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RESEARCH ARTICLE

Determinants of the adoption of the dairy component in dairy-based integrated farming systems in the coastal region of West Bengal

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Abstract: The coastal region of West Bengal is prone to environmental challenges such as cyclones, water salinity, and frequent flooding.Therefore, people prefer diversifying different farming enterprises over the specialization of any farming enterprise. A sample of 200 respondents was collected through a multi-stage random sampling method to analyse the determinants of the adoption of the dairy component in dairy-based integrated farming systems (IFSs) in coastal region of West Bengal. Employing a seemingly unrelated bivariate probit model, the study utilized the profit share of dairy in IFSs and the number of cattle in households as dependent variables (which are the adoption parameters of the dairy component in IFSs), while farmers' socio-economic attributes served as explanatory variables. The finding shows the number of cattle in households had a positive marginal effect on the profit share of dairy in IFSs. In the Dairy + Crop + Goat framing system, the probability of more cattle adoption was low compared to the Dairy + Crop farming system. Regular extension contact by the farmers helped to get more profit from dairy component in IFSs. Most dairy farmers sold their raw milk to retailers. If farmers sell their raw milk to milk vendors, the profit share of dairy in IFSs reduction probability will be 20 per cent compared to a cooperative society. Hence, establishing more cooperative societies and expanding their area coverage in this region become crucial for adopting more dairy components in IFSs.

Keywords: Integrated Farming System, Multistage Random Sampling, Seemingly unrelated bivariate probit model, Latent variable

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Introduction

India's average agricultural landholding has reduced to 1.08 hectares whereas 86.08 per cent of farmers are categorized as small and marginal farmers owning less than two hectares of landholding (GoI, 2015-16). This fragmentation of land resources poses a grave danger to the viability, food security, and profitability of Indian agriculture in the future (Paramesh et al.2022). Integrated Farming System (IFS) is a comprehensive farm management approach that integrates two or more interdependent agricultural components that aim to enhance productivity, profitability, sustainability and minimize risks within the farming system (Chandana et al. 2023).

West Bengal has the highest cattle population (19.0 million), second highest goat population (16.28 million), and fourth highest poultry population (77.3 million) in India, whereas the coastal region plays a substantial role in West Bengal's livestock population which includes indigenous cattle (14.43 per cent), exotic cattle (16.15 per cent), buffalo (7.36 per cent), goats (12.57 per cent), sheep (13.02 per cent), and pigs (3.05 per cent) (GoI, 2019). In this region, where farmers confront distinct environmental challenges, livestock farming act as a flexible approach for farmers to diversify their income source and minimize the effects of climate change and variability on farm income by acting as an adaptive strategy (Das et al.2023). In livestock, dairy has been a crucial component of farmers' households since it contributes substantially to total family income, occupation, and farm waste recycling (Goswami and Biswas, 2021).

The dairy component in IFSs has served as a key link for interconnecting various components within the integrated farming systems (IFSs). So, in this context, the research question of great importance to researchers and policymakers is what are the determinants of the adoption of the dairy component in dairy-based IFSs in coastal region of West Bengal. Hence, this study framed the hypothesis that farmers' different socio-economic factors do not affect on the dairy component adoption parameters.

Materials and Methods

A suitable sampling design was adopted for the present study, including selecting the agro-climatic zone, blocks, cluster of villages, and respondents. The first agro-climatic zone was selected purposively (i.e. Coastal region). This agro-climatic zone is distributed in three districts (i.e. North 24 Parganas, South 24 Parganas and Purba Medinipur). From these three districts, the blocks were selected by the probability proportion to size sampling method. From each block, a cluster of villages was randomly selected in the next sampling stage. In each cluster of villages, 25 respondents were identified randomly. The respondents' selection criteria were that each farmer should have at least two cattle in the household and each component of the dairy-based integrated farming system should contribute at least 10 per cent of gross income and not exceed 90 per cent. In dairy-based IFSs, a dairy component had indigenous and crossbreed cattle; in the crop component, kharif and rabi paddy; in the fishery component, general carp and in the goat component, black Bengal variety was considered in the study.

