Research article

DETERMINANTS OF TECHNICAL EFFICIENCY AMONG DAIRY FARMS IN CHITWAN, NEPAL

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ABSTRACT

Nepalese dairy sector has been showing structural changes with adoption of latest technologies like improved breeds, feeds, cultivated fodder and additives. In the context of these changes, this research was conducted to assess the technical efficiency and its determinants among dairy farms. The study was accomplished with primary data collected through face-to-face interview using semi-structured interview schedule from a sample of 240 dairy farms selected randomly using simple random sampling technique from 8 wards of Bharatpur Metropolitan City, Chitwan. Data were analyzed using descriptive statistics, stochastic production frontier and tobit regression model. Technical efficiency was found to be the highest in mix dairy farms (3.530) followed by cow farms (2.56) and buffalo farms (2.138). Labour was the most contributing factor in all three types of dairy farms. This study had shown that average annual income per farm should be Rs. 542000, Rs. 403225 and Rs. 611400 for getting 90% technical efficiency in milk production at buffalo, cow and mix farms, respectively. Similarly, 57% buffalo farms were operating at efficiency of 30-60%, 46% cow farms were operating at efficiency of 30%, and 67.5% mix farms were operating at efficiency of 30 to 60%. Total investment in dairy farming, training and adopting dairy as primary occupation were positively and significantly affecting technical efficiency on buffalo, cow and mix type of dairy farming system. There is still large scope to increase the annual milk production in the dairy farms of Chitwan through efficient use of available resources with the existing technologies. This is concluded that dairy farming system can be promoted efficiently by increasing total investment in dairy farming through easy access to loan, training on dairy animal production and management, ensuring dairy business as profitable primary occupation, promotion of fodder and pasture production, and securing easy access to medicines and additives.

Keywords: Cow farms, buffalo farms, mix farms, stochastic production frontier, tobit regression

INTRODUCTION

Agrarian economy of Nepal is primarily depending on production of crop, livestock, forestry and fisheries. Agriculture contributes about 26.2% to the National Gross Domestic Product (NGDP) of which 11.5**%** of the contribution comes from livestock and poultry sector in Nepal (MoF, 2020). Milk forms a bulk share in livestock products (MOAC, 2017). The total population of cattle and buffalo in Nepal accounts about 7.6 million and 5.3 million, respectively (MOALD, 2020). In spite of this large population, their contribution towards food and nutritional security, income and livelihood have not been fully realized due to inefficient production system. Low productivity of Nepalese dairy farming systems has been recognized as a major problem hindering dairy development and it can be improved by increasing farm efficiency. Nepal is short of about half million liters of milk daily and spends billions of Rupees importing milk or other dairy products annually (FNCCI, 2017). The Nepalese dairy sector faces higher cost of production (10-20%) than several other Asian countries including India. The efficiency of the dairy sub-sector is a subject that has not been fully investigated at farm level in Nepal. Several studies showed high cost of production attributed to low productivity and high input cost (NDDB, 2014). Agriculture Development Strategy (ADS) of Nepal has also prioritized dairy as the second most important commodity after maize for trade and value chain promotion (MOAD, 2015). As envisioned in the ADS, this study was targeted for increasing self-reliance on milk production, sustainability, competitiveness, productivity, as well as reducing cost of production through identification of technical efficiency and its determining factors.

Chitwan district lies in inner terai region which is very favorable for commercial promotion of livestock production and milk-based processing enterprises (DDC, 2013). From the record of District Livestock Development Office of Chitwan, milk is the lead production of the district. From the business point of view, Chitwan is the urbanizing district with growing local demand of dairy products. However, dairy sector

of the district is in slow motion due to growing remittance economy, fragmentation of land, poor motivation towards dairy business, low yielding dairy animals and poor technological advancement (DLSO, 2016). In the light of these problems and context, commercialization of dairy farming with involvement of youth generation may be possible only after operating the dairy business in viable unit backed by minimized cost of production, maximized productivity and efficiency and, from policy intervention on key socio-economic factors affecting efficiency of production system. In this context, this study was conducted to estimate the technical efficiency of dairy farming and its determinants in Chitwan district of Nepal. Studying technical efficiency and the responsible factors are important for farmers and policy makers. Farmers could use the findings of this study for increasing their performance in dairy farms and policy makers could identify and prioritized the intervention required to make for enhancing the productivity and efficiency of dairy farms in the country (Solís et al., 2009).

