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Farm diversification options for ensuring livelihood security of peri-urban farmers in eastern plateau and hill region: Learnings from Farmer FIRST Project

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ABSTRACT

The research work was undertaken in four villages near Ranchi, Jharkhand under the Farmer FIRST Project to test the effectiveness of the technological options in improving the profitability of peri-urban agriculture system. Based on Principal Component Analysis of data on agri-economic conditions of farmers, the farm households could be classified into five broad typologies, viz. 1: Marginal farmers and landless labourers, 2: Cereal dominated small farmers, 3: IFS based small farmers, 4: Livestock based marginal farmers and 5: Cereal based medium farmers. Results of two years of experimentation indicated promising technological options like rainy season cultivation of solanaceous vegetables, cultivation of crops like wheat, chickpea and other *rabi* and summer season vegetables in rice fallow, management of ecto- and endo parasite in the animals and supplementation of area specific mineral mixture, cultivation of oyster mushroom for increasing income from agricultural production system. The project has resulted in increase in income of all typologies of farmers with a maximum increase in case of small farmers practising integrated farming and minimum increase in case of marginal farmers and landless labourers. Notably, income from non-farm sources saw a decrease in all five typologies.

Key words: Eastern plateau, Farm diversification, Hill region, Livelihood security, Peri-urban farmers'

While at the turn of millennium the ratio of rural and urban population in India was 71.5: 28.5 according to 2001 census, the present ratio stands at 66:34 (Anonymous 2018)). This fast pace of urbanization is throwing challenges for agricultural system too (like other interwoven fields, e.g. economy, governance and employment scenario). It also pushes for rearrangement of various components of economy. Among other necessities of urban areas food is of paramount importance which is to be sourced completely from outside. A regular unabated food influx is to be ensured, a significant part of which may be of perishable nature. Supply of food from farm to household is affected by many factors including distance. Heavy dependence on food from distant places makes the urban food system more vulnerable to climatic uncertainties and price instability (Tesfaw 2104). Therefore, peri-urban agriculture holds a place in stabilization of food process .At the same time, it is also to note that peri- urban agriculture is at cross roads. Farmers are torn between the choice of eking out a respectable earning from their land and of seeking employment in cities.

Farming system in Jharkhand (as also in entire eastern plateau region) is predominantly paddy based and most of the land remaining fallow during *rabi* and summers (Singh *et al.* 2019). Lately, with dwindling forests resulting in decreasing harvest of forest produce compounded with increasing cost of living under influence of modern life style in nearby urban areas, the limited income from rice based production system has been found to be incapable of sustaining livelihood of farmers in peri-urban area. Although animal husbandry is an integral part of rural household in Jharkhand, productivity of animal component has been less on account of poor existing technology. Dependence on urban employment is faced with inconsistencies in engagement, loss of time and a part of earning as fare in commuting daily. Other intangible trade-offs include poor care of children, elderly and livestock. The severity of the problem is more pertinent in case of women folk. Womenfolk's commuting to cities on daily basis makes children more vulnerable. Needless to say, they suffer in terms of under-nutrition, poor health care and lack of education in particular.

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The lower existing productivity of agricultural production system in the eastern plateau and hill region is mainly attributed to poor soil fertility as well as non-adoption of improved agricultural technologies by the farming community. Recent research on the eastern fall of the Plateau (Cornish *et al.* 2015) showed that variable yields and periodic failures of transplanted rice are inevitable on medium-uplands because the requirement for ponding is often not met due to climatic abnormalities. Predictions made for eastern India have shown a significant decrease in the number of rainy days and heavy rainfall days, while an increased frequency of heavy rainfall events is predicted to occur at sporadic locations (Guhathakurta *et al.* 2011). Falling productivity of agricultural system along with vulnerability caused by erratic climatic patterns aggravated by diminishing holding size are deterring new generation from taking up as source of livelihood.

