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Integrated Farming Strategies for Climatic Resilient Agriculture under Rainfed Conditions in North West Himalayan Regions

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ABSTRACT: The results of the National Innovation on Climatic Resilient Agriculture (NICRA) investigations on integrated farming strategies to cope with rain-fed conditions of Hamirpur district of Himachal Pradesh are being described. On the basis of hydrological and technical as well as social and cultural conditions, appropriate technological strategies have been implemented to combat the effects of climate change. The main objective was to enhance the resilience of Indian agriculture. The top most priority of the present study was to way out the source of water for meeting minimum critical water needs of crop diversification and maintenance of ecological balance under rain-fed condition and to analyze their technical and economical feasibility as well as their affordability for future users. The present study reveals that it is economically feasible to apply decentralized technologies and strategies in farming system for climatic resilient agriculture universally.

Keywords: Crop diversification; Livestock; NICRA; Rain-fed and Resilience.

INTRODUCTION: The climate change issue is global, long term and involves complex interaction between demographic, climatic, environmental, economic, health, political, institutional, social and technological processes.[1] It has significant international and intergenerational implications in context of equity and sustainable development. Climatic change will impact social, economic, and environmental systems and shape prospects for food, water and health security.[2] Socioeconomic and resource development technological characteristics of populations strongly affect CO_2 emissions, explaining the pace and capacity of societies to adapt to and mitigate climate change.[3-6] In addition, extreme climate events are registered and some proxies representing local climate at different places across the world reveal that the 20th century is probably neither the warmest nor a uniquely extreme climatic period of the last millennium.[7-11] A variable sun through changes in solar irradiance and processes such as biological regime shifts may have caused the observed climate variability and climate fluctuations over much of the Holocene. Indeed, geophysical, archaeological and historical evidences support a solar output model for climate change during a large part of the Holocene. Climate fluctuations are not necessarily anthropogenic as inferred from biological and geological proxies, terrestrial palaeo-temperature may have been higher due to natural variability.[12] Himachal Pradesh is comparatively a small state in North-West Himalayas.[13-15] Rain is the first and the ultimate source that feeds all rivers, lakes and ground water which are all secondary sources of water and hence remains ignorant of its value, so it is necessary to understand the value of rainwater at the place where it falls. Mittal and Sharma proposed watershed management plans in Shivalik foothills to avoid drought situations.[16] Tied ridging had been found beneficial for moisture conservation and in increasing yield of cotton.[17] Approximately one-third of the irrigated area of Tamil Nadu is watered by eris (tanks).[18] Previous studies have shown that substance agriculture in hilly region could be successfully transformed into a profit-earning enterprise by tapping and utilizing rainwater in limited quantities.[19] Hence, World Development Report (2008) emphasized that the potential of agriculture to contribute to growth and poverty reduction depends on the productivity of smallholder farmers.[20] And raising that productivity will require a much higher level of adoption of new agricultural practices and technologies than presently observed in the smallholder farming population.[21] Certified organic agriculture and polylined tank techniques must meet certain standards in the production, processing and handling which developed in accordance with basic standards established by the International Federation of Organic Agriculture Movements.[22,23] It would be useful investing in decentralized facilities, efficient technologies, policies and human capital to improve overall productivity rather than to find new sources of water supply.[24,25] Traditionally, such systems have been integrated with agro-forestry and ethno-forestry practices, and remain useful in contemporary conservation and ecological restoration of degraded ecosystems.[26,27] The low external input and sustainable agriculture (LEISA) approaches involve limiting the use of external inputs such as inorganic fertilizers and pesticides as well as rain harvested water through polylined tanks relying more on local and naturally available resources and a combination of traditional and improved methods to manage soil fertility, water, pests and other agronomic needs.[28,29]

Climate change is being witnessed all over the world and its impact on agriculture is more vulnerable in countries like India in view of the huge population dependent on agriculture, excessive pressure on agriculture, excessive pressure on natural resources and poor coping mechanisms.[30-36] The results of the National Innovation on Climatic Resilient Agriculture (NICRA) investigations on integrated farming strategies to cope with rain-fed conditions of Hamirpur district of Himachal Pradesh are being described. On the basis of hydrological and technical as well as social and cultural conditions, appropriate technological strategies have been implemented to combat the effects of climate change which are developed, discussed and evaluated. Farmers need to adapt quickly to increasing frequency of drought, flood, variations in rainfall and other extreme events to stabilize crop yields and farm income.[37-42] National innovations in Climate Resilient Agriculture have been aimed to enhance resilience in agriculture to climate change and climate variability through strategic research and technology demonstrations.[42-45] The objective of the project were:

- To enhance the resilience of Indian agriculture covering crops, livestock to climate variability and climate change through development and application of improved production and risk management technologies.
- To demonstrate site specific technology packages on farmer's field for adapting to current climate risks.
- To enhance the capacity of scientists and other stakeholders in climate resilient agricultural research and its application.

