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Impact of technological interventions on livelihood security of resource poor farmers in Vindhyan region of North India

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Abstract

A World Bank funded project under 'National Agricultural Innovation Project' of Indian Council of Agricultural Research was carried out during 2008 to 2014 in *Vindhyan* region of North India with the aim of ensuring 'rural livelihood security' in disadvantaged area. The area is characterized as mostly rainfed, small and fragmented land holdings, undulating topography, crop based farming with low productivity of crops and livestock, low cropping intensity, poor literacy rate and low household income. The project on consortium mode was conducted in three clusters comprising 43 villages and 4256 farm households. The major interventions under the project were construction of check dams and water harvesting bunds for tapping runoff and the water flowing in natural rivulets, distribution of high-density polyethylene (HDPE) water delivery pipes, diesel pumps, introduction of improved crop varieties and production technology, artificial insemination and health care of cattle, breed improvement of local breed of goats through *Barberi* bucks, introduction of *Nirbheek* breed of backyard poultry. All these efforts resulted in increased cropping intensity by 37%, crop productivity by 73% (wheat) to 130% (pearl millet) and bringing additional 370 ha area under irrigation. Manpower engagement increased from 201 to 246 man days and house hold income from US $ 666 to $ 740 per year. Watershed based farming system modules were developed for further improvement of livelihood and household income.

Keywords: check dam, disadvantaged area, food security, improved agricultural practices, water harvesting bund

INTRODUCTION

Mirzapur and Sonbhadra districts in *Vindhyan* region of North India are among 150 disadvantaged districts of the country identified by Planning Commission, Government of India. Large area is rainfed with undulating topography. Sizeable population of these two districts, more particularly the Sonbhadra comprise of tribal people living below the poverty line. Annual rainfall in the area is slightly above 1100 mm but about 87% of the precipitation is received only during monsoon season (June to October). A large number of rivulets flow in the area; however, most of the rain water remains untapped as surface run off is very high. Soil and water conservation practices are not adequately followed. The tribal population mainly survive on field crops, forest based products, fuel wood, leaves of *Diospyrus melanoxylon*, *Butea monsperma* and *Shorea robusta* as well as low yielding livestock and poultry. Livelihood is also earned working as labor in nearby towns.

The project was carried out under consortium mode to develop water shed based farming system modules for improving the living condition of farm households with enough quality food and ensuring livelihood security in disadvantaged area.

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MATERIALS AND METHODS

A sub project under Component 3 of National Agricultural Innovation project of Indian Council Agricultural Research was carried out during 2008 - 2014. Banaras Hindu University led World Bank funded project along with three consortium partners comprising Indian Institute of Vegetable Research, Varanasi and two NGOs viz. *Surabhi Shodh Sansthan*, Mirzapur and *Banwasi Seva Ashram,* Sonbhadra. Three clusters of villages from two target districts i.e. Mirzapur and Sonbhadra were selected in three development blocks for project interventions pertaining to the set objectives of the sub project. Cluster I with 8 villages belonged to *Myorepur* block of Sonbhadra. Whereas, cluster II and III comprising 12 and 13 villages were selected in *Pahari* and *Madihan* blocks, respectively in Mirzapur district. Therefore, in all, there were 33 villages under the sub project. In each village, 100 farm households were selected as beneficiary farmers. However, in cluster I, villages being small, in some of the villages, the entire village was selected. Consequently, program was initiated with 3382 farm households. The project got extension in April 2012. During this period, additional 3 villages each in cluster II and III and 4 villages in cluster I with 874 farm households were included.

Baseline survey was conducted and the targets were fixed against the baseline values pertaining to various issues for developing watershed based farming system modules (Table 1). The major interventions were construction of check dams and water harvesting bunds, improvement in water conveyance system, introduction of improved cultivars and production technology for field crops, vegetables and fodder crops, truthful level (TL) seed production, artificial insemination in cattle and breed improvement of local goats, introduction of Nirbheek breed of backyard poultry, and capacity building of rural youth and farm women.

In different clusters, 8 check dams and 28 water harvesting bunds were constructed besides distribution of 25284 m HDPE water delivery pipes, 44 diesel engines and pressurized system of irrigation for 29.1 ha among the beneficiary farmers. Through water harvesting structures and water conveyance system, 1662 farmers benefited. Fifty nine improved varieties of field crops and 30 that of vegetables were provided to the farmers with emphasis on open pollinated and short duration varieties. In addition to this, fertilizers and pesticides were also made available to the farmers. However, no input was given free of cost to the farmers and the sustainable fund so collected was deposited in Nationalized bank of respective clusters for scaling up the project activities after termination of the project. In order to develop sustainable farming system modules for small and marginal farm households under different water availability conditions, 10 to 15 farmers in each category were selected under rainfed and irrigated condition as well as in the surroundings of check dam and water harvesting bunds. To assess the impact of various strategies with respect to livelihood security and employment generation, data were collected again on the same farm households involved in baseline survey and analyzed.

