Enhancing Agriculture Resilience to Climate Change: Insights from NICRA in Lakhimpur, Assam, India

.Abstract

Aims: This study investigates the adoption of climate-resilient agricultural practices in Lakhimpur, Assam, under the NICRA project. Using a mixed-methods approach involving surveys and interviews, the study identifies key adaptive strategies and their socioeconomic impact. Results highlight increased crop yield and farmer awareness as critical outcomes. These findings underscore the role of sustainable techniques in mitigating climate risks and ensuring agricultural sustainability.

Study design : A multi-stage sampling technique was used to draw samples for the present study. In the first stage, out of nine development blocks of Lakhimpur district, the block where the NICRA project was implemented was selected. In the second stage, all five villages where the NICRA project was implemented in the block were selected purposively. In the third stage, 80 NICRA beneficiary farmers were selected randomly from five villages, which were treated as respondents.

Place and Duration of Study: The present study on NICRA project interventions on climate resilient agriculture was taken up in the Lakhimpur district of Assam. As the project was implemented in the district in 2011, the district was selected for the study. The primary data were collected for the year 2021-22.

Methodology: An attempt had been made in the study to identify the NICRA interventions, economics of selected interventions and constraints faced by the farmers in the study area. Both primary and secondary data were collected to fulfil the stated objectives. A well-structured pre-tested schedule was developed for the collection of primary data as per the objectives Cost concepts were used to estimate the cost of cultivation (cost of production) and derive the various income measures, viz., farm business income, family labour income, net income, and farm investment income. The cost concepts of Commission for Agricultural Cost and Prices (CACP, New Delhi), viz., Cost A1, Cost A2, Cost B1, Cost B2, Cost C1, Cost C2 and Cost C3 were used in the present study. Identifying the constraints that NICRA beneficiary farmers face, closed-ended questions were asked to determine the most significant challenges they were facing, and recommendations for resolving those issues were also sought. The frequency of respondents was then calculated for each constraint. Finally, ranking was done based on finding out both the frequency and the percentage.

Results: The NICRA project includes a "Technology Demonstration" component in which emphasis was given to detecting exact climatic stress and demonstrating site-specific climate resilient solutions in the farmer's field to persuade farmers to adopt locally accessible technology through different interventions. The economics of selected interventions i.e.

change in crop variety (rice) & alternative land use system (mushroom) were analysed. Climate resilient agro interventions by NICRA, like real-time contingency planning, preparedness, Climate Risk Management Committee, Custom Hiring 64 Centre, Village Seed Bank, and alternate land use system were identified to be prevailing in the study area. The costs of production of rice per hectare in marginal farmers were found to be Rs. 27484.90 and for small and medium farmers it was found to be Rs. 30055.43 & Rs. 32096.23 respectively. Cost of cultivation per hectare in medium farmers was found to be maximum. The per hectare cost of cultivation as well as return from the rice cultivation varied directly with farm size. The average yield of rice per hectare was found to be 34.21 quintals. The average gross return was found to be Rs. 44477.42. The average costs of mushroom growers were found to be Rs. 1932.60 and gross return was observed to be Rs. 6152.98. The Gross return over cost was found to be 3.18. The results depicted that constraints confronted by respondent farmers were inversely proportional to the size of the farm holding. The constraint faced by the NICRA beneficiary farmers that ranked at the top was identified to be a poor economic condition of the farmers.

Conclusion: The study revealed the presence of diverse climate-resilient agro-technological interventions introduced by NICRA, such as real-time contingency strategies, preparedness initiatives, Climate Risk Management Committees, Custom Hiring Centres, Village Seed Banks, and innovative alternate land use systems. As land holding size increased, farmers tended to use more machine labour instead of bullock labour. As indicated by the computed gross return over cost ratio of rice, is profitable in the study area. Hence the “change in crop variety” intervention in the study area was found to be economically feasible. It is found that the per hectare cost of cultivation as well as return from the rice cultivation varied directly with farm size. Mushroom cultivation under the intervention of “alternate enterprise selection” was found to be very profitable for the farmers. Spawn cost shares the highest operational cost percentage for mushroom growers. The constraint faced by the NICRA beneficiary farmers that ranked at the top was identified to be the poor economic condition of the farmers.

