Original Research Paper

Title: What's the benefit of adaptation to climate change? Application of Partial Budgeting for the rice growers of Eastern Himalaya in India

Abstract

The objective of the present study was to estimate the cost of adaptation to climate change incurred by the rice growers in Eastern Himalaya (EH) in India. A sample total of 120 cereal farmers were surveyed in Senapati district of Manipur and East Sikkim district of Sikkim in EH. Two main adaptation strategies *i.e.,* changing the transplanting time of rice (Strategy 1) and changing the transplanting and harvesting time (Strategy 2) of rice were widely adopted by the farmers. The cost and benefit of these adaptation strategies were estimated using partial budgeting technique. The cost of rice cultivation has increased by `8505.63/ha and `6374.29/ha in case of the adopters of Strategy 1 and Strategy 2 and the cost was mainly incurred on farm labour. The net benefit realized by the adopters of both the strategies was `1329.30/ha and `1568.67/ha, only, respectively. The strategies adopted were in response to the change in timing of rainfall. Hence, the study recommended the planned interventions of the State Governments through farm mechanization, construction of water harvesting and minor irrigation facilities are the urgent need in the study area.

Keywords: Climate change; Eastern Himalaya; adaptation strategy; partial budgeting.

Introduction

Ample of literatures are available that estimate the costs and benefits of adaptation of agriculture to climate change at the macro-level but farm level evidences are meagre. Literatures provide many evidences in the progress of the work related to adaptation to climate change but the research on this aspect has been concentrated and limited around the identification of the adaptation strategies adopted by the farmers. The widely adopted adaptation strategies were diversification (Nhemachena and Hassan , 2007; Varadan and Kumar , 2014), planting different crops or crop varieties (Ghimire and Aryal, 2013; Maddison, 2007; Nhemachena and Hassan, 2007), changing planting dates (Nhemachena and Hassan, 2007; Ghimire and Aryal, 2013; Shankar *et al.*, 2013; Innocent *et al*. 2016), selling livestock (Varadan and Kumar, 2014), buying insurance (Shankar *et al.*, 2013).

In India farmers particularly the marginalised and small farmers seldom keep records of their farming expenses in but they are very sensitive if any change occurs either in the cost or return structure. But, adaptations to climate change cause changes on the way farming is being practiced which is expected to affect the cost or the return from cultivation. Hence, it is necessary to evaluate the direction towards which these changes occur and the magnitude of change, as these hold the key towards the long term sustainability of farming. The present study worked out the cost and returns of the adaptation strategies adopted by the rice farmers in the Eastern Himalaya (EH) region in India.

Methodology

The study was conducted in Senapati district (1061 m to 1788 m AMSL[1]) of Manipur and East Sikkim district (300 m to 5000 m AMSL) of Sikkim of EH, India. Senapati district is located in the northern part of Manipur at the latitude of 24˚.30’N to 25˚.45’N and longitude of 93˚.30’E to 94˚.30’E and with a geographical area of 3271 sq. km. East Sikkim district occupies

[1] Above Mean Sea Level

the south-east corner of Sikkim at an latitude of 27˚.30’N and longitude of 88˚67’E and with a geographical area of 954 sq. km.

Cereals are the mainly cultivated crops in both the districts. In Senapati district, the arable land account for 20.00% of the total land area. The total area under rice in Senapati district is 16.83 thousand ha in 2010-11 against 24.11 thousand ha in 2004-05 (GoM, 2013). The net sown area in East Sikkim district is 18.10 thousand ha and only 13.97% is under irrigation (GoS, 2014).

Central Research Institute for Dryland Agriculture (CRIDA) has identified 17 districts vulnerable to climate change in the North Eastern Region (NER) and Indian Council of Agricultural Research (ICAR) has implemented a project “National Initiative on Climate Resilient Agriculture (NICRA)” which was renamed as the “National Innovations in Climate Resilient Agriculture in 2015 to provide resilience to climate change in these districts. These vulnerable districts are located at different altitudes and assuming differentiated change in climatic factors, we randomly selected Senapati district of Manipur from lower altitude (200m to 1500m AMSL) and East Sikkim district of Sikkim from higher altitude (1500m to 2500m AMSL).

From each of the districts, two blocks were selected; one was selected randomly and one was selected purposively. One block where ICAR has implemented NICRA was selected purposively as the cereal growers of these blocks were expected to adapt some strategies, atleast the planned strategies to cope up with the changing climatic scenario. Kangpokpi block of Senapati district and Nandok block of East Sikkim district were selected purposively. Saitu from Senapati and Assam Lingzey block from East Sikkim district were selected randomly.