RESULTS AND DISCUSSION

Baseline survey

Baseline survey conducted at the beginning of the project, revealed that cluster I was dominated by tribal people with Schedule cast (SC)/Schedule tribe (ST) population of 87.3% whereas cluster II had 39.9% and that of the cluster III 44.8% SC/ST (data not reported). The majority of farmers in all the clusters were either marginal or small. Living conditions of the farm households in all the clusters was not good particularly in cluster I. The literacy rate in the area is low. Availability of irrigation water is a major constraint; cluster I had only 12.4% area under irrigation, whereas, Cluster II and III recorded 36.6% and 28% irrigated area, respectively. This led to low cropping intensity (151.7 %) as well as poor crop and animal productivity. The household income (US $ 666) and employment (201 man days) were low with large inter-cluster variations. Based on the baseline values and the

interventions, targets were set for the improvement of crop, livestock and poultry productivity as well as employment generation and household income (Table 1).

Construction of check dams and water harvesting bunds to make efficient use of rain water

In spite of the fact that major part of *Vindhyan* region is rainfed and the soil is dry, a large number of rivulets flowing in the area during monsoon are untapped and lead to great loss of water through run off. To make the efficient use of rain water, 25 water harvesting bunds (WHB) and eight check dams (CD) were constructed spread over three clusters under the project (Table 2). In most of the WHBs, the water was retained for 5 to 6 months (till December-January), whereas, in CDs even up to 7 to 8 months (February – March). This not only brought additional area under irrigation to the extent of 140.7 ha but also enhanced the net sown area of 24.2 ha during winter.

Table 1. The baseline status of the issues and the target set for improvement.

Issues	Cluster I Myorepur, Sonbhadra		Cluster II Pahari, Mirzapur		Cluster III Madihan, Mirzapur		Mean	
	BLV	Target	BLV	Target	BLV	Target	BLV	Target
Cropping Intensity	127	166	162	216	162	210	151.7	197
Irrigated area (%)	12.4	16	36.6	45.3	28	34.7	25.7	32.0
Cereal (t/ha)	0.55	1.1	1.62	2.11	1.26	1.9	1.14	1.7
Pulses (t/ha)	0.33	0.66	0.76	1.06	0.55	0.83	0.55	0.85
Oilseeds (t/ha)	0.19	0.38	0.31	0.62	0.34	0.64	0.28	0.55
Cow: Milk (L/cattle)	1.0	1.35	1.59	2.1	1.64	2.2	1.4	1.88
Buffalo: Milk (L/cow)	-	-	1.73	2.25	1.85	2.4	1.79	2.33
Goat: Milk (L/goat)	0.16	0.22	0.13	0.18	0.18	0.24	0.16	0.21
Poultry: Egg/day	0.17	0.5	0.17	0.5	0.15	0.5	0.16	0.50
Meat (kg/bird)	0.83	1.0	1.1	1.4	1.1	1.4	0.91	1.27
Employment (Man days)	225	270	201	250	185	250	201	257
Household income ($ US)	433	972	875	1050	616	821	666	840

Table 2. Construction of Water harvesting structures.

Water harvesting structure	Cluster I (Myorepur, Sonbhadra)	Cluster II (Pahari, Mirzapur)	Cluster III (Madihan, Mirzapur)	Total
Check dam	3	4	1	8
Earthen bund	25	0	3	28
Cost of construction ($ US)	48968	53758	54032	156758

Water storage in structures and the beneficiary farmers

During peak of the rainy season in 2011-12, water collected in all the water harvesting structures was measured (Murty and Jha, 2011). The total rain water stored in structures was 113084 m^3 which was sufficient for irrigating 226.1 ha area with 5 cm water. Water storage capacity of check dam appears less as compared to water harvesting bunds but the water stored in it lasted for longer period. In three clusters, the direct beneficiaries of these structures are 228 comprising 62, 95 and 71 in cluster I, II and III, respectively.

The cost of structures per unit storage capacity was worked out as US $ 1.39/m^3 in the first year (2010-11) and in 4th year (2013-14) it came down to US $ 0.35/m^3. After five years of construction and continuous use there has not been any damage to any of the structures and it is likely to cater the service for prolonged period.

Improvement in water conveyance system

In order to improve the available water utilization, 44 diesel engine pump sets and 25284 m HDPE water delivery pipes were distributed among the farmers groups. In all the three clusters 161 farmers' group were formed and each group consisted of 10 to 15 farm households with 20 to 40 pipes of 6 m each This resulted in bringing additional 228.9 ha area under irrigation.

