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Impact of climate resilient technologies in rainfed agro-ecosystem

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ABSTRACT

Climate change has been given the dubious moniker for asymmetrical development of Indian economy in general and agriculture sector in particular. Climate resilient technologies are promising tool to guard a farming system from climatic variations. National Initiative on Climate Resilient Agriculture (NICRA) has demonstrated, and promoted application of climate resilient technologies in most vulnerable 100 districts. This study has been conducted to recognize the technological and socio-economic impact of these technologies upon the society. To enable impact assessment the study employed with –without and before-after comparison, of samples of two NICRA and two non-NICRA villages constituting 120 respondents. Among the technologies demonstrated in the NICRA villages, improved soil and land management practices, water management practices, crop production interventions and cropping system interventions were compared. Various analyses demonstrated that significant difference between NICRA and non-NICRA, farmers on cropping intensity, crop diversification, average irrigated land area and irrigation frequency, employment generation, land area (leased in) and annual savings, with a favorable tilt towards NICRA group. Before-after comparison of NICRA group, to isolate the project impact also testified significant improvement on a set of indicators like average irrigated land area and irrigation frequency, employment generation, land area (leased in), savings, crop yield and expenditure pattern. The study thus provides a springboard for the policy makers and civil societies to stretch out the activities for wide adaptation.

Key words: Climate resilient technologies, Impact assessment, NICRA, Socioeconomic impact, Technological impact

As a response to these challenges, both farmers as well as research community were developed an extensive range of agricultural practices which insofar could augment farming systems' resiliency to climate change (Wezel *et al.* 2014). Mitigation and adaptation are the prominent strategies to respond climatic aberration. Hulme (2002) defined mitigation as actions taken to prevent, reduce or slow climate change, through slowing or stopping the build-up of greenhouse gases in the atmosphere. Adaptation can be defined as, "adjustments in ecological, social or economic systems in response to actual or expected stimuli and their effects or impacts. This term refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change (IPCC 2001). Among the duo, mitigation attempts to cease climate change by reducing the greenhouse gases emissions and by improving sink opportunities, adaptation seeks to abstain the adverse impacts through a wide-range of system-specific actions (Fussel and Klein 2002). Verchot *et al.* (2007) revealed that planting trees and bushes increases carbon sequestered both above and below ground, thereby contributing to GHG mitigation. A superior solution can be sought with the right mix of farm enterprises, diversification in terms of crops and cultivars, livelihood options and, appropriate policy interventions. Scientifically backed solutions have the ability to respond positively towards any change and it can assume higher sustainability and adaptation thus make the system resilient. Resilience is defined as the propensity of a system to retain its organizational structure and productivity following a perturbation (Holling 1973.) The intrinsic capacity of the improved technologies and methodologies always offered them a good say in climate adaptation strategies and resilience building process. Adaptation strives for well managed natural resources, enhanced food security, social and human capital development and strengthened institutional systems (Adger *et al.* 2003). This idea ignited ICAR – to initiate NICRA, to focus on process of developing contingency plans for all the rural districts of the country and it has been implemented at 100 districts of the country

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in collaboration with ICAR research institutes, SAUs and KVKs. The technology demonstration component of NICRA deals with demonstrating proven technologies for adaptation of crop and livestock production systems to climate variability. Since its inception NICRA has introduced, demonstrated and supported adoption of an extensive range of technologies and improved practices to mitigate and adapt climate change aggravated farming business. Evaluation is an inevitable component for any programme, which would help the policy makers, administers, project staff, sponsors and the beneficiaries to dig into details of the programme consequences and thereby devising appropriate strategies for upscaling, continuing or terminating a programme. Hence this study was undertaken to meet the purpose of evaluation as a means to establish the success and failure of NICRA interventions in farmers' field. The impact study was extended to different spheres of project interventions including technological impacts and socio-economic impacts, which generated quantitative data sets.