Keywords: Climate resilient, constraint, intervention, Innovations, production

INTRODUCTION

Climate change is one of the most pressing issues in today's world, which has significantly changed or is still changing the earth's ecosystems. Although the world has always experienced some degree of climate change, in the last 100 years or so, the rate of this variation has multiplied. Recent years have seen a widespread awareness of the relationship between climate and development. Climate change encompasses altered levels of temperature and humidity, variability in the rainfall pattern, fluctuations in weather parameters, rise in ambient CO_2 levels, emission of greenhouse gases, global warming, etc. that results in extreme events and disasters such as cyclones, floods, droughts, salinity, nutrient and heavy metal stress, change in arthropod diversity and the emergence of new invasive pests(Dash *et .* al 2024). Rising climatic variability and climate change are predicted to increase the problems with future food security by putting pressure on agriculture. A region's composition of species is influenced by its climate. Individual crops and organisms need particular ranges of temperature, precipitation, humidity, and sunlight to survive. The rate of increase in temperature has been much higher in recent decades which not only warmed the global atmosphere but also altered the rainfall patterns, hydrological cycle and increased frequency of extreme weather events viz. flooding and drought spells (Izaurralde et al 2003), which can be regarded as a change in the climate. Agriculture is very sensitive to climate change, which is the major source of variability in the production of major crops i.e. rice and wheat in many regions and a dominant source of disturbance to the ecosystem

(Howden et al 2007). Global food production is projected to be directly impacted by climate change. A rise in the average seasonal temperature can shorten the growing season for many crops, lowering their final yield. Warming will have an immediate impact on yields in locations where temperatures are already close to the physiological maximum for crops (IPCC, 2007). Resilience is the capacity of a system and its constituent elements to foresee, absorb, accommodate, or recover from the impacts of a hazardous occurrence quickly and effectively, especially by assuring the maintenance, improvement, or preservation of its fundamental skeletal and functional elements (IPCC, 2012). Since agriculture accounts for 15% of India's GDP, a 4.5–9% decline in production suggests that the cost of climate change might reach up to 1.5% of GDP annually (Venkateswarlu *et al*., 2013). Farmers need to be educated, and convinced about the importance of Climate Resilient Agricultural technologies, in adapting to changing climate and the adverse effects of changing climate(Manjunath *et* al. 2018).

The Indian Council of Agricultural Research (ICAR) started the network project, National Innovations in Climate Resilient Agriculture (NICRA) on 2nd February 2011. Through strategic research and technology demonstration, the initiative aims to increase the resilience of Indian agriculture to climate change and climate vulnerability. The primary goals of NICRA are to increase the adaptability of agriculture, particularly livestock and fisheries, to climatic unpredictability and change through the adoption and development of higher-quality risk management and production technology (Vijayan and Viswanathan, 2018).NICRA advocates for a multi-faceted approach that integrates cutting-edge technologies, policy reforms, community engagement, and sustainable farming practices to bolster the resilience of Assam's agricultural systems. (Sarmah and Gogoi,2024). All the major climate-resilient technologies have a considerable impact on the livelihood of the farmers in flood-affected NICRA-adopted villages.(Mazumdar et al.,2020)

Assam is located in the foothills of the eastern Himalayas and the middle east of the rivers Brahmaputra and Barak. The state encompasses roughly 2.4% of India's total land area. The Brahmaputra basin occupies 5,80,000 square kilometres, 70,634 of which are in Assam. Over the years, Assam as well as Northeast India has seen an increase in temperature and rainy days (Deka et al., 2009). Climate variability and change are significant sources of risk for farmers who rely on crop production (De and Bodosa., 2015)Lakhimpur district of Assam is one of the most flood-prone districts of the state. The intermittent dry spells during the growing season of winter or sali rice, cultivated in NBPZ of Assam located in the foothills of the Eastern Himalayan region, is a major weather risk causing widespread damage to the crop. (Neog et.al 2020). Every year, a vast quantity of agricultural land is brushed away, and crops are submerged as a result of sedimentation and inundation caused by floods and erosion in the district. Crop productivity is being affected by various climatological factors in the district. Sarkar (2014) observed that various technological advancements improved farmers' abilities to adapt utilizing NICRA's capacity-building initiatives and interventions. The present study is undertaken with the objectives of identifying climate-resilient interventions, economic analysis of selected interventions and constraints faced by beneficiary farmers in Lakhimpur district of Assam.