MATERIAL AND METHODS: To address the climatic vulnerabilities of the district, National Innovation on Climatic Resilient Agriculture (NICRA –KVK Hamirpur, Himachal Pradesh), selected village cluster for the project implementation. Participatory Rural Appraisal (PRA) and Focus Group Discussion (FGD) have been undertaken along with survey at household level. A baseline had been established, constraints were flagged and an action plan prepared in construction with the farmers and VCRMC (Village Climate Risk Management Committee) in year 2011. After a careful study of the gaps, specific interventions from each of the module are selected and an integrated package from all modules formulated as per need of farming community of the village (Table 1, Table 2, Table 3, Table 4).

Table 1: Project village agro-statics.

Name of the village and district	Mann Panchayat and Hamirpur, Himachal Pradesh, INDIA
Number of households	483
Total cultivated area	117.87 hectare
Area under rainfed cultivation	104.79 hectare
Major soil types	Sandy soil and Silty clayey loamy soil
Climatic vulnerability of the village and the extent area affected	Drought condition, a total of 104.79 hectare area affected during the study period (2011-16)

MODULES OF INTERVENTIONS:

Module I: Natural Resource Management (NRM): It consists of interventions related to *in-situ* moisture conservation, rainwater harvesting and recycling for supplemental irrigation, improve drainage in flood prone areas, conservation tillage where appropriate, artificial ground water recharge and water saving irrigation methods, mulching, crop residue recycling, land and soil health management (Figure 1, Figure 2, Figure 3, Figure 4, Figure 5).

Figure 1: Demonstration on polylined tank

Figure 2: Demonstration on RCC tank.

Figure 3: Demonstration on *in situ* plastic mulch.

Figure 4: Demonstration on ridge and furrow cultivation in vegetables.

Figure 5: Demonstration on vermin-tetrabed.

Module II: Crop Production Systems: It comprises the introduction of stress tolerant crops, resilient cropping systems, stress tolerant cultivars to drought/flood, high temperature, cold stress, pest and diseases, contingency crop planning, crop diversification, water saving paddy cultivation methods (SRI, Aerobic, Direct Seedling Rice), advancement of planting dates of Rabi crops in areas with terminal heat stress and frost, site specific nutrient management, community nurseries for delayed monsoon, location specific intercropping systems, integrated pests, disease and crop management (Figure 6, Figure 7, Figure 8, Figure 9, Figure 10, Figure 11, Figure 12).

Figure 6: Demonstration on line sowing in maize crop.

Figure 7: Demonstration on hybrid wheat crop.

Figure 8: Demonstration on Oilseed crop.

Figure 9: Demonstration on pulses.

Figure 10: Demonstration on rhizome crop.

Figure 11: Demonstration on Okra crop.

Figure 12: Demonstration on Pheromone trap for fruit-fly.

Table 2: Rainfall received in mm (no of rainy days) during 2011 to 2016.

Month	Normal rainfall (mm)	Actual-2011	Actual-2012	Actual -2013	Actual-2014	Actual-2015	Actual 2016
January	41.74	33 (1)	58.75 (7)	42.45 (3)	60.4 (2)	77.8 (5)	8.6 (2)
February	63.62	132.5 (7)	15 (3)	79.8 (6)	104.8 (5)	77.5 (5)	17.2 (2)
March	48.44	40.5 (2)	-Nil-	50.7 (3)	76.1 (6)	154.2 (5)	64.4 (50
April	42.93	38.75 (1)	64.75 (4)	7.5 (3)	34.4 (2)	47.5 (3)	20.6 (1)
May	32.16	33.25 (2)	-Nil-	13.27 (2)	69.8 (4)	22.8 (3)	73.6 (6)
June	145.88	133.25 (7)	26.25 (3)	228.68 (12)	104.5 (20)	140.8 (8)	99.1 (8)
July	302.65	221.75 (5)	169 (7)	207.8 (13)	428.0 (14)	281.0 (9)	338.6 (11)
August	420.13	317.5 (10)	319.9 (13)	745 (13)	260.6 (12)	371.3 (8)	516.5 (11)
September	136.30	102.5 (5)	229.2 (8)	102.5 (4)	63.0 (7)	73.6 (5)	76.4 (5)
October	29.03	-Nil-	-Nil-	28 (1)	-Nil-	5.2 (1)	-Nil-
November	5.41	-Nil-	5.4 (1)	22 (1)	2.0 (1)	11.0 (1)	-Nil-
December	26.41	-Nil-	47.7 (2)	32.3 (3)	61 (1)	21.6 (1)	-Nil-
Total	1294.7	1053.45	935.05	1560	1264.6	1284.3	1215

