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REGULAR ARTICLES

Returns and determinants of technical efficiency in small-scale Malabari goat production units in Kerala, India

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Abstract A stochastic frontier production function was employed to measure technical efficiency and its determinants in smallholder Malabari goat production units in Kerala, India. Data were obtained from 100 goat farmers in northern Kerala, selected using multistage random sampling. The parameters of the stochastic frontier production function were estimated using the maximum likelihood method. Cost and return analysis showed that the major expenditure was feed and fodder, and veterinary expenses were secondary. The chief returns were the sale of live animals, milk and manure. Individual farm technical efficiency ranged from 0.34 to 0.97 with a mean of 0.88. The study found herd size (number of animal units) and centre (locality of farm) significantly affected technical efficiency, but sex of farmer, education, land size and family size did not. Technical efficiency decreased as herd size increased; half the units with five or more adult animals had technical efficiency below 60 %.

Keywords Malabari · Economics · Commercialization · Determinants of technical efficiency · Goat

Introduction

The world population of goats is about 921 million, of which over 90 % are found in developing countries. Asia is home to about 60 % of the total world goat population and has the largest goat breed share of 26 % (Devendra 2012). India ranks second in the world goat population with 14.6 % of the population. As per Indian livestock census in 2007, Kerala's share is only 1.23 % in goat population. Yet, goats are a very reliable source of income in rural areas of Kerala.

Goat production in Kerala is mainly centred on its native breed, Malabari (or Tellichery), which is reputable for its high prolificacy, milk yield, excellent growth rate and adaptability to the hot humid conditions prevalent in the state (Alex and Raghavan 2012). It is named after its place of origin, the Malabar region of Kerala state. This breed of goats is a mixed population of Arab Indian goats including Cutch cross and Tellichery. Malabari goats are medium-sized, dual-purpose animals with small, slightly twisted horns and medium-sized ears directed outward and downward (Raghavan et al. 2004). The importance of this valuable genetic resource is largely underestimated, and the extent of its contribution to the livelihood of the poor is inadequately understood. Investment initiatives on research and development to improve the relatively low level of goat productivity often do not match its potential importance. The All India Co-ordinated Research Project (AICRP) on goats (Malabari field unit) in Kerala is one of the government ventures to improve the production potential of Malabari goats in terms of growth, milk production and reproductive traits through selection, and it is working in this regard for the last 12 years.

In Kerala, goats are usually kept in smallholder farming systems. These farming systems are characterized by minimal resources in terms of land and capital, low income, poor food security and informal labour arrangements derived from family members, with some non-agricultural activities to supplement household incomes (Kosgey et al. 2006; de Sherbinin et al. 2008). However, these holdings follow the

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general trend of intensification that has occurred recently in goat systems in many parts of the world (Bouwman et al. 2005; Morand-Fehr and Lebbie 2004; De Rancourt et al. 2006). Little information, however, is available on the economic viability and sustainability of the smallholder system of goat rearing in Kerala. With this background, this paper has explored the economics of goat rearing and its efficiency and identified the determinants of technical efficiency in Malabari goat rearing in Kerala, and thus evaluates the scope of commercialization of goat rearing in the present conditions existing in Kerala.

Materials and methods

Study area and data collection

The study was undertaken in three field centres of AICRP in goats (Malabari field unit) viz., Thalassery, Badagara and Tanur, which are located in the northern part of Kerala, which is the breeding tract of Malabari goats. Baseline information was collected through surveys of smallholder farmers participating in three field centres. Farmers were grouped into five categories in terms of animal units, an animal unit being defined as one doe and its kids. From this, a sample of 100 farmers who had been rearing Malabari goats continuously for more than 2 years was selected randomly on the basis of probability proportional to the number of farmers in each category. Data from the selected farmers, recorded monthly over 3 years, 2007 to 2009, by trained field recorders, were analysed and are presented in this paper. The data include production, reproduction, management, population, feeding, disease, mortality and socio-economic costs and returns.

Analytical tools

Model

The efficiency of a production unit may be defined by how effectively it uses variable resources for the purpose of profit maximization, given the best production technology available. Technical efficiency refers to the maximum attainable level of output for a given level of production inputs, considering the alternative technologies available to the producer. This study measures technical efficiency and identifies the factors associated with inefficiency, and thus, it identifies ways to increase output through better use of available resources in goat production.