Impact of the water harvesting structures and improvement in water conveyance

The overall impact of water harvesting structures and improvement in water conveyance system has been very successful as irrigation water facility was extended to additional 369.6 ha area recording an increase of 40.36% over baseline value (data not reported). However, as regards the three clusters, 46.9, 188.1 and 134.6 hectare increase in irrigated area was recorded in cluster I, II and III, respectively. It was observed that as compared to water harvesting bunds, check dams with the capacity of retaining rain water for longer period proved much effective in bringing large area under irrigation. With the enhanced availability of irrigation water and appropriate cultivars, the cropping intensity has increased up to 188.7%, 193% and 183.4% in cluster I, II and III, respectively. It is also interesting to note that the average water table near the water harvesting structures has improved from 0.81 to 1.12 meter.

The impact of improved water availability on crop productivity was evaluated. For this 10 farmers in the surroundings of each structure were randomly selected and data on productivity of major field crops collected (data not reported). As compared to baseline values, the crop yield near WHBs increased from 56% (green gram) to 95% (barley), whereas, the yield improvements due to check dams were 85% (mustard) to 109% (wheat). Therefore, the impact was better near the check dams than WHBs because it retained water for longer periods during post rainy season. It was further noted that cropping intensity near the WHBs enhanced by 32.8% while in the vicinity of CDs by 42.1%. Similarly, the household income of the farmers through crop component in the surroundings of WHBs and CDs increased through crop production by US $118 and $ 244, respectively.

Impact of improved cultivars and efficient crop production technology

Farmers are now going for improvement of production technologies *viz*. line sowing, intercropping, balanced use of nutrients, integrated nutrient management, integrated weed management, plant protection and diversified cropping. These techniques along with the use of improved varieties have enhanced the crop productivity of the beneficiary farmers in all the three clusters. The maximum productivity enhancement was recorded in pearl millet (130%) followed by Sesamum (108%), barley/mustard (105%), maize (97%), pigeon pea (84%), gram (79%), rice (78%) and wheat (74%). Jin *et al* (2012) also reported that irrigation has strong impact on land productivity.

The introduction short duration cultivars, improvement in irrigation water and water conveyance, better input use as well as motivation of the farmers resulted in enhanced cropping intensity of 183, 194 and 189 % in cluster I, II and III, respectively with overall improvement of 37% over baseline value. The intensive cropping as well as enhanced crop productivity and production led to the 22.4% increase in labour engagement and 66.8% increase in crop based income. However, the maximum increase in crop based income took place in cluster III (84.3%), followed by cluster I (72.6%) and cluster II (53.6%), respectively. This shows that the impact was comparatively more in clusters which were less developed with respect to crop production.

Direct seeding of rice with chemical weed control

With short duration cultivars and effective low dose high efficiency herbicide, direct seeding of rice was introduced. Direct seeding of rice with chemical weed control by spraying Bispyribac Sodium 10% SC @ 200 ml/ha at 18 -20 days of sowing under dryland condition was found very

effective particularly in cluster II (Madihan, Mirzapur). The efficacy of Bispyribac Sodium 10% SC as a post emergence herbicide has also been reported by Khaliq et al (2012) and Singh et al (2014). In a short span of three years, this technology has covered 138 ha area. The cost of cultivation is low mainly due to due labor savings on nursery raising, puddling, transplanting and weeding. It recorded 18.1% higher net return than transplanted rice.

Truthful level seed production (TL) seed production

In each cluster of the project a seed village was selected for the production of truthful level seeds with the aim of faster dissemination of quality seeds in the area at affordable price, ensuring remunerative price to the seed producers and training the rural youth on TL seed production as well as processing. In TL seed production, the major emphasis was put on open pollinated cultivars developed mainly by B.H,U. and I.I.V.R. During four years period (2010-11 to 2013-2014), 167 farmers were involved in the seed production of field crops and the total seed produced was 1448 q of field. The maximum seed production was for rice (902 q) followed by wheat (319 q), pigeon pea (89 q), chickpea (58 q), and barley (57) and field pea (19 q). Out of the total seed produced, 233 q seed was traded every year. Depending on crops and the land put for seed production, the additional household income of the seed producers varied from $ US 209 (rice) to $ US 29.9 (green gram) per year per household.

Commercial vegetable growing with improved varieties and production technology

Farmers were motivated for commercial vegetable growing in the project area particularly in cluster II and Cluster III. Impressed by the performance of improved cultivars under field demonstrations, the area under commercial vegetable has enhanced considerably from 57.3 to 78.8 ha. Through the adoption of improved varieties of vegetables mostly developed by IIVR and the efficient production technology, the productivity of all the vegetables growing in area has improved. As compared to the traditional practice, the maximum of 42% gain in productivity was recorded in vegetable pea. This was followed by Bottle gourd (38.9%), lady's finger (38.8%), bitter gourd (31.4%), cowpea (30.9%), pumpkin (23.5%), cucumber (23%), brinjal (18.3%) and sponge gourd (16.7%). The increased productivity of vegetables resulted in enhanced net return of $ US 165.9 to 559.7 per hectare from commercial vegetable growing as compared to the traditional practice. At household level, the average income of commercial vegetable growers was improved by $ US 324 (16.1%).