Recognizing these negative impacts of climatic aberrations, researchers are focusing on the diversification of cropping systems as an adaption to build resilience into agricultural systems. The changing climate scenario has witnessed frequent occurrences of extreme weather phenomena like cyclones (Eastern coast of Indian peninsula covering Odisha, West Bengal and Andhra Pradesh in 2013, 2018 and 2019), cloud bursts (Uttarakhand in 2013), incessant rains (Chennai in 2015 and Mumbai in 2017), inundation as a result of continuous rains (Patna in 2019) among countless others worldwide. While it is a painful ordeal for all, it is the urban poor who are the worst sufferers. Worldwide studies have shown that urban and peri-urban agriculture may be able to make positive contributions as a local supplier of food to cities and can provide poor households with fresh food (Bhupal *et al.* 2002). Crop diversification has the potential to reduce exposure to climate-related risks and increase the flexibility of farm production to changing climatic conditions (Gebrehiwot *et al.* 2013, Smit & Skinner, 2002). In this context, crop diversification and adoption of appropriate technological options may help in improving the profitability and climatic resilience of periurban agriculture.

Keeping this in view the Farmer FIRST Project is being implemented by ICAR Research Complex for Eastern Region, Farming System Research Centre for Hill and Plateau Region, Ranchi for testing the effectiveness of the technological including crop diversification options in improving the profitability of peri-urban agriculture system. In this paper, the learning on effects of the technological options on livelihood dimensions of different types of peri-urban farm households during the initial two years of the project have been analyzed.

MATERIALS AND METHODS

Profile of experimental villages

Interventions under the project were undertaken in four villages, viz. Malti, Tetri, Kutiyatu and Pindarkom belonging to Khijri block of Ranchi district, located at distances of 22 to 25 km from Ranchi city of Jharkhand. Four villages consist a total of 955 household in which scheduled caste and scheduled tribe families constitute 63.4% of the total population. The villages represent the typical agro-ecological conditions of eastern plateau and hill region. Out of the total geographical area of 1246.68 ha, 45.25% is cultivated of which only 13.8% is under irrigation. The topography is undulating with nearly 50% coming under uplands. The area is situated at an altitude of 660 m consisting of a series of elevated areas with drainage lines and low-lying areas near streams, collectively classified as lowlands, where paddy is traditionally cultivated. Although some crops span across the seasons, major seasons comprise the summer (March to May/June), monsoon (June to September/October) and winter (November to February). Warm-season crops are grown in the *kharif* (monsoon) season. Cool season crops (infrequently) are grown in the *rabi* (winter). The average land holding per household is 1.00 ha out of which the share of upland, medium land and low land is 32.6%, 29.5% and 39.1%, respectively. Rice fallow with long duration paddy varieties (135-145 days) was the major cropping system in the medium and low lands while uplands were mainly used for cultivation of vegetables, pulses like blackgram and oil seeds like mustard. Although 51.3% of the uplands were irrigated, the extent of utilization of uplands was only 31.7% as compared to more that 75% in case of the low land and medium lands. Livestock plays important roles in the livelihood of farm families in the villages. Among the animal population in the project villages, the total number of cattle, buffalo, goats and pigs was 806,141, 1080 and 867 respectively. Infestation by ecto- and endo-parasites and inadequate nutrition were found to be the major factors causing lower productivity of the animal production systems.

Research approach

Activities under the project were initiated in May 2018. A series of interaction meetings were held between scientists and farmers to have a better understanding of socio-economic and agro-ecological situations of the villages. Lack of awareness about improved varieties and production technologies of different crops as well as lack of access to the seeds of improved varieties of different crops was understood to be the main reasons for low rate of crop diversification in the villages. The average annual gross income per household was found to be ₹ 1.20 lakh out of which only 62% was from cropping, animal husbandry and fisheries indicating that farmers had to depend heavily on incomes from other sources for their livelihood (Fig 1).