The stochastic frontier production function analysis was used to estimate the coefficients of the parameters of the production function and also to predict the technical efficiencies of the goat keepers. The production technology of the farmer was assumed to be specified by the Cobb Douglas frontier production function which is defined by Eq. (1):

$$\ln Y = \beta_0 + \beta_F \ln F + \beta_V \ln V + V_i - U_i \quad (1)$$

where

Y=return per goat per year (Rs/goat)
F=cost of fodder and feed per year (Rs/goat)
V=cost of veterinary care per year (Rs/goat)
and β=the parameters to be estimated

Maximum likelihood estimation (MLE) techniques were used to estimate the equation by using the programme Frontier 4.1 (Coelli 1996).

Determinants of technical efficiency

After analysing the stochastic frontier production function, the determinants of technical efficiency were identified. The V_is are random errors that are assumed to be independent and identically distributed as $N(0, \sigma v^2)$'s random variables. The U_is are non-negative technical inefficiency effects associated with the technical efficiency of goat production, and it captures the variation in output due to sex, family size, age, educational status and other socio-economic characteristics that are assumed to be independently distributed among themselves and between the V_is such that U_i is defined by truncation of the $N(\mu_i, \sigma^2)$ distribution where μ_i is defined by:

$$\mu_i = \delta_0 + \sum_{i=1}^{6} \delta_j Z_{ij} \quad (2)$$

where Z_1 represents the sex of the goat keeper (dummied as 1 for female and 0 otherwise), Z_2 represents the centre of AICRP (Malabari field unit) dummied as 1 for Thalassery and 0 otherwise, Z_3 represents dummy variables for educational status of the farmer, Z_4 represents landholding (cent), Z_5 represents the size of the family (in number) and Z_6 represents animal units (number). The Zs are included in the model to indicate their possible influence on the technical efficiency of the goat rearers. The estimates of all the parameters of the stochastic frontier production function and inefficiency model were contemporaneously obtained (Battese and Coelli 1995), and these estimate the variance parameters in terms of $\sigma_s^2=\sigma^2+\sigma_r^2$ and $\gamma=\sigma^2/\sigma_s^2$. Small livestock rearing is considered to be the primary responsibility of women and children. These animals are cared for and controlled by women and contribute to food security for the family (Deshpande and Sabapara 2010). In the present study, majority of the goat farmers were females. As goat

rearing is the sole income source for them, an urge for maximum profit and higher technical efficiency was expected. Land is one of the valuable assets in the rural areas and is considered as proxy and participation in the decision-making process. So the variable is expected to have a significant effect. Another factor, family size, was considered as an alternative for potential household labour supply, and it represents the essence of animal husbandry (Zaibet et al. 2004). The educational status was expected to have a role in technical efficiency on behalf of the quality of decisions and adoption for better management practices. Centres of AICRP on goats (Malabari field unit) can be taken as the locality where the animal is raised, since there are differences in herd management and resources available in the three field centres (Bindu 2006); the centre is also considered as a factor to understand its effect on technical efficiency of goat keepers. The size of the animal unit, the measure of farm size, is one of the major determinants of the financial status of a farmer, which in turn affects the farmer's ability to adopt modern production practices. This factor's significant effect can be also used as an indication for the scope of commercialization of goat rearing in Kerala.

Results and discussion

Socio-economic status

The important characteristics of farmers in the study area are summarized in Table 1. Illiteracy is the major hindrance in the socio-economic development of livestock rearers in India (Suresh et al. 2008). But as far as Kerala is concerned, this statement is not true. In our study area, only 3 % goat keepers were illiterate. Most of the farmers had school-level education (96 %). Among these, 34 % had lower primary education, and the rest had either upper primary or high school education. Only 1 % of goat keepers had college-level education. Land is one of the major limiting factors for goat rearing in Kerala. The average landholding size owned by goat keepers was only 947 m^2. The highest frequency of herd owners (78 %) were those having only less than 1,000 m^2. It is to be noted that only 2 % of goat keepers owned more than 4,000 m^2. This is a clear indication of limited grazing resources available in Kerala. The size of the household and the contribution of family labour largely determine the size of the herd (Verbeek et al. 2007). The average family size was 5.3. More than 50 % of goat keepers had medium-size families (five to eight members). Only 7 % of the goat keepers had a family with more than eight members. The majority of the goat keepers in the project area are rearing only one adult and its kids (46 %). Average herd size was also comparatively lower (2.19).

