Importance of socio-economic and institutional factors in the use of veterinary services by smallholder dairy farmers in India

*Shiv Raj Singh and K. K. Datta**

The present study establishes the determinate of likelihood of using veterinary services in smallholder dairy farming systems in India. Secondary data were used for analysis purpose with the sample size of 29,020 dairy households at the all-India level. The proportional relationship between veterinary services available within the village and use of these services reveals that, distance of availability of veterinary service positively influences the farmer's decision to use the same. There was a positive relationship between large land holdings, herd size and milk prices with the use of veterinary services. Secondly, the educational status of the head of a household, formal training in agricultural practices and continuation of agriculture as a profession had a positive influence on the use of veterinary services. The public institutions like the farm science centres and contact with extension workers played major roles in the use of veterinary services by the dairy farmers. The institutions which support veterinary services could become more effective if they undertake suitable organizational changes to disseminate the latest animal healthcare technologies to the marginalized dairy farmers.

Keywords: Dairy farmers, land holdings, organizational change, public institutions, veterinary services.

THE smallholder dairy farming is one of the most important sub-sectors of the Indian farming system. Dairying in India is more inclusive compared to crop production in the sense that it involves a majority of the marginalized segments in the society for livelihood. Nearly two-thirds of farm households in India are associated with livestock production and 80% of them are small landholders (≤ 2 ha). The future course of growth in milk production will also involve small and marginal holders[1]. In India, most of the dairy farmers keep indigenous breeds. These breeds are disease-resistant and are able to live and produce under extreme environments with minimal feed and fodder. There are various socio-economic and environmental drivers of change in livestock systems. These include population growth, urbanization, economic development, globalization and changing market demands[2,3]. To meet the changing pattern of consumption, enhancement of milk production is needed and this could be possible by adopting new genotypes or cross-breeding which are more productive compared to indigenous breeds. As a result of dynamism of these factors, it is suggested that the new genotypes or cross-breeding with more productive animals are some of the options that could provide rapid productivity gains. Nonetheless, crossbreed dairy animals are more prompt to the disease incidence than indigenous breeds[4]. Transmission of disease infections poses significant threats to dairy animals, both from the standpoint of the economic impacts of the disease itself and the measures taken to mitigate the risk of disease introduction.

The veterinary services have traditionally been funded, managed and delivered by the public sector in India. Due to the importance of dairy farming among the poor and the assumption that the poor cannot afford to pay for the veterinary services, a major pillar of the Government of India's dairy development strategy over the last four decades (Operation Flood programme during 1970–96) has been the highly subsidized public delivery of these services. Over time, the Governments have built-up vast networks of physical and human infrastructure to provide these services to millions of farmers across the country[5]. The State Animal Husbandry Departments are the only institutions serving the diverse needs of farmers in almost all the States. Generally, their role is limited to vaccination and artificial insemination (AI) services, in addition to the treatment services that they render[6]. In India, while

Shiv Raj Singh is in the Shri G.N. Patel Dairy Science & Food Technology College, Sardarkrushinagar Dantiwada Agricultural University, S. K. Nagar 385 506, India and K. K. Datta is in the Dairy Economics, Statistics and Management Division, National Dairy Research Institute, Karnal 132 001, India.
*For correspondence. (e-mail: kkdatta2007@gmail.com)

the dairy animal population has increased enormously, the Government budgets have not kept pace with growth in population and consequently, the veterinary services delivery has suffered. The squeezed Government funds for veterinary services could be a concern jeopardizing the health of the dairy animals and economic losses to the dairy farmers. An estimated annual loss on account of epidemic and endemic diseases, parasites and other pests is INR 200 billion[7]. This is around 14% of the total output of milk and approximately 10% of the value of livestock output in India. The highest loss in milk and meat production from foot and mouth diseases (FMD) alone was estimated to be around INR 40–45 billion per annum[8]. Mastitis is another important disease in terms of losses around INR 28 billion per annum[9]. In order to sustain the large infrastructure and manpower, the veterinary services sector consumes 60–80% of the budget allocated to the livestock support services[10]. Notwithstanding lack of funds for providing veterinary services, about 13–30% livestock population is covered by the state-provided veterinary services[11]. To protect the interests of the resource-poor dairy farmers, it is essential to expand the public veterinary services at a larger scale as the number of dairy animals will be increased which are likely to be affected with the changing scenario.