As per the views of the farmers, the income from cropping, animal husbandry and fisheries was not sufficient to meet the requirement of the family and hence they have to depend on (which forced them to look for) other sources of income. It was interesting to note that farmers assume that cultivating anything with help of available ground water will not be economically viable and therefore, although ground water is available throughout the year in most of the villages, they do not deem it economically feasible to invest in water

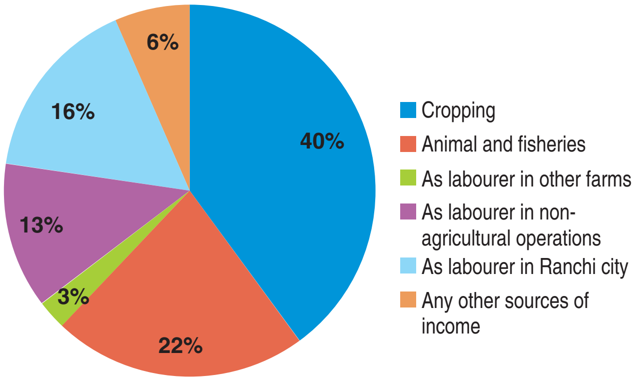

Fig 1 Contribution of different sources of income of the farmers in project villages

pumps. Since, they do not go for cultivating their lands, it is an agreed practice to unleash their livestock for open grazing. Open grazing of animals has some undesirable fall outs which includes loss of cow dung that could otherwise be harnessed as manure. In soils deficient in organic matter, this practice needs to be stopped immediately. Poor organic matter content of soil in turn leads to poor water holding capacity and poor fertility.

As per the discussion with the farm families of the villages, it was decided to test the effectiveness of different technological options in increasing the overall profitability of agricultural production system in a participatory mode. The details of technological options tested along with their rationale are given below.

Performance evaluation of technological options

For testing the performance of the technologies, data were recorded on yield, net income from all the participants and B:C (benefit cost ratio) values of the technologies were calculated. For assessment of the change in the agri-economic condition of the farmers due to the technological interventions, data were recorded from 92 sampled farmers at the beginning of the activities and after the harvesting of rainy season crops of 2019. Principal component analysis of data on pattern of land holding, land use, contribution of income from different components of farming system to the total income of the sampled farmers was undertaken to classify the farmers in to different typologies. The change in the agri-economic condition of the farmers due to the technological interventions was assessed in different typologies of farmers identified. For assessing diversification status in the existing cropping systems, value of Simpson's index was calculated using the following formula;

$$\text{Simpson's index} = 1- \sum(n_i/N)^2$$

where, n= Area under a particular crop, N= Total area of the farmer.

Table 1 Major technological options tested in the project villages

Technological options	Rationale	Total no. of farmers during 2018-19 and 2018-20
Direct seeded rice	For ensuring timely sowing under delayed rainfall scenario and ensuring early harvest in order to go for taking crops in succession of rice in lowlands	188
Rice fallow management with cultivation of wheat, chickpea, mustard and vegetables	For increasing cropping intensity and increasing overall income from rice fallow areas	210
Cultivation of leguminous crops	For crop diversification in uplands and increasing proteins in diet consumption of pulses	20
Rainy season cultivation of solanaceous vegetables	For crop diversification in uplands and increasing consumption	72
Drip irrigation in vegetables	For improving water use efficiency of vegetable production, reducing expenditure on irrigation	20
High density orcharding in papaya and guava	For crop diversification in uplands and increasing consumption	32
Ecto- and Endo-parasite control	For improving health and overall productivity of animals	443
Area-specific (chelated) mineral mixture	For improving health and overall productivity of animals	900
Introduction of superior black Bengal breeding bucks	For improving genetic potential of existing goat population	18
Introduction of T×D breeding boar of pig	For improving genetic potential of existing pig population	6
Upgraded mixed carp culture	For increasing the productivity of ponds	4
Mushroom cultivation	For additional income to women members of farm household, development of entrepreneurship	356
Integrated farming system	Diversified income and household food and nutritional security, augmenting the overall productivity of the system, efficient resource use	3

