



Potential of livestock production systems: Explaining employability and milk productivity through multivariate typology

SANTOSH S PATHADE¹, B P SINGH^{1✉}, MAHESH CHANDER¹, D BARDHAN¹, MED RAM VERMA¹
 and Y P SINGH¹

ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh 243 122 India

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ABSTRACT

A study was conducted in four different agro-climatic zones of Maharashtra state in India. The typology was developed with an aim to identify livestock production system, employment generation, and milk productivity of livestock production system. Multivariate statistical technique, i.e. Cluster analysis (CA) was used to classify groups of farm households with similar farm characteristics into four homogenous clusters, viz. households possessing small landholding, a larger high yielding dairy stock with small goat flock size (37.5%); small landholding with a small stock of high yielding dairy animal and small goat flock size (39%); large landholding with large high yielding dairy stock and small flock size (13.5%); small landholding with small high yielding dairy stock and large flock size (10%). It was observed that 47.5% of the respondents had dairy and 31.3% had a goat production system. The total man-days generated for family labour were high (165.87) for cluster 2 households while, for hired labour, man-days generated were high for cluster 4 households. Milk yield index was significantly high for cluster 3 and cluster 1 households. Spearman correlation revealed that independent variables, viz. total SAU, flock size, income from dairy and goat production system positively correlated with milk productivity, employment generation (man-days) and gross annual income. Multiple regression analysis revealed that the integration of dairy and goat farming along with technology adoption significantly influenced the employment generation of small landholders.

Keywords: Dairy, Goat production system, Man-days, Milk yield index, Multivariate typology

Potential of livestock production system depends upon the generation of annual income, employment and productivity of the milch animal. Livestock production system in Maharashtra state of India is mainly a small farm holder phenomenon, however livestock, having multiple uses, are reared mostly under traditional and subsistence management practices, and provide a source of direct and regular cash inflow (Singh *et al.* 2021). The landless and small landholders depend upon livestock for their earnings and income during the lean agricultural season. It employs 8.8% of total agricultural force and more than three fourths of labour demand in livestock production is met by women. Milk is the main output of livestock sector accounting for 66.7% of the total value of the output of livestock (Anonymous 2019-20). A number of studies on employment, income and productivity of livestock systems have been carried out (Singh and Chauhan 2015, Bayan and Dutta 2018, Satashia *et al.* 2021) in different agro-climatic zones of India. However, scant research attention has been given to identification of typical farm households based on socio-economic criteria, herd size and flock size and examining how employment and productivity

of farm animals vary across these households. In this context, present study was carried out with the objective of identification and description of different livestock production system based on socio-economic criteria using typology study followed by assessment of potential of livestock production system (Dairy+Goat) in terms of employment and milk productivity across different clusters and to study factors influencing employment generation across the whole clusters.

MATERIALS AND METHODS

Sampling and data: Multistage purposive and stratified random sampling was followed in the selection of agro-climatic zones, districts, blocks, the cluster of villages and respondents for the study. Four agro-climatic zones (Scarcity zone, Assured rainfall zone, Moderate rainfall zone, and Eastern Vidarbha zone) of Maharashtra state were selected purposively having familiarity, accessibility and to provide better representation of livestock, highest and lowest productive zone, besides two other zones at equidistant places were selected. Further, two districts from each zone were selected purposively having 50% and more coverage area in a particular zone. From each of the districts, two blocks were selected randomly and a cluster of two villages was selected purposively based on the population of livestock (dairy and goat). Further,

Present address: ¹ICAR-Indian Veterinary Research Institute, Izatnagar, Uttar Pradesh. ✉Corresponding author email: bpsinghextivri@gmail.com

from the purposively selected cluster of two villages, 25 farmers' were selected randomly with equal representation to livestock production system on the basis of possession of minimum 2 adult animals (dairy, goat). Thus, a total of 400 farmers' were included in the study from 8 districts.

The data were collected through personal interview method with the help of well structured, comprehensive and pre-tested interview schedule (Baral and Bardhan 2016). Data were collected on parameters like demographic particulars of households, employment of family and hired labours in hours per day separately for each livestock farming activity and milk production parameters for dairy cattle and lactating goat flock.

Multivariate typology of farm households: Typology constitutes essential steps in the realization of any opportunities and constraints existing within the farm households. For this purpose, typology described by Bidegeza *et al.* (2009) and Baral and Bardhan (2016) were used. Farm household typologies were constructed by using multivariate statistical techniques, i.e. Cluster analysis (CA) using SPSS 20 Software. A hierarchical cluster analysis using wards method and Euclidean distance was carried out to classify the farm households using the variables represented in Table 1.