2. MATERIAL AND METHODS

The project was primarily implemented in Lakhimpur district of Assam. 80 farmers from five villages where NICAR project was implemented were selected randomly. A well-structured pre-tested schedule was developed for the collection of primary data as per the objectives.

Analytical tools

Cost concepts

The cost concepts of Commission for Agricultural Cost and Prices (CACP, New Delhi), viz., Cost A1, Cost A2, Cost B1, Cost B2, Cost C1, Cost C2 and Cost C3 were used in the present study and these are derived as follows.

Cost A1: It includes

Wages of Hired Human labour

Wages of bullock labour (both hired and owned) if any Wages of machinery labour

Value of owned and purchased seed

Value of insecticides and pesticides, manure, fertilizer, Herbicides)

Interest on working capital Land revenue and other taxes

Depreciation of farm machinery, implements, farm buildings, irrigation structures, etc (excluding land)

Cost A2 = Cost A1 + Rent paid for leased in land

Cost B1 = Cost A2 + Interest on the fixed capital invested in the business

Cost B2 = Cost B1 + Imputed rental value of owned land

Cost C1 = Cost B1 + Imputed value of family labour

Cost C2 = Cost B2 + Imputed value of family labour

Cost C3 = Cost C2 + 10 per cent of Cost C2 (on account of managerial functions performed by the farmer)

Cost C1 and Cost C2 together called cost of cultivation (Cost C)

Profitability concepts

i. Gross return (GR): It is the total value of the main product and by-product if

any. GI = (Qm × Pm)

Where,

GI = Gross income,

Qm = Quantity of main product, Pm = Price of the main product.

i. Net income: It is the net profit after deduction of all cost items, variable and

fixed gross income

i.e. Net income = Gross income – Total cost (cost C2)

ii. Gross return over cost ratio = Gross Return per hectare/total cost per hectare

Constraint ranking with frequency and percentage

Identifying the constraints that implementing agency and NICRA beneficiary farmers faced, closed-ended questions were asked to determine the most significant challenges they were facing, and recommendations for resolving those issues were also sought. The frequency of respondents was then calculated for each constraint. Finally, ranking was done based on finding out both the frequency and the percentage.

3. RESULTS AND DISCUSSION

Identifications of NICRA interventions in the study area

The NICRA project was initially implemented at Chamua village in the Lakhimpur district, which is situated in the North Bank Plain Zone of Assam. During the study period, various interventions on climate resilient agro technologies implemented by NICRA in the five selected villages of the study area over the years of implementation of the project were identified and are discussed below.

1. Real Time Contingency Planning (RTCP) interventions

Real-time contingency planning (RTCP) is basically being conceptualised and executed at the micro level at the farmer's field. Implementation of the RTCP during the delayed onset of monsoon, seasonal droughts and floods resulted in improved crop performance, increased agricultural production, increased profitability and overall stability in household livelihoods.

Situation I: Delayed onset of monsoon

Change in Crop/Variety: Farmers combined traditional cultivars with new high-yielding rice varieties such as Dishang (short duration), TTB-404 (medium duration), and Ranjit Sub-1, Bahadur Sub1 (long duration with submergence resistant variety) for cultivation in upland, medium land, and low land, respectively. The average cost of cultivation of the implemented varieties combined was assessed and presented in the table below.

