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Pathways to adoption: Improved farming practices among dairy farmers in Kerala

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Abstract

The study was undertaken in four districts of Kerala to assess the adoption of dairy technologies and the determinants of adoption of scientific dairy farming practices among farmers of Kerala.A total number of 200 dairy farmers and 90 stakeholders from research and extension domain in the study area were selected using multistage random sampling technique across four distinct regions of Kerala. To ascertain the extent of adoption of selected technologies among dairy farmers of Kerala, respondents were asked to elicit their adoption level on a three-point continuum, viz. 'full adoption', 'discontinuation' and 'non-adoption'. Adoption Index value obtained by individual respondent were calculated. The study revealed higher extent of adoption in case of practices viz. artificial insemination, colostrum feeding, and timely vaccination; low adoptionwas observed in case of technologies like calf starter, azolla production, and silage. Factors such as age, annual income, total owned land, and risk orientation had significant influence on overall technology adoption, explaining 52.50% of the variance in adoption rates. The findings suggest that while awareness of dairy technologies is widespread, actual adoption is limited by cost considerations and availability of subsidies. To enhance technology adoption, recommendations include improving access to affordable feed and veterinary services, adjusting milk prices, and developing targeted extension programs. Addressing these barriers and integrating farmer-specific needs into technology development are essential for improving productivity in the dairy sector.

Keywords: Adoption, Kerala State, Scientific dairy farming

Introduction

The dairy industry stands out as a highly promising subsidiary sector within Indian agriculture. India, the global leader in milk production, generated 230.58 million tonnes of milk in 2022-23, accounting for 24% of the world's milk output (NDDB, 2023). The country possesses a substantial livestock population of 512.05 million, representing approximately 57% of the world's buffalo population and 16% of the global cattle population (GOI, 2018). However, the average daily milk yield in India remains relatively low, with cows producing 5.15 kg and buffaloes 5.9 kg per day. Significant regional disparities exist in milk productivity, with cow yields ranging from 1.49 kg in Assam to 13.31 kg in Punjab(Chand 2023). Similarly, buffalo milk output varies from 1.61 kg in Odisha to 9.63 kg in Haryana (Chand 2023). These variations elucidate a production disparity driven by the increasing population demand for milk and the low productivity of Indian cattle. Addressing these disparities necessitates focused interventions, improved breeding techniques, enhanced nutritional practices, and augmented access to veterinary services. The integration of technology and promotion of sustainable practices can further optimize the efficiency of the dairy sector.India's livestock industry predominantly relies on small and marginal farmers who often lack access to scientifically validated practices. This situation necessitates a multifaceted strategy involving institutional support, infrastructural development, and effective dissemination of innovative technologies. Active collaboration among governmental entities, private enterprises, non-governmental organizations, and progressive farmer associations is essential to achieve this transformation (GOI, 2013).This study aimed to evaluate the adoption of modern dairy farming technologies, a critical step toward

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achieving the objective of doubling farmers' incomes.

Materials and methods

Primary and secondary data were utilized in this study. Primary data were collected through personal interview techniques among the respondents using a pre-tested semi-structured interview schedule during 2018-19. The study was conducted in Kerala, a state with significant potential for enhancing dairy production due to its high concentration of exotic and crossbred cattle (87 % in 2018-19 and 93.56 % of the total cattle population in 2021-22) (Economic Review, 2022). Employing a multistage random sampling technique, the state was stratified into four regions (Southern, Central, Northern, and High Range) based on topographical characteristics. One representative district from each region was randomly selected, and two blocks were chosen within each district. From each block, 25 farmers were randomly selected, resulting in a total sample size of 200 respondents (Fig. 1)

Additionally, stakeholders from research and extension organizations in the study area were randomly selected to provide insights into knowledge dissemination. The collected data were analyzed using statistical tools, including the mean, standard deviation, coefficient of correlation, and multiple linear regression. The stakeholders included 30 respondents from research institutions, such as Kerala Veterinary and Animal Sciences University (KVASU), Kerala Agricultural University (KAU)and 60 actors from extension domains, such as Kerala Livestock Development Board (KLDB), Kerala Co-operative Milk Marketing Federation Ltd. (KCMMF), Animal Husbandry Department (AHD), Dairy Development Department (DDD), National Dairy Development Board (NDDB), and input agencies, including Kerala Feeds, KSE Ltd., VC Pharmaceuticals, and credit institutions such as Cooperative Banks.