Table 1. Variables considered for construction of cluster analysis

Variable	Description
Landholding	In acres
Number of crossbred animals owned	Measured in SAU
Number of buffaloes owned	Measured in SAU
Number of indigenous cattle owned	Measured in SAU
Number of goats owned	Flock size

SAU, Standard Animal Units; Source: Patel *et al.* (1988).

Employment: It referred to the overall employment of the family members including husband, wife, son, and daughter in dairy and goat enterprises and was measured in terms of hours per day (duration). Family and hired labour were scored out and calculated for dairy cattle and goat enterprises simultaneously. The employment generated in hours was converted into man-days for each cluster taking into consideration prevalent wage rates in the study area. In the case of dairy enterprise also, the conversion coefficient of male: female was kept 1:1. One man-day consisted of 8 working hours for cost computations (Joshi *et al.* 2019). The employment generation in hours/day and man-days were calculated separately for each cluster along with mean and standard error.

Productivity of milch animals: For calculating the milk production index of the milch animals for a particular household, the formula recommended by Yang (1980) was used. The average yield of milch animal of the particular region was determined and the average yield per animal on the particular household was divided by the average milk yield of an individual animal in the region, which was then multiplied by 100, giving the milk index for the individual

animal. The milk yield index was calculated separately for each cluster to compare productivity across the whole clusters. Standard Animal Units (SAU) of the bovine stock were derived for each farm household as per specification given by Patel *et al.* (1988). The standard animal unit was derived to standardize output of different farms with different species of dairy animals.

Factors affecting employment (Man-days): A multiple regression equation as given below was fitted to identify the factors significantly influencing employment generation in dairy and goat production system (man-days).

$$P = f (X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10}, X_{11}, C_1, C_2, C_3, C_4)$$

where, P, Man-days/household/day; X_1 , Operational landholding in acres; X_2 , Herd size (measured in Standard Animal Unit); X_3 , Flock size in numbers; X_4 , Occupation of the respondents (Agriculture/ Dairy/ Goat farming); X_5 , Knowledge about dairy production technology; X_6 , Knowledge about goat production practices; X_7 , Adoption of technology (adoption index); X_8 , Scientific orientation; X_9 , Education (formal schooling completed in years); X_{10} , Farming experience in years; X_{11} , Family size (number of adult members and young ones); C_1 , Dummy to represent Cluster 1 ($C_1=1$ for small landholding households with larger high yielding dairy animal stock and small goat flock size, 0=otherwise); C_2 , Dummy to represent Cluster 2 ($C_2=1$ for Small landholding households with smaller high yielding dairy animal and small goat flock size, 0=otherwise); C_3 , Dummy to represent Cluster 3 ($C_3=1$ for large landholding households with large high yielding dairy animals stock and small flock size, 0= otherwise); and C_4 , Dummy to represent Cluster 4 ($C_4=1$ for small landholding households with small high yielding dairy animals and large goat flock size, 0=otherwise).

The fitted function was estimated through the OLS technique.

RESULTS AND DISCUSSION

Socio-economic profile: Table 2 lists the socio-economic profile of the respondents belonging to different clusters as identified in typology study. The average age of the households was significantly higher in cluster 1 than the rest of the clusters. This finding is in agreement with the findings of Singh *et al.* (2018) in case of study conducted in Jharkhand state. Education profile of the respondents revealed that majority of the respondents were educated up to middle school, followed by a primary school level. Contrasting findings were reported by Chenyambuga *et al.* (2014) in Tanzania, that most of the respondents had education up to primary level and possess 6.87 acres of land holding. Similar findings were reported by Sone *et al.* (2015) in case of the study conducted in Uttarakhand hills.

Regarding occupation profile, majority of the respondents (38.8%) had dairy+agriculture followed by goat+agriculture as principal occupation across the clusters. Similar findings were reported by Naik *et al.* (2013).

