Assessment of management and reproductive variability among the buffalo farms in Chitwan based on the scores of production efficiency

R. Raut[1], B.N. Devkota[1], G. Gautam[1] and S. Shrestha[2]*

[1]Agriculture and Forestry University, Rampur, Chitwan, Nepal
[2]Scotland's Rural College, Scotland
[*]**Corresponding author**: Rabin Raut, drrobinnpl@gmail.com

ABSTRACT

Buffalo is one of the key contributors of the Nepalese farming system, mainly for milk and meat production. However due to low productivity, buffalo commercialization is getting difficult in the country. The present study was carried out to identify the management and reproductive variability among the buffalo farms based on production efficiency for assessing the constraints that affect in the production efficiency of the farms. The study was conducted from February 2019 to October 2019. A total of 50 households at Chitwan district having at least one milking buffalo were randomly selected for the study. The management, production and reproduction information were recorded with the use of questionnaire. The farms were categorized into three clusters; low efficient, medium efficient and highly efficient farm groups on the basis of production efficiency. The efficiency scores for these farms were found 0.52, 0.72, and 0.92 respectively. The education level and share to household are positively related to production efficiency; however feed consumption and cost of production are negatively related to production efficiency of buffalo farms. Similarly, management practice of deworming was associated with production efficiency. Reproductive parameters of age at first calving, calving interval, number of farmer's observation to see if a buffalo was in heat, adoption of fixed time artificial insemination protocol, and duration between heat detection and insemination were not associated with the production efficiency even though there was a tendency of association of low season breeding potentiality of buffaloes in relation to better production efficiency. In conclusion, the identified variability may be considered to increase the production efficiency of the buffalo farms.

***Keywords**: Buffalo; Management; Production efficiency; Reproductive; Variability*

INTRODUCTION

There are 5.3 million buffaloes in Nepal which have increased by 0.58% (MOALD, 2020). Livestock farming prevails in all regions of the country, including the Mountain, Hill and Terai belts, with variations based on climate, topography, and socio-economic factors (Pradhananga et al., 2015). Buffaloes are considered as the 'black gold" due to its importance in Nepalese agricultural economy. Buffalo contributes 68.68% of the total milk and 58.30% of the total meat production in the country (MOAD, 2017). All buffaloes in Nepal are riverine type (Rasali et al 1998). Lime, Parkote and Gaddi are the major native breeds of buffalo that range from Terai belt to mid Hills of Nepal. The need for buffalo development has been identified as a driving force for food security, self-sufficiency and sustainable development (Soliman, 2008).

Milk production of Murrah and their crossbred is approximately 1500 liter/lactation which still is lower than the potential average productivity of 2300 liter/lactation (NARC, 2015). Though different breed characteristics have been described, the different production characteristics in terms of milk, meat and other outputs have not been reliably measured (Joshi, 1992). Animal production and productivity tends to be low on small, rural farms in Nepal on account of nutrition (Pant et al. 1993), disease (mainly parasitic) (Thakuri et al. 1992), genetics (Shrestha et al. 2003; Pokharel and Neopane 2006), lack of preventative care, and management practices (Shrestha et al. 2006). Thus there are opportunities for intervention leading to improved production. However, knowledge and understanding of prevailing systems is essential for improving production systems by identifying the problems and constraints that limit production (Devendra 2007). Nepalese buffalo farming is largely consisted of subsistence farming system under which farmers raise a small number of livestock on small land holdings (Pradhananga et al., 2015).

Basic information related to household, buffalo farm management and milk production, and access to animal health is still lacking. With variable data in production performance such as average lactation yield, age at first calving and calving interval, generating valid conclusions regarding the productivity of buffaloes seems difficult under various environmental and management regimes (Oil & Morel, 1985; Shrestha et al, 1988 and Joshi et al, 1992). There is a wide variability in production efficiency among buffalo farms (Shrestha et al, 2019). Efficient farm productivity is directly linked to farm economy. Factors affecting the poor reproductive efficiency of Nepalese buffaloes haven't been properly documented yet. This is probably the first research of its kind focused on identifying the factors that help to increase the productivity of buffaloes of Nepal by looking at the variability in production efficiency (PE) among buffalo farms and attempts to identify the constraints that render low efficiency.