This study tried to find out the determinants of the adoption of dairy component in IFSs, and here adoption is a quantitative factor. In an earlier study conducted on the topic of determinants of the adoption of the rice-cattle farming system, it was reported that farm income, land area, number of cows, farmers' perceptions, and farmers' socio-economic characters were the major factors that affect the adoption decision of rice-cattle farming system (Kurniati et al.2021, Purnomo et al.2021). Another research finding showed that in dairy-based IFS units, herd size in a household had a significant role in the profit of the IFS unit (Chandran et al.2023). Hence, in this study, the adoption factor was quantified by the two dependent variables which were the number of cattle in households and the percentage share of dairy component's profit in IFSs.

This study used the seemingly unrelated bivariate probit model to find the explanatory variables that affect on the number of cattle adoptions and the percentage share of dairy component's profit in IFSs. The bivariate probit model is used when the distribution function of the dependent variables is different and where two equations need to be estimated. When the dependent variable in one equation becomes the independent variable in the other, the seemingly unrelated bivariate probit model is used. With this model, it was possible to test whether there was a correlation between the two error terms. A significant non-null correlation between the two error terms would suggest the presence of unmeasurable variables shared by the two dependent variables.

Suppose the latent variable that identified the number of cattle in each household was C^*_{1i} and the profit share of dairy in IFS's was identified by the latent variable P^*_{1i}. Then, the unobserved variables can be modelled as follows,

$$C^*_{1i} = \beta_1 X_{1i} + \mu_{1i}$$

where,

$$C^*_{1i} = \begin{cases} 1, \text{ if } C^*_{1i} > 3 \\ 0, \text{ Otherwise} \end{cases}$$

where,

i = 1, 2 …, n, represents the i[th] individual, X_{1i} refers to the observed determinants of the number of cattle in each household, β_{1i} were the associated parameters, and μ_{1i} was a random error term. The outcome variables were binary with a value of 1 if the cattle number was more than 3 and 0 if the cattle number was less than equal to 3. Similarly, the profit share of dairy in IFSs was measured with the help of the equation,

$$P^*_{1i} = \beta_2 X_{2i} + \mu_{2i}$$

where,

$$P^*_{1i} = \begin{cases} 1, \text{ if } P^*_{1i} > 50 \text{ per cent} \\ 0, \text{ Otherwise} \end{cases}$$

where,

X2i refers to the observed determinants of profit shared of dairy in total IFS's profit, β_{2i} the associated parameters, and μ_{2i} was a random error term. The outcome variables were binary with a value of 1 if the profit share of dairy in the total farming system's profit was more than 50 per cent, and 0 if the dairy component's profit share was less than equal to 50 per cent.

The error terms of the two models were dependent and distributed as a bivariate normal such that E (μ_{1i}) = E (μ_{2i}) = 0, var (μ_{1i}) = var (μ_{2i}) = 1, and rho (ρ) = cov ($\mu_{1i}\ \mu_{2i}$). A Wald test for rho (ρ) = 0 was insignificant, indicating the models should be estimated jointly.

Results and Discussion

Description of the variables

Determining factors for the adoption of the dairy component in the dairy-based integrated farming system are presented in table 1 and ita descriptive statistics are presented in table 2.Table 2 shows the mean value of the number of cattle and profit share of dairy in IFSs were 3.305 and 52.708, respectively. The mean age of farmers was 50.17 years, with the 6[th] number class of average educational background. Farmers had on average 18.37 years of experience and 5.49 family size. In that area, most of the farmers did not have grassland to grow fodder crops (mean value 0.205). The number of cooperatives and their area coverage was limited in the study area; therefore, farmers often sold their milk door to door or in sweet shops. It makes retailers the main source of milk sales (mean value 2.21).

Based on the median value of the distribution of the number of cattle (i.e., 3) and profit share of dairy component in IFSs (i.e., 50 per cent), the continuous variable was transformed into binary variables. Fig 1 and Fig 2 illustrate the kernel density estimation of the number of cattle in a household and the profit share of dairy component in IFSs, respectively. Fig 1 depicts that the maximum probability was concentrated between 3 to 4 numbers of cattle in the sample household. Fig 2 shows kernel density was bimodal, and nearly 50 per cent was the middle of this bimodal distribution of profit share of the dairy component.