From each of the selected blocks, a cluster of villages (consisting of 1-2 village) where NICRA project was implemented were selected purposively. Another cluster of villages were randomly selected from each of the blocks. At the next stage, from the NICRA cluster 20 beneficiary cereal growers were selected randomly. And from the other cluster of villages 40 cereal growers were selected randomly. So, from each district 60 cereal growers were selected, hence, a sample total of 120 farmers were drawn for the present study and the primary data were collected from the selected farm households using the pre-tested well constructed schedule during 2015.

Analytical technique

To estimate the cost and benefit of adaptation Partial budgeting technique was employed. Partial budgeting is a basic method designed to evaluate the economic consequences of minor adjustments in a farming business. As adaptation to climate change was the minor adjustment incorporated by the farmers to that of the normal way of cultivation practices, therefore this was found best suited the condition. The method is extensively used for estimating the financial impact of implementing a new technology, in dairy research and plant protection research.

Partial budgeting technique

Increase in costs and decrease in returns due to adaptation is the total additional cost (A) of that adaptation measure. The benefit (B) is accounted by the decrease in costs and increase in returns due to the adoption of that adaptation measure. The difference (B-A) between the additional returns and additional cost is the net benefit of that adaptation measure.

Results and discussion

The study has identified 11 adaptation strategies but the two major strategies *viz.,* change in transplanting time (Strategy 1) and change in transplanting as well as harvesting time

(Strategy 2) were widely adopted by majority of the farmers. Strategy 1 was adopted by 65.52% in Manipur and Strategy 2 by 70.00% in Sikkim. The other strategies were adopted by merely two to three farmers. Therefore, the cost and benefit incurred in adopting these major strategies only were estimated.

The adopter (mainly for two primary strategies) and non-adapter reveal some distinguishing features which is presented in Table 1.

The adopters were marginally older than the non-adapters but the literacy rate were found to be significantly lower (69.23% to 73.53%) for adopters than non-adapters (90.91%). Primarily the adopters resided in *kuccha* type of houses (64.10% and 35.29%). The non-adapters owned higher number of cattle than the adopters of both the strategies. As the housing structure and livestock ownership reflects the wealth ownership of the household, it is understood that the non-adapters were comparatively wealthier than the adopters.

The average area under rice cultivation (0.77 ha) was marginally higher in case of the adopters of Strategy 1 than the adopters of Strategy 2 and the non-adapters. During the normal period, the productivity of rice was higher in case of the adopters of Strategy 1 than Strategy 2 and the productivity in Manipur was higher than in Sikkim across the categories. But during the drought period, the productivity of rice dropped by 48.24% from that of the normal in case of the non-adapters and 30.53% and 20.56% in case of the adopters of Strategy 1 and Strategy 2, respectively. The adopters of Strategy 2 were also the beneficiaries of the two farm related institutions *viz.,* State Agricultural Department (40.00%) and Agricultural Science Centre known as Krishi Vigyan Kendra (KVK) (25.71%) (Table 1).

Farm input use decision by the adopters in Manipur and Sikkim

The strategies adopted were mainly the change in timing. When the normal timing of any farm operations get changed during the drought period the overall cropping calendar gets affected and this negatively impact the total farm production. The type and the amount of inputs normally used may also change. The change may be in terms of either dropping/introducing an input(s) or increasing/decreasing an input(s). Investigation across the strategies revealed that the adopters of adaptation strategies in Sikkim did not change the input use pattern. In Manipur, some of the adopters made change in input use and others did not. This variation in the decision among the adopter's raises the curiosity that which category is better-off than the other. The decision of changing the input use may not have been abrupt or unreasonable for the farmers as this can change the cost of cultivation as the sample farmers were small and marginal who bear the cost solely rather than the large farmers who sell portion of their production and hence, pass on the cost to the consumers.

Even though, Strategy 2 is related with the change in both the transplanting and harvesting time of rice, the whole of the input change was related with the change in transplanting time only.

All of the adopters in Sikkim did not change the input use from that of the normal period, even though the adopters of the state were better in terms of adaptive capacity than their counterparts in Manipur when judged with relation to wealth ownership (*viz.*, livestock number and type of housing) and the assistance received from the State Agricultural Department (Table 1).