Table 3: Variability in precipitation during the cropping period from 2011-2016.

Month	Date	2011	2012	2013	2014	2015	2016
February	25	-	-	-	-	Hail and Storm	-
March	16	-	-	-	-	Hail and Storm	-
April	16	-	-	-	-	Hail and Storm	-
May	25	-	-	-	-	-	Hail and Storm
September	26	-	-	-	Hail and Storm	-	-
July	14	-	-	-	Lodging	-	-
August	15-16	-	-	Lodging	-	-	-
October	14	-	-	-	Hail and Storm	-	-
October	-	Dry spell	Dry spell	-	Dry spell	-	Dry spell
November	-	Dry spell	-	-	-	-	Dry spell
December	-	Dry spell	-	-	-	-	Dry spell

Table 4: Soil nutrients status of the project village.

Soil pH	Organic content (%)	Nitrogen (kg/ha)	Phosphorus (Kg/ha)	Potassium (Kg/ha)	Sulphur (Kg/ha)	Boron (ppm)
5.3-6.9	0.3-0.5	78-470	11-35	78-316	3.0-15.0	0.23-4.4

Module III: Livestock and Fisheries: In this module interventions include introduction of stress tolerant breeds, improved feed and mineral supplementation, fodder production, silage making, preventive vaccination, improved shelters for reducing heat stress in livestock, innovative fish production systems, use of community lands for fodder production during drought/floods (Figure 13, Figure 14, Figure 15, Figure 16, Figure 17).

Module IV: Institutional Interventions: It maintains support systems in the village include strengthening of existing institutions or initiating new ones VCRMC (Village Climate Risk Management Committee), establishing and management of custom hiring centre for farm implements, seed bank, fodder bank, creation of commodity group, initiating collective marketing by tapping value chains, introduction of weather index based insurance and climate literacy and advisory services using data from automatic eater station and village level manual weather station.

Figure 13: Demonstration on *Azolla* cultivation.

Figure 14: Backyard Palam strain poultry.

Figure 15: Animal health checkup camp.

Figure 16: Routine Vaccination in goatry.

Figure 17: Beetel breed up-gradation in goatry.

RESULT AND DISCUSSION:

I. Natural Resource Management: Drought is the major constraint. Climate variability in terms of historical rainfall trend over the last three decades indicated that dry spells of 10-20 days are increasing particularly during Rabi season. Therefore in order to mitigate drought to some extent major focus was on water harvesting for life saving irrigation through small scale water harvesting structures like farm ponds and roof water harvesting structures. These structures enable reuse of harvested rainwater during critical period of vegetable crop growth stage by ridges and furrows method of irrigation or for providing pre-sowing and life saving irrigation to Rabi crops. The farmers were motivated to construct water harvesting structures through awareness cum training programme which resulted in construction of six poly lined tanks (10m X 6m X 1.5m) and twelve RCC tanks (3m X 3m X 3m). This intervention helped the farmers for diversification to vegetable crops (Table 5, Table 6).

Table 5: Water harvesting interventions taken up in the village.

Structures/Years of Construction	Category	2011-12	2012-13	2013-14	2014-15	2015-16
No. of farm ponds/*Jalkund*	Constructed	-	6 (poly-lined Tanks)	-	12 (RCC Tanks)	-

Table 6: Details of water harvesting structures constructed.

Volume of water harvested i) Poly lined ii) RCC tanks respectively	58000 litre, 12000 litre
Area covered with supplemental irrigation in Kharif	0.16ha
Additional area brought under irrigation in Rabi	0.16 ha
No. of times filled in the year	3
Cost of tanks i) Poly lined ii) RCC tanks respectively	Rs 48000/tank, Rs 58700/tank

Table 7: Extent of adoption/spread of interventions year wise.