MATERIALS AND METHODOLOGY

Data collection

A randomized survey was conducted from February to May of 2019 through face-to-face interviews with 50 farming households in different villages of Chitwan namely Bijaynagar, Madi, Jagatpur and Divyanagar. Each of the sampled household had at least 1 milching buffalo. Most of the households had adopted similar type of feeding and management practices. Buffaloes were reared in 24-hour tie-stall with limited access to grazing. It used a structured questionnaire to collect farm level physical, demographic, financial, management and reproduction information as well as farmers' intentions and perceptions of buffalo production. Characteristics such as age at first calving and calving interval were used to measure reproductive performance. Characteristics such as lactation yield, dry period and daily milk yield were used to measure productive performance of different buffaloes. Socioeconomic characteristics included age, sex, education, experience in buffalo farming of respondents and income from buffalo farming. Households were asked about visual, cow behavior and bull behavior under the observation of signs of estrus in their buffaloes. Interval between heat detection and insemination was grouped into two types i.e insemination upto 12 hours after heat detection and next is 12 hours or more after heat detection.

Calculation of net profitability

After completion of field survey, all the variables of the interview were entered in MS Excel to facilitate tabulation. Income from annual farming operations was obtained by summing up the returns from annual sale of buffalo products (milk sales), annual sale of live calf (animal sales) as by product. We only included milk revenues in this study as that is the main contributor of income on these farms. The farms only sell buffalo when they become unproductive. This is considered when replacement costs were included. Both physical and financial variables are included in the data. The total cost of each farm operation was based on variable costs. The variable costs included in this study are feed cost, labour cost, veterinary cost and breeding cost. The expenses made for medicines; deworming, vaccination and prevention come under veterinary costs. Insemination of buffalo either by bull or artificial means is the breeding expenses. Number of insemination depends upon the skills and success of insemination. Other inputs are calculated as the real value of total expenditures on fuel, machinery/building repairs, utilities and miscellaneous expenses, interest paid, taxes, water, electricity, transport and insurance payments. Following formula was used to calculate the profitability of each farm.

Net Profitability,
π= TR- TC
Where,
TR= Total milk produced per dairy buffalo per lactation multiplied by per liter buffalo milk price of the study area
TC= Sum of all needed costs of inputs for buffalo rearing

Farm clustering and calculation of PE

Farms were grouped using a cluster analysis technique, K-Means technique, in STATA 12.1 (www.stata.com). The K-Means technique was present to three groupings for the analysis and it generated three different means based on PE scores within the farm data. Each of the 50 farms was grouped separately using the Euclidean distance method which determined minimum distance between the group mean and the farm data. The three farm groups thus generated were categorized as; i) low efficient farm group; ii) medium efficient farm group and iii) high efficient farm group on account of the PE scores, farm size and production. Data envelope analysis (DEA) assigns an efficiency score ranging from 0 to 1 to each DMU in the analysis group and can be used to determine how inputs and outputs should be adjusted to obtain DEA efficiency (Stokes et al, 2007).

Efficiency score, $\hat{e}x = (\rho x / revx)/\hat{e}max$
Where ρx = profit of farm x; revx = total revenues of farm x and $\hat{e}max$ = maximum efficiency among farms in the sample.

Management and reproductive variability

In technical adaptations; use of technology like artificial insemination (AI), fixed time AI (FTAI), deworming practices, vitamin and mineral supplementation and vaccination practices and in breeding practices; adoption of pregnancy diagnosis, number of observations made to examine whether the buffaloes are in heat, breeding season and duration between heat detection and insemination were included under management aspects. The productive performances analyzed were daily milk yield and number of dry months and the reproductive performances studied were age at first calving and calving interval of buffaloes of different farm groups.

Statistical analysis

Descriptive statistics included frequency to investigate socio-economic characteristics of the respondents A multivariate regression was used to determine the factors affecting the efficiency of buffalo farms. Education level, experience in buffalo farming, daily milk yield, total cost of production, farm size, share to household, feed consumption and number of dry months are the variables used in this study as regressors in the regression equations. The model can be formulated as the following equation (Agha et al., 2012; Anas et al., 2013; Akan et al., 2015).

$$Y= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots + \beta_n X_n + \varepsilon$$

Where, Y = Annual income (Rs.) from buffalo farming

β_0 = intercept of the regression equation

X_1 = education level of respondent

X_2 = experience of household head

X_3 = daily milk yield of the farm

X_4 = farm total milk production

X_5 = total cost of production

X_6 = farm size

X_7 = share to household

X_8 = feed consumption

X_9 = number of dry months

ε = error term

Similarly, the non-parametric data were analyzed by chi-square test and mean value was analyzed by one way ANOVA using STATA 12.1. Chi squared test was used to show the degree of association between efficient farms and technical adaptations adopted by farmers. Chi square test was also utilized to analyze parameters of breeding practices. One way ANOVA was used to detect significant differences ($P<0.05$) existed in a group of data in case of analysis of productive and reproductive traits. The statistical analysis was set at 95% of confidence where P-value <0.05 was considered as significant, and $0.05>P\leq0.1$ was considered to have tendency.