RESULTS AND DISCUSSION

In order to identify the broad farmer typologies and the key agri-economical parameters contributing towards the classification of the farmer typologies Principal Component Analysis was undertaken at the beginning of the project. The results of principal component analysis based on 47 parameters contributing to household income at the beginning of the project indicated principal components with eigen values more than 2.5 contributing 65.44% of total variation. PC1 contributed 24.26% of total variance with high loading values for the following parameters;

1. Total income from cropping
2. Total agricultural income
3. Total area under cereals
4. Per cent contribution of agricultural income to total household income
5. Total holding under low land

PC2 contributed 12.4% of total variance with high loading values for the following parameters;

1. Per cent contribution from animal husbandry to total income
2. Total income from animal and fisheries
3. Per cent income from uplands
4. Per cent of total area under vegetables
5. Per cent area under irrigation

The Bi-plot was plotted between PC1 and PC2 to compare the farm typologies and to identify the farmer typology groups. The farm households could be classified into five broad typologies (Fig 2) which are as follows;

Group 1: Marginal farmers and landless labourers
Group 2: Cereal dominated small farmers
Group 3: IFS based small farmers
Group 4: Livestock based marginal farmers
Group 5: Cereal based medium farmers

The details of land holding pattern and contribution of different sources of income at the beginning of the project is given in Table 1. Highest proportion of farm household consisted of marginal farmers (49.6%). Two groups of marginal farmers also represented the lowest income groups. Marginal farmers and landless labourers constituted 25.6% of the total population and earn on an average merely Rs 0.80 lakh per year followed by livestock based marginal farmers constituting 14% of total population earning Rs 1.12 lakh per annum. Small farmers (with average holding size of 3 acres) practicing integrated farming earn 27.74 % of their income from animal husbandry and fisheries which is next only to livestock based marginal farmers (35.47%). It is worth mentioning that it is the group comprising small

