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Research Article

INTEGRATED DAIRY MANAGEMENT PRACTICES ADOPTION AND IMPROVEMENT IN MILK YIELD: NEGATIVE BINOMIAL REGRESSION MODEL FOR RURAL INDIA

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Abstract: The adoption of integrated technologies in dairy farming greatly recognised in achieving higher milk productivity thereby income. However, adoption rate of suite technologies in developing country is very low despite the substantial efforts by concerned stakeholders and various government programmes. The study aims at assess the determinants of integrated dairy management practices (IDMPs) the extension related parameters (contact of extension personnel and dairy training programme) and area under fodder crop are positively significant in influencing the adoption intensity of IDMPs at 5% of significant. The farmers who adopted seven IDMPs realized highest milk productivity (4.85 Kgs/animal) as against 3.29 Kgs/animal who adopted 3 IDMPs. The tetra choric correlation coefficients among IDMPs silage making is positively correlated with balanced ration but negatively with mineral mixture. The extension service could be reached effectively by deploying the ICTs tools with more tailored and timely information to dairy farmers as a whole. There is a definite need to increase forage production per unit area through encouraging high yielding fodder crops and forages, in an integrated crop- livestock farming systems. Creating awareness among farmers use of non-conventional feed resources that can improve intake and digestibility of low-quality forages and support them in gaining the first-hand knowledge of these feedstuffs from various livestock extension agencies, thus providing nutritional security to animals.

Keywords: *Dairy, IDMPs, Extension service and fodder crop*

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Introduction

Adoption of technology in agricultural sector particularly dairy farming plays vital role in food and nutritional security. In India more than 70 percent of rural people depend on dairy farming for their livelihood contributes about one third of gross income of dairy households. The adoption of integrated technologies in dairy farming is capable of obtaining higher farm income and returns on investment to extent of 20 to 25 percent [1]. Moreover, previous studies dealt with adoption of single technology which reveals that adoption of milking machine has low bacterial count and contributes in reducing labour required for milking but no improvement in milk yield or welfare of the animals [2]. Perhaps most of the studies focused on single technology rather than integrated approach to achieve desired objectives [3] yet they failed to achieve realized productivity [4]. Moreover, in developing countries like India, adoption of integrated dairy management practices or technologies it is rare, all the farmers are not able to adopt because of impediments such as socioeconomic, institutional and environmental factor [5]. Though some of the authors emphasized by adopting suite of technology rather than single technology in enhancing productivity and welfare of dairy animals. The feeding, breeding, milking and management practices are included in the holistic integrated dairy management practices (IDMPs). Moreover, uses of any of IDMPs mentioned in [Table-1] are complementary or synergistic in nature. Farmers may adopt one or more technologies, first evaluate their practicability and also economic and environmental goals there after decided to adopt technology [6]. Furthermore, farmer's positive attitude with one technology is likelihood to affect their decision to adopt other complementary technologies [7]. Nevertheless, other studies revealed that it is not true that the adoption of more technologies may not necessarily produce higher productivity and welfare of animals [8].

Therefore, this study lends empirical findings to the debate regarding the IDMPs on enhances milk productivity and welfare of the dairy animals. Thus, the outcomes of the present study support to existing literature. The objective of this paper is twofold. The first aim is to assess the determinants of single technology (milking machine) in dairy farming. This appraisal under limited regression model. The second aim is a broader perspective is carried out in order to examine the factors affecting the adoption of IDMP in dairy farming are analyzed by employing the count data models. This approach directs the productivity enhancement realized through simultaneous adoption of a suite of technology rather single technology. The brief summary of previous work done under different categories of management practices is given in [Table-1].