Where,

Gross return = Sum of gross return from milk, manure and calf

Total variable cost = Sum of cost of all variable ite

RESULTS AND DISUSSION

The result reveals that the education level and share of income from buffalo farming to household are positively related to PE, however feed consumption and cost of production are negatively related to production efficiency. The low efficient farm groups have lowest share to household income. Similarly, the cost of production incurred in highly efficient farm group is lower than that of low efficient and medium efficient farm group. The last variable (Cons) represents the constant which is the predicted value of production efficiency when all other variables are zero.

Among the socio-economic characteristics, education was found to influence significantly on PE of the farms. It is evident that the more number of farmers of highly efficient farm group had attained tertiary education in our study. Similar finding was reported by Timsina (2010) in large farm category in Phulbari village of Chitwan. This might be due to more awareness about education and more household income in large category as compared to other categories of households. The results from the study of farmer education and productivity in Nepal agriculture also suggest that the increase in conventional input and investment in education will substantially improve agricultural productivity (Hu Bai and Nainabasti A, 2008). Pudasaini (1979) also reported the higher contribution of college education's in Bara district of Nepal. This indicates that higher education has a significant role in a modernizing environment where new inputs are continually introduced and where economic disequilibria arise as a result of changing technology, perhaps because higher education enables farmers to analyze, understand, and introduce new inputs in modernizing environment (Schultz, 1975).

Table 1: Farm clustering

Farm clusters	**No. of households**	**Average PE**
Low efficient	9	0.52
Medium efficient	20	0.72
High efficient	21	0.91

Table 2: Income from buffalo per month farming in different farm groups

Farm group	Mean	Std. deviation	Frequency
Low efficient	15885.83	14615.412	9
Medium efficient	14207.5	14333.64	20
Highly efficient	31619.048	20675.562	21
TOTAL	21822.45	18981.436	50

Table 3: Multivariate regression estimates of factors affecting production efficiency in different farm categories

Variable	**Regression coefficient**	**p>|t|**
Education	.0577673	0.010*
Experience	.0019849	0.955
Milk yield	-.000022	0.646
Total milk production of the farm	.000014	0.099
Total cost of production	-.0000206	0.000*
Farm size	-.0140922	0.826
Share to household	.2115662	0.005*
Feed consumption	-.0002246	0.050*
Number of dry months	-.0263149	0.479
Cons	.8686771	0.000

*indicates significance level at 5%

Table 4: Education level of farmers of different groups

Education level	Low efficient	Medium efficient	Highly efficient
Primary	4	11	10
Secondary	5	8	6
Tertiary	0	1	5

The cost of milk production is largely shared by labour and fodder. Labour accounts for about 70-80 percent of the total cost and fodder (green and dry) accounts for 15% to 21% on different farm categories (Ghulam et al, 2004). The lower cost of production in highly efficient farm groups is mainly due to controlled amount of feed ($p<0.001$) offered to the buffaloes. Ghulam et al (2004) had also shown higher increase in gross revenues of large farms with respect to small farms. The higher cost of production in low efficient farms might be due to small number of animal units and lower milk in young stocks. The highly efficient farm are cost efficient than the low efficient farms. Farmers of low efficient farm groups are found spending higher cost in market and electricity than their highly efficient farm counterparts. This might be due to the fact that less bargaining power of small dairy farmers, this is due to unorganized or scattered markets they faced (Diru et al, 2019). Moreover, small dairy farmers disburse 3% more mean feed cost per cow per year than their large counterparts. This might be due to the economics of scale (Diru et al, 2019). The more number of services per conception in low and medium efficient farm groups have increased the cost of rearing animal and decreases profitability (Tarabany et al, 2015).

Feed consumption is another important factor that negatively influences the PE. Majority of the farmers of highly efficient farm group made provision of grasses and legumes to their buffaloes. This might have promoted consumption of quality roughages thus improving the efficiency of feeding at lower cost resulting in low milk production cost (NPEC, 2014). The poor plane of nutrition and deficiency of green fodder and forage may be responsible behind poor breeding efficiency in low economic group. A strong association of true anestrus to poor body condition score (BCS) was observed in Nepalese buffaloes suggesting the effects of dry weather resulting shortage of feed and fodder availability during winter and spring months might have played a major role in causing higher incidence of true anestrus in the winter and spring months (Devkota et al., 2012). The low share of buffalo income to household income of low efficient farm group might be due to consumption of milk more for home purposes rather than selling through cooperatives or at local market.