To ascertain the extent of adoption of the selected technologies among dairy farmers in Kerala, respondents were asked to elicit their adoption level on a three-point continuum: 'full adoption' (2),'discontinuation' (1), and 'non-adoption' (0). The total score obtained by individual respondent was calculated, with the help of following formula

$$Adoption\text{Index Value} = \frac{Total Obtained Score by the farmer}{\text{Total Obtainable Score}} * 100$$

Multiple Linear Regression Analysis

Multiple linear regression analysis was employed to evaluate the pooled effects of multiple independent variables on a dependent variable. The regression equation used was:

$y = a + b_1 x_1 + b_2 x_2 + \text{——————} + b_{14} x_{14}$

a= constant

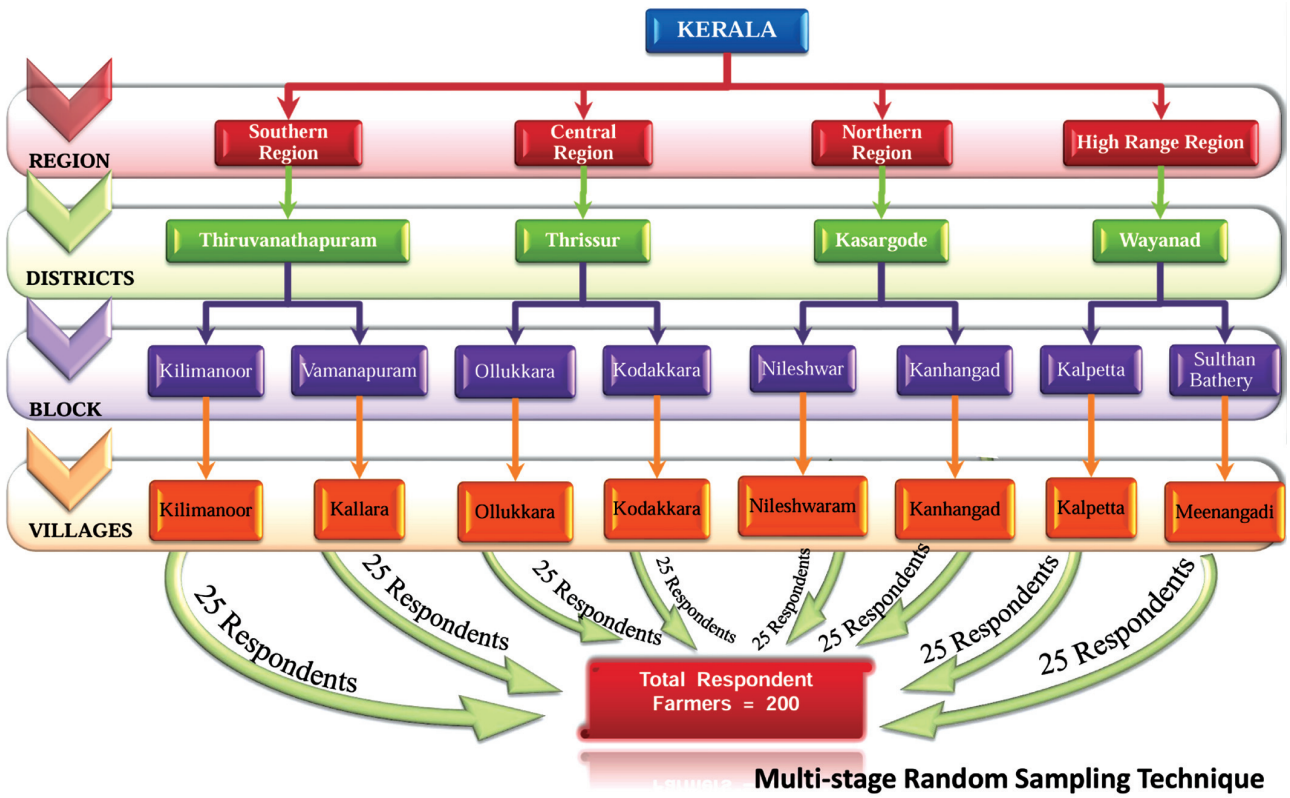

Figure 1 : Sampling Plan of the research study

b_1, b_2, b_3..b_n = regression coefficients
x_1 to x_{18} = independent variables selected for the study
y = dependent variable
The regression co-efficient were tested for its significance and following formula was used.

