Indian Journal of Agricultural Sciences **94** (3-S1): 034–040, March-S1 2024/Article
https://doi.org/10.56093/ijas.v94i3.148583

Farming system diversification: An insight on strengthening the livelihood in a hilly ecosystem

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Received: 16 February 2024; Accepted: 28 March 2024

ABSTRACT

To make Indian agriculture remunerative, and enhance farmers' income, the Government of India initiated a mission for doubling the farmers' income (DFI) by 2022. For DFI under a conventional cropping system, the agriculture sector needs to grow @15% per annum. Therefore, there is a need for reorienting the conventional cropping system with a more productive alternative integrated farming system, combining on and off-farm occupations with high technological support. With this background, the present study was carried out in a cluster of villages where interventions through a research institution (Farmer FIRST project) were made. Such interventions were undertaken in a cluster of 7 villages involving 500 farm families (2016–19). The technological gaps were identified through benchmark surveys using participatory rural appraisal (PRA) and extensive farmers' group discussions. During this, farmers' skills and managerial capabilities were explored, and 16 interventions of various farming modules and sub-modules attributed to higher income were identified and implemented. The farmers were continuously provided technological and partial input support in terms of capacity building and seeds, fertilisers and similar others. The results indicated that mushroom production had high potential for supplementing farm income (117% per farm family). The income from food grains increased by 81% whereas, income from seasonal and off-season vegetable crops increased by more than double. Dairy farming exhibited 52.38% increase in income. In absolute terms, the dairy had maximum contribution in increasing income by ₹24,014 followed by food grains (₹13,251). The intervention modules increased the average per-farm family income by ₹46,979, which was highly significant (P<0.01%). The income of 40% of the farm families increased by more than double, while the income of 1% of the farmers increased by >75% in just 2 years. Overall, when four modules and sub-modules of the model were put together, the total farm income per family increased by 67% from ₹70,290 (2016–17) to ₹1,17,269 (2018–19).

Keywords: Doubling farmers' income, Farming system diversification, Intervention module, Income security, Technology impact

After the Green Revolution, India's food grain production increased 3.8 times, while the country's population multiplied by 2.5 times. In 1950–51, food grain production was 50.82 million tonnes which increased to 295.67 million tonnes in 2019–20 (Anonymous 2018). There has been a 45% increase in food availability per person during this period. Farming being a predominant sector of the rural economy, the growth of this sector has strong linkages with other sectors and consequently a striking effect on poverty and unemployment. The per capita income in the agricultural sector is just one-third of the per capita income in the country, thereby creating a huge income disparity between primary agriculture *vis-a-vis* other sectors of economy. This gap has continuously widened leading to alarming unrest among farming communities across states. This might be one of the reasons for farmers' distress, despite the fact that the country has achieved commendable position in food grain production.

Economic reforms initiated since 1991 have put Indian economy on a higher growth trajectory. The government wishes India to become a $5 trillion economy by 2024, and the country's agricultural sector, being so crucial to its economy, is going to play a key role in this growth trajectory. Past strategies for the development of agriculture sector in India have largely focused on improving food security through raising agricultural output. However, agriculture which accounted for >30% of the total GDP at the beginning of economic reforms, failed to maintain its pre-reform

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growth. Concerned over the slow growth in agriculture and allied sectors, the Government of India launched/ introduced a new additional central assistance Rashtriya Krishi Vikas Yojna (RKVY) scheme in 2007 to incentivise the states to plan for improving the agriculture sector more comprehensively, taking agro-climatic conditions, natural resource issues and technology into account and integrating livestock, poultry and fisheries with farming. Rising income inequalities between farmers and other rural workers (Vinaya *et al.* 2018) and pressure to improve farm income have lately brought the issue of enhancing farmer's income to the center stage.

To ensure food and nutritional security to fast-growing Indian population, making agriculture a remunerative farmer-centric occupation, and enhance farmer's income, the Government of India has initiated a mission for doubling the farmers' income (DFI) by 2022. The goal of doubling farmers' income in a fixed time frame is a challenging task. The challenge is further aggravated by the fact that agriculture in its present context is not seen by most rural youths as a very remunerative occupation. To achieve the DFI goal under a conventional cropping system, the agriculture sector needs to grow @15% per annum. According to Changela and Devi (2018), it can only be achieved by combining technologically driven on-farm operations with off-farm activities Therefore, there is a need for reorienting the conventional cropping system with more productive alternative integrated farming systems, combining on and off farm occupations with high technological support.