Table 1 Socio-economic status of goat rearers in the northern part of Kerala

Slno	Particulars	Percent of the total (%)
1.	Education	
	a. College	1
	b. High school	31
	c. U. P. school	31
	d. L.P. school	34
	e. Illiterate	3
2.	Landholding (m^2)	
	a. <1,000	78
	b. 1,000–2,000	15
	c. 2,000–3,000	3
	d. 3,000–4,000	2
	e. >4,000	2
3.	Family size (level)	
	a. Small (up to 4)	41
	b. Medium (5–8)	52
	c. Big (>8)	7
4.	Herd size	
	a. 1 animal unit	46
	b. 2 animal units	28
	c. 3 animal units	11
	d. 4 animal units	7
	e. >5 animal units	8

Cost and returns in goat farming

The economics of goat farming was worked out for different animal units and has been presented in Table 2. Only variable cost was considered for analysis, since the fixed cost was heritable from year to year. The imputed value of family labour was also not included in the analysis. Regarding the cost of inputs, the study established that feed accounts for the main cost of goat production followed by veterinary care as reported by Kipserem et al. (2011). Although grazing is the main source of feed, which is freely available, many other supplements, which are rather costly, are necessary for balancing the diet to meet the nutrient requirements. The shrinkage of grazing resources as well as mortality and morbidity losses due to diseases in goats is a heavy burden for the poor goat keepers, as has been reported earlier by Komwihangilo et al. (2012). The farmers were found to depend mostly on the government veterinary clinics for treatment of animals. The overall annual average variable cost was calculated to be $66.7/herd. The return over variable cost (net returns/profit) was found to be $198.1, giving a return of $3.7per month per animal. Maximum returns were accrued from the sale of live animals followed by sale of milk and manure. Farmers sold the newly added male kids at an age of 5 to 10 months every year whereas female

Table 2 Cost and returns of goat rearing in Kerala in different animal units ($)

Animal unit	Number	Sale of milk	Sale of manure	Sale of animal	Cost of concentrate	Veterinary aid	Total returns	Total cost	Net returns	Net returns/ month	Net returns/ animal unit/month
1	36	36.2	19.3	102.1	37.7	3.0	157.6	40.7	116.8	5.9	4.2
2	33	63.8	27.7	172.4	65.7	5.0	264.0	70.6	193.4	9.3	3.9
3	16	54.5	31.0	227.2	74.9	5.9	312.7	80.8	231.9	10.7	3.1
4	7	65.2	35.2	319.3	66.3	7.3	419.8	73.6	346.2	15.4	3.4
5 and above	8	103.7	55.0	361.6	127.3	6.4	520.3	133.7	386.6	17.2	2.2
Total	100	55.7	27.9	181.3	62.1	4.7	264.9	66.7	198.1	9.4	3.7

kids were retained for breeding purposes. By virtue of high fecundity and better productivity, goats assured income to the rural people with low input cost (Nandi et al 2011). From Table 2, it is clear that the maximum profit (per animal) was gained by farmers who reared one doe and its kids, as was also found by Teufel et al. (1998) in Punjab (Pakistan). This can be attributed to the low feeding cost as they were raised mainly on domestic food waste and low plain grazing. Similarly, Metawi (2011) reported that the smallholder system was profitable in the economic analysis compared to transhumant/extensive and semi-intensive production systems in Egypt. However, Singh et al. (2009, 2011) reported a higher contribution to the households' total annual income by large herds, followed by medium and small herds.

Technical efficiency and its determinants in goat farming

The maximum likelihood estimates of the parameters in the stochastic frontier model defined by Eqs. (1) and (2) are given in Table 3. The coefficient in the MLE estimates for production function was found to be positive and significant as expected in the case of feed and fodder. This positive and significant value implies that an increase in fodder and feed will likely increase the returns of goat farmers. The estimate for the variance parameter, $\sigma^2/\sigma^2 s$, indicates that the variance, γ, associated with the inefficacy effect is about 41 % of the two variances.

The estimated coefficients of inefficiency model are also recorded in Table 3. Amongst different factors, centre and animal unit turned out to be significant. The animal unit

Table 3 Maximum likelihood estimates for parameters of stochastic frontier model for goat rearers in Kerala

Variable	Coefficient	Standard error	*t* ratio
Production function			
Constant	6.54[a]	0.59	11.14
Fodder and feed (Rs)	0.18[b]	0.07	2.58
Veterinary care (Rs)	0.08	0.07	1.11
Inefficiency model			
Constant	−1.12[b]	0.45	−2.49
Sex	−0.11	0.24	−0.46
Centre	−0.88[a]	0.28	−3.17
Education	0.02	0.03	0.71
Land	−0.00	0.01	−0.50
Family size	−0.05	0.05	−1.17
Animal unit	0.53[a]	0.14	3.82
Variance parameters			
Total parameters	0.14[a]	0.04	3.70
Gamma	0.41[b]	0.16	2.56
Log likelihood function	−22.39		
LR	30.56		
Average technical efficiency	0.88		

