Research Article

Indian Journal of Extension Education
Vol. 58, No. 1 (January–March), 2022, (125-129)

ISSN 0537-1996 (Print)
ISSN 2454-552X (Online)

Understanding Farm Diversity through Typology for Technological Interventions in Western Plain Zone of Uttar Pradesh, India

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ARTICLE INFO

Keywords: Clustering, Diversification, Farm income, Farm typology

http://doi.org/10.48165/IJEE.2022.58128

ABSTRACT

The farming systems having diverse characteristics need to be understand for tailored technological interventions. Farm typology designates the heterogeneous farmers' characteristics in to homogenous groups to understand the factual situation in the region. The multivariate analysis viz. PCA and Cluster analysis performed to minimize data and group them into homogenous characteristics by various farm variables. A cross section survey of 120 farmers in WPZ of Uttar Pradesh was carried out and identified 9 significant variables and generated 4 PCs from PCA. Hierarchical clustering of PCs leads to grouping farms into homogenous class. The predominant farm types based are type-1 (22.5%) livestock based intensive farms, type-2 (23.3%) are resource endowed large farms, type-3 (10.8%) are crop based marginal farms and type-4 (43.3%) are small farmers with high profit margin. Large farms are integrated with crop and animal components earning higher income. The results show that the diversified farms with both livestock and crop sectors are reaping better income and technology adoption capacities.

INTRODUCTION

The farming community in India characterised with scarce resource endowment, technology use and market access. Dependence of these farmers on monsoon makes it to jiggle with lot of risks and uncertainties. Uncertain climatic situations like cloud burst, drought, flood, cyclone etc., lead to huge economic losses to farmers in the form of yield curtailment. These risks can be minimised through mitigation strategies by technology development and dissemination at farm level. Therefore, existing complex system must be understood to develop technologies to minimise the risk and uncertainty. To identification and characterization of existing heterogeneous farm systems is of utmost importance for transfer of technology. To plan the resource endowment for economic benefit, farm families develop different livelihood strategies driven by the opportunities and constraints derived from such diversity. The technology development need slump-sum amount of investment in research and development (R&D) by both public and private sectors to accelerate the economic growth. All the technologies developed in the lab conditions may not perform well at field sometimes, it need to be diagnosed with involvement of respective stakeholders in development of technology through participatory approach to identify the potential technologies. There are technologies with great potential, but are not adopted because of the complexity and heterogeneity of the farm households is not addressed properly by these technologies. As "one size fits all" policy doesn't work in agriculture, particular farmers may need specific technologies as solutions.

The farm typologies are an attempt to capture farming systems heterogeneity and are considered as a useful tool for identifying need-based technology transfer for improving farm performance and rural livelihoods. Moreover, typology studies are of paramount importance for understanding the factors explains the adoption and/or rejection of new technologies. Classification based on structural and functional characters are on the basis of the factors to which the diversity is attributed. The structural typology focuses on

Received 01-11-2021; Accepted 07-12-2021

production side parameters such as land, livestock or labour; whereas the functional typology is based on livelihood orientations and decisions of farmers. In farm or farmer typology studies, classification is based on multiple variables, with the selection of the variables based on the objective and locale of the study (Shukla et al., 2019). However, economic factors have been in limited use, especially in small-scale studies, for farm classification (Briggeman et al., 2007). Different approaches can be used for developing farm typologies, from participatory workshops to statistical multivariate analysis of data for typologies construction (Alvarez et al., 2018; Chatterjee et al., 2015).

Based on the insights gained from farm typology we used a conceptual framework of Alvarez et al., (2014) for capturing drivers of farming in the Western Plain Zone (WPZ) of Uttar Pradesh.

METHODOLOGY

The study was undertaken in six villages viz., Tisang, Maphoda, Meerapurdalpat, Rasulpur Jatan, Chandpur and Dinkarpur of Muzaffarnagar district popularly known as sugar bowl of India, where villages were selected randomly in two blocks.