Aimed at enhancing the farmers' income, a project namely Farmer FIRST (Farm, Innovations, Resources, Science and Technology) was initiated by Government of India in October, 2016 at various locations. The purpose of this initiative was to provide a platform to diverse stakeholders for enriching knowledge and integrating technology. In enhancing farmers' income what is sought to be doubled was the gross income rather than farm output or value added or the GDP of the agriculture sector (Chand 2017, Changela and Devi 2018). Under this initiative, a strategy termed Doubling Farmers Income: A model (Sarial 2016) for hilly and mountainous region was evolved. This was attributed with crop production and animal husbandry integrated with mushroom + beekeeping/processing/ protected cultivation/poultry/goatry; crop production and animal husbandry integrated with beekeeping + processing/ protected cultivation/poultry/goatry; crop production and animal husbandry coupled with processing + protected cultivation/poultry/goatry; crop production and animal husbandry coupled with protected cultivation + poultry/ goatry and crop production and animal husbandry coupled with poultry + goatry. This model has been implemented in several villages of Himachal Pradesh.

MATERIALS AND METHODS

Study location: Himachal Pradesh is a north-western hill state of India (30^{o} 22'40" and 33^{o} 12'40" N and 75^{o} 47'55" and 79^{o} 04'20" E with altitude varying from 350 to 6975 m MSL) agro-climatically divided into four zones, viz. sub-mountain and low-hills sub-tropical zone, mid-hills sub-humid zone, high-hills temperate wet zone, and high-hill temperate dry zone. Among the four agro-climatic zones, the mid-hill sub-humid zone has been characterized as the granary of the state for field crops and milch animals. The farmer FIRST programme was implemented in the Dharer Panchayat having 7 villages namely Dharer, Tara, Jalgran, Kand Kosari I, Kand Kosari II, Beda and Lulani in Baijnath block of Kangra district of Himachal Pradesh during the 3rd quarter of the year 2016–17 covering 500 households of the Panchayat.

Preparation for technological interventions: A benchmark survey was conducted using Participatory Rural Appraisal (PRA) techniques. The farmers of the selected panchayat were practicing cultivation of traditional varieties of cereals (paddy, wheat, maize), oil seeds, pulses and vegetable crops. Based on PRA, different interventions/ modules, viz. the introduction of high yielding varieties and hybrids, in maize-wheat/rice-wheat cropping system for attaining food security, upgradation of the technological knowledge on the issues being faced by farmers in the field of crops and animals were done to enhance their productivity. Some new interventions, like small scale cultivation of mushroom, backyard poultry, value addition and rearing of honey bees for additional family income generation, the components of doubling farmers' income model of Sarial (2106) were formulated and implemented in the operational area.

The farmers were sensitized through farmer-scientist interactions for the adoption of improved farm technologies. Other extension approaches such as group discussions, on and off-campus training programmes, and exposure visits within the state to various institutions and progressive farmers' fields were planned and organized. Demonstrations and on-farm trials (OFTs) on high-yielding varieties (HYVs) and hybrids of cereals along with improved agro-techniques, viz. chemical weed management, balanced and integrated fertilizer use, and appropriate eco-friendly plant protection measures were conducted. The farmers were also educated to diversify the predominant cereal production practices with off-season vegetables cultivation (French bean, pea, cauliflower, summer radish, capsicum, okra and tomato), which have good market prospects in the nearby towns. Animal health check-up camps, veterinary clinical camps and introduction and distribution of balanced location-specific ration, mineral mixture, UMMB and medicines for the control of endo and ecto-parasites of the animals were demonstrated to improve animal health and increase milk production for self-consumption as well as surplus for sale in local market to generate additional income. The off-farm activities, including introduction of small-scale cultivation of white button mushroom, bee-keeping and post-harvest value addition of vegetables and mushroom as pickle (for the glut period) were also demonstrated to the farmers of selected villages.

Methods of data collection and analyses: The impact assessment was carried out during 2018–19 after two years of experimentation on a sample of 150 farmers. The personal interview integrated with group discussion was applied to collect the data periodically. Questionnaire with open-ended and closed-ended questions was developed based on the interventions made with farmers, and tested with non-sampled farmers. Using this questionnaire, data relating to various variables were collected and entered into spreadsheet. Before entering the data into spread sheet, they were properly characterised and curated.