Materials and Methods

Study is based on primary survey of 190 commercial dairy farmers in five districts of Karnataka in year 2016. Respondent were selected following purposive and multistage random sampling procedure. Respondent were intensively surveyed using pretested and structured schedule. Karnataka is divided into five agro climatic zones. So, five districts from each zone have been considered for the study. Selection of district is based on higher number of veterinary institutes, artificial insemination (AI) centres, AI performance, area under fodder crops, pasture and grazing land, gross irrigated area, and bovine density [Table-2]. Based on proportionate sampling, 50 samples from Belgaum district, 40 samples each from Hassan and Tumkur, and 30 samples each from Mandya and Dakshinkannada districts have been surveyed. Assessment of technology adoption can be done using the logit model. Where the dependent variable is categorical taking different value corresponding to the technologies selected.

Table-1 *Summary of integrated dairy management practices*

SN	Dairy Management Practices	Summary
	Feeding Practices and Fodder production	
1	Feeding of mineral mixture and concentrate (MM &C)	The area specific mineral mixture improves the animal productivity [9]
2	Silage making (SIM)	The silage /hay ensure high-quality succulent feed round the year at low cost [10]
3	Area under fodder crop (AFC)	The area under fodder cultivation is only about 4% of the gross cropped area, which helps to bridge the deficit gap in India (MoA& FW, 2016)
	Breeding Practices	
4	Artificial insemination (AIs)	AIs circumvents the physical or behavioral impediments to natural mating and speed up the rate of genetic improvement thereby increases productivity of animals [11]
5	Sexed semen (SES)	The technology aims to alter sex ratio of the offspring toward a desired gender [12]
	Management Practices	
6	Milking machine (MIM)	Milking machines efficiently removes the milk without damaging the teats of the cow and also ensures hygienic of milk [13]
7	Safe disposal of animal wastes (SAW)	The livestock waste is major source of noxious gases, harmful pathogens and odor hence is to be managed properly to protect environment [14]
8	Recycling of animal wastes (RAW)	Proper utilization of livestock waste which facilitates the crop yield and augments farm income and ensures sustainability [14]
	Health care Practices	
9	Vaccination for HS, FMD, BQ and Anthrax (VAC)	These diseases cause with 40 % fatality rate and an economic loss of Rs. 149.7 million among the cattle in India [15]
10	Deworming of animals (DWA)	The gastro- intestinal tract of animals harbors parasites like helminths, which adversely affect health status of animals [16]

Table-2 *Description of selected agro-climatic zone of Karnataka*

Agro-climatic Zones of Karnataka					
Parameters	Northerndry	Eastern dry	Southern dry	Hilly zone	Coastal zone
Gross cropped area (000'ha)	4041	962	954	673	336
Irrigated area (in %)	28	23	34	20	34
Rainfall (mm)	464 to 785	679 to 888	670 to 888	904 to 3695	3010 to 4694
Selected district for study					
Selected Districts	Belgaum	Tumkur	Mandya	Hassan	Dakshinakannada
Veterinary Institutes (Nos)*	234	216	194	186	101
AICs (Nos)*	420	439	325	302	455
AI performance (000'Bovines)*	395	463	507	516	254
Area under fodder crop (%)#	3.9	14.6	2.1	0.6	2.1
Permanent pasture and Grazing land(000'ha)#	25	76	32	33	19
GIA (000'ha)**	589.5	163.9	154.22	116.56	82.3
Bovine density (No per Sq. km)##	106	67	103	110	53

*Note: Veterinary institutes include Veterinary Hospitals, Veterinary Dispensaries, Primary Veterinary Centers, Mobile Veterinary Centers and Clinics, Intensive, Cattle Breeding and Development Scheme. Source: Karnataka State Department of Agriculture (KSDA), Govt. of Karnataka, * Integrated Sample Survey Reports, Directorate of Animal Husbandry and Veterinary Services, Govt. of Karnataka. # Annual Season & Crop Report 2014-15, DES, Bengaluru; ** Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, GoI. ## 19th Livestock Census, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Govt. of India; Mandya and Dakshinkannada districts*

The logit model, which assumes a logistic distribution, is a limited dependent variable model. To examine decision on adoption of milking machine(MM) if adopted then assign 1, otherwise 0, logit model employed [17].