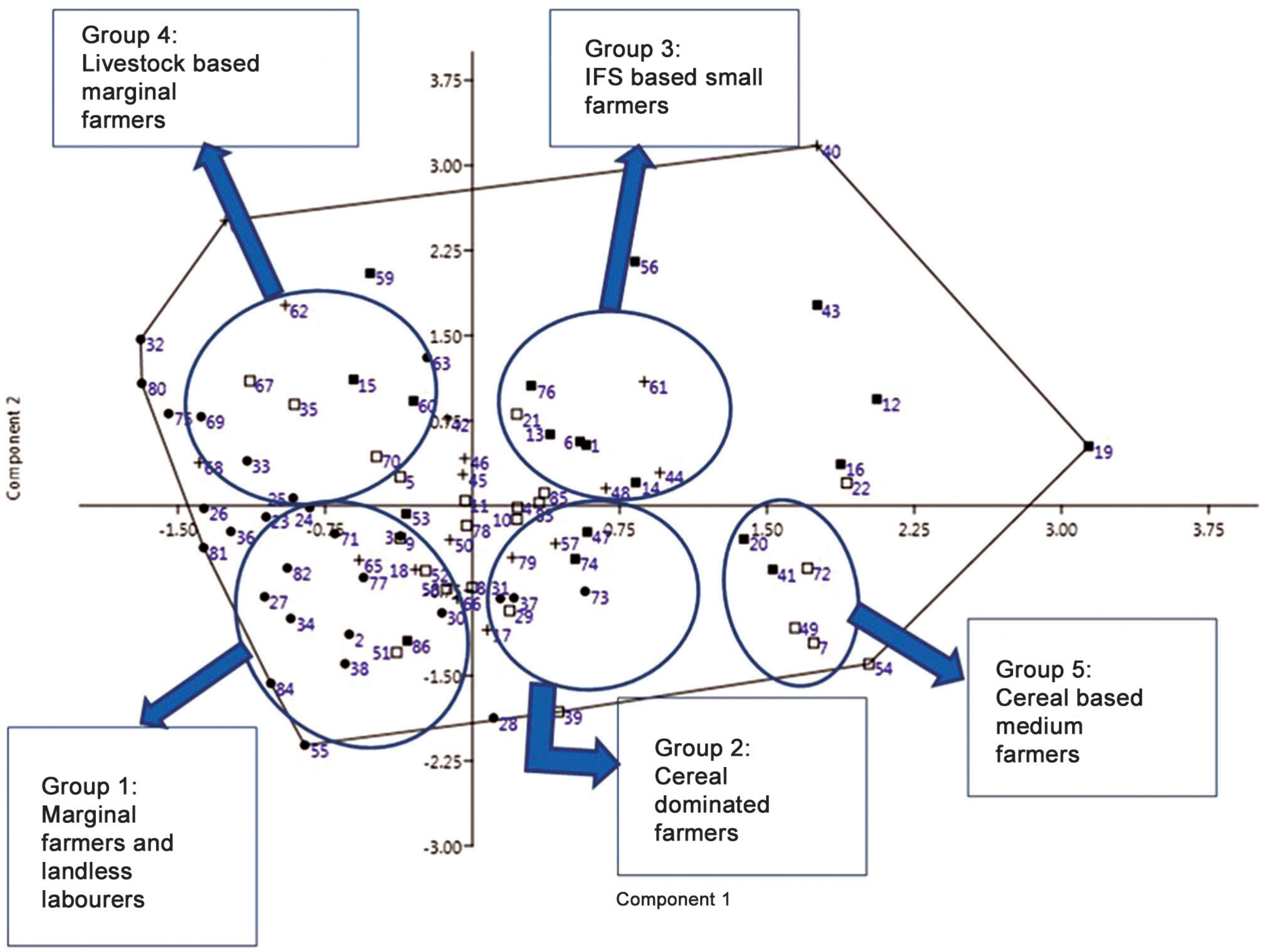

Fig 2 Clustering of farmer typologies in participating villages

farmers practicing integrated farming who earn the highest proportion of their income from agriculture (78.43%) alongside medium farmers (with an average holding of 5.03 acres) who earn 79.43% of their income from agriculture. Marginal farmers and landless labourers earn only 21.18% of their income from agriculture and their major share of income comes from non-agricultural sources which includes urban employment, agricultural labour in the village and non-agricultural labour in the villages.

In those agrarian societies which largely subsists on farming and are frequently subject to vagaries of climate uncertainties, crop diversification can play an important role in ensuring guarantee against crop failures and also in maximizing income without much risk. Moreover, making choices from available options is entirely in farmers' purview. Simpson's index is a measure of crop diversification, a higher value being an indication of higher diversification of cropping system. The maximum Simpson's index was recorded in case of animal based farming marginal farmers (0.59) followed by IFS based farming systems (0.43). It was the lowest in case of medium farmers with cereal based cropping system. A relatively higher value of Simpson's index in case of farmers practicing integrated farming reflects their appreciation for crop diversification made it easy for the scientists to test the technological interventions in their fields.

The performances of major technological options in the farmers' fields have been summarized below in Table 2. Results of two years of experimentation indicated promising technological options which have the potential for ensuring sustained increase the income of the peri-urban farming systems. Technologies like rainy season cultivation of solanaceous vegetables was found to have large scale acceptance among the farmers due to the higher yield as well as the ease in the marketing of the perishable vegetables in the nearby urban and sub-urban markets even during the rainy days. Similarly, provision of fencing was found to be a boon to the farmers for utilization of the vast tracts of rice fallow area for cultivation of crops like wheat, chick pea and other *rabi* and summer season vegetables. Management of ecto- and endo parasite in the animals and supplementation of area specific mineral mixture was found to have the potential for increasing the economic contribution from animal husbandry. Cultivation of oyster mushroom was found to be very effective for ensuring substantial additional income to the farm household particularly to the farm women.

