International Journal of Natural and Social Sciences
ISSN: 2313-4461

Factors influencing dairy farmers' knowledge, attitudes, and practices in selected haor areas of Kishoreganj and Netrokona districts, Bangladesh

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ARTICLE INFO

Article history

Received: 17 August 2026
Accepted: 22 October 2026
Published: 27 October 2026

Keyword

Dairy farming, Haor region, KAP analysis, Climate-smart agriculture, Livestock management, Smallholder farmers

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ABSTRACT

The dairy sector in the Haor region of Bangladesh faces serious environmental challenges, especially seasonal flooding, which affects livestock productivity. This study assessed dairy farmers' knowledge, attitudes, and practices (KAP) regarding farming and management in this vulnerable region to support effective development interventions. A cross-sectional survey was conducted among 770 dairy farmers from six Upazilas of the Haor region. Data were collected through structured interviews. Descriptive statistics, chi-square tests, and multivariable logistic regression were performed using IBM SPSS version 26 to identify factors associated with farmers' knowledge, attitudes, and practices. Most participants were male (61.82%), aged 31-45 years (49.22%), and illiterate (82.6%). Farmers showed high knowledge of estrus detection (92.99%), but knowledge of balanced feeding (9.09%), vaccination (18.96%), and deworming (15.97%) was low. Gender, age, farming experience, and location significantly influenced knowledge levels. Farmers had positive attitudes toward improved breeds (80.8%), artificial insemination (81.9%), and climate-smart practices (72.34%). In addition, 87.14% of farmers recognized the risks of climate change, and attitudes varied by location. However, farming practices were still mostly traditional. About 92.21% of farmers did not follow regular vaccination schedules, and 93.12% reported improper antibiotic use. Male farmers and those with primary education were more likely to adopt improved practices. Dairy farmers in the Haor region generally have positive attitudes and willingness to adopt improved farming methods. However, significant gaps remain in technical knowledge and practical implementation due to environmental challenges and limited support systems. Strengthening local extension services, climate-resilient infrastructure, gender-inclusive training programs, and veterinary support is essential to improve dairy productivity and resilience in the region.

1. Introduction

The dairy sector in Bangladesh is a cornerstone of the national agricultural economy, providing a critical source of nutrition, income, and employment for millions of rural households (Chowdhury et al., 2023). As the country strives to achieve self-sufficiency in milk production, the role of smallholder dairy farmers has become increasingly prominent (Sarma et al., 2025). However, the sector's growth is unevenly distributed, with significant regional disparities influenced by geographical, environmental, and socio-economic factors (Das et al., 2025). Among these, the Haor region in northeastern Bangladesh stands out as a unique and challenging landscape for livestock rearing (Bayazid et al., 2025). Characterized by vast tectonic depressions that remain submerged for nearly half the year, the Haor ecosystem imposes severe constraints on traditional farming systems, particularly during the monsoon season when flash floods are frequent (Hassan et al., 2023). In the Haor basin, dairy farming is not merely an economic activity but a vital survival strategy for communities that are often isolated by water for extended periods (Famous et al., 2021).

Despite the abundance of natural fodder during the dry season, the sudden onset of floods leads to acute shortages of feed, clean water, and suitable animal housing (Islam et al., 2025). These environmental shocks are compounded by a lack of modern technical knowledge and limited access to veterinary services, which are often disrupted by the region's difficult terrain (Hossain et al.,

How to cite this article: Shahiduzzaman M, Hasan M, Jui SA and Rahman MM (2026). Factors influencing dairy farmers' knowledge, attitudes, and practices in selected haor areas of Kishoreganj and Netrokona districts, Bangladesh. International Journal of Natural and Social Sciences, 13(1): 38-55. DOI: 10.5281/zenodo.23853093

2022). Consequently, the productivity of dairy cattle in the Haor region remains significantly lower than the national average, hindering the potential for sustainable rural development (Sultana et al., 2024). The success of any agricultural intervention in such a complex environment depends heavily on the Knowledge, Attitudes, and Practices (KAP) of the local farming community (Sultana et al., 2016). Knowledge refers to the understanding of modern management techniques, such as balanced ration feeding, disease prevention, and reproductive management (Mostari et al., 2025). Attitude reflects the farmers' perceptions and willingness to adopt new technologies, while Practice encompasses the actual implementation of these techniques on the farm (Rahman et al., 2025). Previous research in other parts of Bangladesh has shown that gaps in knowledge and poor management practices are major barriers to enhancing dairy productivity (Sarif et al., 2016). However, there is a dearth of comprehensive studies that specifically evaluate the KAP of dairy farmers within the unique ecological context of the Haor region (Uddin et al., 2019).