MATERIALS AND METHODS

To delineate the impact of plethora of interventions made by NICRA in four selected villages, ex-post-facto research design with treatment and control group was used. The treatment group is the one belonging to NICRA demonstration village and control group was selected from a village, not benefitted from NICRA interventions. Both before-after as well as with-without research designs were employed for comparative impact assessment of climate resilient technologies. Before-after comparison was made possible with the help of baseline data and recall memory of respondents. The study was conducted in Karnataka and Jharkhand states. The research locales were selected purposively, as the project has been implemented in these districts since its inception. Tumkur district of Karnataka and Gumla district of Jharkhand represent rainfed agro ecosystem and are mostly affected by drought and poor soil health. The study locales were vulnerable to climatic variability. The details of locale are given in Table 1. The non-NICRA villages were selected by stratified random sampling technique. The details of *kharif* and *rabi* area and crops grown in the districts are given in Table 2.

From each district, 40 beneficiary farmers were selected from NICRA village and 20 non-beneficiary farmers were selected from non-NICRA village through multistage random sampling (Table 3).

Data was collected from the respondents using personal interview method with the help of structured interview schedule designed for this purpose. Concurrently, secondary sources like NICRA annual reports, KVK data were used to supplement, and to pay triangulation and crosschecking

Table 1 Locales of the study

District	NICRA village	Non-NICRA village
Tumkur	D. Nagenhalli	Chigaranahalli
Gumla	Gunia	Arangi

Table 2 Area and crops grown

Particulars	Tumkur	Gumla
Cultivable area	615074 ha	192571 ha
Kharif area	5.00 lakh ha	1.02 lakh ha
Rabi area	0.15 lakh ha	0.06 lakh ha
Crops grown	Ragi, groundnut, paddy, maize and Red gram	Paddy, ragi, maize, Wheat, Black gram, Ground nut, Niger

Source: http://www.tumkurzillapanchayat.gov.in/agriculture.html, http://agricoop.nic.in/

Table 3 Sample size of the study

	Respondents	Sample size
Farmers	D. Nagenhalli	40
	Gunia	40
	Chigaranahalli	20
	Arangi	20
Total		120

of primary data. Data was collected from the respondents using personal interview method with the help of structured interview schedule designed for this purpose. The obtained data were of quantitative in nature, hence it was tested with t-statistic to obtain the significance of differences using SPSS version 16. The data collection was done on the interventions already implemented by the two KVKs, under the technology demonstration component of NICRA. The details of the interventions are given below in Table 4.

Impact can be operationalized as changes that have occurred in socio-economic aspect of the society due to climate resilient technologies**.** Impact was studied using several variables with the following methodologies 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

Irrigation potential: It was obtained by subtracting frequency of irrigations per season given to crops before project intervention from frequency of irrigations per season at present. Change in area under irrigation can also be used.

Crop diversification index: It is defined as a cropping system where the contribution of farm enterprise (crops) to total productivity or profitability is <50 per cent. The diversification is estimated by Diversity Index (DI). It is a measure of the multiplicity of crops or farm products which are planted and harvested in single year. It is computed as reciprocal of sum of squares of share of gross revenue received from each individual farm enterprise in a single year.

$$DI = \frac{1}{\sum_{i=1}^{n} (Yi / \sum_{i-1}^{n} Yi)^2}$$

DI= Diversity Index, n= No. of enterprises, Yi= Gross revenue of i^{th} enterprise.