While the work aimed primarily at crop diversification with particular emphasis on addition of more of vegetable crops into the cropping system, bringing as much of uplands into cultivation as possible and augmenting the share of income from animal husbandry in total income, the study brought out certain observations starkly. There was an increase in income of all typologies of farmers with a maximum increase in case of small farmers practicing integrated farming and minimum increase in case of marginal farmers and landless labourers. There was a drop in share of income from uplands in case of small farmers practicing integrated farming. This happened on account of sharp rise in income of this group from crops grown in rice fallows and diversification in vegetable crops including mushroom. There was an increase in income from vegetable crops in case of all five typologies. The minimum per cent increase in total household income was seen in marginal farmers and landless labourers. Notably, income from non-farm sources saw a decrease in all five typologies. Mushroom cultivation showed potential to be adopted by this group. However, engagement of these farmers in urban employment and non-availability of paddy straw with them were major hindrances. Making them take to mushroom farming may require sustained handholding. Cereal based medium farmers showed rather less appreciation for diversification and also showed lesser felt need for changing to other crop options. In order to increase their household income they need to be encouraged for increasing cropping intensity in rice fallows. It was observed that this group recorded the highest income from mushroom cultivation. This can be attributed to availability of paddy straw in

Table 2 Land holding pattern and contribution of different sources of income of farmer groups at the beginning of the project

Farmer group	% of total no.	Land holding pattern (Acres)				Gross annual income (₹ in lakh)	% Contribution of different sources of income			Simpson index for crop diversification
		Up land	Low land	Total area	Total area under cereals		Agricultural income	non-agricultural income	Animal and fishery	
Group 1: Marginal farmers and landless labourers	25.6	0.30	0.50	1.35	0.94	0.80	29.18	70.82	8.61	0.35
Group 2: Cereal dominated small farmers	19.8	0.50	1.00	2.50	2.00	1.22	62.34	37.66	11.78	0.36
Group 3: IFS based small farmers	10.5	1.00	1.00	3.00	2.00	1.82	78.43	21.57	27.74	0.43
Group 4: Livestock based marginal farmers	14.0	0.50	0.15	1.13	0.62	1.12	61.59	38.41	35.47	0.59
Group 5: Cereal based medium farmers	5.8	1.04	2.70	5.08	4.22	1.46	79.43	20.57	8.82	0.33