A multistage random sampling method was followed for selecting 120 farmers in the district. In each village 20 farmers were selected randomly totaling 120. A survey was done with a focus on socio-economic and ecological information particularly with farm income from different crops and animal husbandry (Landais, 1998).

The structure of the typology construction framework was adopted from Alvarez et al., (2014) which comprises six steps to go from a heterogeneous population of farms to the grouping into similar farm types. The variables represent factors of farming systems which influence the farmers' decision making in the matter of inputs and outputs (Alary et al., 2002). The key variables used in multivariate statistics should have variability in the data. Keeping this concern in mind we checked the correlation among the variables and dropped the variables which are highly correlated with each other and also having near zero or zero variance. Analysis was carried out using R studio software. The multivariate analysis was done to estimate the classification and grouping of farmers into homogenous groups, at first Principal Component Analysis (PCA) was evaluated using the identified variables. After generating respective PCs the variables are grouped using Cluster analysis with Ward's method of clustering.

RESULTS AND DISCUSSION

The basic characteristics of the farmers are presented in the Table 1. 50 per cent of the farmers were small land holding category remaining 35 per cent were marginal and rest 15 per cent large farmers. The mean age of farmer was 52 years, family size was in proportional to land holding (Singh, 1985), having 8 members per family in large holding and 5-6 members in small and marginal categories. Average land holding with marginal, small and large farmers were 0.71 ha, 1.46 ha and 3.24 ha, respectively. The cost and returns of the farm categories for both crop and livestock is presented in Table 2. The small farmers are more efficient than remaining farmers (Agarwal, 2018) with B:C ratio of 2.95. Small farmer's' crop component was earned higher income as compared to marginal farmers whom livestock was more income contributing component.

Table 1. Characteristics of samples across the farm categories

Farmer category	Marginal	Small	Large	Over all
Number	42(35.0)	60(50.0)	18(15.0)	120(100.0)
Age (years)	50.04	52.85	58.27	52.68
Family size (no.)	5.64	6.46	8.16	6.44
Mean area (ha)	0.71	1.46	3.24	1.8

*Figures in parenthesis indicates percent share

Table 2. Average cost and returns of crop and livestock systems

Category of farmer	Income from livestock (Rs)	Total crop income (Rs)	Total cost of production (farming system) (Rs)	B:C ratio of cropping system
Marginal farmer	53745	194542	93517	2.08
Small farmer	56785	350132	118718	2.95
Large farmer	96085	399838	179827	2.22
Over all	61616	303131	119064	2.55

Initially there were 21 variables considered for the classification before reducing it to meaningful normally distributed variables (Table 3). The mean family members were 6 which provided opportunity for depend more on family labours for farm operations. Small farmers were producing efficient milk yield than the rest with 1875 litre/year/animal leaving behind marginal and large farmers. The per hectare basis labour requirement was lower in large farmers but higher in marginal farmers. Marginal farmers employed 84 labours/ha which was much higher than other categories of farmers. Net profit from crop component of small farmers was more than that of large farmers with Rs. 231414 and Rs. 220011. Profit margin of small farmers was 60 per cent when compared with marginal and large i.e. 41 per cent and 46 per cent, respectively. Marginal farmers were having more cropping intensity (158%) than small and large farmers, whereas large farmers have only 97 per cent cropping intensity. Area under cultivation was higher for cash crop i.e. sugarcane (69%) followed by wheat (30%). Meagre area under paddy and fodder crops cultivation, as the enough water resource available farmers choose sugarcane-ratoon-wheat cultivation. Mechanization for land preparation and harvesting used in the region was 9.5 hr/year, where large farmers (17.5 hr/year) machine use was twice as that of small farmers (9 hr/year).

Histogram of all the variables are verified for normal distribution and correlation among the variables were estimated to selected variables which are devoid of multicollinearity. The correlation matrix shows that the most of the variables considered for the study are not linearly correlated to each other except some. Those correlated variables were dropped along with variables not normally distributed, finally considered only 9 variables for the study purpose out of 21 variables.