	Before NICRA	2011	2012	2013	2014	2015	2016-17
No. of units existing in the village	4	-	6	-	12	-	-
Area benefited in the village (ha)	0.2 ha	-	0.96 ha	-	2.16 ha	-	-
Impact of Intervention	Area under crop diversification shifted from 2.0 ha to 10 ha						

Table 8: *In-situ* conservation measures demonstrated in the village.

Interventions demonstrated	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17	
	No. of Farmers	Area (ha)	No. of Farmers	Area (ha)	No. of Farmers	Area (ha)	No. of Farmers	Area (ha)	No. of Farmers	Area (ha)	No. of Farmers	Area (ha)
Mulching Plastic	-	-	-	-	-	-	-	-	25	1.2	-	-
Biomass	-	-	2	0.2	7	0.8	8	1.0	11	1.2	22	2.5
Ridge& Furrow	2	0.08	7	1.0	8	1.5	2	1.48	16	1.48	18	1.8

Table 9: *In situ* moisture conservation through biomass mulching.

Intervention	Demo	Check
Crop in which mulching is done	Turmeric, Colocasia, Ginger	Turmeric, Colocasia, Ginger
Nature of biomass	Locally available leaves of fruit & forest trees, grass and Lantana	Turmeric, Colocasia, Ginger
Area (ha)	3	1
Biomass quality (q/ha)	20-22 ton./ha/season	-
Method of irrigation	Rain-fed area	Rain-fed area
No. of irrigation reduced	20	25
Water saved due to irrigation	-	-
Yield (q/ha)	Turmeric-190 Colocassia-215 Ginger-130	Turmeric-165 Colocassia-180 Ginger-105
Weed infestation	10%	100%

Table 10: Effect of biomass mulching in vegetable crops (No. of farmers involved = 25).

Treatment	Crop	Yield (Kg/ha)	Gross returns (Rs/ha)	Net return (Rs/ha)	B:C ratio
Improved Practice of Biomass mulching	Bitter gourd Bottle gourd Cucumber	35500 31500 17200	305000 315000 172000	213000 227000 104000	3.3 3.5 2.5
Farmer's Practice	Bitter gourd Bottle gourd Cucumber	26000 24000 11800	222000 240000 118000	134000 154000 53000	2.5 2.8 1.8

These tanks were able to provide irrigation to transplanted cauliflower, cabbage, broccoli, tomato, cucurbits, okra and other vegetable crops. Earlier to construction of rainwater harvesting structures, farmers were reluctant to opt for vegetable cultivation in rainfed situation in study village. They also faced a big challenge to cope with irrigation problems especially during critical period of growth. However, after construction of rain water harvesting structures, the farmers use harvested rain water for irrigation by ridges and furrows method in their vegetable crops. Hence, there is an increase in irrigated area of the village as well as enhanced production of crops (Table 7). Through this intervention, there has been a significant change in the cropping pattern as the area under vegetable crops has increased, replacing area under cereals. About 30-35 percent vegetable growers have been adopted technology of rain water harvesting for use in their kitchen gardening.

***In-situ* moisture conservation through plastic mulch:** Plastic mulching technology in vegetables especially cucurbits (bitter gourd, bottle gourd and cucumber) help in conserving soil moisture and also reduce weed infestation. The farmers get better yield by adopting this technology. The water losses are reduced besides saving labour employed for hand weeding. The extent of adoption of this technology varied from 20-22 per cent among vegetable growers of NICRA village. By adopting plastic mulching technology, the number of irrigation was reduced to 30-35 per cent as compared to earlier frequency of irrigations. Similarly weeding and hoeing operations which employ at lot labour were also reduced to nil after adopting this technique.

***In-situ* moisture conservation through biomass mulch:** Biomass mulching helped in in-situ soil moisture conservation and as consequence during dry spell, no adverse effect on standing crops of turmeric, colocasia and ginger noticed where as in check plots withering of plants observed, resulted in higher yield of demo fields (Table 8, Table 9). Likewise, less number of weeds also contributed to enhance crop yield. After use of biomass mulch 20 number of irrigation were reduced as earlier 25 irrigations in cucurbits (Table 10).