$$t_{(n-k-1)d.f} = \frac{bi}{SE(bi)}$$

Where,
n = number of observations
k = number of independent variables
SE = standard error
bi = regression coefficient
t = test criterion for significance

Coefficient of Multiple Determination (R^2)

The coefficient of multiple determination (R^2) was calculated to determine the proportion of variation in the dependent variable (y) explained by the independent variables (x_i)variables collectively. It is expressed as:

$$R^2 = \frac{Regressionsumofsquares\ (RSS)}{Totalsumofsquares\ (TSS)}$$

Where,
RSS = $b_1\Sigma x_1\ y + b_2\Sigma x_2\ y + \text{— ——— — —} + b_{21}P\Sigma\ x_{21}\ y$
TSS = Σy^2
R^2value ranges between 0 and 1, is expressed as a percentage to indicate the extent of variation in dependent variable (y), explained by the independent variables (x_i) together.

Stepwise Regression Analysis

Stepwise regression analysis was used to identify the most influential variables contributing to the maximum variation in the dependent variable through an elimination process. This approach sequentially adds or removes variables based on their statistical significance and contribution to the model.

The significance of R^2 was tested using F-testto ensure the reliability of the model.

Result and discussions

Adoption Status of selected technologies/practices among dairy farmers

Adoption of breeding practices among dairy farmers

The results presented in Table 1 show the adoption status of three selected breeding technologies/practices among dairy farmers in Kerala. All the respondent farmers adopted artificial insemination for breeding within three to four months after calving. They reported no difficulties in accessing these services from local veterinary officials.The number of Artificial Insemination centers in the State during 2016-17 was 2515 (Economic Review, 2017).Majority of respondent farmers (99.50%) regularly utilized pregnancy diagnosis services for their dairy animals in around two and a half months after insemination. In terms of anoestrus management, 64.00 per cent of farmers did not utilize services for the treatment of repeat breeding issues, which resulted in the disposal of animals with such issues. Farmers perceived that repeated unsuccessful artificial insemination attempts in an animal often indicate the onset of infertility issues. Consequently, treatment is perceived as challenging and financially burdensome. While 36.00% of farmers utilized diagnostic and therapeutic services, including traditional remedies such as feeding sprouted Bengal gram as a corrective measure, the majority did not seek professional intervention.

Adoption of Feeding Practices among dairy farmers of Kerala

The results presented in Table 2 delineate the adoption of various feeding practices among dairy farmers in Kerala.

Table 1. Adoption of breeding practices among dairy farmers of Kerala

(n=200)

No	Technologies	Adoption		Discontinuance		Non Adoption	
		Frequency	Per cent	Frequency	Per cent	Frequency	Per cent
1	Artificial Insemination	200	100	0	0.00	0	0.00
2	Pregnancy Diagnosis	199	99.50	0	0.00	1	0.50
3	Anoestrus management	72	36.00	0	0.00	128	64.00

Table 2. Adoption status of feeding practices among dairy farmers of Kerala

(n=200)

No	Technologies	Adoption		Discontinuance		Non Adoption	
		Frequency	Per cent	Frequency	Per cent	Frequency	Per cent
1	Colostrum Feeding	200	100	0	0.00	0	0.00
2	Calf Starter	25	12.5	0	0.00	175	87.50
3	Mineral Mixture	198	99.00	1	0.50	1	0.50
4	Bypass protein supplement	6	3.00	0	0.00	194	96.50
5	Balance Compounded Feed	200	100.00	0	0.00	0	0.00
6	Azolla production and feeding	11	5.50	6	3.00	183	91.50
7	Silage	0	0.00	5	2.50	195	97.50

Colostrum feeding is universally adopted (100%), with farmers storing excess colostrum for future use. In contrast, only 12.5% of respondents utilize calf starter, with the majority (87.5%) not adopting the practice, primarily due to limited availability and lack of awareness. Some farmers indicated that the insufficient regular availability of calf starter from the dairy cooperative societies or nearby stores is another factor that impedes its adoption. The vast majority of the respondents (99.00%) adopted the practice of feeding mineral mixture to their cattle due to its established role in enhancing milk production. However, 3.00 percent of farmers use bypass protein supplements, reflecting limited awareness and concern regarding the cost component. Balanced compounded feed is widely adopted (99.0%) by the farmers. Azolla production is less prevalent, with only 5.5 per cent of farmers adopting it, largely due to labour intensity, pest issues, and poor palatability among cattle. The survey results showed that none of the respondent farmers produced or used silage for their cattle, highlighting a significant gap in adopting this fodder preservation method that could improve year-round feed availability and quality.