Table-1: Cost of cultivation of rice per hectare of different farm sizes

Particulars	Marginal(Rs.)	Small(Rs.)	Medium(Rs.)	Pooled(Rs.)
1. Family labour Cost	10030.30 (36.49)	6303.97 (20.97)	6115.78 (19.05)	7317.07 (24.26)
2. Hired labour Cost	5803.72 (21.12)	11320.12 (37.66)	10492.02 (32.69)	9500.83 (31.50)
Total labour	**15834.01 (57.61)**	**17624.10 (58.64)**	**16607.80 (51.74)**	**16817.90 (55.76)**
3. Bullock labour	1285.06 (4.68)	452.37 (1.51)	379.69 (1.18)	669.91 (2.22)
4. Machine labour	2670.86 (9.72)	2705.30 (9.00)	3848.13 (11.99)	3025.38 (10.03)
5. Seed	2704.52 (9.84)	3160.83 (10.52)	3434.97 (10.70)	3109.26 (10.31)
6. Manures and fertilizer	712.90 (2.59)	1353.16 (4.50)	2110.38 (6.58)	1388.37 (4.60)
7. Plant protection	367.18 (1.34)	438.18 (1.46)	842.99 (2.63)	534.71 (1.77)

8. Interest on working capital	785.82 (2.86)	857.80 (2.85)	907.47 (2.83)	851.52 (2.82)
Total operational cost (A)	**24360.35 (88.63)**	**26591.73 (88.48)**	**28131.42 (87.65)**	**26397.05 (87.52)**
9. Rental value of own land	1318.10 (4.8)	1482.13 (4.93)	1646.12 (5.13)	1710.90 (5.67)
10. Depreciation on fixed capital	1350.00 (4.91)	1500.00 (4.99)	1800.00 (5.61)	1550.00 (5.14)
11. Land revenue	225.00 (0.82)	225.00 (0.75)	225.00 (0.70)	225.00 (0.75)
12. Interest on fixed capital	231.45 (0.84)	256.57 (0.85)	293.69 (0.92)	278.87 (0.92)
Total fixed cost (B)	**3124.55 (11.37)**	**3463.70 (11.52)**	**3964.81 (12.35)**	**3764.77 (12.48)**
Total cost (A+B)	**27484.90**	**30055.43**	**32096.23**	**30161.83**

The total cost of cultivation per hectare was observed to be highest for medium farm size, followed by small and marginal farm size. The total cost of cultivation for medium farm size was Rs.3964.81, while it was Rs3463.81 for a small farm size and Rs.3124.55 for a marginal farm size. In a study by Sultana *et al.(2020)* it was found that NICRA Project interventions could exert a positive impact on the crop productivity of the participant farmers.

Table 2 : Cost of cultivation on farm management (CACP) cost concept basis

Particulars	Size-group (Rs./hectare)			
	marginal	Small	Medium	pooled
Cost A1	15905.05	22012.75	24040.64	20854.98
Cost A2	15905.05	22012.75	24040.64	20854.98
Cost B1	16136.50	22269.32	24334.33	21133.86
Cost B2	17454.60	23751.45	25980.45	22844.76
Cost C1	26166.80	28573.30	30450.11	28450.93
Cost C2	27484.90	30055.43	32096.23	30161.83
Cost C3	30233.39	33060.97	35305.85	33178.01

Table 3 : Average yield, returns and gross return over cost ratio of sample farms

Particulars	Size- group			
	Marginal	Small	Medium	Pooled
Yield (q/ha)	30.40	34.20	37.99	34.21
Gross return (Rs/ha)	39543.83	44464.07	49392.20	44477.42
Net return (Rs/ha)	12058.93	14408.65	17295.98	14315.60
Total cost (Rs/ha)	27484.90	30055.43	32096.23	30161.83
Gross return over cost ratio	1.44	1.48	1.54	1.47

The sample average gross return over cost ratio was found to be 1:1.47, which was highest in medium farm size (1:1.54) followed by small (1:1.48) and marginal farm size(1:1.44). This implies that the farmers coping with climate change through a change of verities were still able to generate a surplus income for their sustainability. Dutta *et*. al. (2023) in their study regarding assessing the effectiveness of climate-resilient rice varieties in Assam also found a B : C ratio of 1.34 in the case of small holdings.