Although several studies have been conducted in haor-dominated areas such as Sylhet Division, these findings may not be generalizable across all haor ecosystems due to spatial heterogeneity in socio-economic conditions, flood dynamics, and access to extension services. In particular, central haor areas such as Kishoregonj and Netrokona remain underrepresented in empirical KAP-based research. Therefore, this study addresses this gap by focusing on these comparatively less-studied haor settings.

The factors influencing KAP are multifaceted, ranging from individual socio-demographic characteristics like age, gender, and education to structural factors such as farm size and access to institutional support (Kamal et al., 2014). In the Haor region, the impact of climate change has added another layer of complexity, as increasing unpredictability in flood patterns necessitates more resilient and adaptive farming practices (Sima et al., 2023). Understanding how these factors interact to shape farmers' behaviors is essential for designing targeted extension services and policy interventions that are both culturally appropriate and ecologically sound (Alam et al., 2024).

This study aimed to evaluate the factors influencing dairy farmers' knowledge, attitudes, and practices in selected haor areas of Kishoregonj and Netrokona districts of Bangladesh. By employing a paragraph-wise analysis of socio-demographic determinants and their impact on KAP, this research aims to identify the specific bottlenecks and opportunities for dairy development in this vulnerable ecosystem. The findings provide a robust evidence base for policymakers, non-governmental organizations (NGOs), and extension workers to develop climate-smart strategies that can enhance the resilience and productivity of the Haor dairy sector, ultimately improving the livelihoods of thousands of smallholder farmers.

2. Materials and methods

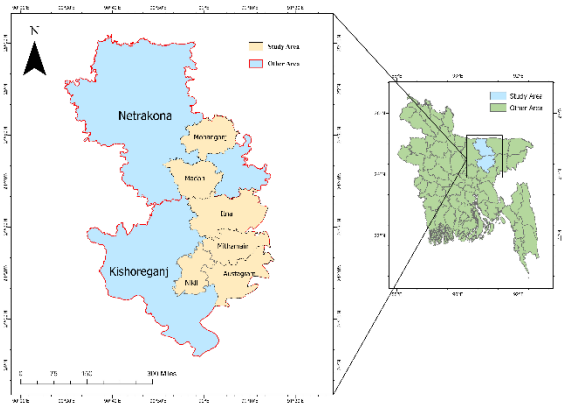
2.1. Study area

This study focused on selected haor areas of Kishoregonj and Netrokona districts and excluded other prominent haor regions, including those in Sylhet Division, which may exhibit distinct agro-ecological conditions and socio-economic contexts, renowned for its extensive wetlands that remain submerged for approximately half of the year. This unique geographical feature presents significant environmental and socio-economic challenges for agricultural practices, particularly livestock rearing, due to frequent flash floods during the monsoon season. The study specifically focused on (Figure 1) six administrative Upazilas of kishoregonj and Netrokona (Nikli, Itna, Mitamoin, Austagram, Madan and Mohongonj) districts. These locations were strategically chosen to encompass the diverse socio-economic landscapes and varying geographical conditions prevalent in dairy farming communities across the Haor basin.

2.2. Study population and sampling

A total of 770 dairy farmers were purposively selected to participate in this study. The sampling strategy aimed to ensure a representative cross-section of the dairy farming population within the

chosen Upazilas. Participants were selected based on their active involvement in dairy farming, ensuring that the collected data accurately reflected the knowledge, attitudes, and practices of the target demographic. The distribution of participants across the six Upazilas was carefully managed to maintain regional balance, with proportions ranging from 15.58% to 17.79% of the total sample, thereby providing a robust foundation for generalizable findings within the study area.



2.2.1. Inclusion and exclusion criteria

Inclusion criteria:

- Dairy farmers actively involved in cattle rearing and milk production
- Residents of the selected Upazilas (Nikli, Itna, Mitamoin, Austagram, Madan, and Mohongonj)
- Aged 18 years or older
- Provided informed consent to participate

Exclusion criteria:

- Individuals not directly involved in dairy farming
- Farmers without cattle at the time of the survey
- Respondents unwilling to participate or with incomplete responses
- Individuals outside the selected study area.