MATERIALS AND METHODS

Study area and sampling design

The study was conducted in Bharatpur Metropolitan City of Chitwan district in Nepal. It is one of the potential districts for dairy enterprise promotion characterized by gradual commercialization of different agriculture and livestock-based firms. A total of 8 most commercial wards from the metropolitan city and one Dairy Cooperative from each selected ward were selected to frame the sample required for the study. A total of 10 dairy farms from each cow, buffalo and mix farms were selected randomly from each cooperative using simple random sampling technique to make a sample of 240.

Data collection

Literature review and preliminary field visit were done to develop coordination schema. This coordination schema was used to develop interview schedule required for collecting primary data. Thus, primary data were collected from selected respondent households using semi-structured interview schedule. Interview schedule prepared in this manner was pretested in 10 dairy farming households at ward number 7 of the Metropolitan city. Collected data were entered in Microsoft excel sheet and analyzed using STATA and SPSS software wherever applicable.

Analytical tools

Socioeconomic and demographic variables were analyzed using the tools of descriptive statistics like mean, frequency and percentage. The technical efficiency of an individual farm is defined in terms of the ratio of the observed output to the corresponding frontier output given the available technology. Farrel (1957) discussed that there are two components of efficiency, technical efficiency and allocative efficiency. Technical efficiency is the ability to produce on the frontier isoquant, in other words technical efficiency is the ability of a firm to produce maximum level of possible outputs from given inputs and technical inefficiency reflects deviation from frontier isoquant (Hanan & Rahaman, 2017). To measure mean technical efficiency, parametric (Stochastic Frontier Approach) and non-parametric (Data Envelopment Approach) method have been used (Wahid et al., 2017). The main disadvantage of Data Envelopment Approach is it assume that the deviation from the frontier is due to inefficiency of farmers but Stochastic Frontier Approach described that all the deviation from the frontier is not only due to inefficiency of farmers rather due to random error (weather condition), which is beyond control of farmers (Aigner et al., 1977). Stochastic frontier production model proposed by Battese and Coelli (1988) was used for determining technical efficiency of dairy farms in Chitwan, Nepal. Accordingly, technical efficiency was estimated as:

Technical Efficiency (TE)=Yi/Yi^*
Where:
Y_i^*=Frontier output
Following form of Cobb-Douglas frontier production function was used to estimate the function required for estimating the technical efficiency.

$$LnY_i=B_o+B_1LnX_1+B_2LnX_2+B_3LnX_3+B_4LnX_4+B_5LnX_5+V_i-U_i$$

Where:
Y_i= Annual value of milk produced in Rs. Per farm
X_1= Cost of green grasses in Rs. per farm
$X_{2=}$ Cost of dry fodder in Rs. per farm
X_3= Cost of labour in Rs. per farm
X_4= Cost on medicines and veterinary charges in Rs. per farm
X_5= Additive cost in Rs. per farm
U_i= Random error
V_i= Technical efficiency
B_0, B_1------B_5= Coefficients to be estimated

After estimation of technical efficiency, tobit regression model was used for estimating factors affecting the technical efficiency. Tobit model has been extensively used by agricultural economists to estimate the determinants of technology adoption in agriculture (Akinola & Young, 1985). Tobit model with dependent variable as technical efficiency was used to determine the factors that have effect on technical efficiency of dairy milk production in Chitwan district of Nepal. This model assumes that most of the variables have a lower (or upper) limit and take on the limiting value for a substantial number of respondents. For remaining respondents, the variable takes on a wide range of values above (or below) the limit (Tobin, 1958). The Tobit regression model used in this study was considered in the following form:

$$TEi= \delta 0+ \sum \delta kWik+wi$$

Where, TEi is the level of technical efficiency, and Wik is the variable representing socioeconomic parameters of farmers to explain technical inefficiency. The different variables considered in the estimation of Tobit regression model were age of household head, education of household head, family size, land size, total investment in dairy farms, received training, access to loan and practicing dairy as primary occupation.