Determinants of the adoption of the dairy component in dairy-based IFSs: result from seemingly unrelated bivariate probit model

The estimated coefficients are presented in Table 3 and Table 4. Table 3 displays the coefficients for the numbers of cattle and the profit share of dairy in IFSs in households, using a single probit model. Comparing these estimated coefficients with those from Table 4, obtained using the seemingly unrelated probit model, reveals minor values and statistical significance differences. In the seemingly unrelated probit model, the rho (ρ) value represents the correlation between the residuals in the system of equations. It suggests that if there is an association between the two errors in the probit model, the estimates of the probit model might be biased. Under these conditions, the joint estimation procedure can enhance the efficiency of the estimates. It justifies the main focus of the study on the seemingly unrelated bivariate probit model. The positive correlation coefficient rho (ρ) between the residuals is 0.37, which is statistically significant at the 10 per cent level of significance. It suggests the presence of unmeasurable factors common to the profit share of dairy in IFS and the number of cattle in a household. Table 4 presents the results of the joint estimation of the probability of profit share of dairy in IFS and the number of animals. The evidence of endogeneity is supported by both the Wald test (Wald $\chi2 = 154.88, p < 0.01$) and the likelihood-ratio test ($\chi2 = -178.28, p < 0.01$).

The average marginal effect of the profit share of dairy showed that more animal numbers have 23 per cent higher chances of having a profit share of dairy in IFSs of more than 50 per cent, compared with those whose share is less than 50 per cent. Education level positively influenced the dairy sector's profit share in IFSs but had a negative relationship with the adoption of more cattle and, its marginal effect showed that if the education level (number of classes) increases, the probability of getting a profit share of more than 50 per cent of dairy by 2.1 per cent, and

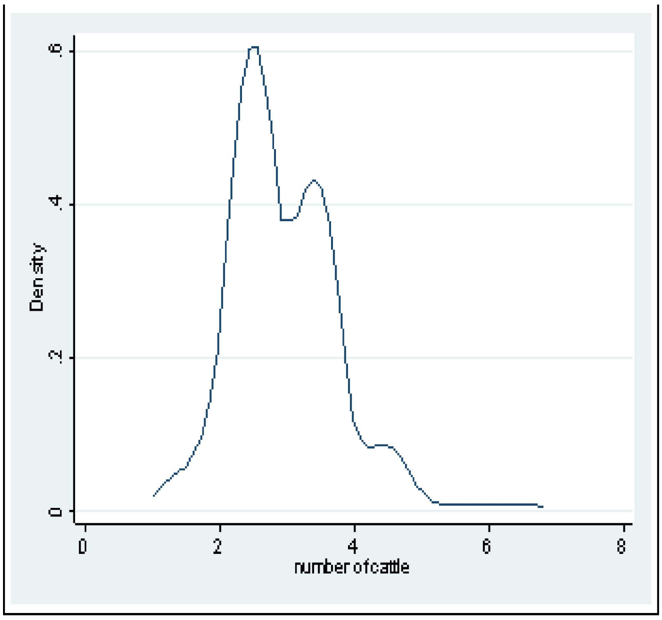

Fig. 1 Kernel density estimate (Number of cattle in households)

Table 1: Determining factors of farmers for the adoption of the dairy component in the dairy-based integrated farming system

Variables	Operational definition
Education Level	It was operationalized as the respondent's number of classes in formal education.
Gender	The gender of the household head was operationalized as the sex of the respondent.
Family Size	The total number of household members present in a family.
Availability of gross land for fodder	It was the land area which is allotted for fodder crop cultivation.
Types of cattle shade	Cattle shade type, i.e., Pucca, Kutcha
Extension contacts	It referred to the respondent's familiarity with the interactions with experts, VLW, ADA, BDO, and bank officials.
Dairy-based IFS type	Different dairy-based IFSs had been identified in the study area.
Market agency	Different sources of selling milk, i.e., ccooperative societies, milk vendor, retailers and direct consumers.

the probability of cattle adoption of more than three is reduced by 1.7 per cent. Previous studies also found that education level had a positive correlation with milk production but had a negative correlation with the field operation of dairy farming (Manoj, 2018). Family size was positively correlated with the adoption of more cattle (more than 3), and its marginal effect was 2.2. It means more