Table 4 Climate resilient interventions and their contributions to agriculture

Interventions	Contribution to agriculture development	
Soil management	Crop mulching and stubble mulching	• Protects the soil against run-off and erosion (Freebairn and Boughton 1985) • Reduces temperature extremes (Radford *et al* 1995 and Shinners *et al*,1994) • Weakens direct evaporation (Liu *et al* 2000, and Steiner *et al*. 1989).
	Dolomite application	• Dolomite is one of the commercial limes and could increase pH level of soils and reduces the toxic effect of Al, Fe and Mn, and increases the availability of P, Mo, Ca, and Mg (Bodruzzaman 2010; FRG 2012)
	Zero tillage	• Allows to sow wheat sooner • after rice harvest, so the crop heads and fills the grain before the onset of pre-monsoon • hot weather. • Continuous adoption of zero-tillage has reduced the infestation of *Phalaris minor* in wheat to a large extent, and has helped the farmers to overcome • the problem of isoproturon resistance in Haryana. This reduces the herbicide load and cuts down on emissions (Pathak *et al*, 2012)
	Land levelling	• Improves irrigation efficiency by control of water distribution with negligible losses (Pathak *et al*, 2012)
	Trench cum bunding	• Traps the top fertile soil in trenches, allowing safe disposal of excess rainwater and to conserve precious soil moisture. • The soil trapped due to trench cum bunding was in the range of 11.5-21.2 m^3/acre in Umrani village. The farmers could save the valuable top soil being eroded from their fields with the treatment of trench cum bunding (Prasad *et al*, 2014)
	Contour bunding	• Improves the management of land and water resources (Zemadim *et al*, 2014)
	Deep ploughing	• Deep ripping and controlled traffic led to a significant increase in rooting depth, rooting density in the subsoil, water use efficiency and a yield increase of 30% for maize and 19% for wheat.(Bennie and Botha 1986)
	Ploughing across the slope	• Preserves the soil and prevents erosion, contour ploughing helps cut down fertilizer loss, as well as increasing crop yields by up to 50 percent. (http://www.nicra-icar.in/)
	Live bunds	• The live barrier may benefit from the additional soil moisture, detain runoff and accumulate soil which has been eroded from upslope (http://www.fao.org/)
	Soil health card	• Interpretations and fertility recommendations based on soil analyses and the information obtained with soil samples on cropping systems, tillage practices, soil types, manure use, and other parameters have contributed to the increased efficiency of agricultural production(Sims *et al*,1998)
	Compost production units	• Compost amendment of soils degraded by urban development is seen as a way to improve soil and landscape quality, reduce runoff, and create a high-value market for locally produced compost (Cogger 2005)
Water management	Farm ponds (new and renovated)	• Help farmers provide supportive irrigation to the crops when required and secondly to allow maximum seepage of water into the ground so as to recharge the underground aquifers. (http://www.nicra-icar.in/)
	Percolation ponds	• Reduce the velocity of water flowing down from the fields and recharge the borewells. (http://www.nicra-icar.in/)
	Water storage/ harvesting structures	• To collect runoff rain water and ensure availability of water during summer (http://www.nicra-icar.in/)
	Desilting and widening of catchment channels/canals/ defunct canals	• The water storage capacity is increased by desilting and widening of defunct water harvesting structures. (http://www.nicra-icar.in/)
	Micro irrigation	• Microirrigation methods have been shown to increase the yield and quality of fruit and vegetable crops through reduced water and nutrient stresses (Evans and Sadler 2008) • Microirrigation when complemented with effective soil water monitoring program, good design, and appropriate management practices, can have an application efficiency of 95% or better without drought stress (NASS 2002)

Contd.

Table 4 (*Concluded*)

Interventions	Contribution to agriculture development	
	Green manuring	• Green manuring can improve soil physical, chemical, and biological properties and consequently crop yields. Furthermore, potential benefits of green manuring are reduced nitrate (NO_3^-) leaching risk and lower fertilizer N requirements for succeeding crops (Fageria, 2007).
Crop interventions	Tomato var. Arka Meghali	• Tolerance to water stress and quick recovery from the shock (http://www.nicra-icar.in/).
	Chilli var. Arka Lohit	• Drought tolerant, multiple disease & pest tolerant. (http://www.nicra-icar.in/)
	Ragi var. ML 365	• Drought tolerant • Medium duration variety resistant to lodging and blast • High seed and fodder yield • Suitable for late sowing(http://www.nicra-icar.in/)
	Maize var. NAH-1137	• Drought tolerant • High seed and fodder yield • Resistance to leaf blight, • Downy mildew and rust(http://www.nicra-icar.in/)
	Red gram var. BRG-2	• Performing well in the rainfed condition • Resistance to pod borer • Suitable for late sowing (http://www.nicra-icar.in/)
	Groundnut var. GPBD-4	• Foliar disease tolerant • Uniform kernels and high yield (http://www.nicra-icar.in/)
	Aerobic rice var Anjali	• Drought tolerant, highly resistant to brown spot and gall midge biotype 5 and, 1and moderately resistant to leaf blast (http://www.nicra-icar.in/)
	Mustard var Pusa Mahuk	• Temperature tolerant variety (http://www.nicra-icar.in/)
	Mustard var. Bonex Gold	• Temperature tolerant variety (http://www.nicra-icar.in/)
Cropping system interventions	Ragi + Red gram	• Equivalent yield of ragi was 16.63 (Q/ha) in ragi-pigeonpea combination (4:2) against a sole crop yield of 10.97 (Shashidhara *et al*, 2000) • Grain yield of ragi was increased to the tune of 25% with intercrop of pigeonpea (Thorat *et al*, 1986) • Highest B:C ratio 0f 4.29 was obtained for ragi-redgram (4:2) combination compared to sole cropping B:C ratio of 2.83 and 3.81for ragi and pigeon pea respectively (Shashidhara *et al*, 2000)
	Maize + Red gram	• Intercropping of maize and pigeonpea at 4:2 row ratio with 50 per cent pigeonpea population resulted in maximum maize equivalent yield (80.76 q/ha-1), net returns (₹ 30 492/ ha) and B:C ratio (2.75) over other intercropping systems and sole crops (Marer *et al*, 2007).
	Groundnut + Red gram	• Early clearance of land occupied by the groundnut intercrop facilitated a better spread of red gram resulting in a higher interception of solar radiation which reflected in the increased yield of red gram. Intercropping red gram with groundnut either at 1:2 or 1:3 row proportion recorded a high income compared to cowpea and jowar intercrops (Keshava and Ramachandrappa 2000)