Table 5. Farm level reproduction and production data of different farm group

Parameters	Low Efficient	Medium Efficient	Highly Efficient	p-value
No. of dry months	2.44±0.53	2.5±0.51	2.42±0.60	0.788
AFC (years)	3.5±0.35	3.23±0.34	3.37±0.33	0.983
CI (months)	13±0.87	12.85±0.59	12.61±0.86	0.216

DMY (L)	5.69±1.26	5.54±1.26	5.60±1.30	0.987

Table 6. Farm level adoption of some reproductive and management practices

Technical intervention	**Farm Group**			**p-value**
	Low Efficient	**Medium Efficient**	**Highly Efficient**	
Use of AI	0	4	5	0.285
Use of FTAI	0	1	4	0.177
Deworming practices	6	20	21	0.001**
Practice of vitamin-mineral premix	3	4	7	0.589
Practice of vaccination	3	12	16	0.083*

The higher practice of deworming in highly efficient farm group might be an effort to lower the incidence of parasitism in their buffalo herds. The pasture contaminated due to feces of affected buffaloes and close confinement/interaction of buffaloes within a dairy shed also enhance the multiplication of parasites in low efficient farm group where herd size is greater (Sharif et al, 2014). Parasitism results reduced feed intake thereby decreasing the efficiency in feed utilization (Akanda et al, 2014). The extra expenses in treating secondary diseases probably because of parasitism might have increased the cost against its treatment. Gastrointestinal parasites decrease the growth rate of growing dairy buffalo calves, causes anemia, general weakness and debility, reduce the resistance to other secondary diseases and cause complications (Sharif et al, 2014). The adoption of vaccination practice in low and medium efficient farm might be attributable to poor infrastructure and farmer's perception towards vaccination that vaccine administration could lead to reduced milk yield, swelling and fever. There was frequent contact of farmers of highly efficient farm group with extension services. Knowledge and awareness of farmers of that group about possible economic losses due to reduced performance and sudden outbreak of diseases was good against other groups. Very few farmers of these groups had proper access to market and veterinary drugs retailer. Singh et. al. (2018) obtained best BCR in vaccination of both the adult and young population at the beginning of the program followed by an annual vaccination of the replacement calves.

Table 7. Breeding management practices adopted by buffaloes farmers

Practice	**Category**	**Low Efficient**	**Medium Efficient**	**Highly Efficient**	**p-value**
PD	Yes	2	5	11	0.12
	No	7	15	10	
Number of observation to see in heat	Once a day	6	14	2	
	Twice a day	1	2	6	0.588
	3 and above	2	4	8	
Breeding season	Active	9	15	13	0.092
	Low	0	5	8	
Duration between heat	Less than 12 hours	6	8	7	0.231

detection and insemination	12 hours and above	3	12	14

The comparatively higher breeding efficiency in highly efficient farm group is mainly due to good level of training on heat detection in that group. In the buffaloes in Southern Nepal, silent estrus was a common problem round-the-year, although its higher incidence was observed during low breeding month (Devkota et al, 2012). The pregnancy rate is very poor despite of high ovulation rate in low breeding season (Devkota et al 2009). The awareness of farmers of this group to provide vitamin supplementation and improved concentrated feeds during low breeding season might have enhanced the breeding efficiency of buffaloes.

CONCLUSION

The education level and income from buffalo to household are highly significant to increase production efficiency; however feed consumption and cost of production significantly decrease the production efficiency. Similarly, management practice of deworming was associated with production efficiency. The highest income from buffalo farming in highly efficient farm group suggests that more income can be generated if cost of production is minimized. Adoption of novel reproductive technologies like FTAI and low season breeding protocol seem to be difficult at current level due to poor knowledge of farmers. It seems imperative to conduct further research and studies on more number of sample sizes, include different regions and production scales and focus on breed effect and ultimately expanding to pocket areas of buffalo in Nepal.