The farmers face different socio-economic circumstances in their own settings, which are likely to cause differences in the attitudes towards the available alternatives[12]. Other than socio-economic factors in the smallholder dairy farming, institutional arrangement plays a pivotal role for service delivery systems. The demand of veterinary services by the smallholder dairy farmers would depend on the awareness of the farmers, acessibility to the services, availability, household characteristics and institutional framework of the delivery mechanism of the services. Institutional arrangements and enabling policies are critical for the delivery of veterinary services in case of smallholder dairy farmers. The available evidence suggests that use of veterinary services by the dairy farmers is somehow related with the social factors, household characteristics, economic factors and institution factors.

The objective of this study is to understand the decision-making process of the milk producers to avail veterinary services with respect to socio-economic attributes of the milk producers (socially forward, family size, sales price of milk, herd size, land holding and principal source of income from agriculture), household characteristics (literacy and farmer likes an agriculture as a profession), and institutional factors (availability of veterinary services, formal training attended, farm science centres and contact with extension workers). The objective of the study was, therefore, to assess important factors that determine the use of veterinary services by dairy farmers.

Materials and methods

Source of data

The study is based on the secondary data available from National Sample Survey Organization (NSSO) on *Situation assessment survey of farmers* in the year 2003 (visit-1). The survey was conducted (rural sector) in two rounds, i.e. visit-1 (January–August 2003) and visit-2 (September–December 2003). Under visit-1 detailed information on socio-economic condition, crop husbandry, animal husbandry, access to basic and modern farming resources and consumption expenditure were collected.

This survey focuses on rural areas and the unit of observation is rural farm households. The sampling design used in the NSSO data is stratified multi-stage random sampling with districts as strata, villages as first-stage units and farm households as the second-stage units. There are a total of 51,770 farm households (i.e. number of surveyed households which includes both dairy and non-dairy farm households) at the all-India level. The survey covered 51,770 farm households, out of which 30,039 belonged to dairy farming that were rearing at least one milch dairy animal. Some information was missing from 1019 dairy households and the remaining 29,020 dairy households were selected for analysis in this study.

Model specification and analysis

Both descriptive statistics and econometric methods are employed for data analysis. The logit model is used for binary response analysis. Given the binary response of the variable under consideration (use of veterinary services in the last six months), the econometric specification followed a logistic regression. Logistic regression is a useful statistical modelling technique in which the probability of a binary outcome is related to a set of potential explanatory variables. The binary logistic regression has been widely used to address decisions involving binary choice in farm technology adoption studies[13–15]. For calculation of contribution of different factors to the use of veterinary services, it is assumed that a use of veterinary services by dairy farmers is a random phenomenon affected by a set of factors that could explain the outcome. This binary variable is then regressed onto a set of explanatory variables. As the dependent variable is binary, we cannot use least squares method to estimate the coefficients. Instead, one can use maximum likelihood estimation technique to calculate the coefficients. In this study, we have used logit model that allows us to calculate marginal contributions of different factors on the use of veterinary services. To predict the dependent variable, the farmers have been classified into two groups – those who use veterinary services and those who do not, and we used the logit model as discussed below.

$$P_n = \frac{1}{1+e^{-z_n}},$$

where P_n is the probability that a dairy farmer used the veterinary services.

$$1-P_n = 1-\frac{1}{1+e^{-z_n}},$$

where $1 - P_n$ is the probability that a dairy farmer did not use the veterinary services.

$$\text{The Odd's ratio} = \left(\frac{P_n}{1-P_n}\right) = e^{z_n}.$$

Taking logarithm on both sides

$$\ln\left(\frac{P_n}{1-P_n}\right) = Z_n = \alpha + \beta_n X_n + e_n, \quad (1)$$

where α is the intercept, β the vector of response coefficient, e the vector of random disturbance and X_n is the set of explanatory variables.

