 1.15 lakhs per year) (Table 4).

But annual average income values decline by 31.5% to only INR 1.00 lakh per year when the villages are affected by floods or agricultural drought with the decline of 40.7 and 34.3 % in the villages of Jassaulipatti and Chintamanpur, respectively. This loss in income gets further aggravated due to limited non-farm activities forcing the land owner to work as a labourer in the fields of resource-rich farmers or seek temporary employment in nearby towns. The reduction in annual income is not sufficient to support an average family size of 4-5 members (Table 2) and provide basic necessities, causing even more hardships in terms of food security.

Table 4: Income (INR in lakhs/year) profile of sampled farmers from the four villages and reduction caused by climatic events

Village	Sample size	Income in Normal year (₹ in lakh/year)	Income when affected by flood/ drought (₹ in lakh/year)	% decline
Chandrahiya	99	1.15	0.83	27.40
Jassaulipatti	88	1.20	0.72	40.73
Khairimal Jamunia	70	2.03	1.43	29.46
Chintamanpur	75	1.49	1.03	34.33
Average		1.46	1.00	

(All values are mean of sampled farmers).

CONCLUSION

The study area represents the typical agrarian setting in this part of Bihar, where small and marginal farmers are severely affected by unexpected climate-related events due to several reasons *viz*., high dependence on rainfed farming, farms location in vulnerable or marginal landscapes like flood plains, small and scattered land holdings, low capacity to adapt technological changes and limited exposure to improved farming practices, etc leading to a significant decline in crop yields. It is therefore important to provide timely information on the occurrence of agricultural drought to landowners and provide alternatives to reduce the impact of these events. Conservation of moisture in post-monsoon season for drought-proofing by the adoption of low-cost *in situ* moisture conservation practices is an important adaptation strategy. Besides this, there needs to be a focus on harvesting runoff water in small ponds made at multiple locations and the adoption of integrated farming practices which is ideal for vulnerable locations.

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