2.3. Questionnaire development, pilot testing, and data collection

Primary data were collected using a structured questionnaire designed to assess the socio-demographic characteristics and knowledge, attitudes, and practices (KAP) of dairy farmers. The questionnaire was developed based on an extensive review of relevant literature and expert consultation to ensure clarity, relevance, and contextual suitability. The Knowledge, Attitude, and Practice (KAP) questionnaire was subjected to a rigorous validation process to ensure the internal consistency and reliability of the data collection tool. Initially, a pilot study was conducted with a sample of 26 dairy farmers to evaluate the clarity of the questions and the technical feasibility of the survey. The internal consistency of the instrument was assessed using Cronbach's alpha coefficient. Based on the preliminary results of the pilot test, the instrument was refined by removing items that exhibited negative or low item-total correlations. This refinement process resulted in an overall Cronbach's alpha of 0.603. While a coefficient of 0.70 is often preferred for established scales, a value exceeding 0.60 is considered acceptable for exploratory research, pilot testing, and the development of new questionnaires in the social and veterinary sciences (Hair et al., 2010; Shaver and wrightsman 1991). Following the validation phase, the refined instrument was administered to the full study population of 770 respondents. This large-scale implementation provides high statistical power and ensures that the reliability estimates are stable and representative of the target population. The final reliability of the domains was further monitored during the full-scale data analysis to ensure the robustness of the findings. Data were collected using an online-based survey tool (Google Forms). The questionnaire link was shared directly with respondents. In cases where farmers had limited digital literacy or internet access, the researchers conducted face-to-face interviews and recorded the responses into the Google Form, ensuring data accuracy and completeness. The questionnaire covered four main sections: (i) Socio-demographic variables included age, sex, educational status, farming experience, income source, cattle breed type, and farm size. Age was categorized into three groups (15-30 years, 31-45 years, and >45 years). Educational status was classified as illiterate (no formal education), primary education, and secondary education, (ii) knowledge of dairy farming practices, (iii) attitudes and (iv) farm management practices. These are detailed assessments of farmers' understanding, perceptions

and actual implementation of dairy farming and management techniques.

2.4. Data analysis

All collected data were initially entered and organized in Microsoft Excel. Subsequently, the data were transferred to IBM SPSS statistical software for comprehensive statistical analysis. Descriptive statistics, including frequencies and percentages, were primarily utilized to summarize the socio-demographic characteristics of the study participants and to present the overall distribution of knowledge, attitudes, and practices among the dairy farmers. To explore the associations between the independent socio-demographic and farm-related variables and the dependent KAP outcomes, chi-square tests of independence were performed for all categorical variables. Variables with a p-value of less than 0.20 in the univariable analysis were considered for inclusion in the multivariable logistic regression model. In addition, variables considered biologically and contextually important based on previous literature, including age, sex, education level, farming experience, Upazila, income source, breed type, and farm size, were included in the final model to control for potential confounding effects. Multivariable logistic regression analysis was then conducted to identify factors significantly associated with farmers' knowledge, attitudes, and practices regarding dairy farming. Crude odds ratios (COR) and adjusted odds ratios (AOR) with 95% confidence intervals (CI) were calculated. A p-value of less than 0.05 ($p < 0.05$) was considered statistically significant.

3. Results and discussion

3.1. Socio-demographic characteristic of farmer

The study included a total of 770 participants. As presented in Table 1, the majority of respondents were male (61.82%), while females participants accounted for 38.18% of the sample. In terms of age distribution, nearly half of the participants were between 31-45 years (49.22%), followed by those aged over 45 years (35.06%), and a smaller proportion aged 15-30 years (15.71%). Educational attainment was generally low, with the vast majority being illiterate (82.6%). Only 16.23% had completed primary education, and a very small fraction (1.17%) had attained secondary education. Farming experience was relatively high among respondents: more than half (56.49%) reported over 10 years of farming experience, while 23.38% had 0-5 years, and 20.13% had 6-10 years of experience. Participants were drawn from six Upazilas, with representation fairly balanced across locations. The highest proportions were from Nikli (17.79%) and Mohongonj (17.53%), followed closely by Austagram (16.88%), Madan (16.49%), Itna (15.71%), and Mitamoin (15.58%).