REFERENCES

1. Afridi, Z.K., K. Khan, G. Zaman, S. Ullah and Q. Habib-Ullah. (2007). Prevalence of gastro-intestinal nematode parasites of economic importance in dairy buffaloes in Peshawar. *Sarhad J. Agric*., **23**:787 – 792.
2. Akan, R. and Uzundurukan, S. (2015). Multiple regression model for the prediction of unconfined compressive strength of jet grout columns. *Procedia Earth and Planet. Sci*., **15**:299-303.
3. Bohara, T. P. and Devkota, B. (2009). Assessment of some of the serum biochemical profile and ovarian status of cyclic and non-cyclic anestrus buffaloes of Shivnagar VDC and IAAS Livestock Farm of Chitwan, Nepal. *J. Inst. Agric. Anim. Sci*. **30**:199-205.
4. Borghese A. (2013). Buffalo Livestock and Products. *A. Borghese and C.R.A. Ed*., 1-511.
5. Borghese, A. (2005). Buffalo Production and Research. A. Borghese and FAO Ed., *REU Technical Series* **67**: 1-315
6. Bufano, G., Carnicella D., De, Palo P., Laudadio V., Celano, G., Dario, C. (2006) The effect of calving season on milk production in water buffalo (Bubalus bubalis). Arch Latinoam Prod Anim 14:60-61.
7. CASA (2020). Commercial Agriculture for Smallholders and Agribusiness. Dairy sector strategy Nepal.
8. Devendra, C. (2007). Perspectives on animal production systems in Asia. *Livestock science* **106**:1-18. DOI: 10.1016/j.livsci.2006.05.005

9. Devkota, B., Bohara, T. P. and Yamagishi, N. (2012). Seasonal variation of anestrus conditions in buffaloes (Bubalus bubalis) in Southern Nepal. *Asian J. Anim. Vet. Adv*, **7**: 910-914.
10. Devkota, B., Nakao, T., Kobayashi, K., Sato, H., Sah, S.K., Singh, D.K., Dhakal, I.P., Yamagishi, N. (2013). Effects of treatment for anestrus in water buffaloes with PGF2 and GnRH in comparison with vitamin-mineral supplement, and some factors influencing treatment effects. *J. Vet. Med. Sci*., **75**: 1623-27
11. Devkota, B.N. (2017). Update on attempts of developing breeding strategy for Nepalese buffaloes (bubalus bubalis) during low breeding season. *Proceedings of International Buffalo symposium 2017,* 108-111.
12. Dhakal, I.P. and Thapa, B.B. (2003). Economic impact of clinical mastitis in buffaloes during lactation. *Nepalese veterinary journal*. **27**:24-33.
13. Hu, Bai and Nainabasti, A. (2008). Farmer Education and Productivity in Nepal Agriculture. *Journal of Rural Problems*, **1**:14-23. DOI: 10.7310/arfe1965.44.14
14. Joshi, B.R. (1987). Evaluation of rice straw as a potential source for fasciola infection of ruminants in Nepal. *Proceedings of 2nd conference of NVA*, Nepal.
15. MoAD. (2017). Ministry of Agricultural Development, Kathmandu, Nepal. *Statistical information on Nepalese agriculture, 2015/16.* Kathmandu, Nepal.
16. MOALD. (2020). Ministry of Agriculture and Livestock Development. *Statistical information on Nepalese agriculture, 2018/19*. Kathmandu, Nepal. https://www.moald.gov.np/publication/Agriculture%20Statistics
17. NARC. (2015). National Agricultural Research Council. Retrieved from www.narc.gov.np
18. NEPC. (2014). Nepal Environment Protection Center. *Final report on study on cost of milk production*. Kathmandu, Nepal.
19. Pradhanang, U.B., Pradhanang, S.M., Sthapit, A., Krakauer, N.Y., Jha, A. and Lakhankar, T. (2015). National Livestock Policy of Nepal: Needs and Opportunities. *Agriculture* **5**:103-131; DOI: 10.3390/agriculture5010103.
20. Pudasaini, Som.P. (1979). Farm Mechanization, Employment, and Income in Nepal: Traditional and Mechanized Farming in Bara District. *Research Paper Series*, No. 38, International Rice Research Institute, Los Bafios, Philippines.
21. Rasali, D.P. (2017). Buffalo production for household food security in Nepal. *Proceedings of International Buffalo symposium 2017.* 29-33.
22. Schultz, T. W. (1975). The Value of Ability to Deal with Dis- equilibria. *J. Econ. Lit,* **13**:827-46
23. Soliman, I. (2008). Role of dairy buffalo in Egypt food security. *Buffalo Newsletter, Europe-Near East, Bulletin of the FAO*, Inter-Regional Cooperative Research Network on Buffalo and of the International Buffalo Federation, **23**:9-17.
24. Singh, B., Kostoulas, P., Gill, J., and Dhand, N. (2018). Cost-benefit analysis of intervention policies for prevention and control of brucellosis in India. *Neglected tropical diseases.*doi.org/10.1371/journal.pntd.0006488
25. Timsina, K.P. (2010). Economics of Dairy Farming: A Case Study of Phulbari Village in Chitwan District of Nepal. *Nepal Agric. Res. J.* **10**:55-63.