The estimable equation can be written as:

$$\begin{aligned}\text{vet\_service} = {} & \beta_0 + \beta_1 \text{ village} + \beta_2 \text{ family size} \\ & + \beta_3 \text{ socforw} + \beta_4 \text{ land holding} \\ & + \beta_5 \text{ principal income} + \beta_6 \text{ training} + \beta_7 \text{ literate} \\ & + \beta_8 \text{ like agri} + \beta_9 \text{ herd size} + \beta_{10} \text{ price milk} \\ & + \beta_{11} \text{ farm science centres} + \beta_{12} \text{ extension workers} \\ & + \beta_{13} \text{ farm science centres} \times \text{entension worker} + e_n \quad (2)\end{aligned}$$

where vet_service is the veterinary service used by the dairy farmers in the last six months, while $\beta_1 \cdots \beta_{13}$ are coefficients associated with each explanatory variable and e_n is the error term. Several factors were hypothesized to influence the farmer's decision to use the veterinary services. A description of these factors is presented in Table 1. The choice of these explanatory variables was mainly based on the general working hypothesis and partly on empirical findings from the literature, and, therefore, a positive or negative sign was assigned depending on the potential influence of a particular variable on the use of the veterinary services.

Multicollinearity can undermine the statistical integrity of the model. Multicollinearity in logit models is a result of strong correlations between independent variables. The variance inflation factor (VIF) is generally used to detect the multicollinearity in binary models. In the logit models often VIF value above 2.5 is considered as the cut-off point for multicollinearity detection[16]. In our analysis only two variables, i.e. self-employed in agriculture (VIF = 2.92) and principal source of income from agriculture (VIF = 2.87) are collinear on the basis of VIF value and we omitted self-employed in agriculture variable from the analysis. The resultant value of VIF for principal source of income from agriculture was 1.12 in the permissible limit.

Survey data were applied to the logit model in eq. (2) and estimation was made through the application of logit command of the STATA-10 econometric computer program. In order to predict the effect of change in an explanatory variable on the probability of a favourable attitude towards a veterinary service used, the marginal probability concept was used. To workout the marginal effect, *mfx compute* command in STATA-10 software was used. The interaction effect helped us to infer how the effect of one independent variable on the dependent variable depends on the magnitude of another independent variable. Interaction terms are also used extensively in nonlinear models, such as the logit model. Unfortunately, the intuition from linear regression models does not extend to nonlinear models. The marginal effect of a change in both interacted variables is not equal to the marginal effect of changing just the interaction term. More surprisingly, the sign may be different for different observations. The statistical significance cannot be determined from the *z*-statistic reported in the regression output. For this purpose, we used *inteff* command in the STATA-10 software[17].

Results and discussion

Important characteristics of dairy farmers

Descriptive statistics on the characteristics of dairy farmers are presented in Table 2. According to our earlier discussion, *Situation assessment survey of farmers* was the only survey which provided detailed information regarding the important attributes of the farming community.

Overall, 55.23 million farmers were engaged in dairy farming out of which about 41% used veterinary services during the survey period. According to a study by Murage and Hatsia[18], distance from veterinary services inversely affects the use of services by the farmers. In India, around 23.42% dairy farmers were able to access veterinary services within the village itself. Remaining 76.58% dairy farmers admitted that veterinary services were not available to them in the village periphery, in contrast to the findings of Ahuja *et al.*[5], which indicate that most of the veterinary services were used by farmers at their doorsteps and around 48–96% of total veterinary expenditure incurred by dairy farmers was in the name of home visit charges by the different veterinary service providers. Therefore, to improve the quality and affordability of veterinary services, there is a need to improve the penetration of such services in the village itself. Majority of dairy farmers (70.12%) indicated that their principal source of income was only agriculture, with the

Table 1. Description of dependent and explanatory variables used in the analysis and the expected signs