Ridge and furrow technology: Ridge and furrow method of cultivation has been promoted in the study area (Table 11). The technique resulted in obtaining higher yield, water saving up to 25-10 per cent and better crop management as compared to farmers' practice of direct flooding.

Table 11: Effect of Ridge and Furrow technology in cucurbits (No. of Farmers involved = 24).

Treatment	Crop	Yield (kg/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
Improved practice of Ridge and Furrow technology in cucurbits	Bitter gourd Bottle gourd Cucumber	35500 31500 17200	305000 315000 172000	213000 227000 104000	3.3 3.5 2.5
Farmer's practices	Bitter gourd Bottle gourd Cucumber	26000 24000 11800	222000 240000 118000	134000 154000 53000	2.5 2.8 1.8

Interventions of vermi-composting: This intervention has been adopted in study area through pit method and tetra vermin-beds. It resulted in 1.2 quintals vermin-compost on dry basis from one unit in one season and reduced nutrient application by 30 per cent.

II. Crop Production System: Wheat and maize are the major crops grown in study area. Farmers are getting low remunerations from existing varieties of cereals. High yielding varieties of maize and wheat (Early, timely and late sown group) have been demonstrated in the village. In order to conserve the residual moisture after harvest of maize, a *Zaid* crop of *Toria* was also introduced and demonstrated. *Toria* variety Bhawani has been resistant to drought and yielded good returns to marginal farmers. Crop diversification to oilseed and vegetable crops has enhanced economy of farmers.

Interventions related to crop production: Vegetable growers face big challenge to combat fruit fly menace especially in cucurbits crops. Therefore, KVK demonstrated the technology of pheromone trap as a low cost and eco-friendly alternative to manage this insect. The farmers have been able to harvest more yield. About 60-65 per cent farmers have adopted this technology. As far as progressive farmers concerned, the adoption rate is above 90 per cent. Earlier farmers restored to indiscriminate application of insecticides for control of fruit fly in cucurbits. Spray application of 5-7 numbers were applied under cucurbits cultivation. However, with the adoption of pheromone trap of fruit-fly, numbers of spray applications have been reduced to 2-3 only (Table 12, Table 13, Table 14, Table 15, Table 16, Table 17).

Table 12: Summary of Crop production interventions.

Interventions demonstrated	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17	
	No. of farmers	Area (ha)	No. of farmers	Area (ha)	No. of farmers	Area (ha)	No. of farmers	Area (ha)	No. of farmers	Area (ha)	No. of farmers	Area (ha)
Improved varieties of crops Maize												
Plant Gene (2465)	-	-	33	2.5	-	-	-	-	-	-	-	-
Vyas	64	5.0	-	-	-	-	-	-	-	-	-	-
4640	-	-	-	-	-	-	5	0.96	13	3.0	-	-
Polo gold	-	-	-	-	-	-	-	-	-	-	16	2.5
Girja	-	-	2.5	29	-	-	-	-	-	-	-	-
Proline (3440)	-	-	-	-	3.0	25	-	-	-	-	-	-
Wheat (Early sown)												
VL 829	20	0.2	-	-	6	1.0	-	-	-	-	-	-
HPW 360	-	-	-	-	-	-	-	-	5	1.0	-	-
HS 542	-	-	-	-	-	-	-	-	-	-	2	1.0
Wheat (Timely sown)												
HPW 236	8	1.5	25	4.0	9	2.0	-	-	-	-	-	-
HPW 349	-	-	-	-	-	-	6	2.0	28	3.0	-	-
VL 907	7	0.25	-	-	-	-	-	-	-	-	-	-
HPW 368	-	-	-	-	-	-	-	-	-	-	17	2.0
Wheat (Late sown)												
HS 490	6	0.25	-	-	-	-	-	-	-	-	-	-
VL 892	2	0.2	-	-	5	1.3	-	-	6	0.36	-	-
Short duration variety of Toria (Bhawamni) as *Zaid* Crop	45	3.3	-	-	-	-	-	-	20	1.0	21	0.83
Gobhi Sarson (ONK-1)/GSC-7)	42	2.0	23	1.0	-	-	22	1.0	50	2.0	19	1.0
Brown Sarson (KBS-3)	-	-	37	2.0	22	2.0	19	1.0	25	1.0	18	2.0
Okra (P-8)	12	0.6	-	-	-	-	-	-	-	-	-	-
Tulsi	26	1.6	-	-	8	0.32	-	-	-	-	-	-
Drought escaping / tolerant varieties	-	-	-	-	-	-	-	-	-	-	-	-
Heat / Flood	-	-	-	-	-	-	-	-	-	-	-	-
Intercropping systems	-	-	-	-	-	-	-	-	-	-	-	-
1Maize (4640) +Soyabean (Harit Soya)	-	-	-	-	-	-	8	1.04	-	-	-	-
Crop diversification												
Okra (P-8)	12	1.6	-	-	-	-	-	-	-	-	-	-
Tulsi	26	1.6			8	0.3						
Turmeric Palam-Pitamber	-	-	22	0.12	37	0.16	-	-	-	-	-	-
Caoliflower (626)	-	-	-	-	-	-	7	0.4	12	1.2	9	0.8
Cabbage (Green Voyager)	-	-	-	-	-	-	7	0.2	-	-	-	-