RESULTS AND DISCUSSION

Socio-economic and demographic characteristics

The average age of the household head among dairy farming households was 53.25 years in study area. The study showed all household heads in the study area were economically active population which is higher than national distribution of economically active population in agriculture (64.00%) (CBS, 2011). As far as educational background of respondents is concerned, it was found average of 8.05 formal years of education. Family size of respondents' household was 5.68 out of which 2.81 were female and 2.87 were male. Majority of the respondents (69.17%) were male respondents whereas percentage of female respondents were 30.83% only. The proportion of female respondents varied by type of farms and was 20.0%, 31.25% and 41.25% in mix, buffalo and cow farms, respectively. The average own land was 17.87 kattha with 12.54 kattha as irrigated land. Out of which, 2.22 kattha was allocated for fodder, and 2.15 kattha was allocated for pasture. The average number of adult milching cows and buffalos in study area were 3.04 and 2.11, respectively.

Technical efficiency of dairy farms

Green grass, dry fodder, labour, medicine and additives were four productive factors used to measure technical efficiency in different type of dairy farms. In buffalo farms, green grass, labour, medicine and additives had positive effect on output while dry fodder had negative effect on output as shown in Table 1. Labour had significant effect on output (revenue from dairy farms) at 5% probability and its coefficient was 0.488 which suggest that with 10% increase in labour revenue will increase output by 4.88%. The efficiency indicator of buffalo farms was found at 2.138.

Table 1. Technical efficiency of buffalo farms in study area

Parameters	Coefficient	Std. error	Z	p-value
Ln green grass	0.014	0.067	0.21	0.833
Ln dry fodder	-0.023	0.030	-0.77	0.441
Ln labour	0.488***	0.077	6.34	0.000
Ln medicine	0.012	0.011	1.13	0.258
Ln additives	0.011	0.007	1.61	0.108
Constant	6.805***	1.043	6.52	0.000
Ln sig2v	-2.910	0.705	-4.13	0.000
Ln sig2u	-1.390	0.543	-2.56	0.010
Sigma_v	0.233	0.082		
Sigma_u	0.499	0.135		
Sigma2	0.303	0.104		
Lambda	2.138	0.210		
*** significant at 1% level				
No. of observation	80			
Wald Chi-squared	61.44			
P value for Chi-squared	0.001			

Green grass, labor, medicine and dry fodder had positive effect on output while additives had negative effect on revenue in cow farms. Green grass, dry fodder, labour and additives had significant effect on output at 5% probability. Numerous studies have suggested that the use of dry fodder and pasture based dairy farming reduced the milk yield (Kolver & Muller, 1998; Bargo et.al., 2002). Labor affects the output more as compared to other parameters and its coefficient was 0.576 which suggest that with 10% increase in labor there will be 5.76% increase in output. The efficiency indicator of cow farm was 2.56 (Table 2).

Table 2. Technical efficiency of cow farms in study area

Parameters	Coefficient	Std. error	Z	p-value
Ln green grass	0.041***	0.008	5.04	0.000
Ln dry fodder	0.050**	0.023	2.21	0.027
Ln labour	0.576***	0.044	12.89	0.000
Ln medicine	0.034	0.027	1.25	0.213
Ln additives	-0.007***	0.003	-19.20	0.000
Constant	5.250***	0.154	33.98	0.000
Ln sig2v	-34.54	460.35	-0.08	0.940
Ln sig2u	-0.427	0.158	-2.70	0.007
Sigma_v	0.003	7.26		
Sigma_u	0.807	0.063		
Sigma2	0.652	0.103		
Lambda	2.560	0.063		
***, ** and * represent significant at 1%, 5% and 10% level, respectively				
No. of observation	80			
Wald Chi-squared	8.26			
P value for Chi-squared	0.001			

Labor, medicine, dry fodder and additives had positive effect on output while green grass had negative effect on output in mix type of dairy farms. Labor and medicine had significant effect on output at 5% probability. Labor affects the output more as compared to other parameters and its coefficient was 0.217 which suggest that with 10% increase in labor there will be 2.17% increase in revenue. The efficiency indicator of mix farm was 3.530.