Table 2. Socio-economic profile of respondents belonging to different clusters

Particular	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Overall	F value
<i>Respondents specific characters</i>						
Age (Years)	39.8 ^c (0.78)	38.03 (0.65)	36.57 (0.85)	35.5 ^c (0.88)	38.25 (0.42)	3.87**
Education (Mean±SE)	2.6 (0.13)	1.66 (0.13)	2.88 (0.234)	1.97 (0.22)	2.21 (0.08)	12.09**
Illiterate	11.3	35.9 ^{ab}	13.0	10	17.55	
Primary	16	19.2	13	35	18.8	
Middle school	22.7 ^c	17.3	14.1 ^{ac}	27.5	20.4	
High school	17.3	9.6 ^{ab}	16.7	12.5	13.8	
Higher secondary	15.3 ^c	6.4 ^{ab}	22.2 ^{ac}	5.0 ^c	11.8	
Graduate and above	17.3	11.5	21.0 ^{ac}	10	14.95	
Occupation (Mean±SE)	4.76 (0.17)	4.94 (0.16)	6.18 (0.05)	5.82 (0.18)	5.13 (0.09)	
Dairy	23.3 ^a	0	0	0	8.8	
Goat	1.3	27.6	0	2.5	11.5	
Goat+Agriculture	1.3 ^{ab}	35.9 ^a	0	52.5 ^a	19.8	
Dairy+Agriculture	74 ^a	0	81.5 ^{ab}	0	38.8	
Dairy+Goat+Agriculture	0	32.1	18.5	45	19.5	
Dairy+Goat	0	4.5	0	0	1.8	
Gender (Mean±SE)	0.78 (0.03)	0.80 (0.03)	1.00 (0.00)	0.87 (0.05)	0.83 (0.01)	
Male	78.7 ^c	80.1	100 ^{ab}	87.5	83	
Female	21.3 ^c	19.9	0	12.5 ^a	17	
<i>Household specific characteristics</i>						
Family type (Mean±SE)	0.63 (0.039)	0.64 (0.03)	0.5 (0.06)	0.7 (0.07)	0.63 (0.024)	0.76 ^{NS}
Nuclear	63.3	64.7	55.6	70	63.5	
Joint	36.7	35.3	44.4	30	36.5	
Family size	5.82 ^b (0.16)	5.27 ^{ab} (0.17)	4.81 ^{ac} (0.31)	6.2 ^c (0.38)	5.5 (0.11)	4.9**
Annual income (₹)	88853.83 ^{ab} (5802.1)	103071.46 ^{ab} (5230.14)	4,47,760.60 ^c (34081.1)	2,23,835.46 ^c (15165.0)	156348.56 (8298.5)	152.64**
Dairy income (₹)	59493.8 ^c (5246.0)	16721.1 ^{ab} (2308.39)	94686.52 ^c (8802.01)	14700 ^{ab} (3011.85)	43084.1 (2869.40)	43.34**
Goat income (₹)	620 ^{ac} (474.46)	62734.92 ^c (3404.10)	1592.52 ^{bc} (556.71)	126410.4 ^c (6773.68)	37555.1 (2869.4)	254.33**
Agriculture income (₹)	28740 ^{bc} (2058.7)	23615.3 ^{bc} (1896.86)	351481.4 ^c (32169.8)	82725 ^c (13516.9)	75710 (7207.7)	187.2**
<i>Farm specific characteristics</i>						
Herd size (SAU)	3.90 ^c (0.13)	1.41 ^{ab} (0.18)	6.77 ^c (0.27)	1.348 ^{ac} (0.29)	3.06 (0.13)	116.09**
Flock size	0.18 ^{ac} (0.09)	17.30 ^c (0.38)	1.2 ^{bc} (0.44)	35.77 ^c (1.13)	10.57 (0.611)	1102.5**
Land owned (Acres)	2.50 ^{bc} (0.16)	2.08 ^{bc} (0.14)	8.8 ^c (0.45)	4.25 ^c (0.42)	3.3 (0.15)	132.8**
Housing (Mean±SE)	5.5 (0.19)	4.44 (0.23)	6.44 (0.246)	5.75 (0.27)	5.27 (0.12)	
No house	2.0 ^c	15.4 ^{ab}	0	0	6.8	
Hut	3.3 ^c	16.7 ^{ab}	0	0	7.8	
Kutchha	48.7 ^c	27.6	24.1	21.5 ^b	30.47	
Pukka	17.3 ^c	19.2	37	40 ^b	28.37	
Concret	17.3	12.8	31.5	30	22.9	
Mixed	11.3 ^c	8.3	7.4	8.5	8.8	
Livestock production system (Mean±SE)	1.00 (0.01)	2.36 (0.38)	1.37 (0.10)	2.45 (0.07)	1.73 (0.39)	
Dairy	97.3	0	81.5	0	47.5	
Goat	2.7	63.5	0	55	31.3	
Dairy+goat	0	36.5	18.5	45	21.3	
Farming experience	5.11 ^{ab} (0.21)	2.91 ^c (0.19)	6.72 ^c (0.35)	5.10 ^{bc} (0.22)	4.47 (0.13)	40.31**

*Figures in parenthesis indicate the standard error of corresponding values. *P<0.05, **P<0.01; *Figures having different superscript across clusters are significantly different up to 5% level of significance between them.