Cropping intensity: Cropping intensity is determined by dividing net cropped area by gross cropped area in a year.

$$\text{Cropping intensity} = \frac{\text{Net cropped area}}{\text{Gross cropped area}} \times 100$$

Area under farming practices: Increase in area was determined from difference between percentage increase in land area under cultivation, of NICRA farmers and increase in land area under cultivation of non- NICRA farmers over the last three years.

Expenditure pattern: Information on expenditure incurred at present and pre-project period by the beneficiaries on various developmental indicators like education, health, household nutrition, modern technologies and assets were taken to enable formal comparison.

Savings: It was measured in terms of amount in rupees saved per year by both the NICRA and non-NICRA farmers to aid in the comparison so as to isolate the impacts produced as a result of NICRA intervention.

RESULTS AND DISCUSSION

Comparison of NICRA and non-NICRA farmers to isolate the impact of climate resilient technologies

Cropping intensity

Analysis of the data on average cropping intensity from both districts has shown that average cropping intensity of NICRA farmers is higher than that of non-NICRA farmers. The difference was tested using t-test to know statistical significance (Table 7). The cropping intensity in NICRA village was 124.75 per cent against 96.22 percent cropping intensity in non-NICRA villages and the difference was statistically significant at less than five per cent level of significance. The difference may be a result of positive response of farmers to NICRA interventions and due to increased availability of irrigation water during *rabi* and summer season from water harvesting structures and due to cultivation of drought tolerant crop varieties. Prasad *et al*. (2014) reported an increase in average cropping intensity across farmers by 17% due to de-silting works of six open wells during 2011 in summer at Sarkho village, Guna. "Sustainable intensification fosters more efficient resource use, and contributes to adaptation and mitigation through effects on farm productivity and incomes, and reduced emissions per unit of product" (AGRA 2014).

Crop diversification

Diversification of various crops was determined on the basis of income obtained from each crop. Based on t-test, the parameter was compared between both groups of farmers and the data indicated that NICRA farmers obtained a higher diversity index (3.04) than non-NICRA farmers (2.07). Findings were highly significant. The test statistics and its significance level is given in Table 7. The higher diversification can be attributed to increased awareness of NICRA farmers on the protection offered by multiplicity of crops, in case any mishap occurs. Crop diversification was ranked four after ranking of various adaptation technologies in Indian agriculture based on importance, urgency of action, no regret character, co-benefit, mitigation potential and economic benefit (Pathak *et al.* 2012). More diverse agroecosystems with a broader range of traits and functions will be better able to perform under changing environmental conditions (Matson *et al*. 1997, Altieri 1999), which is important given the expected changes to biotic and abiotic conditions (Lin 2011). Crop diversity is critical not only in terms of production but also because it is an important determinant of the total biodiversity in the system (Matson *et al*. 1997).