After finalizing the variables, PCA was executed to identify the principal components (PCs) and their rotated component matrix. The KMO test shows the significance resulting in the data adequacy. The results are provided in the Figure 1 shows the 4 PCs with eigen value >1 generated with variance explaining 74 per cent of the data using varimax rotation. The first PC constitutes of factors related to crop cultivation, second PC can be classified as labours category, and third component shows the variables related to animal husbandry.

Table 3. Variables considered under different farm categories

	All farmers		Marginal		Small		Large	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total area (ha)	1.8	0.9	0.7	0.2	1.5	0.3	3.2	1.1
Family member (no.)	6.4	3.0	5.6	2.4	6.5	3.1	8.2	3.4
TLU	2.7	1.8	2.0	1.6	2.3	1.4	2.7	1.8
Milk total (liters)	1804.4	672.8	1693	805.0	1875.7	539.3	1825.6	699.7
Labour total off farm (no.)	76.5	44.3	50.3	34.2	84.1	39.3	123.1	42.1
Labour (no/ha)	64.5	48.1	84.7	69.8	58.2	25.6	38.6	10.7
Labour (no./HH)	78.6	44.8	51.7	34.1	84.1	39.8	123	42.09
Crop revenue (Rs.)	303131.5	151117.4	194542.1	93514.2	406917.4	143068.0	399838.3	149643.8
Crop profit (Rs.)	184067.5	138541.4	101024.9	79721.9	231414.0	129227.5	220011.8	180575.3
Profit (Rs/ha)	134127.6	117620.8	125791.2	158931.9	159605.0	83483.5	68654.6	58722.5
Profit margin (%)	51.0	44.1	41.6	56.9	59.0	28.7	46.0	46.7
Revenue by crop (%)	81.7	14.7	77.8	17.9	84.6	11.3	81.3	13.9
Crops cultivated (no)	4.4	1.1	4.0	1.1	4.4	0.9	5.3	0.8
Cropping intensity (%)	136.1	61.0	158.7	98.7	120.7	37.5	97.6	35.2
Age of HH head (years)	52.7	11.3	50.0	11.4	52.9	10.4	58.3	12.1
Cost of production (%)	49.0	44.1	58.4	56.9	41.0	28.7	54.0	46.7
Mechanization (%)	9.5	6.1	6.5	3.7	9.2	3.9	17.3	9.1
Milch animals (%)	80.1	72.9	60.1	52.1	88.5	72.1	100.0	99.5
Total cows (no.)	2.2	1.6	2.0	1.6	2.3	1.4	2.7	1.8
Improve breed cow (%)	59.5	78.1	43.3	41.5	61.1	40.5	52.3	36.8
Revenue by milk (%)	18.3	14.7	22.2	17.9	15.4	11.3	18.7	13.9