TABLE 1 Socio-demographic characteristics of participants

Variable	Category	Participants (n, %)
Sex	Male	476 (61.82)
	Female	294 (38.18)
Age group (Years)	15-30	121 (15.71)
	31-45	379 (49.22)
	>45	270 (35.06)
Education Level	Illiterate	636 (82.60)
	Primary	125 (16.23)
	Secondary	9 (1.17)
Farming Experience	0-5 years	180 (23.38)
	6-10 years	155 (20.13)
	>10 years	435 (56.49)
Upazila	Nikli	137 (17.79)
	Mohongonj	135 (17.53)
	Austagram	130 (16.88)
	Madan	127 (16.49)
	Itna	121 (15.71)
	Mitamoin	120 (15.58)
Main Income Source	Livestock & Crops	742 (96.36)
	Livestock	28 (3.64)
Breed Type	Crossbred	398 (51.69)
	Local	372 (48.31)
Farm Type	Small	437 (56.75)
	Medium	261 (33.90)
	Large	72 (9.35)

Abbreviations: n = number of participants; %=number of percentages

Regarding income sources, almost all respondents (96.36%) depended on livestock and crops, while only 3.64% relied solely on livestock. Breed type distribution was nearly even, with crossbred cattle (51.69%) slightly more common than local breeds (48.31%). Farm size analysis revealed that small farms dominated (56.75%), followed by medium

farms (33.90%), and a minority operated large farms (9.35%). The demographic profile indicates that the study population was predominantly male, middle-aged, illiterate, and highly experienced in farming, with small-scale mixed farming systems being the most common livelihood strategy.

TABLE 2 Knowledge of participants about dairy farming in hoar region.

Variable	Category	Frequency (n)	Proportion (%)	Chi-square (χ^2)	p-Value
Do you know balance ration of dairy cattle?	Yes	70	9.09	515.455	<0.001
	No	700	90.91		
Do you know the signs of estrus detection of cows?	Yes	716	92.99	569.148	<0.001
	No	54	7.01		
Do you know ideal age of first breeding (heifer)?	Yes	135	17.53	324.675	<0.001
	No	635	82.47		
Do you know ideal calving interval?	Yes	143	18.57	304.229	<0.001
	No	627	81.43		
Knowledge about deworming frequency (month)	Yes	123	15.97	356.592	<0.001
	No	647	84.03		
Do you know use of antibiotic and its withdrawal period?	Yes	145	18.83	299.221	<0.001
	No	625	81.17		
Do you know about modern dairy farming?	Yes	138	17.92	316.930	<0.001
	No	632	82.08		
Knowledge about vaccination	Yes	146	18.96	296.732	<0.001
	No	624	81.04		
Knowledge of proper management of calf	Yes	166	21.56	249.148	<0.001
	No	604	78.44		
Knowledge of proper management of lactating cow	Yes	131	17.01	335.148	<0.001
	No	639	82.99		

Abbreviations: n = number of participants; χ^2 = Chi-square test; p < 0.001 indicates statistical significance

3.2. Knowledge of participants and its potential factors

As shown in Table 2, respondents demonstrated varying levels of knowledge regarding dairy cattle management practices. Awareness of balance ration feeding was very low, with only 9.09% reporting knowledge, while the overwhelming majority (90.91%) lacked understanding in this area. In contrast, knowledge of estrus detection signs was exceptionally high, with 92.99% of respondents correctly identifying these signs, indicating strong familiarity with reproductive management. Knowledge of the ideal age for first breeding of heifers was limited, with only 17.53% aware, and similarly, only 18.57% knew the ideal calving interval. Awareness of deworming frequency was also low (15.97%), suggesting gaps in preventive health management. Knowledge of antibiotic use and withdrawal periods was reported by 18.83%, highlighting potential risks of misuse among the majority (81.17%). Understanding of modern dairy farming practices was limited (17.92%), and knowledge of vaccination protocols was similarly low (18.96%). Slightly higher awareness was observed in calf management practices, with 21.56% reporting knowledge, while only 17.01% demonstrated knowledge of proper management of lactating cows. All variables showed statistically significant differences ($p < 0.001$) in chi-square tests, indicating that knowledge gaps were not random but systematically distributed across the population. The findings reveal that while farmers are generally familiar with estrus detection, they lack adequate knowledge in critical areas such as balanced feeding, preventive health, and modern dairy practices, which may hinder productivity and animal welfare.