Irrigated area

The Table 7 represented the average irrigated area of NICRA and non-NICRA farmers in various seasons. The average irrigated land area of NICRA farmers was much higher than that of non-NICRA farmers all through in *kharif*, *rabi* and summer season. T-test was used to find significance of the difference and it was found significant for all three seasons. The role played by the water management component is well reflected here. The finding is reinforced by other studies also. Positive responses were detailed by Gumla KVK as renovation of ponds lead to enhancement in water storage capacity by 30 percent, fish mortality reduced from 15-20 per cent to 6-7 per cent, and obtained additional water for irrigation. This was due to enhancement in water holding capacity of soil, and well-functioning water storage structures. Bora bandi (sand bag check dam) was a low cost temporary check dam constructed across a river in Gumla, had shown magical results on water table because water table was increased by 44 per cent which contributed an area expansion under off season vegetable cultivation in 10 ha and paved a way for summer paddy cultivation in 10 ha and wheat cultivation in 50 ha.

The Table 5 showed the data obtained on land area irrigated in various season, before and after project interventions in NICRA villages. A significant increase in area under irrigation in all the three seasons was observed. It was tested using paired t test. The increase was found to be significant at less than one per cent level of significance. Irrigation efficiency of Sarkho village doubled as the farmers took up de-silting works of three open wells during 2011-12 and three open wells during 2012-13 in summer, while irrigated area increased by 50% due to de-silting (Prasad *et al.* 2014).

Irrigation frequency

Average number of irrigations given in each season by NICRA and non-NICRA farmers was tested using t-test inorder to obtain the statistical significance of difference between them (Table 7). The table highlighted that non-NICRA farmers were lagging behind NICRA farmers in frequency of irrigation during *kharif* season. It may be due to increase in water holding capacity in NICRA village as a result of water management interventions. 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 help of water harvesting and storage structures, increased the ground water level, hence the capacity for irrigation during *kharif* season. Similarly, during *rabi* and summer, the same trend was obtained to show that NICRA farmers scored more on irrigation frequency than non-NICRA farmers. It is a positive indicator to substantiate that irrigation potential of NICRA farmers was increased and they were in a position to give more number of irrigation during second and third season as compared to non-NICRA farmers. The computed p value is less than significant at five percent level ($P>0.05$). 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. Such structures

Table 5 Before-after comparison of NICRA beneficiaries on various aspects

Variables		Year	Mean	Std. deviation	t-value
Irrigated area (acre)	*Kharif*	Before 2010	0.66	0.68	8.769*
		2014	1.69	0.94	
	Rabi	Before 2010	0.23	0.70	9.721*
		2014	0.70	0.59	
	Summer	Before 2010	0.19	0.65	9.756*
		2014	0.65	0.59	
Irrigation frequency (no. of irrigation)	*Kharif*	Before 2010	2.75	3.00	-2.039**
		In 2014	5.43	4.88	
	Rabi	Before 2010	3.44	5.00	-1.711
		In 2014	4.87	.87	
	Summer	Before 2010	2.35	1.84	.005
		In 2014	5.14	2.52	
Employment (Days /year)		Before 2010	198.70	275.94	-15.234*
		2014	275.94	69.95	
Savings (₹/annum)		Before 2010	19843.75	34843.75	-6.562*
		2014	20865.54	18550.32	
Leased in land area (acre)		Before 2010	5.08	3.19	-5.834*
		2014	6.61	3.67	
Expenditure pattern (₹/annum)		Before 2010	19714.78	3348.75	-6.072*
		2014	29867.55	8550.32	

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

also often provide benefits to neighbours and downstream water users by mitigating flooding, enhancing biodiversity, and reducing sedimentation of waterways. Rainwater harvesting is considered as the single most important means to enhance agricultural productivity and offer a source of domestic water supply in drought prone areas (Getaneh and Tsigae, 2013).

Data on before-after comparison of irrigation frequency of NICRA villages has been given in Table 5. The data indicated significant difference in frequency of irrigation in *kharif* season (P<0.05), but the differences were found to be non-significant in the case of *rabi* and summer irrigation frequencies.

Employment

The Table 7 represented the average employment (in days) for both beneficiaries and non-beneficiaries. From the obtained data, it is clear that average number of days of employment generated for NICRA farmers (mean 275.93 days) was higher in comparison to non-NICRA farmer (181.05 days). In order to get the statistical significance of the difference, t-test was run.