Cabbage (Char-mant)	-	-	-	-	-	-	-	-	10	0.64	6	0.4
Broccoli (Green Magic)	-	-	-	-	-	-	-	-	-	-	4	0.2
Onion Seed (N-53)	-	-	4	0.16	-	-	20	0.24	-	-	-	-
Bitter Gourd (Palee)	-	-	-	-	-	-	9	1	5	0.4	-	-
Cucumber (Ma-lav)	-	-	-	-	-	-	9	0.4	6	0.4	-	-
Summer Squash (Korean germ)	-	-	-	-	-	-	3	0.2	-	-	-	-
Bottle Gourd (Sharda)	-	-	-	-	-	-	5	0.4	5	0.48	-	-
Elephant Foot Yam (Narendra2)	-	-	-	-	-	-	-	-	8	0.04	-	-
Management of Fruit Fly by use of BAT and male annihilation technique (Phe-romoe Traps)			59	2.4	82	3.3	25	1.0	95	2.0	19	0.6

Table 13: Impact and performance of the demonstration on crop production.

Year	Crop	Variety	Demon. Yield (Q/ha)	Gross Re-turn	Net return	BC ratio
2011-12	Maize	Vyas	22.2	26536	9289	1.54
2012-13		Plant Gene (2465)	29.2	26577	9316	1.55
2012-13		Girza	22.3	26566	9294	1.54
2013-14		Proline (3440)	19.2	31500	10680	1.57
2014-15		4640	25.1	31108	14658	1.89
2015-16			23.0	33504	11508	1.52
2016-17		Pologold	23.1	33561	11561	1.52
2011-12	Wheat (Early Sown)	VL-829	25.7	36087	16712	1.92
2013-14			25.6	36008	16342	1.94
2015-16		HPW 360	26.7	37500	17500	1.87
2016-17		HS 542	27.9	41850	19350	1.86
2011-12	Wheat (Timely Sown)	HPW 236	26.8	31441	12041	1.62
2011-12		VL 907	25.7	36114	16614	1.94
2012-13		HPW 236	25.8	31439	12039	1.61
2013-14			26.0	31286	11886	1.61
2014-15		HPW 349	27.3	41126	19126	1.86
2015-16			27.2	41300	18800	1.84
2016-17		HPW 368	27.4	42150	19650	1.87
2011-12	Wheat (Late Sown)	HS 490	27.0	31422	12022	1.62
2011-12		VL 892	25.2	35700	17200	1.93
2013-14			25.8	31356	11956	1.61
2015-16			26.3	41277	18772	1.83
2011-12	Toria	Bhawani	6.2	19741	7090	1.56
2015-16			6.0	19776	6846	1.53
2016-17			6.5	19500	7500	1.62
2011-12	Gobhi Sarson	ONK-1	6.8	19750	6750	1.51
2012-13			6.9	19795	6795	1.50
2014-15			6.5	21060	7360	1.54