$$Prob\ (MM = 1/x) = \frac{e^{x'\beta}}{1 + e^{x'\beta}} = \gamma(x'\beta)$$

Parameter β reflect the impact of change in x on the probability of adopting the MM and γ shows the logistic cumulative distribution function. Using the logit model, β parameters cannot be directly interpreted other than for sign, thus marginal effect are estimated for a continuous variable using the logit model as estimated by Greene (2000):

$$\delta E\ (y/x) = \gamma\ (\beta' x)\ [1 - \gamma\ (\beta' x]\ \beta \delta x$$

Negative Binomial regression model

The count data models such as Negative Binomial Regression (NBR)and Poisson Regression Modeling (PR) are employed to estimate technology selection, in which dependent variable is the number of technologies adopted. These models mainly focus on adoption intensity. In principle, count data suffers from over dispersion and under dispersion as consequences underestimate the standard errors and overstate the significance of regression parameters [18]. The Wald statistic employed to test dispersion and results reveals that presence of over dispersion in data. Thus, negative binomial model preferred for examining technologies adoption intensity among the dairy farmers. The NBR that accounts the equi dispersion limitation of the PR. The model uses incentives to inject the latent heterogeneity in the conditional mean of the Poisson model.

$$E[y_i/x_i, \varepsilon_i] = \exp\ (\alpha + X_i'\beta + \varepsilon i) = h_i\lambda_i,$$

Where $h_i = \exp\ (\varepsilon_i)$ is presumed to have a one parameter gamma distribution, G (θ,θ) with mean 1 and variance 1 / θ = κ;

$$f\ (hi)\ = \frac{\theta^{\theta}\ exp\ (-\theta hi^{\theta-1})}{T(\theta)}, hi \geq 0, \theta > 0$$

Once integrating h_i out of the joint distribution, we find the marginal negative binomial (NB) distribution

$$Prob[Y = yi|xi] = \frac{r(\theta + yi)r_i^{\theta}(1 - ri)^{yi}}{r(1 + yi)r(\theta)}$$

$$Yi = 0,1.\theta > 0, \quad ri = \frac{\theta}{\theta + \lambda i}$$

The latent heterogeneity persuades over dispersion maintain the conditional mean

$$E[yi/Xi] = \lambda i$$

$$Var[yi/Xi] = \lambda i[1 + (1/\theta)\lambda i = \lambda i[1 + k\lambda i]$$

$$\text{Where k} = \text{Var[hi]}$$

The maximum likelihood estimates can be obtained by log likelihood method. When modelling farmers' choices on the number of technologies to adopt, especially in a developing country, it imperative to consider the effect of the number of non-adopters in order to expose the effect of more zeros in the raw data [17]. Vuong (1989) test performed in order to know the zero-inflated model fits better to data.

Results and Discussion

The [Table-4] summaries the means of characteristics differences of non-adopter and adopter of milking machine. There appeared to be significant difference in all parameters barring AIs centre, proximity of milking collection centre.

Table-3 *Descriptive statistics of variables and hypothesized effects on adoption of IDMPs in study area*

Variable	Description	Mean	SD	Hypothesized sign
Independent variables				
Household characteristics				
Education	Years of education/schooling	6.56	3.78	+
Household size	Number of Family members	4.56	0.85	+
Experience in Dairy farming	Years of farming experience	35.56	9.85	+
Farm related parameters				
Herd size	Total number of Milch animals	14.53	6.37	+
Cropped area	Area under cereals crop (ha)	5.78	5.89	-
Irrigated area	Area under irrigation (ha)	2.36	1.89	+
Fodder crop area	Area under fodder crop (ha)	0.89	2.86	+
Institutional Factors				
AIs Centers	Distance of AIs centres (kms)	12.68	6.36	-
Milk collection centers	Distance of milk collection centres (in kms)	3.65	5.63	-
Non-dairy income	Total income from sources other than non-dairy farming	49.51	85.75	+
Extension related parameter				
Extension contact	Number of extension contacts with extension agent last year by farmer	12.35	7.43	+
Attendance at training programme	= 1 if the farmer attended any dairy training , 0 otherwise	0.52	0.69	+