The data were analysed that included computation of averages, percentages, ratios and indices to interpret the results. The impact of various interventions was assessed as follows:

$$\text{Difference of mean (MD)} = \overline{X_a} - \overline{X_b}$$

The significance of mean difference was tested following z-test using the formula:

$$z_{cal} = \frac{\overline{X_a} - \overline{X_b}}{\sqrt{\frac{S_a^2}{n_a} + \frac{S_b^2}{n_b}}},$$

and compared with the theoretical value of 1.96 and 2.58 at 5% and 1% level of significance, where $\overline{X_a}$, Mean of different variables under consideration after the project; $\overline{X_b}$, Mean of different variables under consideration before the project; S_a^2, Sample variance, Number of respondents before the project; S_b^2 Sample variance before the project; n_a, Number of respondents after the project; n_b, Number of respondents before the project

The regression analysis was done to quantify the impact of interventions in the project area. The model used is as follows:

$$Y = a + b_1 \text{ HOLD} + b_2 \text{ MILCH} + b_3 \text{ TECH} + U$$

where Y, Farm income before and after the project interventions (INR/farm family); HOLD, Size of holding (ha/farm family); MILCH, Number of milch cows (local and cross-bred); TECH, Dummy variable showing the impact of technological interventions (0 before the project and 1 after the project); a, Intercept; b_1, b_2 and b_3, Regression coefficients; U, Random term.

Efforts were also made to establish linkages of these farmers with various developmental departments of the state, viz. Agriculture, Horticulture, Veterinary and Animal Husbandry, Local Development Block, Marketing Committee of the vegetable market (Mandi) etc. so as to realize the aim of doubling income through better marketing.

RESULTS AND DISCUSSION

Socio-economic status of the farmers: The results indicated that the average size of the family was 3.80 and sex ratio was 939 females/1000 males (Table 1), comparable to the sex ratio in the state. The literacy rate among heads of the family was 54.55%, indicating a low literacy rate for elder members of the family while it was high at 87.53% among members of the family as revealed by their educational status. With the majority of family members educated up to primary, matriculation and secondary levels their literacy rate was higher than the average of the district (80.02%) and the state (75.93%) (Statistical Yearbook 2018–19).

The majority of study farmers (75.21%) had agriculture as the main occupation, while 25% households had one member employed in the government or private sector to aid to the income. Greater employment in government or private services indicated good cash inflow, resulting in less attention to agricultural activities. The land holdings were very small. A large percentage of the holdings (86.36) had less than 0.5 ha, 10.33% which ranged between 0.5–1 ha; while 3.32% had >1 ha, reflecting the predominance of marginal holdings.

Table 1 Socio-economic features of sample households

Particular	Parameters
The average size of farm family (no.)	
Male	1.96
Female	1.84
Total	3.80
Sex ratio (females/1000 males)	939
Educational status of heads of family (%)	
Illiterate	45.45
Primary	21.07
Middle	9.09
Matric	10.74
Secondary	9.92
Graduate	3.72
Educational status of family members (%)	
Illiterate	11.73
Non-School going	5.97
Primary	28.12
Matriculate	17.37
Secondary	22.26
Graduate	10.21
Postgraduate	2.71
Technical	1.63
Literacy rate (%)	87.53
Occupation of family member (%)	
Agriculture	75.21
Business	0.00
Service	24.79
Size of holdings (%)	
0–0.5 ha	86.36
0.5–1.0 ha	10.33
1.0 ha and above	3.32
Average size of holdings (ha)	0.35

Land inventory and land use classification (Table 2) revealed that ownership of land accounted for 93.57%, leased-in land 7.80% and leased-out land 1.37%. Among land use categories, the cultivated land accounted for 81.71% pasture and grassland 10.42% while fallow land 7.87% of the total holding.

Performance survey of doubling farmers' income modules: In the selected villages all, 10 out of 16 modules were implemented in the first year and 14 in the second year including varietal introduction for cereals and vegetable crops and balanced ration/mineral supplements for livestock rearing. The willingness and interest of the individual farmer were considered to opt for the modules/interventions. The majority of the farmers were covered under cereal modules, vegetable crops, balanced ration and mineral supplements for livestock, and intervention for control of fruit fly (most severe insect problem in the area).

Performance survey based on suitability of the variety, planting method, weed control and increase in yield/farm income after the first year of implementation rated Module 1 (maize), Module 2 (wheat) and Module 3 (Hybrid rice) as very good to excellent (Table 3). The better on-farm response of management practices in major crops of Himachal Pradesh had been amply demonstrated earlier (Sharma *et al.* 2013, 2015 a). Module 4 (vegetable crops) was rated good to very good for most of the crops while very good to excellent for peas and potatoes. Vegetable-based diversification for enhancing income has also been documented (Rana *et al.* 2010, Sharma *et al.* 2015b). The performance rating of tomatoes and french beans was fair to good. Long-standing severe insect problems in vegetable crops specifically in cucurbits faced by the farmers were solved through control of fruit flies under Module 6 which was rated very good to excellent.