Table 2: Variable selection and descriptive statistic

Variable n=200	Mean	Std. Dev.
Numbers of cattle in a household (no)	3.305	0.797
The profit share of dairy in IFS (per cent)	52.708	21.132
Age of the head of the household (year)	50.170	12.072
Gender of Head of the HH (female=0, male=1)	0.785	0.412
Education Level (number of classes)	6.075	3.944
Family Size (no)	5.495	1.791
Extension contacts (never = 0, occasionally = 1, regular = 2)	1.045	0.822
Source of selling of milk (cooperative Society = 0, milk vendor = 1, retailers = 2, direct consumer = 3)	2.210	1.054
Availability of gross land for fodder (not available = 0, available = 1)	0.205	0.405
Types of cattle shed (kutcha = 0, pucca =1)	0.180	0.385
Experience of dairy farmer (year)	18.370	9.639
Profit share of dairy in IFS (more than 50 per cent = 1, less than equal to 50 per cent = 0)	0.505	0.501
Numbers of cattle in a household (more than 3 = 1, less than equal to 3 = 0)	0.335	0.473

Table 3: Factors affecting on the profit share of dairy component and number of cattle adoption in households: Single probit model

Variables	Number of Cattle		Profit share of dairy in IFSs	
	Coefficient	ME	Coefficient	ME
Constant	-0.977	-	0.412	-
Education Level (Number of Classes)	-0.098***	-0.018***	0.073***	0.023***
Number of cattle (No)	-	-	0.448**	0.143***
Family Size (No)	0.124	0.023	0.053	0.017
Availability of gross land for fodder (Not available=0, Available=1)	3.218***	0.602***	0.014	0.004
Gender of Head of the HH (Female=0, Male=1)	0.349	0.065	0.366	0.117
Experience of Dairy farmer(year)	0.012	0.002	0.033***	0.010***
Types of cattle shed (Kaccha=0, Pucca=1)	0.691**	0.129**	1.137***	0.363***
Dairy-based IFSs				
D + C	Reference			
D + C + F	0.457	0.071	-0.331	-0.105
D + C + G	-0.931**	-0.171**	-0.147	-0.047
D + C + F + G	0.630	0.105	0.091	0.029
D + C + P	0.528	0.085	-0.055	-0.018
D + F	0.654	0.109	0.056	0.018
Source of selling of milk				
Cooperative Society	Reference			
Milk Vendor	0.354	0.067	-0.710***	-0.228
Retailers	-0.514	-0.072	-0.070	-0.022
Direct Consumer	0.298	0.056	0.037	0.012
Extension contacts				
Never	Reference			
Occasional	-0.123	-0.024	0.160	0.051
Regular	-0.178	-0.034	0.469*	0.151
Log-likelihood	-66.841		-112.791	
Likelihood-Ratio chi-square ($\chi2$)	121.38		51.66	
Pseudo R2	0.475		0.486	

no of family size has a 2.2 per cent higher probability of adoption more numbers of cattle (more than 3). One research found that farmers with larger family sizes have more chances to adopt livestock-related technologies on their farms (Quddus, 2022). Availability of grassland for fodder crops had a positive relation with the number of cattle adoption (more than 3), and it shows 60 per cent more chances of adoption of more cattle if a farmer had grassland for fodder crops as compared to those farmers who was not having grassland for fodder crop. The marginal effect of the experience of the farmers (year) was 0.01 and significant at 1 per cent level, it revealed that more experienced farmers had 1 per cent more chances to get more profit share of dairy in IFS (More than 50 per cent). The coefficient and the marginal value of the variable named types of cattle shed showed if the type of cattle shed is pucca, there is a 39 per cent more chance to get more profit share of dairy in IFSs and a 13 per cent chance to adopt more cattle in IFSs as compared to those farmers who had kacha cattle shed. Across the different dairy-based integrated farming systems, only the Dairy + Crop + Goat (D + C + G) farming system had a significant relationship with the numbers of cattle adoption; its marginal effect showed that if farmers practiced this farming system, 17 per cent less chanced to adopt more cattle as compared to Dairy + Crop (D + C) farming system. The respondents with regular contact with extension persons had a 14 per cent higher probability of getting more profit share of the dairy component