Table 1 Basic information about adopter and non-adopter households

(N= 85)

Variables	Units	Adopters ($N_1 + N_2 = 74$)						Non-adapters		
		Strategy 1			Strategy 2					
		Manipur (n_{m1} = 38)	Sikkim (n_{s1} = 1)	Overall (N_1 = 39)	Manipur (n_{m2} = 14)	Sikkim (n_{s2} = 21)	Overall (N_2 = 35)	Manipur (n_{m3}= 2)	Sikkim (n_{s3} = 9)	Overall (N_3= 11)
Age of the farmer respondent	years	44.08	42.00	44.13	48.71	43.65	45.74	36.00	43.33	42.00
Literacy rate	%	68.42	100.00	69.23	78.57	70.00	73.53	100.00	88.89	90.91
Family size	No.	6.29	8.00	6.33	6.71	5.50	6.00	4.50	6.00	5.73
Primary social category	%									
ST		71.05	100.00	71.79	25.00	25.00	50.00	44.44	44.44	45.45
General		28.95	0.00	28.21	30.00	30.00	23.53	22.22	22.22	27.27
Percentage of *kuccha* house	%	64.10	0.00	64.10	26.47	8.82	35.29	9.09	9.09	18.18
Number of cattle	no.	1.21	3.00	1.26	1.00	1.90	1.55	4.00	2.11	2.45
Land holdings	ha	0.79	0.40	0.78	0.77	1.21	0.90	0.63	0.78	0.75
Irrigated area	ha	0.66	0.00	0.66	0.75	1.01	0.88	0.56	0.50	0.55
Area under rice cultivation	ha	0.78	0.40	0.77	0.77	0.53	0.63	0.63	0.46	0.49
Rice productivity during normal	kg/ha	2278.39	1926.60	2269.37	2547.50	1320.22	1825.57	2621.64	1591.78	1779.03
Rice productivity during stress	kg/ha	1589.73	1111.50	1576.45	2108.63	915.48	1450.32	2000	800.88	920.79
Drop in productivity	%	30.23	42.31	30.53	17.23	30.66	20.56	23.71	49.69	48.24
Labour sharing	%	63.16	0.00	61.54	64.29	23.81	42.86	100.00	33.33	45.45
Support from Agricultural Department	%	2.63	100.00	5.13	7.14	61.90	40.00	0.00	44.44	36.36
Support from KVK	%	26.32	0.00	25.64	57.14	4.76	25.71	0.00	0.00	0.00

Added farm inputs per hectare across the strategies

Adaptation Strategy 1 and Strategy 2 were traditional and autonomous in nature. No new input or technique was introduced, only the amount of inputs already in use was changed.

The additional use of human labour across different activities were relatively higher (5.54 mandays/ha) in case of Strategy 1 in comparison to Strategy 2 during the period of drought (Table 2). The additional mandays were used maximum for weeding, followed by transplanting and application of fertilizers and Plant Protection Chemicals (PPC). With low water availability during drought weed infestation is comparatively high, that increases the competition for space and nutrients between weed and the main crop.

Table 2 Additional input use and productivity across the adaptation strategies

(N= 74)

Sl. No.	Additional inputs/output	Units	Strategy 1 (n_1 = 39)	Strategy 2 (n_2= 35)
A.	Additional input			
1	Human labour	mandays/ha	16.66	11.12
	Weeding		8.35	4.93
	Transplanting		6.23	4.49
	Application of fertilizers and PPC		2.07	1.71
2	Bullock labour	hours/ha	4.50	3.85
3	Fertilizers	kg/ha		
	Urea		97.77	31.17
	DAP		48.81	86.21
4	Insecticides	ml/ha	202.02	324.07
5	Weedicides	g/ha	282.85	427.30
B.	Additional productivity	kg/ha	655.66	529.53

Generally land was ploughed twice in the study area, once during the pre-monsoon period and the final with the onset of monsoon showers. Sufficient soil moisture was required for ease in ploughing but during drought years, the soil becomes hard, thus increasing the requirement of additional human labour. The increase in demand for labour if not met by the supply, the gap in demand and supply raises the wage rate of the available labour. In the hills where farm mechanization is constrained by the different topographical condition of the place, bullock labour is the secondary source of farm power for ploughing. In such a situation, to supplement the requirement of labour, farmers increase the working hours of bullock labour. Additional 4.50 hours and 3.85 hours bullock labour were used by the adopters of Strategy 1 and Strategy 2, respectively in the study area (Table 2).

Urea and Diammonium Phosphate (DAP) were the commonly used fertilizers in the study area. The additional amount of urea used in case of Strategy 1 (97.77 kg/ha) was significantly higher than the Strategy 2 (31.17 kg/ha) whereas, the trend was reverse in case of DAP (48.81 kg/ha and 86.21 kg/ha). The application of insecticides and weedicides were more in case of Strategy 2 (324.07 ml/ha and 427.30 g/ha) than Strategy 1 (202.02 ml/ha and 282.85 g/ha). This may be one of the reasons that the adopters of Strategy 1 used additional human labour (3.42 mandays/ha) for weeding compared to that of the adopters of Strategy 2 (Table 2).

The adopters of Strategy 1 and Strategy 2 harvested an additional 655.66 kg/ha and 529.53 kg/ha of rice, respectively in comparison to the non-adapters.