The Table 5 highlighted difference in average employment days before and after project intervention. The difference was tested using paired t-test to know the level of significance. There was a significant and noticeable increase in average days of employment, from a mean of 198.7 to 275.9. Involvement in different activities under NICRA such as construction of new farm ponds, percolation pond and rainwater harvesting structures, renewal of farm ponds and other water storage structures resulted in more employment; training, capacity building and custom hiring services empowered the local people and improved activity of beneficiaries in farm sector. Extreme weather events such as droughts, cyclones and/or floods resulted in reduction of employment opportunities. They will also arise from slower processes such as sea level rise. Adaptation policies can start a virtuous circle driving local jobs creation which, with decent wages, can increase workers' wealth, and thus reduce their vulnerability (ILO, 2010).

Annual savings

Difference in average annual savings of beneficiaries and non-beneficiaries were compared and tested using t-test (Table 7). It represented that average savings of beneficiaries (₹ 34843.75) were higher than non-beneficiaries (₹ 33950.00) but it failed to meet the test criterion for acceptance because it was found to be non-significant (P=0.083). Average savings of the farmers increased over the years of project intervention (₹ 19843.75 to ₹ 20865.54). This is evident from the Table 5. The difference was statistically significant at less than five per cent level of significance which was tested using paired t-test. The increased saving might have a result of increased income obtained from taking additional area for agriculture and extending cultivation to new seasons due to adoption of resilient crop varieties and water management practices. Schrooten and Stephan (2005) showed that per capita income positively influences saving. So the findings can be positively attributed to an increased income coming from climate resilient farms.

Land area (leased in)

Average land area (leased in) by NICRA and non-NICRA farmers was found to be different, with a higher average leased in land area (mean-6.61 acre) by NICRA members. The data, value of test statistics and its level of significance is given in Table 7. When NICRA farmers had obtained good results, they developed more confidence and interest in farming and were trying to increase their area under cultivation to tap more benefits. Similar result was reported by Akter *et al*. (2006). Their study says "the coefficient of agricultural ability points out that a 10 percent increase in agriculture ability results in a likely increase in the probability of having rented in land by more than 4 percent and a likely decrease in the probability of rented out land by more than 3 percent."

The Table 5 contained data on land area (leased in) in acres before and after project interventions. Paired t-test was used to compare the data so as to get information on change in land area over years. The results from the Table 5 showed that there has been an increase in average land area leased in by farmers (5.08 to 6.61 acres), and it was found to be significant at less than five per cent level.

Expenditure pattern

Table 5 displayed expenditure pattern of farmers on various household items, education and health care, at two different point of time. Data of before 2010 (₹ 19714.78) was much lower than data at the time of study (₹ 29867.55). This increase in mean value was tested using paired t-test to know the level of significance. The differences found significant at one per cent level. The expenditure increased because of their ability to spend more on quality life, comes from higher income generated after using climate resilient technologies. The study conducted by Ismail and Tendot (2012), implies that a majority of household expenditures are allocated to rental and loan payments and healthcare expenses when there is an increase in income

Crop yield

To unveil the impact of improved varieties and other climate resilient technologies on yield of major crops, the yield data of respective crops before the project intervention and at the time of the study were compared. The yield data during *kharif* season was taken for comparison, since the cultivation during *rabi* and summer were negligible before project inception. The Table 6 depicted an increase in average yield for rice, maize, ragi, redgram and groundnut with yield 41.51, 35.64, 26.53, 6.28 and 7.33q/ha respectively in comparison to previous yield. The differences were found to be significant in all the cases. A multitude of factors including drought tolerant, high yielding, pest-resistant varieties, timely sowing, planting and transplanting, high moisture content in soil, increased frequency of irrigations, improved soil and water management practices would have dovetailed in realization of better yields. NICRA demonstrations in other sites have also shown favourable results. Demonstrations on improved varieties of off- season vegetables showed an increase in yield of French beans (78.7%), radish (70.5%) and spinach (90.3%) over the traditional varieties in Lagga village, Himachal. The yield and quality of horticulture crops improved and also the weed problem was minimized by adoption of drip irrigation system (Venkateswarlu *et al*. 2012).