Table-4 *The statistical significant difference between adopters and non–adopters of milking machine*

Variable	Non-Adopter	Adopter	Difference	t-value/chi-square test
Education	4.56	6.66	-2.10	2.56**
Household size	5.23	3.56	1.67	3.28**
Experience in dairy farming	32.13	40.23	-8.10	2.56**
Herd size	10.25	14.23	-3.98	3.26**
Cropped area	2.65	4.56	-1.91	1.56
% of area under fodder	0.16	0.56	-0.40	2.89**
AIs centre Distance (in Kms)	14.23	10.26	3.97	1.56
Proximity of Milking collection centre (in Kms)	2.23	1.56	0.67	1.78
Non-Dairy Income	36.65	41.56	-4.91	2.65**
Extension contact	7.56	15.23	-7.67	2.15**
Attending dairy training programme	0.23	0.65	-0.42	2.65**

*** implies 5 % level of significant respectively.*

Table-5 *Tetrachoric correlations estimates of IDMPs*

IDMPs	MM & C	SIM	AFC	AIs	SES	MIM	RAW	SAW	VAC	DWA
MM& C	1									
SIM	-0.45*	1								
AFC	-0.65*	0.58**	1							
AIs	0.45*	0.23	0.12	1						
SES	0.45	0.56	-0.45	-0.67*	1					
MIM	0.15	0.45	0.35	0.41	-0.56	1				
RAW	-0.23	0.56*	0.49**	0.14	0.52	0.19	1			
SAW	0.21	0.45	0.51**	0.16	0.23	0.45	0.25**	1		
VAC	0.56*	0.19	0.35	0.41*	0.32*	0.25	0.23	0.23	1	
DWA	0.45*	0.25	0.36	-0.25	0.89	0.25	0.45	0.17	0.19*	1

*** indicates the 1 % significance, * indicates the 5 % significance.*

The farmers contacted extension personnel and attended training programme are found to be higher than non-adopter of MM. Perhaps due to higher education level and experience in dairy farming.

Tetrachronic correlations

Thetetrachoric correlation coefficients of dairy management practices presented in [Table-5]. The positive significant correlation implying technologies are complementary in nature whilst negative significant correlation coefficient indicates technologies are mutually exclusiveness. The balanced ration feeding is negatively correlated with mineral mixture implies mutual exclusive management for dairy farming. The silage making is positively correlated with balanced ration but negatively correlated with mineral mixture this suggests that dairy farmers prefer the succulent feed over the mineral mixture due to its accessibility and affordability compared to concentrates. The area under fodder crop is highly positive significant with silage making and moderately negative significant with mineral mixture which clearly indicates that fodder crop could be utilized for silage making to ensure high quality succulent feed round the year at low cost.

Intensity of IDMPs adopted the dairy farmers.

The intensity of practices, herd size and productivity of animals has presented in [Table-6]. Around 22 percent of farmers are adopted 3 IDMPs [Table-1]. The findings are similar with [19] who estimated that 22 percent of the farmers adopted more than 50 percent of technologies. Among the farmers who adopted 7 management practices such as MM&C, SIM, AIs, VAC, DWA, SIM and RAW which enhances the productivity level 4.85 kg/animal. While about 6 percent of the farmers adopted all the IDMPs and achieved milk productivity of 4.22 kg/animal. The findings clearly indicate that higher number management practices may not necessarily yields higher productivity of the dairy animals.

Logit model

The estimated coefficients of the parameters and marginal effects of the logit model are summarized in [Table-7]. The power of prediction of the assessed model is 77.5 % of the observations were precisely predicted by the model. Among the variables in farmer characteristics farmer's education found to be significant in adoption of MM technology as expected with hypothesis. Framers who are better educated have greater ability to access the information and explore the technologies which suits to production endowments than those who are less educated [5]. The estimated marginal effect of education indicates that the probability of adopting a technology increases by 5% for an additional year increase in formal education. The area under fodder crop found to be significant at 1 percent as expected which implies safeguards fodder security due to frequent occurs of drought.