Situation II: Early season drought

Supplemental irrigation from harvested rainwater

Early season drought was observed in medium and long duration Sali paddy during the tillering stage for 10 days in 2021. However, crops got 48.4 mm total rainfall in two days and were unaffected. Similarly, in the rabi crop, a 27-day dry spell was recorded in potato and toria during the active vegetative stage under upland and medium land conditions.

Situation III: Mid-season drought

Supplemental irrigation from harvested rainwater

Farmers were recommended to irrigate one additional life-saving irrigation of (5 cm) depth from the farm pond using a water raising pump.

Situation-IV: Terminal drought

i) Supplemental irrigation and land situation specific rice cultivation

The village experienced 27 days of long dry spells during the milky stage of long duration Sali rice. Supplemental irrigation was provided for this situation. However, no terminal dry spell was reported in Rabi crops, therefore crop development and establishment was unaffected.

2.Preparedness Interventions

1) **Rain water management**

a) In-situ rainwater management

b) Rainwater management is an essential technique for drought management. Farmers in NICRA village produced turmeric, ginger, and other rainfed crops by mulching with locally accessible organic materials such as rice husk, rice straw, toria stover, water hyacinth, rice stubble and so on for in situ moisture conservation. Mulching conserved moisture, decreased weed growth, and provided manure to crops as they decomposed. Mulching was completed in the months of April and May, prior to crop emergence.

c) Ex-situ rainwater management

During dry spells, notably during the rabi season, farmers used water from farm ponds. During the summer and monsoon seasons, these ponds were used to collect rainwater. In the case of a delayed onset of monsoon, water harvested from farm ponds was efficiently used for raising nursery beds of rice and supplemental irrigation in rabi crops during dry seasons.

3. Cropping systems: Double/relay cropping systems Before the implementation of the NICRA project, the farmers of the NICRA village practised monocropping of Sali (winter) rice. Farmers are constantly encouraged to grow one or more crops, either before or after the sowing of Sali rice by NICRA.

4. Village Climate Risk Management Committee (VCRMC): The Village Climate Resilient Management Committee (VCRMC) is responsible for community procurement, project monitoring, coordination and anchoring climate actions at the community level. The Village Climate Risk Management Committee, Chamua, was formed by the guidelines and is headed by the Committee's President. The VCRMC was founded to manage the various activities of the NICRA project. The committee is assisting in the identification of interventions to be implemented in the villages. This VCRMC promotes the adoption of climate-resilient technologies in the NICRA-adopted village and surrounding villages.

5. Custom hiring centre: CHCs are basically a unit comprising a set of farm machinery, implements and equipment meant for custom hiring by farmers. The custom hiring centre of NICRA village Chamua is run by the "Custom Hiring Centre Management Committee (CHCMC)" which was formed with 11 members including one president and one secretary. The rate of hiring of the implements was fixed and revised from time to time by the committee. Farmers of adopted villages can hire the CHC implements for their use in different agricultural activities.

6. Village seed bank: NICRA farmers were encouraged to produce various seeds of high-yielding varieties and seeds are kept with the farmers which helps the farmers to tackle the adverse situations arising due to the occurrence of extreme weather events. The establishment of a village seed bank helps the small and marginal farmers of the village self-reliant on seed, which is one of the most important inputs in agriculture.

7. Alternate land use system: Alternate land use systems in connection with crops, livestock, or other agricultural production factors have considerable potential for contributing to sustainable land-use systems capable of overcoming land degradation and the imminent "food crisis". It also allows for more diverse production and consequently greater food diversity. Few of the alternate land use systems were identified in the study area.

(a) **Mushroom cultivation:** During 2021-22, many farmers cultivated mushroom as an alternative source of income as well as nutritional security to the farm family. Most of the mushroom growers of the study area were found to be small growers. Mushroom cultivation found to be very profitable for the farmers.