2015-16		GSC 7	7.2	21750	6750	1.45
2011-12	Okra	P-8	180	180000	1300000	2.6
		Tulsi	160	155000	150000	2.4
2013-14			210.3	210000	140000	3.00
2012-13	Turmeric	Palam Pitamber	315	252000	172000	2.15
			320	320000	227500	3.4
2012-13	Cauliflower	F_1-71	290	290000	210000	2.63
2014-15		626	172	265000	184400	3.2
2015-16			185	270000	188000	3.3
2016-17			205	280000	195000	3.2
2014-15	Cabbage	Green voyager	200	225000	144400	2.79
2015-16		Charmant	190	230000	148000	2.8
2016-17			170	250000	140000	2.7
2016-17	Broccoli	Green magic	135	170000	130000	2.6
2012-13	Onion seed	N-53	270	190000	150000	2.9
2014-15			265	192000	155000	2.8
2014-15	Bitter Gourd	Palee	340	282000	194400	3.2
2015-16			355	305000	213000	3.3
2014-15	Cucumber	Malav	160	160000	93000	2.3
2015-16			172	172000	104000	2.5
2014-15	Summer Squash	Korean Green	280	280000	207000	3.8
2014-15	Bottle Gourd	Sharda	330	330000	245500	3.9
2015-16			315	315000	227000	3.5
2016-17	Elephant Foot Yam	Narendra 2	500	450000	200000	1.8
2014-15	Bitter Guard	Pheromone Traps for fruit fly	265	265000	175000	2.94
2015-16	Cucumber		150	225000	144000	2.78

Table 14: Extent of spread/adoption/Scaling up of intervention of crop diversification to vegetable crops year wise.

	Before NICRA	2011	2012	2013	2014	2015	2016
Area under intervention (ha)	2.9	3.2	3.5	4.2	4.5	5.5	7.0
No. of Farmers adopted	5	7	8	9	11	12	14

Table 15: Characters and attributes of crop varieties demonstrated.

Variety	Characters and attributes				
	Year of release	**Potential Yield (q/ha)**	**Benefits/Remarks**	**Date of Maturity**	**Days to Maturity**
Wheat (HPW 360)	2015	32	Early sown variety, uses residual moisture, yellow rust resistant, high yielding	1st week of May	160
Wheat (HPW 349)	2011-12	35	Timely sown variety, yellow rust resistant, high yielding	Last week of April	150
Maize 4640	Pvt. Hybrid	45	High yielding, medium height, comparatively resistant to lodging	Till 25th September	100
Gobhi Sarson GSC-7	2014	14-15	High yielding and quality oil content	1st week of April	150-155
Toria (Bhawani)	>10 years	7-8	Zaid crop, short duration, less water requirement	Till 15th December	80

Cabbage (Charmant)	Pvt. Hybrid	270	High yielding , synchronous maturity and disease resistant	1st Fortnight of February	Varies depending upon time of translating/seeding
Bitter gourd (Aman)	Pvt. Hybrid	355	High yielding and disease resistant	June-September	-
Bottle Guard (Sharda, Shambu)	Pvt. Hybrid	370	High yielding and disease resistant	June-September	
Cucumber (Malav)	Pvt. Hybrid	160	High yielding and disease resistant	May-July	

Table 16: Impact of crop diversification through vegetable cultivation.

INTERVENTION	BEFORE NICRA		AFTER NICRA	
	Area	Yield (q/ha)	Area	Yield (q/ha)
Cauliflower	1.28	247	2.0	290
Bitter gourd	3.00	180	3.5	250
Cucumber	0.64	150	1	190
Okra	1.31	105	1.5	130

Table 17: Extend of Spread/adoption/scaling up of interventions year wise.

	Before NICRA	2011	2012	2013	2014	2015	2016
Area under intervention (ha)	0	-	2.4	3.3	1.0	2.0	0.6
No. of farmers adopted	0	-	59	82	25	95	19

Table 18: Summary of livestock interventions taken in the NICRA village.

Interventions demonstrated	2011-12		2012-13		2013-14		2014-15		2015-16		2016-17	
	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)
Improved annual fodder crops (Guinea grass) demonstrated	-	-	16		36	-	-	-	-	-	-	-
Azolla (Culture) as green fodder in lean period	-	-	28	-	47	-	18	-	7	-	7	-
Perennial fodder crops introduced	-	-	-	-	-	-	-	-	-	-	-	-
Improved Beetel breed introduced 0n dated 26-04-2013	-	-	-	-	2	-	-	-	-	-	-	-
Silage units demonstrated on dated 27-09-2013	-	-	-	-	84	-	11 (refilling)	-	2 (refilling)	-	-	-
Mineral mixture demonstrated	371	-	228	-	128	-	73	-	47	-	48	-
Improved shelter for animal	-	-	-	-	-	-	02	02	-	-	-	-
Backyard poultry birds introduced	-	-	250	-	-	-	09	45	-	-	-	-
Animal health camp taken up	46	-	31	-	22	-	41	-	44	-	25	-

Table 19: Details about individual interventions demonstrated.