The proportion of male households in cluster 1 was significantly lower than cluster 3, while for female households' proportion was significantly high for cluster 1 than cluster 4 which is consistent with the findings of Sone *et al.* (2015) and Baral and Bardhan (2016).

The disaggregated analysis of annual income across whole clusters revealed that income from dairy and goat was significantly different across all four clusters. Bashir *et al.* (2017) reported that the majority of goat farmers had an annual income of ₹10,000-20,000 per annum. Average herd size in terms of the standard animal unit (SAU) per household was significantly high in cluster 3, while flock size was significantly high in cluster 4. Average landholding per household was significantly low in cluster 2 than other clusters. Similar findings were reported by Bidogeza *et al.* (2009) while Sone *et al.* (2015) reported different findings and found average herd size, flock size and landholding as 1.70, 11.58 and 1.01, respectively. Bashir *et al.* (2017) reported that 39.24% of goat farmers had mixed type of house. The profile of respondents across clusters for a livestock production system (LPS) revealed that (47.5%) of the respondents had dairy followed by goat (31.3%) and dairy+goat (21.3%) as major livestock production systems.

Employment generation through livestock production activities across different clusters: The employment generation for each activity was assessed and presented in Table 3. The employment generation was calculated separately for family and hired labour into hours per day and man-days respectively. Data revealed that, most of the duration of the day time was spent on the grazing activity followed by cleaning of shed, feeding, and watering. Singh and Chauhan (2015) studied in Meghalaya that among the different activities, maximum time was utilized in feeding animals (1.30 h) followed by cleaning cattle shed (0.81 h)

and cooking dana (0.73 h). The maximum family labour (6.63 hrs/day) was utilized in cluster 2 households. Further, most of the hired labour utilization (4.5 hrs/day) was done by cluster 4 households. Bayan and Datta (2018) found that farm household with crossbred cattle has 24.77 % higher monthly labour use in Assam.

The total man-days generated for family labour were high (165.87) for Cluster 2 households and Cluster 4 households. While, for hired labour, man-days generated were high for Cluster 4 followed by Cluster 3 households. Similar findings were reported by Singh and Chauhan (2015). Mean and standard error was calculated for each cluster. F value was significant ($P < 0.01$) implying that figures obtained for each cluster differ significantly but not with the same order. Superscripts across different clusters were significant up to 5%.

Milk productivity (Milk yield index) across different clusters: Milk productivity was calculated for each cluster using the milk yield index (Yang) (Table 3). Data revealed that, milk yield index was high (120.20) for Cluster 3 (Rich households with larger yielding stock) followed by Cluster 1 (Poor households with larger high yielding stock). Milk yield index was low in Cluster 2 and Cluster 4 (Households with goat flock size) as productivity of goat was poor than dairy cattle. Mean and standard error were calculated for each cluster.

Spearman correlation between independent variables with milk productivity, employment generation and gross annual income: Data revealed that (Supplementary Table 1) independent variables, viz. education, landholding, total SAU, occupation, farming experience, knowledge about scientific dairy technologies, adoption of technology, income from dairy production and land holding were positively and significantly ($P < 0.01$) correlated with milk productivity. Further, other variables, viz. flock size,

Table 3. Employment generation and milk production index among different clusters