The intervention on balanced ration and mineral supplements under various modules particularly Uromin Mol Bricks and mineral supplementation resulted in apparent improvement in health and productivity of dairy animals. The farmers rated the performance of the modules as very good to excellent. Under the mushroom cultivation module 52 farmers each were given 7–8 compost bags and the performance rating was very good to excellent. This module had the best performance rating, and was the most successful intervention in the project area.

Table 2 Land inventory and land use classification

Particular	Land use (%)
Land ownership	
Owned land	93.57
Leased-in	7.80
Leased-out (-)	1.37
Total holding (ha)	0.35
Land use pattern	
Cultivated Land	81.71
Pasture/grassland	10.42
Fallow Land	7.87

Factors affecting farm income: The impact of intervention modules on farm income was further assessed with the help of regression analysis. It is expected that land holdings and number of milch animals were observed to be the important factors contributing to farm income besides technological interventions. Therefore, these two factors have been considered as the explanatory variables affecting farm income. The impact of technological interventions was captured through a dummy variable (0 before project and 1 after project intervention). The results of regression analysis are presented in Table 4. The intercept was estimated at ₹56534.85 per farm family as the base level income. The effect of holding size was found to be negative, but non-significant which clearly showed that holding size may not increase the income until improved technology is used. However, with an increase in the unit of milch animals, the farm income increased significantly by ₹10560.38. The impact of technology interventions was so explicit that the intervention modules implemented in the project area increased the farm income ₹46325.75 per farm, which was highly significant at 1% level. The value of R^2 was 0.367, which showed that 37% of the variation in the farm income model explained was due to the included variables, and there may be other variables contributing to farm income.

Impact of doubling farmers' income modules on income variability: In food grain crops, the inter-farm variability, which was earlier observed to be as high as 75.30%, was reduced to 54.84% (Fig. 1). However, the income from vegetables was highly skewed, the standard deviation even exceeded the sample means though there was a remarkable decrease in the inter-farm variability after the project. This clearly shows that vegetable cultivation is yet to gain an impetus in this area, and the farmers need to be motivated to adopt vegetable cultivation in the irrigated land on a commercial scale. The inter-farm variability in dairy income was relatively low as all the farmers were operating at the same level of dairy management practices. With the project interventions, the variability in dairy income was reduced from 52.37 to 36.39%. A similar degree of variability was also witnessed in income from other enterprises as they were adopted by fewer farmers. Inter-farm total income variability was decreased from 47.31% before the project to 38.75% after the project interventions. Therefore, it can be concluded that the intervention modules not only raised the farm income from different components, but also reduced the degree of inter-farm variability, bringing more stability in the income of farmers.

It is evident from the results (Table 5) that interventions carried out under different modules had a significant impact on improving the farm income. The component-wise impact revealed that mushroom production, an ancillary enterprise, had a high potential for supplementing farm income. It showed a significant increase of 117% from ₹4,500 to 9,759 per farm family. The income resulting from high productivity of food-grain crops increased by 81% from

