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IMPACT OF CLIMATE RESILIENT TECHNOLOGIES IN CLIMATICALLY VULNERABLE VILLAGES ACROSS INDIA

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ABSTRACT

The National Initiative on Climate Resilient Agriculture (NICRA) is implemented as a network project of the Indian Council of Agricultural Research (ICAR) and was launched in February 2011 in 121 vulnerable districts across India. Project aims to enhance resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstrations in four modules. Present study was conducted in 121 NICRA villages across in India during 2021 based on 11 type of vulnerabilities to assess impact of climate resilient technologies across four modules and comparison of before and after situation was made at village level. Among the technologies demonstrated in the NICRA villages, Natural Resource Management (Ex situ and In-situ), crop production and livestock interventions were compared. Various analyses demonstrated that significant difference between before and after NICRA project on number of Water harvesting structures, Farm ponds, check dams, percolation tanks, area under drip irrigation, area under BBF (ha), area under Mulching (ha), area under horticulture (ha), area under double cropping in the village (ha), total Fodder area (ha) in the village, quantum of green fodder produced in the village, average Quantity of silage prepared per farmer, crop residue availability in the village and number of milch (milking) animals in the village was studied. Before and after comparison of NICRA group to isolate the project impact also testified significant improvement on a set of indicators like number of Bore and open wells, area under drip irrigation, area under BBF, area brought under irrigation (during kharif and Rabi), crop yield. This study provides a springboard for the policy makers and civil societies to stretch out the activities for wide adaptation.

Keywords: *climate resilient technologies, NICRA, Adoption, Village level data.*

INTRODUCTION

The research focuses on the impacts of climate change and variability on Indian agriculture, particularly the vulnerabilities stemming from unpredictable monsoons, rising temperatures, and extreme weather events like droughts, floods, and heatwaves. Given that two-thirds of India's farmland is rain-fed, the adverse effects of climate variability are compounded, leading to significant economic losses and challenges to livelihoods. (Source: IPCC (2021). *Climate Change 2021: The Physical Science Basis. Sixth Assessment Report (AR6)*. https://www.ipcc.ch/report/ar6/wg1/).

National Initiative on Climate Resilient Agriculture (NICRA) is a pilot project launched by the Indian Council of Agricultural Research (ICAR) in 2010-11. This initiative aims to develop agricultural strategies that address the challenges posed by climate variability, especially in dryland and other vulnerable regions (Singh et al., 2021; Vinaya and Tapan 2023; Vinaya and Shivamurthy 2021). The NICRA project was initially implemented in 121 vulnerable districts across India, with Krishi Vigyan Kendras (KVKs) playing a key role in the project's execution in various agro-climatic zones.

The NICRA project focuses on enhancing the resilience of Indian agriculture through adaptive strategies like drought-resistant crops, efficient water management, and sustainable practices. It also addresses emerging pests, such as the Fall Armyworm, exacerbated by climate change (Jasna et al., 2014). The research aims to evaluate the effectiveness of these strategies in mitigating climate change impacts on vulnerable farming communities. By reducing vulnerability and promoting sustainable practices, the project seeks to improve productivity, ensure food security, and support rural livelihoods. The present study aims to quantify the impact of climate resilient technologies demonstrated through NICRA at village level in terms of chosen to set of parameters. The study ultimately provides critical insights for developing adaptive strategies and informing climate-resilient agricultural policies in India.

OBJECTIVE

Assessing the impact of climate resilient technologies demonstrated under four modules at village level as a comparison of before and after situation of the project.

METHODOLOGY

This study was conducted in 121 NICRA villages across in India during 2021 based on 11 types of vulnerabilities to climate change as determined by National Innovations on Climate Resilient Agriculture (NICRA) project of Indian Council of Agriculture Research (ICAR), Government of India. Before and after comparison was used to outline the impact of the climate resilient practices upon the NICRA beneficiaries. The data collection was done on the interventions already implemented by 121 KVKs, under the technology demonstration component of NICRA. Impact can be operationalized as changes that have occurred in socio-economic aspect of the society due to climate resilient technologies. Impact was quantified in terms of several variables and then the values between NICRA and non-NICRA farmers were compared and tested with suitable test statistics. The obtained data were quantitative in nature, hence it was tested with t-statistic to find the significance of differences.