Particulars Activities	Cluster 1		Cluster 2		Cluster 3		Cluster 4		Overall		F value
	FL	HL	FL	HL	FL	HL	FL	HL	FL	HL	
(Hrs/day)											15.78**
Cleaning of shed	0.48	0.29	1.14	0.26	0.39	0.54	1.67	0.43	0.92	0.38	
Chaffing of fodder	0.34	0.25	0.40	0.23	0.15	0.43	0.01	0.175	0.25	0.27	
Feeding and watering the animal	0.49	0.23	2.33	0.22	0.37	0.48	0.71	0.53	0.975	0.36	
Grazing the animal	0.55	1.10	2.73	1.80	0.13	0.31	1.08	3.6	1.12	1.70	
Milking the animal	0.89	0.25	0.83	0.21	0.97	0.65	0.58	0.25	0.81	0.34	
Animal healthcare	0.47	0.12	0.47	0.15	0.44	0.19	0.37	0.09	0.43	0.13	
Input purchase	0.13	0.01	0.15	0.08	0.11	0.0	0.07	0.0	0.11	0.02	
Record keeping	0.17	0.0	0.16	0.0	0.14	0.009	0.74	0.004	0.30	0.003	
Marketing	0.88	0.13	0.52	0.23	0.90	0.23	0.34	0.0	0.66	0.14	
Total (hr/day)	4.34	2.27	6.63	2.45	4.14	2.84	5.04	4.5	6.86	2.41	
Man-Days	100.7	55.84	165.87	61.02	106.82	71.02	130.4	112.88	172.38	60.32	
Mean±SE	(7.41) ^{ab}		(13.28) ^{ab}		(7.91) ^c		(32.89)		(7.18)		
Milk yield index	105.41 ^c (1.73)		75.85 ^{ab} (0.83)		120.20 ^c (3.01)		82.42 ^{ab} (1.27)		93.59 (1.19)		132.94**

*Figures in parenthesis indicate standard error; ** $p < 0.01$; FL, Family labour; HL, Hired labour. Superscripts across different clusters are significant up to the 0.05 level.

income from goat production and knowledge of scientific goat technology practices were significant ($P < 0.01$) and negatively correlated with milk productivity.

Also total SAU, flock size, knowledge of goat technology, income from dairy and income from goat were significantly ($P < 0.01$) and positively correlated with employment generated in man-days. Further, correlation of gross annual income across whole clusters was carried out with independent variables. It was found that except education, other variables, viz. family size, economic motivation and knowledge of goat production practices were significantly ($P < 0.01$) and positively correlated. This is consistent with the findings of Kumar and Tripathi (2016) in Uttar Pradesh.

Multiple regression analysis of the productivity of milk animals and employment generation with a gross annual income: Multiple regression analysis was carried out (Supplementary Table 2). Results revealed that employment generated in (hrs/day and man-days) was significantly ($P < 0.01$) and positively contributing to the gross annual income.

This implies that annual income increases as employment generation from dairy and goat production increases. Further, milk productivity was significantly ($P < 0.01$) and positively contributing to gross annual income. This is evident in this study that for cluster 3 (Households with larger yielding dairy stock) income increases with an increase in milk output.

Multiple regression analysis of independent variables with employment generation (man-days): During the course of multiple regressions, the software calculates the intercept by including a hidden extra variable which is a constant, i.e. 1 for each and every observation in the data set. So as to avoid perfect collinearity in the data set, the software automatically dropped one dummy variable from the data set (Supplementary Table 3). The dummy variable dropped was that of cluster 2, i.e. small dairy farmers with small goat flock size.

Overall factors significantly affecting the employment generation were landholding, total SAU significant at ($P < 0.05$), while flock size and adoption of technology were significant at $P < 0.01$. This implies that the integration of dairy and goat farming along with technology adoption with agriculture will augment employment generation. Bayan and Dutta (2018) reported that adoption of crossbreed enhances employment generation in Assam. None of the three dummy variables, representing different clusters was significant. However, signs and magnitude of regression coefficient provide some implication regarding their extent and direction of influence on employment generation. The magnitude of the coefficient of regression was highest for cluster 4 (Households with large flock size and small dairy stock). This implies that cluster 4 was most profitable in terms of employment generation.

The study concluded that utilization (hrs/day) of family and hired labour and generation of man-days were high in cluster 2 and cluster 4, respectively. Hence, dairy and

goat as an integrated enterprise should be popularised among the small landholders for the generation of more employment. It was found that the milk yield index was high for cluster 3 and 1, respectively. Milk productivity contributes positively to employment and annual income. Therefore, scientific animal health, feeding, breeding, and management practices need to be promoted among the farmers for increasing the productivity of milch animals. Further, landholding, herd size (SAU), flock size and adoption of technology contributed positively with employment generation (man-days). Therefore, dairy and goat farming along with scientific recommended technology should be focussed in livestock policy for the welfare of small landholders. Government policies regarding dairy and goat production system are likely to be more effective if they consider the heterogeneity of farms in the design and delivery of extension approaches and interventions.

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