3.3. Factors influencing participant's knowledge on dairy farming

TABLE 3 Multivariable logistic regression analysis of factors associated with farmers' knowledge of dairy farming practices in the Haor region

		Knowledge				
Variable	Category	Good (%)	Poor (%)	COR (95% CI)	AOR (95% CI)	p-Value
Sex	Male	234 (49.2)	242 (50.8)	1.3 (1.00-1.80)	1.4 (1.04-1.94)	0.0275
	Female	123 (41.8)	171 (58.2)	-	-	-
Age group (years)	15-30	53 (43.8)	68 (56.2)	0.8 (0.52-1.24)	0.6 (0.36-0.99)	0.0461
	31-45	171 (45.1)	208 (54.9)	0.8 (0.62-1.16)	0.8 (0.54-1.08)	0.1293
	>45	133 (49.3)	137 (50.7)	-	-	-
Educational status	Primary	64 (51.2)	61 (48.8)	1.3 (0.85-1.84)	1.4 (0.91-2.10)	0.1323
	Secondary	3 (33.3)	6 (66.7)	0.6 (0.15-2.41)	0.7 (0.18-3.07)	0.6717
	Illiterate	290 (45.6)	346 (54.4)	-	-	-
Age (years)	15-30	87 (48.3)	93 (51.7)	1.2 (0.87-1.74)	1.4 (0.89-2.07)	0.1529
	31-45	82 (52.9)	73 (47.1)	1.5 (1.02-2.13)	1.5 (1.02-2.30)	0.0378
	>45	188 (43.2)	247 (56.8)	-	-	-
Upazila	Austagram	67 (51.5)	63 (48.5)	1.0 (0.65-1.69)	1.0 (0.62-1.66)	0.9644
	Itna	53 (43.8)	68 (56.2)	0.8 (0.47-1.26)	0.7 (0.40-1.14)	0.1463
	Madan	62 (48.8)	65 (51.2)	0.9 (0.58-1.52)	0.8 (0.50-1.38)	0.4707
	Mitamoin	40 (33.3)	80 (66.7)	0.5 (0.30-0.82)	0.4 (0.26-0.74)	0.0020
	Mohongonj	66 (48.9)	69 (51.1)	0.9 (0.50-1.52)	0.9 (0.52-1.39)	0.5239
	Nikli	69 (50.4)	68 (49.6)	-	-	-
Main income source	Livestock	14 (50.0)	14 (50.0)	1.2 (0.55-2.47)	1.2 (0.57-2.69)	0.5938
	Livestock & Crops	343 (46.2)	399 (53.8)	-	-	-
Breed type	Crossbred	181 (45.5)	217 (54.5)	0.9 (0.70-1.23)	0.9 (0.70-1.25)	0.6557
	Local	176 (47.3)	196 (52.7)	-	-	-
Farm type	Small	201 (46.0)	236 (54.0)	-	-	-
	Medium	123 (47.1)	138 (52.9)	1.0 (0.77-1.42)	1.1 (0.77-1.45)	0.7251
	Large	33 (45.8)	39 (54.2)	1.0 (0.60-1.64)	1.0 (0.58-1.62)	0.9046

Abbreviations: AOR, adjusted odds ratio; COR, crude odds ratio; CI, confidence interval

Table 3 summarizes the associations between socio-demographic, educational, farming, and farm-related characteristics with the outcome variable. Male respondents were more likely to report good outcomes compared to females, with significantly higher odds in the adjusted model (AOR: 1.4, 95% CI: 1.04-1.94, p = 0.0275). Age was also influential, as farmers aged 15-30 years had lower odds of good outcomes compared to those above 45 years (AOR: 0.6, 95% CI: 0.36-0.99, p = 0.0461), while the 31-45 year group showed no significant difference (AOR: 0.8, 95% CI: 0.54-1.08, p = 0.1293). Table 3 presents the factors associated with farmers' knowledge of dairy farming practices in the Haor region. Male farmers were significantly more likely to demonstrate good knowledge compared to female farmers (AOR: 1.4, 95% CI: 1.04-1.94, p = 0.0275). Farmers aged 15-30 years had significantly lower knowledge levels than those older than 45 years (AOR: 0.6, 95% CI: 0.36–0.99, p = 0.0461). In addition, farmers with 6–10 years of farming experience showed significantly higher knowledge compared to those with more than 10 years of experience (AOR: 1.5, 95% CI: 1.02-2.30, p = 0.0378). Geographical variation was also evident, as farmers from Mitamoin were significantly less likely to have good knowledge compared to those from Nikli (AOR: 0.4, 95% CI: 0.26–0.74, p = 0.0020). Other variables, including education level, income source, breed type, and farm size, were not significantly associated with knowledge levels.