Improving the productivity of cattle and poultry

1. Cattle

Vaccination of the entire livestock population in each village was done against common fatal disease viz. *Hemorrhagic septicaemia,* 'foot & mouth' and black quarter during 2009-10 and 2012-13. Thirty households in each village were selected for the support of health care and mineral mixture support to their cattle. This accompanied with improved feeding and the provision of green fodder, improved the milk yield of cow from 1.41 to 1.88 l/day and that of buffalo from 1.39 to 2.25 l/day. The annual household income through cattle was enhanced from $ US 140.3 to $ US 180.4.

2. Backyard poultry

With the view to promote the backyard poultry, 1300 chicks of '*Nirbheek*' obtained from Central Avian Research Institute, Barielly, India were distributed among the marginal and landless farmers @ 10 birds/household; so, in all, 130 farm households benefitted. The farmers are very much satisfied with the performance this improved poultry breed. As compared to 41.9 eggs/year of local breed, '*Nirbheek*' laid 96.5 egg/year. Moreover, one year old cock of *Nirbheek* weighed 3.3 kg against 2.1 kg of local. An enhanced income of $ US 26.1/hh/year was recorded with *Nirbheek*.

3. Breed improvement of local goats

Twenty five Barberi bucks obtained from Central Institute for Research on Goats (CIRG), Mathura, India were distributed for breed improvement of local nondescript goats in three clusters. During the project period, 172 kids of improved cross breed were produced. Improved cross bred goats in all the clusters recorded enhanced milk productivity with overall average of 163%. as compared to respective baseline value. Through the improvement in both milk and meat productivity of 'Barberi cross bred' improved herd, the household income increased by $ US/year/HH.

Recommended livelihood model

Based on the project interventions, water availability, average land holdings and resource condition, integrated farming system models were developed based on 10 to 15 farm households separately for the two districts of *Vindhyan* region for different situations (Table 3). Under each situation, the household income was found to be considerably higher than the average baseline household income of respective clusters. By adopting crop (0.7 ha) + goat (5+1) + backyard poultry (10), marginal farm households of Mirzapur and Sonbhadra under rainfed condition can earn income of US $ 835 and $ 636.1, respectively. The models developed for small farmers near check dam recorded US $ 597.6 and $ 168.3 higher household income than those near water harvesting bunds in Mirzapur and Sonbhadra, respectively. The inter-cluster differences could be due to variations in water availability as well as the crops grown in different clusters and the market. However, the model comprising Crop (1.15 ha) + Vegetables (0.25 ha) + Dairy (3 cows) developed for small farm household of Mirzapur with assured irrigation recorded household income of US $ 2544.1 per year. The results are in conformity with the findings with of Singh et al (2007), Shamim et al. (2011) and Nath et al. (2016).

Table 3. Watershed based livelihood models for Mirzapur and Sonbhadra districts of *Vindhyan* region.

District & Model	Suitability Target	Number of household covered	Area covered (ha)	Net return ($ US/HH /year)
Sonbhadra				
Crop (0.7 ha) + goats (5+1) + poultry (10)	Marginal Farmer Rainfed	15	10.5	636.1
Crop (1.2 ha) + goat (5+1) + poultry (10)	Small Farmer Near WHB	12	14.4	785.0
Crop (1.2 ha) + goat (5+1) + poultry (10)	Small Farmer Near CD	10	12.0	953.3
Mirzapur				
Crop (1.15) + vegetables (0.25) + dairy (3 cows)	Small Farmer with irrigation	13	15.6	2544.1
Crop (0.7 ha) + goats (5) + poultry (10)	Marginal Farmer Rainfed	10	7.0	835.0
Crop (1.4 ha) + dairy (2 cows)	Small Farmer Near WHB	10	14.0	1103.0
Crop (1.15 ha) + vegetables (0.25 ha) + Dairy (3 cows)	Small Farmer Near CD	10	14.0	1700.6

CONCLUSIONS

The following conclusions can be drawn from the study:

- Livelihood security in the disadvantaged area of Vindhyan region in north India can be ensured by improving irrigation facilities through construction of water harvesting structures, improving water conveyance system, adoption of improved cultivars, production technology as well as watershed based integrated.
- Farming system modules.

- Livestock and poultry health care, breed improvement and balanced feeding will further enhance the farm household income.

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