Variable	Description of the variable	Expected signs
Dependent variable		
Vet_service	Veterinary service used Yes = 1, No = 0	
Explanatory variables		
Village	Veterinary services available within the village = 1, otherwise = 0	+
Family size	Family size (1–5) = 1, otherwise = 0	+
socforw	Socially forward (general and OBC) = 1, otherwise = 0	+
Land holding (ha)	Land holding (continuous)	+
Principal income	Principal source of income from agriculture = 1, otherwise = 0	±
Training	Head of household attended any formal training in agriculture = 1, otherwise = 0	+
Literate	Literate head of household = 1, otherwise = 0	+
Like agri	Farmer likes agriculture as a profession = 1, otherwise = 0	+
Herd size (No.)	Herd size of milch dairy animals (continuous)	+
Price milk (INR)	Price per litre of milk (continuous)	+
Farm science centres	Whether accessed Farm Science Centre = 1, otherwise = 0	+
Extension workers	Whether accessed extension workers = 1, otherwise = 0	+
Farm science centres × entensionworker	Whether accessed Farm Science Centre and extension workers (interaction)	+

Table 2. Selected institutional and socio-economic characteristics of dairy farmers using veterinary services

Characteristics	Number	Percentage*
Sample households (million)	55.23	–
Veterinary services used (million)	22.42	40.59
Veterinary services available within the village (million)	12.94	23.43
Family size (1–5; million)	28.33	51.29
Socially forward (million)	39.28	71.12
Average land holding (ha)	1.47	–
Principal source of income from agriculture (million)	38.73	70.12
Head of household attended any formal training in agriculture (million)	1.01	1.83
Literate head of household (million)	29.98	54.28
Farmer likes agriculture as a profession (million)	34.78	62.97
Average herd size of milch dairy animals	3.11	–
Average price per litre of milk (INR)	10.92	–
Whether accessed farm science centres (million)	0.36	0.65
Whether accessed extension workers (million)	3.54	6.41

*Figures indicate percentage to sample households (55.23 million).

average land holding size being 1.47 ha. The household size of half the dairy farmers was 1–5. The head of the household played an important role in the decision-making processes. The literacy of the dairy farmers was also an important attribute determining the use of veterinary services. From Table 2 it can be found that 54.28% heads of dairy households are literates, but only 1.83% heads of households had obtained formal training in agriculture. About 63% of the dairy farmers admitted that they liked agriculture as a profession. The average herd size of milch animal per dairy farmer is about 3.11. The average sales price (during the last 30 days of survey day) per litre of milk was INR 10.92. Access to farm science centres and contact with extension workers are the surrogate indicators of access to public sectors institutions. These institutions have a mandate to transfer information and technology to the farmers. From Table 2 it can be seen that only a fraction (0.65%) of dairy farmers had accessed the farm science centres, personally. However, the contacts of the extension workers with the dairy farmers were somehow satisfactory.

Factors influencing the use of veterinary services

Empirical estimates derived from the binary logit model are presented in Table 3. Signs of empirical estimates correspond with as purposed in Table 1. Given that the model included several binary variables, the chosen level of statistical significance was 1% and 10%.

Out of the 13 influential factors, 10 are statistically significant at 1% and 10% level. However, the explanatory power of logit model is quite low, as pseudo R^2 value is 0.0543. But goodness of fit is not as important as statistical and economic significance of the explanatory variables[19,20]. The observed proportional relationship between

Table 3. Binary logit model coefficient estimates for determining farmers using veterinary services

Characteristics[a]	Coefficients[b]	SE	*z*	$p > z$
Veterinary services available within the village	0.8473	0.0275	30.81	0***
Family size (1–5)	0.0344	0.0251	1.37	0.171
Socially forward	0.2218	0.0279	7.95	0***
Land holding	0.000011	0.0000057	1.93	0.063*
Principal source of income from agriculture	0.0248	0.0278	0.89	0.371
Head of household attended any formal training in agriculture	0.5264	0.0864	6.09	0***
Literate head of household	0.0975	0.0252	3.87	0***
Farmer likes agriculture as a profession	0.3185	0.0261	12.20	0***
Herd size of milch dairy animals	0.0670	0.0054	12.41	0***
Average price per litre of milk	0.0238	0.0022	10.82	0***
Whether accessed farm science centres	0.8854	0.1835	4.83	0***
Whether accessed extension workers	0.4392	0.0509	8.63	0***
Whether accessed farm science centres and extension workers	0.1845	0.3196	0.58	0.56
Constant	–1.3837	0.0397	–34.85	0***