3.4. Farmer's attitude and its potential factors

The results from the chi-square analysis demonstrate a consistently high level of agreement among farmers regarding key aspects of dairy farming practices in the Haor region, with all variables showing statistically significant differences ($p < 0.001$). Majority of the respondents affirmed that dairy farming provides reliable income (69.6%), that improved breeds enhance profitability (80.8%), and that vaccination remains essential even during flood seasons (67.1%) (Table 4). Preventive and management practices were strongly endorsed, with balanced feeding (71.0%), regular cleaning of cattle houses (81.6%), and record-keeping (68.2%) widely recognized as critical for productivity and disease control. Technological interventions such as artificial insemination was also valued, with 81.9% agreeing on its role in improving genetic quality. Social and institutional dimensions emerged prominently, as most farmers encouraged women's participation (84.3%), expressed trust in government veterinary services (84.8%), and acknowledged the usefulness of training programs (71.8%) and cattle insurance (80.8%). Climate-related concerns were particularly salient, with 87.1% perceiving climate change as a major risk to dairy farming, 72.3% recognizing the importance of climate-smart practices, and 87.8% prioritizing methane reduction. Furthermore, 84.3% indicated willingness to adopt new practices, while 74.0% emphasized the necessity of government and NGO support. Collectively, these results highlight a strong consensus among farmers in favor of progressive, preventive, and climate-smart strategies, underscoring both the readiness of farming communities to embrace innovation and the critical role of institutional support in fostering sustainable livestock development in Bangladesh's Haor ecosystems.

TABLE 1 Farmers' attitudes toward dairy farming and management practices in the Haor region of Bangladesh

Variable	Category	Frequency (n)	Proportion (%)	Chi-square (χ^2)	p-Value
Dairy farming is reliable income in Haor	Agree	536	69.61	513.626	<0.001
	Neutral	205	26.62		
	Disagree	29	3.77		
Improved breeds increase profit	Agree	622	80.78	796.816	<0.001
	Neutral	118	15.32		
	Disagree	30	3.90		
Vaccination is essential even during flood season	Agree	517	67.14	462.751	<0.001
	Neutral	219	28.44		
	Disagree	34	4.42		
Balanced feeding is more important for production	Agree	547	71.04	557.862	<0.001
	Neutral	203	26.36		
	Disagree	20	2.60		
Regular cleaning house reduces disease outbreak	Agree	628	81.56	827.730	<0.001
	Neutral	124	16.10		
	Disagree	18	2.34		
AI improves genetic quality	Agree	631	81.95	839.582	<0.001
	Neutral	121	15.71		
	Disagree	18	2.34		
Record-keeping is necessary	Agree	525	68.18	479.099	<0.001
	Neutral	209	27.14		
	Disagree	36	4.68		
Women's participation should be encouraged	Agree	649	84.29	907.795	<0.001
	Neutral	93	12.08		
	Disagree	28	3.64		
Govt veterinary services are	Agree	653	84.81	925.249	<0.001

trustworthy	Neutral	89	11.56		
	Disagree	28	3.64		
Training programs are useful	Agree	553	71.82	554.153	<0.001
	Neutral	181	23.51		
	Disagree	36	4.68		
Insurance for cattle is beneficial	Agree	622	80.78	795.790	<0.001
	Neutral	119	15.45		
	Disagree	29	3.77		
Climate change increases dairy risks	Agree	671	87.14	1006.553	<0.001
	Neutral	70	9.09		
	Disagree	29	3.77		
Attitudes [Climate-smart practices are important]	Agree	557	72.34	570.392	<0.001
	Neutral	181	23.51		
	Disagree	32	4.16		
Attitudes [Willing to adopt new practices]	Agree	649	84.29	909.945	<0.001
	Neutral	97	12.60		
	Disagree	24	3.12		
Attitudes [Methane reduction is a priority]	Agree	676	87.79	1031.410	<0.001
	Neutral	69	8.96		
	Disagree	25	3.25		
Attitudes [Govt./NGO support is needed]	Agree	570	74.03	611.948	<0.001
	Neutral	170	22.08		
	Disagree	30	3.90		

Abbreviations: n = number of participants; χ^2 = Chi-square test; p < 0.001 indicates statistical significance