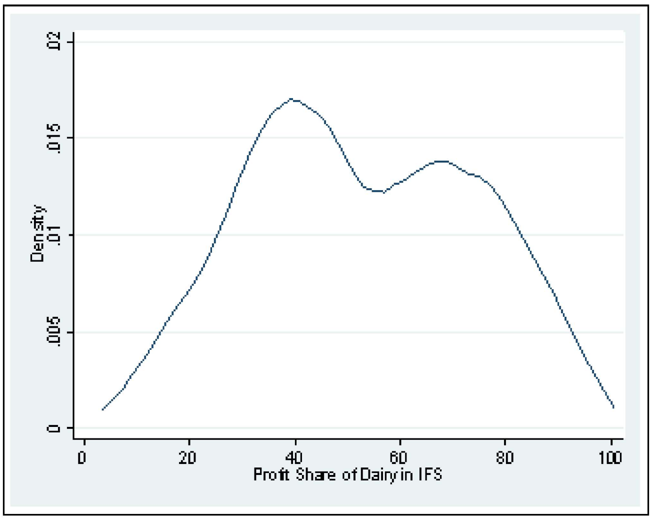

Fig. 2 Kernel density estimate (Profit share of dairy in IFSs)

Table 4: Factors affecting on the profit share of dairy component and number of cattle adoption in households: Seemingly unrelated bivariate probit regression

Variable	Number of Cattle		Profit share of dairy in IFSs	
	Coefficient	ME	Coefficient	ME
Constant	-1.022*	-	1.225	-
Education Level (Number of Classes)	-0.093**	-0.017***	0.069***	0.021***
Number of cattle (No)	-	-	0.738***	0.229***
Family Size (No)	0.121*	0.022*	0.055	0.017
Availability of gross land for fodder (Not available=0, Available=1)	3.233***	0.603***	0.353	0.109
Gender of Head of the HH (Female=0, Male=1)	0.316	0.059	0.383	0.119
Experience of the farmer(year)	0.015	0.003	0.034***	0.010***
Types of cattle shed (Kaccha=0, Pucca=1)	0.701**	0.131**	1.269***	0.393***
Dairy-based IFSs				
D + C	Reference			
D + C + F	0.433	0.067	-0.266	-0.082
D + C + G	-0.911**	-0.167**	-0.058	-0.018
D + C + F + G	0.487	0.077	0.159	0.050
D + C + P	0.521	0.084	-0.006	-0.002
D + F	-0.668	0.113*	0.148	0.046
Source of selling of milk				
Cooperative Society	Reference			
Milk Vendor	0.347	0.066	-0.632**	-0.197**
Retailers	0.591*	0.081*	0.083	0.026
Direct Consumer	0.265	0.049	0.028	0.009
Extension contacts				
Never	Reference			
Occasional	-0.158	-0.030	0.123	0.038
Regular	-0.175	-0.033	0.435*	0.136*
Numbers of observation	200			
log pseudolikelihood	-178.288			
Wald χ 2	154.88			
Rho (ρ)	0.370*			

in IFSs (more than 50 per cent) compared to those farmers without extension contact. As per the source of milk selling, if a dairy farmer sold their raw milk to a milk vendor, their profit share of dairy in IFSs (over 50 per cent) reduction probability was 20 per cent compared to those farmers who was selling their milk to a cooperative society. A previous study revealed that, in West Bengal, cooperative dairy farmers had fewer constraints and severity in milk production expansion than non-cooperative dairy farmers (Sarker & Ghosh, 2008). Since there weren't many cooperative societies in the area, farmers often sold their milk in sweet shops. It made retailers the main source of milk sales. Therefore, if farmers sold their milk to retailers, they have 8 per cent more chances to adopt more cattle (more than 3) compared to a cooperative society.So, the profit share of dairy in IFSs was the major factor affecting the adoption of the dairy component in the integrated farming systems because it affects the number of cattle adopted in IFSs, and these two adoption parameters are significantly influenced by the various explanatory variables (education level, family size, experience, gender, availability of grassland, type of cattle shed, extension contact, source of selling of milk, and types of dairy-based IFSs). So, in a dairy-based integrated farming system, farmers are more concerned about the profit share of dairy components in IFS, which leads to more cattle adoption in the household.