Adoption of health care technologies/practices among dairy farmers of Kerala

Table 3 demonstrates the comprehensive adoption of essential health practices among respondent farmers. All farmers participate in timely vaccination programs through campaigns and veterinary camps, targeting diseases such as Foot and Mouth Disease (FMD), Anthrax, Hemorrhagic Septicemia (HS), and Black Quarter (BQ). These efforts are supported by the "GORAKSHA" scheme, an initiative of the Kerala State Animal Husbandry Department and the National Dairy Development Board. Deworming is widely implemented, with 98.5% of farmers adhering to recommended schedules, biannually for adults and heifers, and quarterly for calves. All farmers maintain stringent sanitation practices, including twice-daily cleaning of cattle sheds and regular disinfection using sodium carbonate, quick lime, washing soda, or bleaching powder. The widespread adoption of these health practices is attributed to the high level of awareness and training received by the farmers. This comprehensive approach to animal health management has significantly contributed to improved hygiene and effective disease control

Adoption of housingtechnologies/practices among dairy farmers of Kerala

Table 4 indicated the adoption rates of various housing technologies among dairy farmers in Kerala. Automated drinking water systems were utilized by 55.50 percent of farmers, who reported benefits such as reduced heat stress for dairy animals. However, 44.50 per cent of farmers have not adopted this technology, primarily due to pending subsidy approval from the dairy department. The use of rubberized floor mats was adopted by 90.00 per cent of respondents, contributing to a notable decrease in hoof-related ailments. The remaining 10.00 per cent have not adopted this practice, largely due to the absence of financial subsidies, though they express a willingness to adopt once such support becomes available. Nearly half of the respondent farmers (46.00%) adopted the practice of using milking machine units, and a significant percentage (7.00%) of the respondents had discontinued the usage due to the laborious cleaning practice of milking machines after use. The utilization of technologies such as fans and water sprinklers was minimal, with only 3.00 per cent adoption, and non-adoption of these practices was attributed to the high cost of installation and electricity charges.

Adoption of dairy farm waste management technologies/ practices among dairy farmers of Kerala

The adoption profile of dairy farm waste management technologies and practices among respondent farmers in Kerala reveals varying levels of implementation and utilization (Table 5). Biogas units demonstrate moderate adoption, with 50.00% of respondents implementing and

Table 3. Adoption status of health care technologies/practices among dairy farmers of Kerala

n=200

No	Technologies	Adoption		Discontinuance		Non Adoption	
		Frequency	Per cent	Frequency	Per cent	Frequency	Per cent
1	Timely Vaccination	200	100	0	0.00	0	0.00
2	Deworming	197	98.5	0	0.00	3	1.50
3	Disinfection of shed	200	100.00	0	0.00	0	0.00

Table 4. Adoption profile of technologies related to dairy animal housing practices

n=200

No	Technologies	Adoption		Discontinuance		Non Adoption	
		Frequency	Per cent	Frequency	Per cent	Frequency	Per cent
1	Automated Drinking Water	111	55.5	0	0.00	89	44.50
2	Rubberized Floor Mat	180	90.00	0	0.00	20	10.00
3	Use of fan and water sprinklers	6	3.00	0	0.00	194	97.00
4	Machine Milking	92	46.00	14	7.00	94	47.00

Table 5. Adoption profile of waste management technologies/practices among dairy farmers of Kerala

N=200

No	Technologies	Adoption		Discontinuance		Non Adoption	
		Frequency	Per cent	Frequency	Per cent	Frequency	Per cent
1	Biogas units	101	50.50	8	4.00	91	45.50
2	Vermi composting	0	0.00	35	17.5	165	82.50

utilizing the technology primarily for cooking and, to a lesser extent, for domestic lighting. The majority of adopters perceive biogas as economically advantageous compared to Liquified Petroleum Gas (LPG). However, 45.50% of farmers have not adopted biogas units, while 4.0% have discontinued their use due to technical issues such as blockages requiring frequent maintenance and labor shortages. Despite these challenges, there is a general willingness to adopt biogas technology, contingent upon the availability of subsidies.