Table 3 Performance of technological options in farmers' fields

Technology	Performance
Direct seeded Rice cultivation	• Yield range: 0-2.1 t/ha • Average yield: 1.3 t/ha • Crop failure in 27 out of 86 farmers • B: C ratio – 1.14 to 2.36
Crop diversification with Black gram	• Yield range: 0.2 – 0.7 t/ha • Average yield: 0.56 t/ha • B:C ratio – 3.35 • Net income- ₹ 1970 per 500 m^2 area
Rainy season cultivation of brinjal and tomato	• Yield of brinjal variety Swarna Pratibha: 21.2 t/ha to 35 t/ha • Average net income: ₹ 5500 per family • B:C ratio- 2.99 to 3.71 • Yield of tomato variety Swarna Lalima : 184 kg/40 m^2 (46 t/ha) to 260 kg/40 m^2 (65 t/ha) • Average net income: ₹ 16500 per family • B:C ratio: 2.71 to 3.16
Ecto- and endo-parasite control	• Cattle: Reduced 88 % to 22 % • Goats: 72% to 12 % • Pigs: Reduced from 94 % to 8% • Ecto-parasite control: 82 % reduction
Area-specific (chelated) mineral mixture	• Cow: 20% to 50% increase in milk yield (43 animals) with B:C ratio- 7.1 • Goat: Mean daily body wt. gain of 88.12 g (28 no.) as compared to 56.31 g in untreated (22 no.) with B:C ratio-9.17 • Pig: Mean daily body wt gain of 321 g (18 no.) as compared to 246 g in untreated pigs (18 no.) • (B:C ratio- 6.6)
Introduction of superior Black Bengal breeding buck	• Number of bucks provided: 14 • Survival of bucks: 10 no • Till date, in total 81 kids have been born in four villages
Introduction of T×D breeding Boar of Pig	• Number of boars provided: 6 • Average initial body weight: 21.4±4.6 kg • Survival of boars: 5 no • Body weight after 6 months: 53.4±10.1 kg
Upgraded mixed carp culture	• No. of ponds: 4 (0.09 ha) • Harvesting: Last wk of March, 2019 • Weight of fish: 215 g to 560 g • Total harvest: 168 kg • Income: ₹ 33200.
Mushroom cultivation	• Biological efficiency: 68% to 93% • Net income per family: Marginal farmer: ₹ 2699, Small farmers: ₹ 4824 , Medium farmers: ₹ 7538 • B:C ratio: 2.8 to 3.5
Rice fallow management	• > 7 ha area brought under the cultivation • Wheat - Yield: 1.4 t/ha to 1.9 t/ha (B:C ratio: 1.31-1.59) • Mustard- Yield: 0.57 to 0.70 t/ha (B:C ratio: 2.38-2.63) • Garden pea- Yield: 9.8 to 12.4 t/ha (B:C ratio: 3.53 – 5.21)
Vegetable cultivation with drip irrigation and mulching	• Average yield: Brinjal - 950 kg and tomato -1600 kg per 500 m^2 • Average income per family: ₹ 23900
Integrated farming system	• Paddy: Area- 5.5 acres; income- ₹ 32000 • Vegetables: Area- 0.16 acre; income- ₹ 22800 • Animal husbandry: Numbers- Buffalo- 3, goat- 15, poultry – 35; income- ₹ 36500 • Total income per annum: ₹ 91300

Table 4 Effect of technological intervention on agro-economical profile of farmer typologies

Farmer typologies	Total income from vegetables (₹ in lakh/family)		% income from uplands		Income from mushroom cultivation (₹/family)	Total household income (₹)		% contribution of animal husbandry to total income		% contribution of non farm income to total income		% contribution of cropping to total income	
	Before trial	After trial	Before trial	After trial		Before trial	After trial	Before trial	After trial	Before trial	After trial	Before trial	After trial
1	0.10	0.15	38.56	42.86	7680.00	0.83	0.98	5.89	5.55	67.03	58.40	27.08	33.89
2	0.16	0.25	35.97	35.53	9280.00	1.14	1.43	10.88	10.44	42.53	34.83	46.59	52.21
3	0.41	0.55	54.40	43.85	6000.00	1.48	2.25	22.62	20.65	21.02	13.54	56.36	65.23
4	0.11	0.32	49.39	54.22	4400.00	0.95	1.34	29.32	27.91	43.71	31.74	26.97	39.43
5	0.24	0.27	32.65	30.08	11200.00	1.40	1.68	5.01	4.96	20.56	17.34	74.43	74.10

ample quantity and infrastructure for initiating mushroom farming.

Many researchers (Gurr *et al.* 2003, Krupinsky *et al.* 2002, Lin 2011) have stressed on crop diversification as a better management strategy to avert or escape the adversities of climate and is a high priority adaptation measure in both irrigated and non-irrigated areas. Under the similar agro-ecological conditions, Singh *et al.* (2019) have demonstrated increased income levels and improved understanding on better options that lead to climate proofing of agriculture in the eastern plateau region. Increased income enhanced the capacity of the farmers to cope up with the adversities in climate by enabling dynamic adoption of practices to such changes. While, it may take longer experimentation to identify a strategy for imparting resilience to the existing agriculture production system, from the study conducted so far, it can be concluded that crop diversification and application of typology based appropriate combination of technological options will be capable to make the farmers able to cater to the demand of nearby cities and to ensure an income level lucrative enough to do away with the need to trade off the convenience of working on one's own farm and discharging multiple familial and social responsibilities with ease.

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