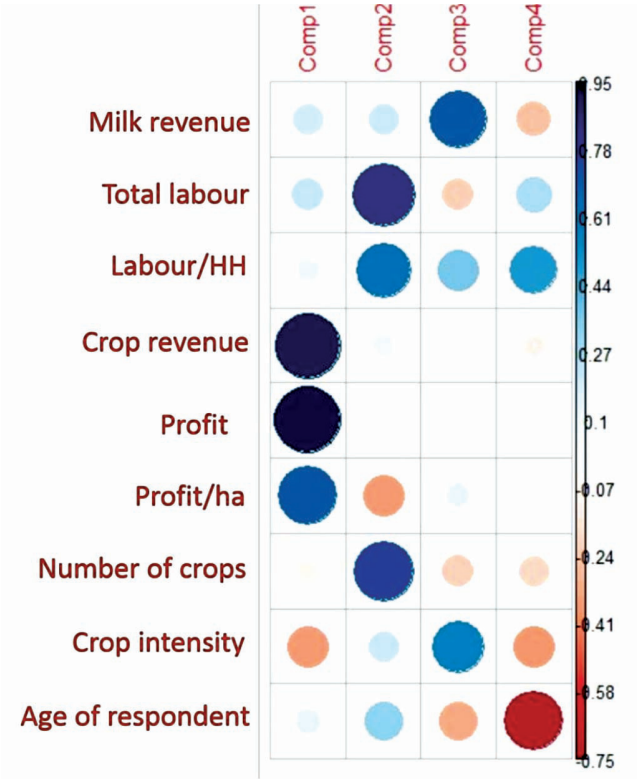

Figure 1. Rotated component matrix of principle components

After generating PCs, we forwarded to make clustering the farmers in to homogeneous groups using Hierarchical clustering. The cluster dendrogram in Figure 2 classifies the observations in to 4 homogeneous clusters. After the detailed study of cluster, the following four types of farms have been classified indicating the scope for identifying technologies suitable for each farm type to adoption against risk. Clustering of farms shows that large number of small farmers was in type-4 (47) and type-1 (20) group. Type-3 having only small farmers with meagre farm income at subsistence level. Medium and large farmers were in type-2 group with enough resource endowment for livelihood.

Each farm type with different parameters given in the Table 4 is discussed below in detail.

Type-1: (Highly intensive livestock-based farms) (22.5%): These farms are having higher cropping intensity (188%) with highest milk production. Study showed that the Farmers with small land holding earns lower profit per hectare as their profit margin was significantly lower (7.22%). This makes them vulnerable to investment for technology adoption due to financial constraints. **Type -2** (Resource endowed large farms) (23.3%): These farms were characterized with large land holding along with high use of labour and mechanization. These farms were financially stable with huge profit/ha and major revenue was from crop sector, indicating the potential to adopt the high cost technologies for more intensification at farm level evidence in line with Patra et al., (2018) Choudhary et al., (2017). **Type-3** (Crop based marginal farms) (10.8%): These farms have land holding <1 ha with major revenue from crop sector and vary less income from livestock. The efficient labour use resulting in more profit/ha and moderately intensive farms. Farms are less mechanised due to lower financial resources (Sarkar, 2020). **Type-4 (**Profitized small farms) (43.3%): Farms with small land holding are earning revenue both from livestock and crop sectors supported by Priscilla et al., (2021). The profit/ha was higher compared to other farms as they utilized very less labours among all. These profit earnings show the potential to adopt cost intensive technologies and can have efficient operations.

CONCLUSION

The result from multivariate analysis shows that there exist four groups of farms in the selected study area, elucidation of characteristics by considering several variables which influence the