In contrast, vermicomposting units exhibit limited adoption, with 82.5% of farmers not utilizing this technology. Among those who have used it, 17.50% have discontinued the practice due to its labor-intensive nature and limited observable benefits. Currently, none of the respondents are actively utilizing vermicomposting.

These findings highlight the differential adoption patterns of waste management technologies in the region, emphasizing the need for targeted interventions to address barriers to adoption and promote sustainable waste management practices in dairy farming.

Overall adoption of technologies among the dairy farmers

Data presented in Table 6 shows theoverall adoption profileof technologies among the dairy farmers of Kerala

Table 6. Distribution of farmers according to their overall adoption of technologies

(n=200)

No.	Category	Frequency	Per cent
1.	Low (<40.01)	39	19.50
2.	Medium (40.01-54.36)	138	69.00
3.	High (>54.36)	23	11.50
	Total	200	100.00

The distribution of respondents according to their overall adoption of technologies, as presented in Table 6, reveals a notable pattern. A substantial majority of the respondents (69.00%) demonstrated a medium level of adoption, while 19.50% and 11.50% exhibited low and high levels of adoption, respectively. This trend aligns with numerous studies that have reported medium to low levels of dairy technology adoption among farmers (Kumawat and Verma, 2016; Mariyappan et al., 2018). Several factors may contribute to this observed pattern of technology adoption, including the extent of technology dissemination, awareness levels among the target population, ease of technology implementation, and the influence of socio-personal and socio-economic profiles. Previous research has emphasized the crucial role of socioeconomic conditions in determining the adoption of dairy production technologies. Notably, farmers with greater resources and better connections in developed areas tend to exhibit a higher likelihood of adopting new technologies (Basunathe et al., 2010). The present findings corroborate those of several other studies in the field. For instance, Chavan et al. (2016), Gupta (2017), Meena et al. (2017), and Triveni et al. (2017) similarly reported that the majority of respondent farmers in their respective studies demonstrated medium levels of technology adoption. This consistency across multiple investigations suggests a broader trend in the dairy farming sector. It is important to note that while medium adoption levels predominate, there remains a significant proportion of farmers (19.50%) with low adoption rates. This highlights the need for targeted interventions to address barriers to technology adoption among this group. Conversely, the presence of a smaller group (11.50%) with high adoption rates presents an opportunity to study and potentially replicate the factors contributing to their success.

Determinants of adoption of technologies among dairy farmers.

Prediction of contribution of independent variables for maximum variation in overall adoption of technologies among dairy farmers

Multiple linear regression analysis was carried out to assess/ analyze the relative contribution of the 13 independent variables, which found significantly correlated with overall adoption of technologies among dairy farmers, which is specified in Table 7.

The highly significant regression coefficient (P<0.01) of four independent variables, namely age, annual income, total owned land, and risk orientation, was found to have contributed to the increase of overall technology adoption among dairy farmers. The value of the coefficient of multiple determination (R2) of 52.50 with F value 13.01 indicates its significance at the 0.01 level of probability and revealed that 52.50 percent of variation in technology adoption among dairy farmers could be explained in terms of the aforementioned four variables.

Table 7. Multiple linear regression analysis of selected variables of overall technology adoption among dairy farmers

No	Independent variables	Unstandardized coefficients		Standardized coefficients	't' value	Level of significance
		B	SE	(Beta)		
	Intercept	24.283	6.162		3.941	0.000
X_1	Age	-0.060	0.216	0.665	0.105	0.004**
X_3	Education	0.216	0.785	0.596	0.080	0.104
X_4	Family Size	0.528	0.051	0.000	0.285	0.040
X_8	Annual income	0.026	0.216	0.665	0.105	0.004**
X_9	Total owned land	0.013	0.216	0.665	0.105	0.004**
X_{10}	Total Herd Size	0.050	0.785	0.596	0.080	0.104
X_{11}	Total milk production	0.031	0.051	0.000	0.285	0.040
X_{13}	Extension participation	0.559	0.785	0.596	0.080	0.104
X_{15}	Innovativeness	0.285	0.051	0.000	0.285	0.040
X_{16}	Risk orientation	0.709	0.216	0.665	0.105	0.004**
X_{17}	Decision making ability	0.587	0.785	0.596	0.080	0.104
X_{18}	Farmer researcher linkage	0.183	0.051	0.000	0.285	0.040
X_{19}	Farmer extension linkage	0.200	0.204	0.129	0.982	0.328
			R^2 =52.50	F= 13.01		