Table 3 Doubling farmers' income modules and their performance rating

Module	Crop/technology assemblage	Variety (seeds)		Number of demonstrations		Performance rating (%)			
		2017–18	2018–19	2017–18	2018–19	Fair	Good	Very good	Excellent
Module 1	Maize	Hybrid	Hybrid	110	108	0.00	6.37	57.27	36.36
Module 2	Wheat	HPW 368, HPW 349 and HPW 155	HPW 155; HPW236	118	280	0.00	5.08	54.24	40.68
Module 3	Paddy	Hybrid, Kasturi Basmati, HPR 1068, HPR 2143 and HPR 2612	Hybrid; HPR 214	118	623	0.00	2.54	50.85	46.61
Module 4	Vegetables								
	Okra	Hybrid	Palam Komal; Hybrid	106	306+203	0.00	42.45	51.89	5.66
	Potato	Kufri Jyoti	-	112		0.00	19.64	58.93	21.43
	Tomato	Hybrid	-	111		56.76	23.42	16.22	3.60
	Brinjal	Arka Keshav	-	26		0.00	19.23	53.85	26.92
	Beans	Contender		88		28.41	43.18	22.73	5.68
	Peas	PalamTriloki, PB 89 and GC 477	GS-10	99	261	21.21	12.12	29.29	37.38
	Cauliflower	Hybrid	Hybrid	32	24+22	0.00	18.75	65.63	15.63
	Chilli	-	Surajmukhi	-	316	-	-	-	-
	Radish	-	Ivory White		250	-	-	-	-
Module 5	Off-season vegetables	-		-		-	-	-	-
	Cucumber	-	Hybrid		407	-	-	-	-
	Bottle gourd	-	Hybrid		51	-	-	-	-
	Bitter gourd	-	Hybrid		51	-	-	-	-
	Brinjal	-	Hybrid		51	-	-	-	-
	Tomato	-	Hybrid		251	-	-	-	-
	Turnip	-	PTWG		261	-	-	-	-
	Palak	-	Pusa Harit		250	-	-	-	-
Module 6	Management of fruit fly	Palam Trap	-	150	634	4.00	8.00	45.33	42.67
Module 7	Honey Bee	-	-	3	6	0.00	0.00	66.67	33.33
Module 8	Mushroom and Dhingri	-	-	52	78	0.00	0.00	48.08	51.92
Module 9	Nutritionally rich grasses and fodder trees	-	-	-		-	-	-	
Module 10	UrominMol Bricks	-	-	135	303	0.00	19.26	45.18	35.56
Module 11	Mineral mixture supplementation	-	-	135	303	0.00	23.70	40.74	35.56
Module 12	Balanced milk-ration	-	-	135	303	2.22	37.04	34.07	26.67
Module 13	Vaccination to improve animal health	-	-	-	303	-	-	-	-
Module 14	Rain water harvesting	-	-	-		-	-	-	-
Module 15	Processing and value addition	-	Mushroom pickle; Rhododendron juice etc	-	100	-	-	-	-
Module 16	Nutri-garden	-	All summer and winter season vegetables	-	100	-	-	-	-

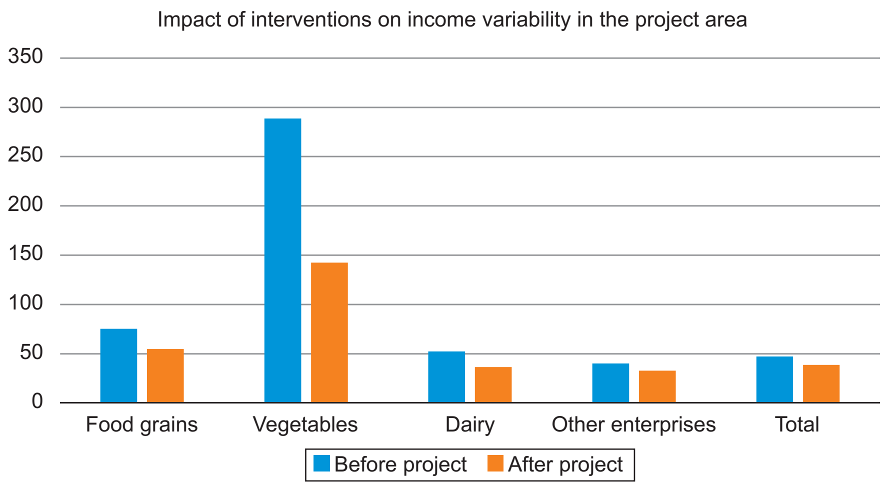

Fig. 1 Impact of doubling farmers' income modules on total farm income.

Table 4 Factors affecting farm income and their impact

Variables	Regression coefficient	Standard error	T-value
Intercept	56534.85**	5157.74	10.96
Holdings size (ha)	-1163.82	6549.63	-0.18
Milch animals (no.)	10560.38**	2393.55	4.41
Dummy (0,1)	46325.75**	4469.48	10.36
R^2 value	0.367**		
F-value	43.66		

**Significant at 1% level.

₹16,416 to ₹29,667. The income from seasonal and off-season vegetable crops increased by more than doubled from ₹3,528 to ₹7,983 despite the fact that the area under vegetable crops increased only marginally after project intervention. In dairy farming, the income increased by 52.38% from existing ₹45,.846 to 69,860. The dairy module and sub-modules had the maximum increase in income (₹24,014) followed by food grain (₹13,251) and mushroom (₹5,259) while vegetables were the minimum (₹4,455). Different modules and their sub-modules combined resulted in a higher net increase, viz. food grain and dairy (₹37,265) while three combining food, dairy and mushroom gave more income (₹42,524) than food, dairy and vegetables. Overall, when all four modules and sub-modules put together the total form income per family increased by ₹46,979 from ₹70,290 (2016–17) to ₹1,17,269 (2018–19). The impact of technology interventions under the DFI model was so explicit that the intervention modules increased the average per farm family income in just two years by 67%.