[a]n = 29,020; log likelihood = –18,750.85; LR $\chi^2(13)$ = 2155.31; Prob > χ^2 = 0.00 and Pseudo R^2 = 0.0543.
[b]Significant at 1% (***) and 10% (*).

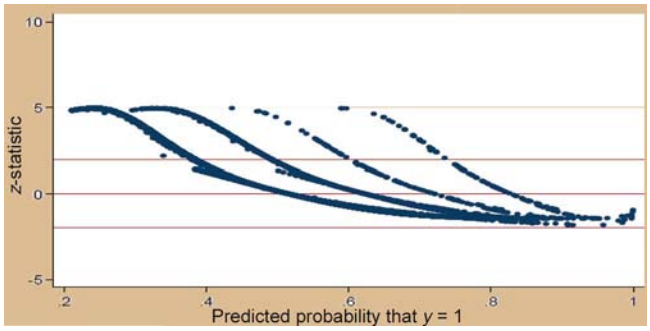

Figure 1. *Z*-statistics of interaction effect (access to farm science centers and extension workers) using the logit model.

veterinary services available within the village and use of veterinary services implies that distance of availability of veterinary services positively influences the farmers decision to use them. The family size and principal source of income from agriculture are positively related with the use of veterinary services, but these do not significantly influence the decision to use them. The results further indicate that farmers belonging to the socially forward class are more likely to use the veterinary services. As we know that in India land holdings are much more unequally distributed among the farming community compared to dairy animals[21]. From the analysis carried out in this study, it is seen that the size of land holdings of dairy farmers significantly influences the decision to use veterinary services. This means inequality of land distribution among the dairy farmers influences unequally the decision to use veterinary services. A positive relationship was observed between literacy levels of the heads of the dairy farmer households and use of veterinary services. It implies that improving the literacy level of dairy farmers would increase the likelihood of using veterinary services. Formal training of the head of a household in agriculture significantly influences the decision of the household to use the veterinary services. It means to strengthen the decision of dairy household to use the veterinary services, needs more training on animal healthcare and management practices. Dairy farmers who liked agriculture as a profession indicated profitability as a criterion for their being in the profession.

The logit analysis further establishes that farmers who express their liking for agriculture as a profession positively (statistically significant) influence the decision of dairy farmers to use of veterinary services. The farmers who keep large number of dairy animals are more particular on the use of veterinary services. In reality, farmers with large herds are relatively cautious regarding the use of veterinary services, since this has economic implications on their enterprises. This also indicates that as commercial dairy farming increases in India, it will open up new opportunities for veterinary service providers. Returns from milk production positively influence the decision of dairy farmers to use veterinary services. This implies that as dairy farming becomes more remunerative, there is a greater need for diffusion of new healthcare services at farm level. Institutional framework plays an important role in the adoption of any technology at farm level either its agriculture or veterinary practices. Accessibility of farmers to the farm science centres and contact with extension workers also play an important role in the pro-poor farm societies for adoption of new technologies. It is found that access to farm science centres and contact with extension workers are statistically significant at 1% level of significance, which indicates that these contribute positively in the decision-making process towards the use of veterinary services. Nonetheless, their interaction term is non-significant (*z*-statistic is 0.58), which implies that persons who have access to farm science centres and contact with extension workers are not likely to use veterinary services. This can be explained by the cumulative effects between pull and push

Table 4. Marginal effects of explanatory variables on the probability of veterinary services used