Table 1: Zone-wise distribution of KVKs involved in technology demonstrations under NICRA

Zone	ATARI	States and the KVKs involved	No. KVKs involved
I	**Ludhiana**	Jammu & Kashmir (3), Himachal Pradesh (4), Punjab (4) and Uttarakhand (2)	13
II	**Jodhpur**	Haryana (2) and Rajasthan (5)	7
III	**Kanpur**	Uttar Pradesh (13)	13
IV	**Patna**	Bihar (7) and Jharkhand (6)	13
V	**Kolkata**	West Bengal (3), Odisha (5) and UT of Andaman & Nicobar Islands (1)	8 + 1
VI	**Guwahati**	Assam (5), Arunachal Pradesh (3) and Sikkim (1)	9
VII	**Barapani**	Tripura (2), Manipur (3), Meghalaya (3), Mizoram (2) and Nagaland (4)	14
VIII	**Pune**	Maharashtra (8) and Gujarat (5)	13
IX	**Jabalpur**	Madhya Pradesh (9) and Chattisgarh (3)	12
X	**Hyderabad**	Andhra Pradesh (5), Telangana (2) and Tamilnadu (4)	11
XI	**Bengaluru**	Karnataka (6) and Kerala (1)	7
	Total	28 states + 1 UT	121

RESULTS AND DISCUSSION

Impact of NRM interventions (Ex situ) at village level before and after NICRA project

Analysis of the data on number of water harvesting structures, farm ponds, check dams, percolation tanks, bore wells and open wells before and after the NICRA project had shown that after NICRA project was started, the quantity / Nos of water harvesting structures, farm ponds, check dams, percolation tanks, bore wells and open wells was higher than that of before the NICRA project, The difference was tested using t-test to know the statistical significance (Table 2). The average of water harvesting structure, farm ponds, check dams, percolation tanks, bore wells and open wells were 7,5,8,5,90,88 against 4, 2,4,3,55,63 respectively before NICRA in the village and the difference was statically significant at less than one percent of level of significance. The difference may be a result of a positive response of farmers to NICRA interventions. Similarly, before the NICRA project, flood water receded in the village within 22 days after the duration was reduced to 19 days in the project area. The water harvesting structures constructed under the project provided benefits to neighbors and downstream water users by mitigating flooding, enhancing biodiversity, and reducing sedimentation of waterways (Harikrishna and Naberia, 2021). Rainwater harvesting is considered as the single most important means to enhance agricultural productivity and offers a source of domestic water supply in drought prone areas (Getaneh and Tsigae, 2013). Rainwater harvesting makes possible cultivation of crops twice or more a year, as well as the possibility for supplemental irrigation when rain stops early (Yosef and Asmamaw,2015). Retained moisture content in soil from monsoon rains with the help of water harvesting and storage structures increased the ground water level, hence the capacity for irrigation during kharif season, rabi and summer. After the NICRA project, farmers owned more irrigation facilities than before the NICRA project implementation. Blanco and Lal (2008) identified benefits of soil and water conservation structures. For the farmer, these structures can provide benefits by reducing water erosion, improving water quality, and promoting the formation of natural terraces over time, all of which would lead to higher and less variable yields.

The table showed the data obtained on land area irrigated in various season, before and after the project implementation. A significant increase in area under irrigation in both Kharif and Rabi was observed. It was tested using paired t test. The increase was found to be significant at less than one percent level of significance. While irrigated area was increased by 110 % during Kharif and 56 % during Rabi due to more construction of water harvesting structures after the NICRA project (Prasad et al. 2014).