Dependent Variable: Overall technology adoption ** Significant at 0.01 level of significance R^2- Coefficient of determination SE- Standard Error
B value- Regression coefficient value Beta-Standardized regression coefficient

These findings align with several studies in the provided context, which also emphasize the importance of age, income, land ownership, and risk orientation in technology adoption among dairy farmers. Age has been identified as a significant factor in technology adoption, although its impact varies. El-Osta and Morehart (1999) note that younger farmers are more likely to adopt capital-intensive and combined capital- and management-intensive technologies. Similarly, Saqib et al. (2021) find that farmers' age is positively associated with the adoption of certain risk management tools. Annual income and farm size (which often correlates with total owned land) are consistently reported as influential factors. Jera and Ajayi (2008) indicate that dairy herd size and land holding size are key factors influencing farmers' adoption of fodder bank technology (Jera & Ajayi, 2008). Kelly et al. (2020) note that farm structure changed dramatically with increased milk production, suggesting a link between farm size/income and technology adoption. Drewry et al. (2019) report that higher levels of income and acreage are associated with significantly higher levels of internet access and digital technology adoption on farms. Risk orientation, or farmers' perception and attitude towards risk, also plays a crucial role in technology adoption. Barnes et al. (2013) identify different classes of farmers based on their perception of climate change risks, which influences their likelihood of adopting new practices. Saqib et al. (2021) find that farmers' risk-averse attitude is positively associated with the adoption of certain risk management tools. In conclusion, these findings are well-supported by the existing literature, which consistently demonstrates the importance of age, income, land ownership, and risk orientation in technology adoption among dairy farmers. However, it is worth noting that other factors, such as education level (El-Osta & Morehart, 1999; Jera & Ajayi, 2008), gender (Drewry et al., 2019), and access to information and markets (Jera & Ajayi, 2008), also play significant roles in technology adoption decisions.

Conclusion

This study provides valuable insights into technology adoption among small-scale dairy farmers with 2 to 7 cows. Key factors influencing adoption include age, income levels, land ownership status, and risk orientation, accounting for 52.50% of the variance. Younger farmers, those with higher incomes, land ownership, and higher risk tolerance are more likely to adopt new technologies. Based on these insights, the study proposes a series of recommendations aimed at promoting technology adoption and enhancing the overall sustainability and productivity of the dairy sector. One key suggestion is to address the high costs associated with animal feed, which often represent a significant financial burden for small-scale farmers. This could involve exploring alternative feed sources, improving feed efficiency, or implementing subsidies to make quality feed more accessible.

Another recommendation focuses on adjusting milk prices to ensure fair compensation for farmers, thereby increasing their financial capacity to invest in new technologies. This approach could involve implementing price stabilization mechanisms or exploring value-added dairy products to improve farmers' profit margins. The study also emphasizes the importance of subsidizing veterinary medicines to improve animal health and reduce the economic risks associated with livestock diseases.Furthermore, the research suggests tailoring technology adoption interventions to address the specific needs and characteristics of farmers based on the key variables identified in the study. This

personalized approach could involve developing targeted training programs, providing customized financial support, or offering technology packages that align with farmers' risk profiles and resource constraints.

A critical recommendation highlighted in the study is the integration of extension services with client representation in the technology development process. This collaborative approach ensures that the technologies being developed are relevant, practical, and aligned with the real-world needs of small-scale dairy farmers. By involving farmers in the design and implementation of new technologies, adoption rates are likely to improve, and the technologies themselves will be more effective in addressing on-the-ground challenges.

In conclusion, the study advocates for a multifaceted approach to enhancing technology adoption among small-scale dairy farmers. This comprehensive strategy addresses various interconnected factors, including cost barriers, veterinary care accessibility, socioeconomic considerations, and improved extension processes.

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