Conclusion

The findings provide valuable insights into the determinants of dairy component adoption in IFSs in the context of the environmental challenges in the coastal region of West Bengal. By understanding the determinants, policymakers can devise targeted interventions to promote sustainable and profitable dairy farming practices in IFSs in this region. Policy implications from this study suggest investing in education and extension services to enhance farmers' understanding of profitable dairy farming practices in IFSs. Additionally, improving access to resources such as grassland for fodder crops and promoting the establishment of cooperative societies can significantly boost the profitability of dairy-based IFSs. Future research could explore the long-term impacts of policy interventions on dairy farming outcomes and assess the potential for scaling up successful models of dairy-based integrated farmings.

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References

Chandana TS, Praveena PLRJ, Lakshmi T, Subramanyam D, Reddy BR (2023) Sustainable Livelihood Security of Integrated Farming Systems Practicing Farmers through Different Enterprise Combinations in Andhra Pradesh. Indian J Ext Edu 59(1):101–106. https://doi.org/10.48165/ijee.2023.59121

Chandran V, Chakravarty R (2022) The extent of Adoption of Available Components in the IFS Units of Kerala. Indian J Ext Edu 58(4): 130–133. https://doi.org/10.48165/ijee.2022.58426

Chandran V, Saurav S K, Chakravarty R, Ashok K (2023) Contribution of Integrated Farming System (IFS) Units Towards Household Income in Kerala. Indian J Ext Edu 59(3):69-73. https://doi.org/10.48165/IJEE.2023.59313

Das S, Majumder S, Sharma KK (2023) Assessing integrated agricultural livelihood vulnerability to climate change in the coastal region of West Bengal: Implication for spatial adaptation planning. Reg Stud Mar Sci 57. https://doi.org/10.1016/j.rsma.2022.102748

GoI. (2019). 20th Livestock Census-2019 All India Report. Ministry of Department of Animal Husbandry, Dairying and Fisheries. Ministry of Agriculture & Farmers Welfare, Government of India, New Delhi.

GoI. (2019). Agricultural Census 2015-16, Department of Agriculture, Co-operation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India, New Delhi

Goswami A, Biswas S (2021) Study on knowledge, communication & adoption practices in livelihood generation of livestock owners in coastal agro-climatic Zone Of West Bengal, India. Indian J Ext Edu 21(3): 1–7.

Kurniati N, Sukiyono K, Purmini P, Sativa M O (2021) The adoption level of an integrated farming system based on Rice-Cattle and its determinants related to sustainable agriculture. E3S Web Conf 226:1–9. https://doi.org/10.1051/e3sconf/202122600034

Manoj S (2018) Effect of age and educational level of dairy farmers on knowledge and adoption of dairy farming practices in Kapurthala district of Punjab. Int J Farm Sci 6(4): 254–262.

Paramesh V, Ravisankar N, Behera U K, Arunachalam V, Kumar P, Solomon Rajkumar R, Dhar Misra S, Mohan Kumar R, Prusty A K, Jacob D, Panwar AS, Mayenkar T, Reddy VK, Rajkumar S (2022) Integrated farming system approaches to achieve food and nutritional security for enhancing profitability, employment, and climate resilience in India. Food Energy Secur 11(2):1–16. https://doi.org/10.1002/fes3.321

Purnomo SH, Sari AI, Emawati S, Rahayu ET (2021) Factors influencing the adoption of integrated crop-livestock to support land conservation of organic agriculture in Mojosongo area, Karanganyar, Indonesia. IOP Conf Ser: Earth Environ. Sci 724(1). https://doi.org/10.1088/1755-1315/724/1/012049

Quddus MA (2022) Dissemination of Technological Innovations of Livestock in Bangladesh: Adoption Levels and Behavioral Precision. Proc Natl Acad Sci India Sect B Biol Sci 92(2):461–472. https://doi.org/10.1007/s40011-022-01357-z

Sarker D and Ghosh BK (2008) Economics of Milk Production in West Bengal/ : Evidence from Cooperative and non-cooperative Farms. East West J Econ Bus 11(1):132–152.