Similarly, table.2 also reflected number of farmers having access to water and average depth of ground water (meters) during rainy season before and after the NICRA project. The average of farmers having access to water and average depth of ground water (meters) was 195, and 24.8 against 83, and 28.24 respectively before the NICRA project in the village (Mills et al., 2017)

Table 2: Impact of NRM interventions (*Ex situ*) at village level before and after of NICRA project

Impact indicator	Situation	Mean	SD	SEM	t value
Number of Water harvesting structures	Before NICRA	4	8.84	1.42	3.203*
	After NICRA	7	11.04	1.77	
Number of Farm ponds	Before NICRA	2	4.87	0.74	4.286*
	After NICRA	5	6.19	0.94	
Number of Check dams	Before NICRA	4	4.46	0.81	3.522*
	After NICRA	8	8.35	1.52	
Number of Percolation tanks	Before NICRA	3	2.88	0.83	1.214
	After NICRA	5	7.85	2.27	
Number of Bore Wells	Before NICRA	55	110.84	15.08	6.419*
	After NICRA	90	171.79	23.38	
Number of Open wells	Before NICRA	63	132.36	18.18	3.170*
	After NICRA	88	159.48	21.91	
Flood water receded in the village(days)	Before NICRA	22	36.54	7.31	-0.374
	After NICRA	19	29.37	5.87	
Number of farmers having access to water	Before NICRA	83	110.67	14.79	4.870*
	After NICRA	195	228.93	30.59	
Area brought under irrigation (during kharif) (ha)	Before NICRA	79.71	123.29	19.26	3.556*
	After NICRA	168.04	209.34	32.69	
Area brought under irrigation (ha) (rabi)	Before NICRA	110.17	213.02	24.12	5.819*
	After NICRA	172.45	260.93	29.54	
Average depth of ground water (meters) during rainy season	Before NICRA	28.24	33.81	3.96	-3.179*
	After NICRA	24.8	29.46	3.45	

Impact of NRM interventions (Ex situ) at village level before and after of NICRA project

The impact of NRM interventions under Ex situ moisture conservation such as area under drip irrigation, area under Broad Bed Furrow (BBF), area under ridge and furrow irrigation and area under mulching is presented in Table 3. From the obtained data, it was clear that the average area under drip irrigation, area under BBF, area under ridge and furrow and area under mulching was higher after the implementation of the project. The average area under drip irrigation, BBF, ridge and furrow and mulching was 72.98, 61.68, 50.52 and 29.48 ha which was way higher than before the project implementation of the village (25.41, 0.8, 8.32 and 2.31 ha) respectively . The difference was statistically significant at less than five percent level of significance which was tested by using the paired t-test. The differences were found to be significant in all the cases. The yield and quality of horticulture crops improved and also the weed problem was minimized by adoption of drip irrigation (Tajpara et al., 2018).

Table 3: Impact of NRM interventions (In situ) at village level before and after of NICRA project

Impact indicator		Mean	SD	SEM	t value
Area under drip irrigation (ha)	Before NICRA	25.41	42.64	9.78	2.812*
	After NICRA	72.98	103.72	23.8	
Area under BBF (ha)	Before NICRA	0.8	3.1	0.78	2.539**
	After NICRA	61.68	95.95	23.99	
Area under Ridge and Furrow (ha)	Before NICRA	8.32	23.5	4.52	3.195*
	After NICRA	50.52	81.39	15.66	
Area under Mulching (ha)	Before NICRA	2.31	7.64	1.04	2.887*
	After NICRA	29.48	75.13	10.22	

Impact of crop production technologies at village level before and after NICRA Project

Information on the impact of crop production technologies before and after the NICRA project interventions is presented in Table 4. Paired t-test was used to compare the data so as to get information on impact of crop production technologies over the years. The difference was statistically significant at less than 5 % level of significance. The productivity of the crop in the village was increased by 193 % compared to before the NICRA project implementation and number of farmers using improved varieties was increased by 433 % after the project implementation and this difference data was statistically significant at less than 1 % level of significance. Area under horticulture crops was increased by 117 % and area under double cropping in village was decreased by 97 percent as an outcome of implementation of NICRA project in adopted villages.