Table 6 Before-after comparison of yield of crops in NICRA farms

Crop	Category	Mean (q/ha)	Std. deviation	t-value
Rice	Before 2010	30.78	32.75	-6.644*
	In 2014	41.51	40.84	
Maize	Before 2010	29.18	28.76	-6.041**
	In 2014	35.64	37.89	
Ragi	Before 2010	18.61	20.07	-4.734**
	In 2014	26.53	24.45	
Groundnut	Before 2010	5.01	5.73	-5.078*
	In 2014	6.28	4.76	
Redgram	Before 2010	5.42	4.81	-7.426**
	In 2014	7.33	7.41	

*Significant at P < 0.01.**Significant at P < 0.05

Cropping pattern

Information on crops grown before and after was obtained based on interaction with the respondents. No major change in crops cultivated was found but changes occurred to the varieties of the crops grown. Before the project intervention, both NICRA and non-NICRA farmers cultivated the traditional and conventional varieties, which were more prone and susceptible to crop damage. But after the project interventions NICRA farmers started growing drought tolerant and high yielding disease resistant varieties like, tomato cv. Arka Meghali, chilli cv. Arka Lohit, ragi cv. ML 365, GPV 28, maize cv. NAH 1137, Suwan1, redgram cv. BRG 2, BRG 1, Asha, groundnut cv. GBPD 1, GBPD 2, but no significant change in varieties was noticed in case of non-beneficiaries. The scenario prevailed because of resistance and fear of farmers to leap into a new list of crops, given their adaptation and marketability under

Table 7 Comparison of NICRA and non-NICRA farmers to isolate the impact of climate resilient technologies

Variables	Farmer Group	Mean	Std. Error Mean	t value
Cropping intensity (%)	NICRA	124.75	5.37	7.297*
	Non-NICRA	96.22	3.57	
Crop diversification	NICRA	3.04	0.19	3.900*
	Non-NICRA	2.07	0.16	
Kharif-irrigated area (acre)	NICRA	1.69	0.10	-2.149**
	Non-NICRA	1.13	0.31	
Rabi irrigated area (acre)	NICRA	.71	0.07	6.358*
	Non-NICRA	.09	0.04	
Summer irrigated area (acre)	NICRA	.64	0.07	2.374**
	Non-NICRA	.40	0.08	
Kharif irrigation frequency (in numbers)	NICRA	5.00	0.09	-15.328*
	Non-NICRA	3.40	1.88	
Rabi irrigation frequency (in numbers)	NICRA	4.88	0.21	4.275*
	Non-NICRA	2.68	0.60	
Summer irrigation frequency (in numbers)	NICRA	5.00	0.28	1.845
	Non-NICRA	4.03	0.49	
Days (per family) employed	NICRA	275.94	7.82	8.086**
	Non-NICRA	181.05	5.47	
Annual savings (₹)	NICRA	34843.75	2073.99	0.215
	Non-NICRA	33950.00	3593.61	
Land area-leased in (acre)	NICRA	6.6150	0.41	2.409**
	Non-NICRA	4.9875	0.54	

*Significant at P < 0.01.**Significant at P < 0.05

question, and the new varieties of conventional crops are offering them quiet good alternative to the exiting situation of climate variability. A sustainable cropping system calls for stress-tolerant crop varieties and livestock breeds, decision support models and sophisticated analytical tools and small-scale irrigation technologies suitable for smallholder farmers (Giordano *et al*. 2012).

Climate resilient technologies are promising tool to guard a farming system from climate variations. Impact study of these technologies are prerequisite for guiding the adaptive research for better customization, for upscaling, and outscaling them. The study focused on impacts of climate resilient technology due to increased adoption. High cropping intensity followed by the NICRA beneficiary farmers was one of the positive impacts of climate resilient technologies in the adopted villages. Increased awareness on land management practices acquired through training, timely availability of inputs and right technologies and machineries for agricultural operations through CHC and seed bank contributed right side of the project. This reinforced finding of the present study that a significant difference of crop diversification, land area irrigated during *kharif, rabi* and summer and irrigation frequency achieved between NICRA and non-NICRA farmers. Involvement in different farming practices and improved activity of beneficiary farmers resulted in higher employment. This finding was reinforced by significant increase in employment at present as compared to pre-project period in NICRA households. There was non-significant difference between beneficiaries and non-beneficiaries in terms of savings, but there was considerable difference between pre and post intervention of amount of beneficiary farmers saving. NICRA farmers were more engaged in farming and were trying to increase their area under cultivation, this 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. Yield of crops of beneficiary and non-beneficiary farms manifested much difference and increase in crop yields of beneficiaries farmers over years were found significant. This is likely due to effect of improved varieties coupled with healthy soil and better water management practices. All these findings displayed a positive impact of the technologies in different realms of life.

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