Technology demonstrated and details of the practice	Improved annual fodder crops demonstrated as *Azolla* Culture as dietary protein inclusion for live stock in lean period
Farmer's practice	Preparation of *Azolla* unit (3X1x0.2)m produced 1.5 kg/m^2/week After continuous consumption increase 10-15 % milk yield
Year of start	2012

Significant observations about the performance of crop interventions are:

- The area under vegetables increased gradually due to availability of water harvesting structures and higher return as compared to traditional crops. The farmers show interest to adopt the crops which has less requirement of water and follow the technology of ridge & furrow and biomass mulching where water requirement is less.
- *Toria* is grown as *Zaid* crop in residual soil moisture. Demonstration on Gobhi Sarson also showed farmers' preference as oilseed crop in the project area due to quality oil content.
- About 60-65 per cent farmers have adopted male annihilation technique (Pheromone traps) as eco-friendly method of management of fruit fly. The numbers of spray applications for management of this insect pest have been reduced to 2-3 only.

III. Livestock and Fisheris:

Intervention on *Azolla* Production: *Azolla pinnata* is a high quality protein rich aquatic fern which need minimal water requirement for its propagation and it serve as an effective fodder supplement for livestock and poultry. Besides containing around 21-23 per cent crude protein, *Azolla* is also reported to be rich in essential minerals and fibres. In contest to water scarcity situation especially in the lean period (month of April to June as well as November to February) it becomes an efficient source of green fodder. About 30-40 per cent livestock rearers have been adopted technology of *Azolla* cultivation. Demonstrations of Silage preparation, Hay-making, Uromol-bricks and Mineral mixture have also been implemented in the study area and prove adoptable technologies under rain-fed situations.

Intervention on Beetel buck breed upgradation: Beetel buck has been introduced in the study areas during the year 2014. The breed adapted and performed well in the rainfed conditions of study area. Mass by weight of this breed was found to be more than 1.5-2.5 kg of 6 month old and milk yield also has higher (200-250 ml/day) as compared to local breed.

Intervention on Backyard poultry in NICRA: Demonstration on backyard poultry for self employment has conducted with '*Palam*'chick procured from CSK HPKV, Palampur. The farmers were trained for this profitable venture to increase their income and for self employment avenue (Table 18, Table 19).

IV. Institutional Interventions:

Village level seed bank to combat seed shortage: Seed shortage of suitable varieties is an important limitation faced by farmers to implement contingent crop plans to tackle aberrant rainfall situations. Farmers trend to dispose of the entire produce of grain and then depend on external source for seed supply in the next season. Therefore participatory village level seed production of wheat verities occur by establishing community seed banks (Table 20).

Table 20: Community Seed bank developed in NICRA village.

Name of Intervention	Area demonstrated (ha) /qty produced (q)					Increase after demonstration
	2012-13	2013-14	2014-15	2015-16	2016-17	
Community based nursery (Onion & Cauliflower)	0.24	0.28	0.32	0.0	0.20	0.12 ha
Wheat HPW 236	3q	7q	10 q	0.0	0.0	8 ha
Wheat HPW 349	-	-	-	3q	-	

CONCLUSION: The top most priority of the present study was to way out the source of water for meeting minimum critical water needs of crop diversification and maintenance of ecological balance under rain-fed condition and to analyze their technical and economical feasibility as well as their affordability for future users. This can lead to sustainable management of biodiversity i.e. the fauna and flora of Hamirpur district and also lead to substantial improvement in the socio economic condition of the small and marginal farmers of NICRA village district Hamirpur also. Poverty and lack of employment is a serious problem in the study region, to overcome this situation it is a necessary to enhance agricultural production through promotion of irrigation through climatic resilient strategies as people gain more cash crops, development of agro-forestry system on wastelands and livestock development with a special focus on generation of productive self-employment for the rural poor. These strategies should enhance the economy of rural poor by providing them gainful self employment opportunity in seasonal and off seasonal vegetables especially in protective cultivation year around. The remote areas are also deprived of basic infrastructural facilities so they should be the target areas of current development programmers. There is also a need to develop low cost economically, climatic resilient agriculture technologies as the target population is poor these technologies enhances the capacities of rural poor and enable them to take active part in the process of strengthening the regional economy. The present study reveals that it is economically feasible to apply decentralized technologies and adopted strategies in farming system for climatic resilient agriculture universally.

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