Additional cost and return across the adaptation strategies

The additional physical inputs used across the adaptation strategies increased the cost of rice cultivation of the adopters in the study area. But the adopters harvested an additional quantity of rice during drought in comparison to the non-adapters which increased the return too. This additional return is the benefit of adaptation to the adopters.

On an average, the cost of rice cultivation increased by `8505.63/ha and `6374.29/ha for Strategy 1 and Strategy 2, respectively during the drought period in comparison to the normal period. The share of additional cost incurred on human labour (35.76%) was the highest to the total additional cost, followed by bullock labour and fertilizers in case of Strategy 1. Whereas, the share of incremental cost of bullock labour was maximum (37.24%) to the total additional cost in case of Strategy 2, followed by human labour and fertilizer. The additional cost incurred in weedicides was comparatively higher than insecticides (Table 3).

The adopters of Strategy 1 received an additional return of `9834.93/ha. Therefore, the adopters derived a net benefit of `1329.30/ha than the non-adapters. The adopters of Strategy 2 fetched an additional return of `7942.96/ha and the net benefit is estimated to be `1568.67/ha.

Hence, adaptation of both the strategies has lead to the positive net change in income of the farmers in the study area, but the change is negligible. This was because of the high cost of adaptation but low incremental returns from differential productivity of rice in case of both the strategies.

Table 3. Result of the partial budget across the adaptation strategies

(`/ha)

	Particulars	Strategy 1 (n_1= 39)	Strategy 2 (n_2= 35)		Particulars	Strategy 1 (n_1= 39)	Strategy 2 (n_2= 35)
A_1)	Increase in costs	8505.63	6374.29	A_2)	Decrease in costs	0.00	0.00
	Human labour	3042.16 (35.76)	1559.87 (24.47)				
	Bullock labour	2800.00 (32.92)	2373.68 (37.24)				
	Fertilizers	2142.23 (25.19)	1636.31 (25.67)				
	Urea	1096.99	343.21				
	DAP	1045.24	1293.10				
	Insecticides	181.82 (2.14)	291.67 (4.58)				
	Weedicides	339.42 (3.99)	512.76 (8.04)				
B_1)	Decrease in returns	0.00	0.00	B_2)	Increase in returns	9834.93	7942.96
C_1)	Total increased costs and reduced returns	8505.63	6374.29	C_2)	Total reduced costs and increased returns	9834.93	7942.96
D)	Net change in income ($C_2 – C_1$)	1329.30	1568.67				

Summary and conclusions

Changing the transplanting time and changing the transplanting as well as harvesting time were the two main adaptation strategies identified in the study area. These strategies were autonomous and traditional in nature and were adopted as a response to change in arrival of rainfall. The decision of the farmers regarding the use of inputs during drought period across the study area was highly skewed. In Sikkim, the farmers did not change the input use structure at all, whereas, 3/4th of the adopters in Manipur have increased the input use. The costs were high for both the adaptation strategies which kept the net benefit of adaptation at very low level to become tangible to the rice growers. To meet the long term sustainability of rice farming in the study area, it is necessary for the rice growers to go beyond the traditional strategies. Hence, it is recommended that planned interventions in terms of construction of water harvesting facilities and farm mechanization, need to be initiated by the State Governments in the study area.

Rice is a water sensitive crop, so water harvesting serve as the supplemental source of water supply during the prolonged dry season in *kharif* season. Pandey and Bhandari (2009) and Rao *et al*. (2016) proposed the use of water harvesting as a mean to reduce the impact of climate change in India. In Himachal Pradesh and South India water harvesting was one of the strategies adopted by the farmers to adapt to the change in climate (Venkateshwarlu *et al*. 2012; Shankar *et al*., 2013). Sahoo and Panda (2016) studied the effect of size of on farm pond (OFP), for supplemental irrigation, on the net profit of the rice farmer in Orissa and found that the net profit of the farmer was maximum (`18648) when the OFP was 6% of the farm area and decreased gradually with the increase in size. Khataniar and Benazir (2013) reported the increase in the productivity of farm crop by 4.75 q/bigha under minor irrigation project in Assam. Mony (1995) has worked out the effect of irrigation on paddy cultivation in Kerala and found that irrigation increases the production of paddy by 18.71 per cent per acre which was 529kg without irrigation to 628kg with irrigation.

Farm mechanization help in effective utilization of farm inputs, reduces the drudgery in farm operations, increases the safety and comfort of the working environment, enhances productivity and production (Verma and Tripathi, 2015). Sarkar *et al.* (2013) reported that farm mechanization increased the production of rice by 4.61 per cent in West Bengal. Researcher like Mehta and Pajnoo (2013) also proposed the need of incentive and policy for the promotion of farm mechanization in hill agriculture in India.

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