Characteristics[a]	Marginal effect	SE	*z*	*p* > *z*
Veterinary services available within the village	0.2082	0.0066	31.55	0***
Family size (1–5)	0.0084	0.0061	1.38	0.171
Socially forward	0.0540	0.0067	8.06	0***
Land holding	0.000002	0.0000011	1.82	0.063*
Principal source of income from agriculture	0.0061	0.0068	0.90	0.37
Head of household attended any formal training in agriculture	0.1308	0.0213	6.14	0***
Literate head of household	0.0238	0.0062	3.84	0***
Farmer likes agriculture as a profession	0.0773	0.0063	12.27	0***
Herd size of milch dairy animals	0.0164	0.0013	12.62	0***
Average price per litre of milk	0.0058	0.0005	11.60	0***
Whether accessed farm science centres	0.2168	0.0422	5.14	0***
Whether accessed extension workers	0.1091	0.0127	8.59	0***
Whether accessed Farm Science Centre and extension workers	0.0456	0.0797	0.57	0.567

[a]Significant at 1% (***) and 10% (*).

factors. In case of few observations, the interaction effect is statistically significant, which are smaller in numbers whereas for others it is non-significant, which are larger in numbers (Figure 1). However, after running the *inteff* command, the mean interaction effect was found to be positive (0.0237) and varies widely. This implies that policy interventions required for making prompt to the state extension functionary and farm science centres, resultant more dairy farmers could use veterinary services.

Table 4 presents marginal effects of the variables which are presented in Table 3, with significant coefficients for the use of veterinary services. These probabilities show how changes in specific variables affect the probabilities of dairy farmers reacting positively or negatively towards the use of veterinary services.

Truly, marginal effect computed for continuous variables is not comparable with those computed for binary variables. The responses of dairy farmers towards the use of veterinary services are greatly influenced (21.68%) by the unit increase in access of farm science centre. The next most influential variable is given an increase in veterinary services availability in the villages is enhanced 20.82% of probability for the use of veterinary services. Alternatively, longer distances may imply inability to access veterinary services. The result of marginal effect also shows that with unit increase in the training of dairy farmers, one can enhance the probability of use of veterinary services by 13.08%. If increase in accessibility to extension workers is enhanced by a unit, then it would increase the probability of use of veterinary services by 10.91%. Overall, these four variables are most likelihood variables that could increase the probability of use of veterinary services among the dairy farmers. From the policy perspective purpose, there is a need to strengthen the institutional framework in the country. Institutions like veterinary hospitals, farm science centres and extension departments could play an important role in the adoption of use of veterinary services in India.

Conclusion

This study has shown the importance of identifying factors that determine the likelihood of using veterinary services in smallholder dairy farming systems in India. Descriptive analysis revealed that for majority of dairy households, the principal source of livelihood is agriculture and they have small landholdings. The integration of small landholding with dairy farming offers an opportunity to these marginalized famers to diversify farming business and secure their livelihoods. In the smallholder production system it is important that Government and other related agencies make efforts to improve the socio-economic profile of the farmers through planned extension activities along with other policy instruments.

Based on the logit model, it is found that the dairy farmers using veterinary services possess attributes like large landholdings, own large herds and receive higher prices for milk. In addition, the heads of these households are educated, formally trained in agricultural practices and have a liking for agriculture as a profession. In the social structure, farmers belonging to the forward class are more likely to use the veterinary services. The proportional relationship between veterinary services available within the village and use of these services implies that distance of availability of veterinary services positively influences the farmer decision to use them. Farmers who have access to public institutions like farm science centres and contact with extension workers are more likely to use veterinary services. Direct Government involvement in veterinary services has been justified on social rather economic grounds, particularly under the background of the Indian smallholder dairy farming system. The institutions supporting veterinary services would become more effective if they introduce suitable organizational changes and use technology to reduce transaction costs.

1. Singh, S. R. and Datta, K. K., Understanding value addition in Indian dairy sector: some perspectives. *Agric. Econ. Res. Rev.*, 2010, **23**, 487–493.