Table 4 : Average cost of cultivation and returns of mushroom

	Total number of mushroom growers	30
	Average mushroom bags per farm(No)	31.93
	Particulars	**Average Price(Rs.)**
Sl no	Total spawn cost	766.40
1	Hay cost	375.20
2	Chemical cost	174.42
3	Rack /Rope cost	266.76
4	Miscellaneous cost	349.83
	Total Cost	**1932.60**

Average yield per bag(kg)	0.92
Average yield per farm(kg)	29.93
Total cost(Rs)	1932.6
Gross return(Rs)	6152.98
Net return(Rs)	4220.38
Gross return over cost ratio	**3.18**

Mushroom cultivation proved to be a beneficial alternative for the farmers in case of alternative enterprise selection in the study area. From Table 4, it was observed that spawn cost was the highest (Rs.766.40) among all inputs of cultivation. It was observed that the average yield per bag was found to be 0.92kg. The average yield of mushrooms per farm was 29.93kg. It was also identified from the table that the average gross return was Rs.6152.98 among the mushroom growers. The average price per kg of fresh mushroom were found to be Rs.207.00.The net return was Rs.4220.38. For per rupee investment, a generous 3.18 rupees gross return was found in the study.

(b) Low-cost poly house: Low-cost poly house is one of the important interventions under alternate use of land in the study area. During the study, it was observed that 7 farmers of the adopted village use low-cost polyhouses for the cultivation of high-value seasonal vegetables and raising vegetable seedlings in advance of rabi season.

(c) Constraints perceived by NICRA beneficiary farmers

1. From table 5, It was observed that highest incidence of constraints was faced by marginal farm size (68.45 per cent) , for small farm size the percentage was 65.52 percent ,and lowest was confronted by medium farm size (56.94 per cent).For

pooled, the average percentage of constraint was 66.09 percent. The results depicted that constraints confronted by respondent farmers were inversely proportional to the size of the farm holding. The constraint faced by the NICRA beneficiary famers that ranked the top was identified to be poor economic condition of the farmers.

Table-5 : Constraints perceived by NICRA beneficiary farmers

Sl No	Constraints/Size Groups	Marginal (n=42)		Small(n=29)		Medium(n=9)		Pooled(N=80)		Rank
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	
1	Poor Economic condition of farmers	37	88.10	23	79.31	6	66.67	66	82.5	
2	Lack of assured market	34	80.95	24	82.76	7	77.78	65	81.25	
3	Higher percentage of small land holding of farmers	32	76.19	20	68.97	6	66.67	58	72.5	
4	Non use of recommended dose of inputs	34	80.95	15	51.72	4	44.44	53	66.25	
5	Post harvest storage problem	26	61.90	20	68.97	5	55.56	51	63.75	
6	High incidence of pest and disease	27	64.29	14	48.28	6	66.67	47	58.75	
7	Low access to agricultural credit	21	50.00	23	79.31	2	22.22	46	57.5	
8	Shortage of labour	19	45.24	13	44.83	5	55.56	37	46.25	
Average		68.45		65.52		56.94		66.09		

CONCLUSION

Climate change and variability pose a significant threat to agricultural production & rural livelihoods. Climate change may have an impact on agriculture in several different ways, including crop quantity and quality in terms of productivity, growth rates, photosynthesis, and so on. Climate change is anticipated to have a direct impact on the global food supply. An increase in the mean seasonal temperature can shorten the growing season of many crops hence reducing yield. (Mahato A.,2014).

Climate resilient agro-technology intervention by NICRA, like real-time contingency planning, preparedness, Climate Risk Management Committee, Custom Hiring Centre, Village Seed Bank, and alternate land use system were identified to be prevailing in the study area. As indicated by the computed gross return over cost ratio of rice, is profitable in the study area. Hence the “change in crop variety” intervention in the study area was found to be economically feasible. It is found that the per hectare cost of cultivation as well as return from the rice cultivation varied directly with farm size. As land holding size increased, farmers tended to use more machine labour instead of bullock labour. All the respondent mushroom growers in the study area were found to be small-scale growers. Mushroom cultivation under the intervention of “alternate enterprise selection” was found to be very profitable for the farmers. As Assam falls under a very vulnerable category for climate change (Report, DST, Govt. of India, 2020), it is an utmost need of the hour to implement projects like NICRA on a large scale in the state to make the farmers capable of coping up with the changing climate with proper interventions for sustainability.

Declaration

We, Mriganka Barman and Amvrin Baruah hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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