3.5. Factors influencing farmer's attitude on dairy farming

Multivariable logistic regression (Table 5) examined the association between farmers' socio-demographic and farm-related characteristics and their attitudes toward dairy farming practices in the Haor region. This analysis identified geographical location as the only significant factor associated with farmers' attitudes toward dairy farming practices in the Haor region (Table 5). Farmers from Madan (AOR: 2.79, 95% CI: 1.64-4.75, p < 0.001) and Mitamoin (AOR: 2.17, 95% CI: 1.28-3.69, p = 0.004) demonstrated significantly more positive attitudes compared to those from Austagram. No statistically significant associations were observed for gender, age, education level, farming experience, income source, breed type, or farm size. These findings suggest that local institutional and socio-economic contexts may play a more important role in shaping farmers' attitudes than individual demographic characteristics.

TABLE 2 Multivariable logistic regression analysis of factors associated with farmers' attitudes toward dairy farming in the Haor region.

		Attitude				
Variable	**Category**	**Positive n (%)**	**Negative n (%)**	**COR (95%CI)**	**AOR (95%CI)**	**p-value**
Sex	Female	167 (56.8)	127 (43.2)	-	-	-
	Male	281 (59.0)	195 (41.0)	1.10 (0.82-1.47)	1.08 (0.79-1.48)	0.626
Age group (years)	15-30	75 (62.0)	46 (38.0)	-	-	-
	31-45	215 (56.7)	164 (43.3)	0.80 (0.53-1.22)	0.89 (0.56-1.42)	0.635
	>45	158 (58.5)	112 (41.5)	0.87 (0.56-1.34)	0.96 (0.57-1.62)	0.891
Education level	Illiterate	361 (56.8)	275 (43.2)	-	-	-
	Primary	80 (64.0)	45 (36.0)	1.35 (0.91-2.02)	1.05 (0.68-1.62)	0.822
	Secondary	7 (77.8)	2 (22.2)	2.67 (0.55-12.9)	2.63 (0.52-13.4)	0.243
Farming experience (years)	0-5	108 (60.0)	72 (40.0)	-	-	-
	6-10	91 (58.7)	64 (41.3)	0.95 (0.61-1.47)	1.06 (0.67-1.70)	0.792

	>10	249 (57.2)	186 (42.8)	0.89 (0.63-1.27)	0.99 (0.65-1.52)	0.979
Upazila	Austagram	62 (47.7)	68 (52.3)	-	-	-
	Itna	65 (53.7)	56 (46.3)	1.27 (0.78-2.09)	1.26 (0.75-2.11)	0.376
	Madan	92 (72.4)	35 (27.6)	2.88 (1.71-4.85)	2.79 (1.64-4.75)	0.000
	Mitamoin	80 (66.7)	40 (33.3)	2.19 (1.31-3.66)	2.17 (1.28-3.69)	0.004
	Mohongonj	78 (57.8)	57 (42.2)	1.50 (0.92-2.44)	1.46 (0.90-2.39)	0.127
	Nikli	71 (51.8)	66 (48.2)	1.18 (0.73-1.91)	1.18 (0.72-1.93)	0.506
Main income source	Livestock	12 (42.9)	16 (57.1)	-	-	-
	Livestock & Crops	436 (58.8)	306 (41.2)	1.90 (0.89-4.07)	1.93 (0.88-4.23)	0.102
Breed type	Crossbred	236 (59.3)	162 (40.7)	-	-	-
	Local	212 (57.0)	160 (43.0)	0.91 (0.68-1.21)	0.92 (0.68-1.23)	0.572
Farm type	Large	38 (52.8)	34 (47.2)	-	-	-
	Medium	148 (56.7)	113 (43.3)	1.17 (0.69-1.98)	1.16 (0.68-1.98)	0.588
	Small	262 (60.0)	175 (40.0)	1.34 (0.81-2.21)	1.32 (0.79-2.21)	0.288

Abbreviations: AOR, adjusted odds ratio; COR, crude odds ratio; CI, confidence interval

3.6. Farmer's practice and management of dairy farming

The chi-square analysis (Table 6) revealed significant variation across multiple household and farm management variables. Housing type was predominantly kacha (50.1%) and semi-pucca (47.3%), with only 2.6% reporting pucca housing (χ^2=328.281, p<0.001). Similarly, mud floors (52.2%) and brick floors (44.0%) were most common, while concrete floors were rare (3.8%) (χ^2=310.647, p<0.001). Feeding practices were heavily reliant on crop residues (96.1%), with minimal use of silage (3.9%) (χ^2=654.675, p<0.001). Seasonal feeding systems differed markedly: during the dry season, free grazing dominated (76.1%), while in the rainy season stall feeding was nearly universal (97.9%) (χ^2=641.839 and χ^2=707.330, respectively, both p<0.001). Water sources were mainly rivers (73.1%) compared to tube-wells (26.9%) (χ^2=164.592, p<0.001). Preventive health practices were weak, with 92.2% not up-to-date on vaccination and 90.1% reporting deworming last done more than six months ago (χ^2=548.701 and χ^2=496.005, respectively, p<0.001).