The results (Fig. 2) revealed that during the project period of 2 years, the income rise of farmer families was of 40% more than doubled, 10% of the farm families registered a rise by more than 75%, while 9.33% showed an increase in the range of 50–75%. The income of about 11% of the farm families increased to the extent of 25–50%, 12% recorded a marginal increase by <25% while 18% did not exhibit any change in income. An increase in income of about 82% of the farm households suggested an appreciable impact of interventions made in the form of modules and sub modules.

Conclusion and policy implication

It has been concluded that technological interventions through different modules and sub-modules could create an enabling environment in increasing farm income per family by 67%. Among farm families the income of 40% families increased by more than doubled. While the income of 10%

Table 5 Impact of technological interventions on total farm income

Crops	Before project	After project	Mean difference	Percent increase
Food grains (Module 1, 2, 3)	16416 (12361)	29667 (16269)	13251** (1681.07)	80.72
Vegetables (Module 4)	3528 (10185)	7983 (11374)	4455** (1865.32)	126.28
Dairy (Module 10, 11, 12)	45846 (24011)	69860 (25420)	24014** (3146.14)	52.38
Others enterprises (Module 7 and 8)	4500 (1800)	9759 (3200)	5259** (582.23)	116.87
Food grains + dairy	62262	99527	37265	59.85
Food grains + dairy + vegetables	65790	107510	41720	63.41
Food grains + dairy + other enterprises	66762	109287	42524	63.69
Food grains + dairy + vegetables + other enterprises	70290 (33253)	117269 (45436)	46979** (4597.24)	66.84

**Significant at 1% level. Figures in parenthesis show the standard deviation of means and standard errors of mean difference.

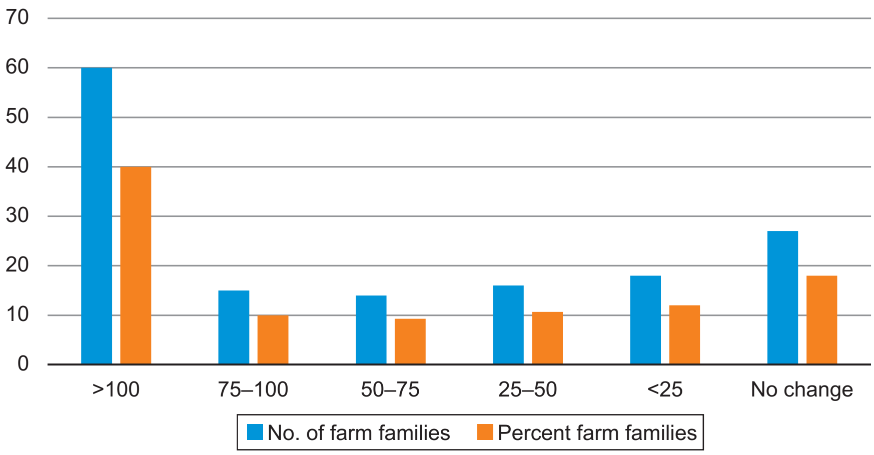

Fig. 2 Distribution of beneficiary households according to level of income enhancement.

farm families increased by >75%. It could be inferred that well planned interventions strengthening diversification in the farming system ease farm families to enhance their income. The key insights suggested that involvement of diverse stakeholders provide opportunities to converge the resources and strengthen farmers' adaptive capacity with concomitant risks reductions while trying new technological interventions. The scaled-up models of interventions helping in diversification of farming system and increasing income, as demonstrated and may help developmental agencies and policy makers to replicate it at large scale.

Ethical statement

There is no conflict of interest amongst the authors for publishing the paper. The farmers of study location were explained about the aim of study, and their knowledge and information was recorded with prior consent. Farmers agreed to share the information anonymously without disclosing their personal details.

ACKNOWLEDGEMENTS

The authors are grateful to the Indian Council of Agricultural Research (ICAR), New Delhi for funding the project. The Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidalaya, Palampur, Himachal Pradesh is also acknowledged for providing logistic and administrative supports while executing the project activities. Special thanks are due to the farmers of the area for their active cooperation in executing different project interventions.

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