Table 4: Impact of crop production technologies at village level before and after NICRA project

Impact indicator		Mean	SD	SEM	t value
Quantity of seed of improved crop varieties produced in the village (q)	After NICRA	430.13	784.91	175.51	2.167**
	Before NICRA	146.62	278.58	62.29	
Number of farmers using improved varieties	After NICRA	208	222.11	28.68	6.400*
	Before NICRA	39	41.17	5.31	
Area under horticulture (ha)	After NICRA	57.76	100.73	11.63	5.237*
	Before NICRA	26.5	54.66	6.31	
Area under double cropping in the village (ha)	After NICRA	169.68	208.07	27.32	5.185*
	Before NICRA	85.99	149.34	19.61	

Impact of livestock interventions at village level before and after of NICRA project

Table 5 unveils the impact of different livestock interventions before and after the project implementation. The livestock interventions impacted parameters such as number of farmers cultivating fodder in the village, total fodder area in the village, quantum of green fodder produced in the village, average fodder yield of a farmer in village, number of farmers making silage in the village, average quantity of silage prepared per farmer, green fodder availability during summer in the village, crop residue availability in the village and number of milch (milking).The difference was statistically significant at less than five per cent level of significance when tested using paired t-test. It can thus be concluded that farmers showing more interest towards livestock interventions can minimize the risk of crop failure by having livestock interventions (Tajpara et al. 2020, Bhabhor et al., 2024, Fazely et al., 2024, Thakor & Joshi 2024, Ghasura et al., 2024).

Table 5: Impact of livestock interventions at village level before and after of NICRA project

Impact indicator		Mean	SD	SEM	t value
No. of farmers cultivating fodder in the village	Before NICRA	80	206.79	25.85	4.928*
	After NICRA	145	280.73	35.09	
Total Fodder area (ha) in the village	Before NICRA	30.26	116.94	14.39	3.434*
	After NICRA	54.08	166.86	20.54	
Quantum of green fodder produced in the village (tons)	Before NICRA	714.77	2265.09	290.02	2.733*
	After NICRA	1231.67	3640.69	466.14	
Average fodder yield (t/ha) of a farmer in village	Before NICRA	80.67	232.62	29.31	3.304*
	After NICRA	89.74	242.77	30.59	
No. of farmers making silage in the village	Before NICRA	28	108.44	13.56	3.247*
	After NICRA	78	204.4	25.55	
Average Quantity (t) of silage prepared per farmer	Before NICRA	0.03	0.13	0.02	3.519*
	After NICRA	10.64	16.77	3.01	
Green fodder availability during summer (t) in the village	Before NICRA	305.72	1306.41	171.54	3.314*
	After NICRA	485.14	1484.73	194.96	
Crop residue availability (t) in the village	Before NICRA	289.4	1108.21	138.53	2.386**
	After NICRA	663.67	2109.49	263.69	
Number of milch (milking) animals in the village	Before NICRA	231	348.7	45.02	5.052*
	After NICRA	387	467.48	60.35	

***Significant at $P < 0.01$ and **Significant at $P < 0.05$**

CONCLUSION

Climate resilient technologies are promising tool to guard a farming system from climate variations. Impact study of these technologies is a prerequisite for guiding the adaptive research for better customization, for upscaling, and out scaling them. The study focused on impacts of climate resilient technology due to increased adoption. This finding was reinforced by significant increase in water harvesting structures, which benefited the farmers by reducing water erosion, improving water quality, and promoting the formation of natural terraces over time, all of which led to higher and less variable yields. The yield and quality of horticulture crops improved and also the weed problem was minimized by adoption of drip irrigation. There was a significance difference between Natural Resource Management, Crop production and livestock interventions. NICRA farmers were more engaged in farming and were trying to increase their area under cultivation, which has been reflected in their higher land holding size, either owned or leased in. NICRA beneficiary farmers adopted improved varieties tolerant to drought, whereas non-NICRA farmers were still cultivating conventional varieties. High cropping intensity followed by the NICRA beneficiary farmers was one of the positive impacts of climate resilient technologies in the adopted villages. Since water harvesting and efficient use of stored water is one of the key elements of climate smart agriculture, the results of the study highlights the importance of government support to Ex-Situ and In-situ moisture conservation measures in all the vulnerable areas. Seed of abiotic stress tolerant varieties that can insure against climatic variability should be made readily available to farmers in climatically stressed areas through the introduction of these varieties in the seed chain. Climate smart livestock interventions also need to be promoted as they ensure year round income to the farmers even in the years when there is reduction in productivity of crops due to weather vagaries.

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CONFLICT OF INTEREST

All authors declare that they have no conflict of interest.

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