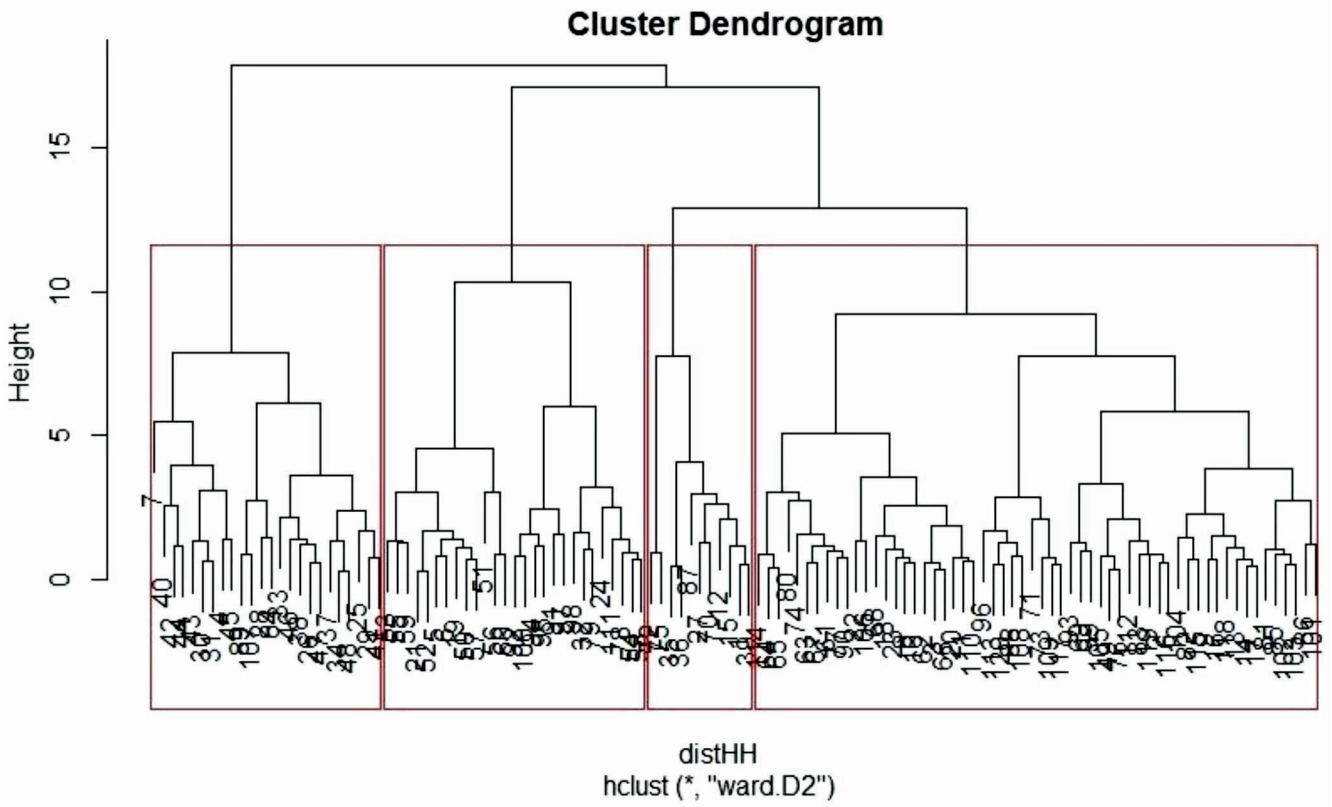

Figure 2. Hierarchical clustering of the observations

Table 4. Characteristics of identified farm types and p-value of Kruskal–Wallis test

Variables	Type-1 (N=27)	Type-2 (N=28)	Type-3 (N=13)	Type-4 (N=52)	p value
Total area (ha)	1.27	2.23	1.01	1.28	0.00
Family member (no.)	6.41	6.36	5.15	6.42	0.29
TLU	2.89	2.14	1.54	2.87	0.00
Total milk (liters)	2078	1772	751.5	1943	0.00
Total off farm labour (no.)	85.37	117.7	60.38	53.83	0.00
Labour/ha (no.)	93.92	63.00	60.76	50.87	0.00
Labour/HH (no.)	58.13	57.46	41.56	30.83	0.00
Crop revenue (Rs)	189926	408710	169213	338541	0.00
Crop profit (Rs)	50500	287978	83372	222641	0.00
Profit/ha (Rs)	30966	162913	94725	182042	0.00
Profit margin (%)	7.22	69.29	46.71	64.92	0.00
Revenue by crop (%)	69.37	88.32	88.69	82.85	0.00
Crop intensity (%)	188.1	113.5	113.7	126.8	0.00
Cost of production (%)	92.78	30.71	53.29	35.08	0.00
Mechanization (hrs)	9.22	13.39	7.38	8.00	0.03

farming. Around 65 per cent of sampled farmers classified under two farm categories i.e. profit oriented small farms and resource endowed large farms. Type-1 are highly intensive livestock-based farms, they are more dependent on livestock for their revenue as enough green fodder availability in the region makes them more oriented to livestock. Very small number of farmers classified under crop based marginal farms, mainly depends on crop sector with less profit and less mechanization, having lower potential for cost intensive technology adoption. The results clarify that the diversified farms with both livestock and crop sectors were reaping better income and technology adoption capacities. This classification asks for differentiated farm planning and extension intervention to outreach technologies on need based. With vast extension system involving ICAR, KVKs, SAU and line departments of state can construct typology at its regional level and can identify the specific farm types and can arrange for need based technological intervention at farm levels.

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