Table-6 *Intensity of IDMPs, herd size and productivity of animals*

Number of IDMPs	Frequency of farmers adopted	% of farmers	herd size	productivity per animal (kg/day)
3	41	21.58	12	3.27
4	35	18.42	11	3.56
5	33	17.37	15	4.13
6	22	11.58	17	4.48
7	16	8.42	14	4.85
8	17	8.95	16	4.29
9	15	7.89	13	4.2
10	11	5.79	13	4.22
Total/Mean	190	100	14	4.12

Table-7 *Coefficients and marginal effects of logit model*

Variable	Coefficient estimates			Marginal effects		
	Coefficient	Std.error	t value	Marginal effects	Std.error	t value
Education	0.05*	0.009	5.11	0.05*	0.07	7.29
Household size	0.06	0.090	0.67	0.08	0.22	0.36
Experience in dairy farming	0.02	0.190	0.08	0.02	0.10	0.15
Herd size	0.04*	0.007	5.57	0.04*	0.01	3.25
Cropped area	-0.02	0.009	-2.56	-0.07	0.01	-5.00
Irrigated area	0.07*	0.009	7.33	0.05*	0.01	3.92
Area under fodder crop	0.11**	0.010	11.00	0.13**	0.01	7.65
Institutional factors						
Ais centre	-0.05	0.050	-0.94	-0.05	0.06	-0.82
Proximity of milking collection centers	-0.03*	0.008	-3.25	-0.02*	0.01	-3.00
Non- dairy income	0.04*	0.009	4.44	0.01*	0.015	2.40
Extension						
Extension contact	0.10**	0.010	10.00	0.14**	0.01	14.00
Attendance at training centers/agriculture fair	0.12**	0.020	6.00	0.13*	0.06	2.17
Power of prediction (%)	77.56					
Log likelihood function	-2156.23					
Mcfadden r^2	0.075					

*Note: ** indicates the 1 % significance, * indicates the 5 % significance.*

Table-8 *Coefficient and Marginal effects of the negative binomial regression model*

Variables	Negative binomial regression model					
	Coefficient	Std.error	t value	Marginal effects	Std.error	t value
Household characteristics						
Education	0.04*	0.01	3.26	0.05*	0.01	3.73
Household size	-0.05	0.12	-0.43	-0.06	0.12	-0.55
Experience in dairy farming	0.25	0.14	1.77	0.15	0.14	1.09
Farm related parameters						
Herd size	0.18*	0.07	2.52	0.24*	0.09	2.54
Cropped area	-0.05**	0.00	-11.91	-0.05*	0.01	-4.72
Irrigated area	0.04*	0.01	4.8	0.052*	0.01	4.33
Area under fodder crop	0.05*	0.01	3.11	0.056*	0.01	4.6
Institutional factors						
Als centers	0.05	0.04	1.23	0.06	0.05	1.25
Proximity of milking collection centers	-0.06*	0.03	-2.22	-0.06*	0.02	-2.57
Non- dairy income	-0.05*	0.02	-2.56	-0.09*	0.03	2.87
Extension related						
Extension contact	0.12**	0.01	10.41	0.11**	0.01	7.73
Attending dairy training programme	0.15*	0.05	2.69	0.10**	0.01	6.79
Dispersion parameter	268.6					
Mcfadden pseudo r^2	0.041					

*Note: ** indicates the 1 % significance, * indicates the 5 % significance.*

The estimated marginal effects suggest that area under fodder crop increases the likelihood of MM adoption by 13 percent. The proximity of milking centre collection found to be negatively significant influence on adoption of MM technology, perhaps due to higher distance (3.2 Kms) distance from dairy farm. The predicted marginal effect that the probability of adopting a technology decreases by 2 for an additional distance of milking collection centre. The extension contacts and attending dairy training programme were found to be significant in influencing adoption MM technologies. Perhaps farmers who are attended the training programme facilitate to learn, understand and adopt novel technologies in their farm. Thus, access to such capacity augmentation increases the probability of adoption MM technologies to extent of 14 percent in extension contact and 13 percent for dairy training programme.