Table 3. Technical efficiency of buffalo and cow mix farms in study area

Parameters	Coefficient	Std. error	Z	p-value
Ln green grass	-0.012	0.020	-0.62	0.538
Ln dry fodder	0.075*	0.420	1.80	0.073
Ln labour	0.217***	0.074	2.93	0.003
Ln medicine	0.111***	0.430	2.59	0.009
Ln additives	0.003	0.007	0.00	0.997
Constant	9.127	0.860	10.60	0.000
Ln sig2v	-3.910	0.559	-6.99	0.000
Ln sig2u	-1.380	0.254	-5.46	0.000
Sigma_v	0.141	0.039		
Sigma_u	0.499	0.063		
Sigma2	0.269	0.058		
Lambda	3.530	0.091		

***and * represent significant at 1% and 10% level, respectively

No. of obs	80
Wald Chi-squared	27.21
P value for Chi-squared	0.0000

Desirable level of income for different level of technical efficiency

In buffalo farms, 30%, 60% and 90% level of technical efficiency was achieved by the farm with the average income of NRs. 105960, 201663 and 542000, respectively. In cow farm, 30%, 60% and 90% level of technical efficiency was achieved by the farm with the average income of NRs. 223259, 254341 and 403225, respectively. In buffalo and cow mix farms, 30%, 60% and 90% level of technical efficiency was achieved by the farm with the average income of NRs. 270483, 395789 and 611400, respectively (Table 4). This clearly shows the need of increasing farm size for achieving higher technical efficiency. A study conducted in Indo-Gangetic plain of India had also suggested to increase the size of farms and focus on larger farms to increase the technical efficiency of dairy farms (Kumar, 2012).

Table 4. Desirable level of annual income from dairy enterprise for different level of technical efficiency

Level of technical efficiency (%)	Annual mean level of income (Rs.)		
	Buffalo farms	Cow farms	Mix farms
0	NA	102175	105433
30	105960	223259	270483
60	201663	254341	395789
90	542000	403225	611400

A total of 71.25%, 26.25% and 2.50% buffalo farms were in the range of technical efficiency 30% to 60%, 0% to 30% and 60% to 90%, respectively. Among cow farms, 46.25%, 33.75%, and 10% farms were in the range of technical efficiency 0% to 30%, 30% to 60%, and 60% to 90%, respectively. Similarly, 67.50%, 25%, 3.75% and 3.75% mix farms were in the range of technical efficiency 30% to 60%, 0% to 30%, 60% to 90% and 0%, respectively (Table 5).

Table 5. Frequency distribution of dairy farms in different range of technical efficiency

Range of technical efficiency (%)	Buffalo farms	Cow farms	Mix farms
0	0 (0)	8 (10)	3 (3.75)
More than 0 to 30	21 (26.25)	37 (46.25)	20 (25.00)
More than 30 to 60	57 (71.25)	27 (33.75)	54 (67.50)
More than 60 to 90	2 (2.50)	8 (10)	3 (3.75)
More than 90 to 100	0 (0)	0 (0)	0 (0.00)
Total	**80 (100)**	**80 (100)**	**80 (100)**

Note: Figures in parenthesis indicate percentage of dairy farms

Factors determining technical efficiency

Tobit model was used to determine the effect of age of household head, education of household head, family size, own land, total investment in dairy farms, received training, assess to loan and dairy as primary occupation on technical efficiency in different type of farms. In buffalo farm, total investment in dairy farms and trainings had positive effect on technical efficiency while age of household head, education of household head, family size, own land, access to loan and dairy as primary occupation had negative effect on technical efficiency as shown in Table 6. The dairy farming households with large size of land make more emphasize on the agricultural activities than the livestock and thus may decline the efficiency in dairy farming system. A higher size of family labour use is inefficient in diary farming system (Singh, 2020). Total investment in buffalo farm had significant effect at 5% level of probability. Age of household head, education of household head, own land, access to loan, dairy as primary occupation and trainings had positive effect on technical efficiency on cow farms while family size and total investment in dairy farms had negative effect on technical efficiency as shown in Table 7 in cow farming households. Trainings in cow farms had significant effect at 5% level of probability. In buffalo and cow mix farms, age of household head, access to loan, dairy as primary occupation, total investment in dairy farms and trainings had positive effect on technical efficiency while education of household head, own land and family size had negative effect on technical efficiency as shown in Table 8. Dairy as primary occupation in mix farms had significant effect at 5% level of probability. In a similar study conducted by Singh (2020) in Bihar State of India had revealed that efficiency in dairy farming system is higher with the increase in farmers age and education. Similarly, technical efficiency was higher in the dairy farms with the size of more than two milching animals in the same study.