[a] Significant at 1 % level

[b] Significant at 5 % level

Table 4 Distribution of farmers by level of technical efficiency in different animal units (percent)

Technical efficiency category	Animal units					Overall
	1	2	3	4	5 and above	
Below 60	0.0	0.0	11.8	16.7	50.0	7.0
60–65	0.0	0.0	0.0	0.0	0.0	0.0
65–70	0.0	0.0	5.9	16.7	12.5	3.0
70–75	0.0	0.0	11.8	0.0	0.0	2.0
75–80	0.0	6.1	11.8	0.0	25.0	6.0
80–85	0.0	0.0	11.8	0.0	0.0	2.0
85–90	0.0	33.3	0.0	33.3	12.5	14.0
90–95	52.8	30.3	47.1	33.3	0.0	39.0
Above 95	47.2	30.3	0.0	0.0	0.0	27.0
Total farmers	36.0	33.0	16.0	7.0	8.0	100.0

factor turned to be positive, which indicates that the farmers with more animal units are more inefficient than others. This is because of the effective utilization of the available resources for attaining maximum profit. One-animal-unit producers mostly depend on household waste (particularly rice gruel water), leaves and grazing for raising their animals. But as the number of animal units goes on increasing, they have to depend on other sources of feed and fodder like concentrates which are commercially available at a higher cost. Available grazing land is also limited in Kerala, and day by day, it is shrinking. Due to these reasons, the profit decreases as the animal unit increases as evidenced by Tables 2 and 3. The trend of intensification of goat rearing in Kerala constitutes a medium- or long-term risk for these farms which are uncompetitive due to their location and production characteristics, for as they intensify their production systems, they also increase their dependence on external resources, thereby limiting their sustainability over time as reported earlier by Gaspar et al. (2011) in the Villuercas-Ibores area in SW Spain. But in other parts of India like Maharashtra, Madhya Pradesh, Bihar and Uttar Pradesh, commercialization is prominent due to the relatively better grazing resources (Kumar and Pant 2003; Kumar 2007). The positive coefficient for the centre indicates that farmers in Thalassery are more efficient than those of other centres. This may be due to the better management practices they adopted in goat rearing. They fetch more money due to their better performance and bargaining power in that area.

However, the coefficients of sex, education, land size and family size are all statistically insignificant, indicating no relationship between these variables and technical efficiency in goat production in the study area as reported by Kumar (2012). Contrary to this, Ogunniyi (2010) had earlier reported that years of establishment, years of education and feeding frequency have significant impacts on economic inefficiency of sheep and goat production in Nigeria.

Distribution of technical efficiency

The technical efficiency was found to vary widely across different farming units: it ranged from 0.34 to 0.97 with a mean value of 0.88 indicating farmers are fairly efficient in producing a pre-determined quantity of goat at a minimum cost for a given level of technology. Economic efficiencies range more widely; between 0.166 and 0.954 had earlier been reported for sheep and goat production in Ekiti State, Nigeria (Ogunniyi 2010). The highest mean efficiency was obtained by farmers with one animal unit (0.95) and the least by farmers with five and above animal units (0.65). For a better indication of distribution of technical efficiencies in different categories of farmers based on animal units, frequency distribution of technical efficiency within a range of 0.05 was prepared, and this has been presented in Table 4. The overall highest technical efficiency (39 %) was in the category of 90 to 95 %, followed by above 95 % (27 %). Even though only 7 % of the total farmers had technical efficiency less than 60, 50 % of the goat farmers having five or more adult animals were below 60 % technically efficient.

Conclusion

The study examined the technical efficiency of Malabari goat production in three field centres of AICRP in goats (Malabari Field Unit) in northern Kerala. Findings from the study showed goat production was profitable in the study area as depicted by the net returns per animal per month of $3.7. The study also confirmed that feed cost accounted for the major share of production cost. Individual levels of technical efficiency range between 0.34 and 0.97 with a mean value of 0.88, suggesting that opportunities still exist for increasing productivity and income of goat farmers in

the state by increasing the efficiency. The inefficiency model showed that important factors directly related to technical efficiency are farm size (animal unit) and centre (locality in which the animal was raised) while no significant relationship was found between technical efficiency and sex, education, land size and family size. It has been established that a greater number of adult animals will reduce their technical efficiency as well as the returns per animal. Raising one or two goats without much labour involvement and cost will provide an additional source of income for the rural people, particularly to women. So from this study, it can be concluded that the scope of commercialization in goat rearing is limited given the prevailing socio-economic scenario of Kerala.

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