Negative binomial regression model

The [Table-8] summaries the factors influencing in adoption of technology intensity by employing the negative binomial regression. A hypothesis test implies the presence of over dispersion value at 268.60 and likelihood ratio of 0.006 is less than chi-square critical value of 7.625 at 1 % of significance, which suggest that negative binomial regression model is an adequate representation of data. The same set of variables as in logit model is used in this component of the analysis. As expected, that education is positively significant in adoption intensity of IDMP at 5 % significant. Implying that educated farmers may have more ability for adopting an innovative technology.

The dairy farmers with large herd size relatively higher probability of intensity of IDMP adoption than small herd size.

As expected, they are less vulnerable from trying new technologies than farmers with small herd size. The cropped area found to be negatively significant associated with intensity of IDMP adoption. The possible explanation due to fragmentation of land devoting farmers biased towards food crops safeguards the food security [20]. The estimated marginal effect of this variable represents that probability of intensity of IDMP adoption decreased by 5 percent for an addition area under cropped area. Irrigated area and area under fodder are positively significant in adoption intensity of IDMPs at 5 % of significant. As expected, the irrigation facility ensures fodder cultivation thereby enables the adequate availability of feed round the year.

The distance of milk collection centre is negatively associated with intensity of IDMP adoption. As expected, proximity of milking centre reduces the cost of transport and ensures the quality of milk and hygienic conditions, till milk reaches to consumers [21,22]. The estimated marginal effect implies that as additional distance for milking centre increases reduces probability of intensity of IDMPs technologies adoption by 6 percent.

The Non-dairy income is negatively associated with intensity of adoption of IDMPs technologies perhaps the dairy farmers might have been spent on other farm activities and household consumption rather on dairy technology investments. The extension variables are positively associated with intensity of IDMP adoption at 1 % significant level, as in the binary model. These variables are having greater marginal effects than other adoption variables. These variables are the prerequisite for adoption of innovative practices since these extension activities will augment farmer's capacity to adopt the dairy management practices resourcefully [23]. Furthermore, exposure of farmers to dairymela reduces subjective uncertainty about the IDMPs and thus accessibility of extension persons induces the adoption [24].

Conclusion

Dairy farmers captivated to enhance productivity and income from dairy farming through modernizing the farms by adopting integrated dairy management practices. The study reveals that higher number management practices may not necessarily yields higher productivity of the dairy animals. The factors influencing the adoption of single technology (MM) and integrated technologies (IDMPs) in dairy farming by employing logit and negative binomial regression model respectively. The contact of extension personnel and attending the dairy training programme found to be positively significant in adoption of MM and IDMPs. In spite of this, majority of the farmers in India do not have access to extension services and relevant information which seriously limits their ability to increase their productivity and income thereby poverty. The extension service could be reached effectively by deploying the ICTs tools with more tailored and timely information to dairy farmers as a whole. The area under fodder also significant however, which is less than 4 % as against of 8 % to gross cropped area. There is a definite need to increase forage production per unit area through encouraging high yielding fodder crops and forages, in an integrated crop- livestock farming systems. Creating awareness among farmers use of non-conventional feed resources that can improve intake and digestibility of low-quality forages and support them in gaining the first-hand knowledge of these feedstuffs from various livestock extension agencies, thus providing nutritional security to animals.

Application of research: Dairy farmers captivated to enhance productivity and income from dairy farming through modernizing the farms by adopting integrated dairy management practices

Research Category: Dairy Science

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Study area / Sample Collection: Mandya and Dakshinkannada districts

Cultivar / Variety / Breed name: Nil

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