Table 6. Tobit estimates for factors determining technical efficiency in buffalo farms

Factors	Coefficient	Std. error	t	p-value
Age of household head (yrs.)	-0.001	0.001	-1.21	0.231
Education of household head (yrs.)	-0.001	0.002	-0.61	0.547
Family size (No.)	-0.007	0.008	-0.83	0.409
Own land (kattha)	-0.005	0.005	0.90	0.374
Total investment in dairy farms (Rs.)	0.018***	0.059	3.09	0.003
Received training (1=yes)	0.038	0.046	0.83	0.407
Access to loan (1=yes)	-0.035	0.033	-1.06	0.293
Dairy as primary occupation (1=yes)	-0.006	0.036	-0.18	0.855
Constant	0.778***	0.081	9.52	0.000

*** represents significant at 1% level

LR Chi-squared: 17.02 and Pseudo R-squared: 0.212

Table 7. Tobit estimates for factors determining technical efficiency in cow farms

Factors	Coefficient	Std. error	t	p-value
Age of household head (yrs.)	0.002	0.002	1.00	0.320
Education of household head (yrs.)	0.007	0.006	1.08	0.284
Family size (No.)	-0.008	0.015	-0.55	0.585
Own land (kattha)	0.002	0.001	1.14	0.260
Total investment in dairy farms (Rs.)	-0.030	0.031	-1.04	0.302
Received training (1=yes)	0.135***	0.050	2.68	0.009
Access to loan (1=yes)	0.048	0.050	0.95	0.344
Dairy as primary occupation (1=yes)	0.044	0.047	0.93	0.355
Constant	0.328	0.201	1.63	0.108

*** represents significant at 1% level

LR Chi-squared: 14.93 and Pseudo R-squared: 1.13

Table 8. Tobit estimates for factors determining technical efficiency in buffalo and cow mix farms

Factors	Coefficient	Std. error	t	p-value
Age of household head (yrs.)	0.002	0.001	1.60	0.115
Education of household head (yrs.)	-0.002	0.005	-0.41	0.683
Family size (No.)	-0.014*	0.007	-1.89	0.063
Own land (kattha)	-0.006	0.008	-0.80	0.426
Total investment in dairy farms (Rs.)	0.597	0.412	1.45	0.152
Received training (1=yes)	0.046	0.045	1.01	0.314
Access to loan (1=yes)	0.049	0.038	1.29	0.202
Dairy as primary occupation (1=yes)	0.072**	0.036	2.01	0.048
Constant	0.558	0.121	4.61	0.000

** and * represent significant at 5% and 10% level, respectively

LR Chi-squared: 15.94, and Pseudo R-squared: 0.261

CONCLUSION

This study examined the effect of farmers practices and inputs used on technical efficiency in different types of dairy farms in Chitwan district of Nepal. The study used Stochastic Production Frontier taking a sample of 240 dairy farms and assessed valuable information on the level of technical efficiency and its determinants. Technical efficiency was maximum in mix dairy farms with coefficient of 3.530 followed by cow farms (2.56) and buffalo farms (2.138). Research had shown that average annual income per farm should be Rs. 542000, Rs. 403225 and Rs. 611400 for getting 90% technical efficiency in milk production at buffalo, cow and mix farms, respectively. Similarly, 57% buffalo farms were operating at efficiency of 30-60%, 46% cow farms were operating at efficiency of 30% and 67.5% mix farms are operating at efficiency of 30 to 60%. Total investment in dairy farming, training and adopting dairy as primary occupation were positively and significantly affecting technical efficiency at buffalo, cow and mix type of dairy farming system in study area. Average size of farms for all three categories is to be expanded for achieving 90% technical efficiency in milk production. Mix types of dairy farms were technically most efficient due to larger size of farms and minimized risk with diversification. Total investment in dairy farming, training and adopting dairy as primary occupation were positively and significantly affecting technical efficiency of dairy farms. Dairy farming can be promoted in terms of technical efficiency by increasing total investment in dairy farming through easy access to loan, training on dairy animal production and management, ensuring dairy business as profitable primary occupation, promotion of fodder and pasture production, and securing easy access to medicines and additives.

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