2. Delgado, C. L., Rosegrant, M. W., Steinfeld, H., Ehui, S. K. and Courbois, C., Livestock to 2020: the next food revolution. Markets and Structural Studies Division Discussion Paper 28. International Food Policy Research Institute, Washington, DC, 1999.
3. Herrero, M., Drivers of change in crop-livestock systems and their potential impacts on agro-ecosystems services and human well-being to 2030, CGIAR Systemwide Livestock Programme, ILRI, Nairobi, Kenya, 2009.
4. Grasty, S., Agriculture and climate change. *TDRI Quart. Rev.*, 1999, **14**, 12–16.
5. Ahuja, V., McConnell, K. E., Umali-Deininger, D. and Hann, C. D., 2003, Are the poor willing to pay for livestock services? Evidence from rural India. *Indian J. Agric. Econ.*, 2003, **58**, 84–99.
6. Gautam Dalal, R. S. and Pathak, V., Indian dairy sector: time to revisit operation flood. *Livestock Sci.*, 2010, **127**, 164–175.
7. GoI, Centre to alleviate poverty through livestock centric employment agenda, Press Information Bureau, 2011; http://www.pib.nic.in/newsite/erelease.aspx?relid=49744
8. GoI, Report of the Working Group on Animal Husbandry and Dairying for the Tenth Five Year Plan (2002–07), Working Group Sr. No. 42/2001, 2002, Planning Commission, Government of India.
9. Sirohi, S. and Sirohi, S. K., Cost of bovine mastitis to Indian dairy farmers. In Proceedings of Round Table on Mastitis, VIII Annual Conference of Indian Association for the Advancement of Veterinary Research, 2001, vol. IV, pp. 164–170.
10. Prabaharan, R., Livestock-research investment crucial. *The Hindu Survey of Indian Agriculture*, Chennai, 2000, pp. 137–140.
11. Sen, A. and Chander, M., Privatization of veterinary services in developing countries: A review. *Trop. Anim. Health Prod.*, 2003, **35**, 223–236.
12. Tambi, N. E., Mukhebi, W. A., Maina, W. O. and Solomon, H. M., Probit analysis of livestock producers' demand for private veterinary services in the high potential agricultural areas of Kenya. *Agric. Syst.*, 1999, **59**, 163–176.
13. Mburu, L. M., Wakhungu, J. W. and Gitu, K. W., Determinants of smallholder dairy farmers adoption of various milk marketing channels in Kenya Highlands. *Livestock Res. Rural Dev.*, 2007, **19**; http://www.lrrd.org/lrrd19/9/mbur19134.htm
14. Kumar, A., Milk marketing chains in Bihar: implications for dairy farmers and traders. *Agric. Econ. Res. Rev.*, 2010, **23**, 469–477.
15. Suresh, A., Gupta, D. C., Solanki, M. R. and Mann, J. S., Reducing the risk in livestock production: factors influencing the adoption of vaccination against bovine diseases. *Indian J. Agric. Econ.*, 2007, **62**, 483–491.
16. Allison, P. D., *Logistic Regression using the SAS System: Theory and Application*, SAS Institute, North Carolina, USA, 1999.
17. Norton, E. C., Wang, H. and Ai, C., Computing interaction effects and standard errors in logit and probit models. *Stata J.*, 2004, **4**, 154–167.
18. Murage, A. W. and Hatsia, E. D., Factors that determine use of breeding services by smallholder dairy farmers in Central Kenya. *Trop. Anim. Health Prod.*, 2011, **43**, 199–207.
19. Wooldridge, J. M., *Econometric Analysis of Cross Section and Panel Data*, MIT Press, Cambridge, Massachusetts, 2002.
20. Gujarati, D. N., *Basic Econometrics*, McGraw-Hill, New York, 2003, 4th edn.
21. Kumar, A. and Singh, D. K., Livestock production system in India: an appraisal across agro-ecological regions. *Indian J. Agric. Econ.*, 2008, **63**, 577–597.

Received 25 June 2012; revised accepted 28 May 2013

Smile with Science

By – Santosh Kumar Sharma
e-mail: santosh_ujj@yahoo.com