TABLE 3 Farmer's practice and management of dairy farming

Variable	Category	Frequency (n)	Proportion (%)	Chi-square (χ^2)	p-value
Housing type	Kacha	386	50.13	328.281	<0.001
	Semi-pucca	364	47.27		
	Pucca	20	2.60		
Floor type	Mud	402	52.21	310.647	<0.001
	Brick	339	44.03		
	Concrete	29	3.77		
Feed types used	Crop residues	740	96.10	654.675	<0.001
	Silage	30	3.90		
Feeding system (dry season)	Free grazing	586	76.10	641.839	<0.001
	Stall + Free grazing	124	16.10		
	Stall feeding	60	7.79		
Feeding system (rainy season)	Stall feeding	754	97.92	707.330	<0.001
	Stall + Free grazing	16	2.08		
Water source	River	563	73.12	164.592	<0.001
	Tube-well	207	26.88		
Vaccination status	Not up-to-date	710	92.21	548.701	<0.001

	Up-to-date	60	7.79		
Deworming last done	>6 months	694	90.13	496.005	<0.001
	3-6 months	76	9.87		
Tick control	Spray	47	62.67	4.813	0.028
	Dip	28	37.33		
Use of antibiotics	Yes	717	93.12	572.592	<0.001
	No	53	6.88		
Use of commercial feed/supplement	No	686	89.09	470.655	<0.001
	Yes	84	10.91		
Flood preparedness	Fodder stock	679	88.18	449.018	<0.001
	Raised platform	91	11.82		
Milk sold to	Middleman	439	57.01	15.148	<0.001
	Direct consumer	331	42.99		
Manure management	Heap	653	84.81	373.112	<0.001
	Pit	117	15.19		
Use of manure	Fuel	646	83.90	353.875	<0.001
	Fertilizer	124	16.10		
Use of improved breeds	No	768	99.74	762.021	<0.001
	Yes	2	0.26		
Received training/support	No	646	83.90	353.875	<0.001
	Yes	124	16.10		
Breeding method	Artificial insemination	676	87.79	439.901	<0.001
	Natural	94	12.21		

Abbreviations: n = number of participants; χ^2 = Chi-square test; p < 0.001 indicates statistical significance.

Tick control was more often through spraying (62.7%) than dipping (37.3%) (χ^2=4.813, p=0.028). Antibiotic use was widespread (93.1%) (χ^2=572.592, p<0.001), while commercial feed/supplement use was limited (10.9%) (χ^2=470.655, p<0.001). Flood preparedness strategies were largely fodder stocking (88.2%) rather than raised platforms (11.8%) (χ^2=449.018, p<0.001). Milk was more often sold to middlemen (57.0%) than directly to consumers (43.0%) (χ^2=15.148, p<0.001). Manure was primarily managed in heaps (84.8%) and used as fuel (83.9%), with smaller proportions using pits (15.2%) or fertilizer (16.1%) (χ^2=373.112 and χ^2=353.875, respectively, p<0.001). Adoption of improved breeds was negligible (0.3%) (χ^2=762.021, p<0.001), and only 16.1% reported receiving training or support (χ^2=353.875, p<0.001). Artificial insemination was the dominant breeding method (87.8%) compared to natural service (12.2%) (χ^2=439.901, p<0.001). The results highlight a strong reliance on traditional housing, feeding, and manure management practices, limited adoption of improved technologies, and inadequate preventive health measures, all of which have implications for livestock productivity and resilience.

3.7. Factors influencing farmer's practice and management on dairy farming

TABLE 4 Factors influencing farmer's practice and management

		Practice				
Variable	Category	Positive n (%)	Negative n (%)	COR (95% CI)	AOR (95% CI)	p-value
Sex	Female	116 (39.5)	178 (60.5)	-	-	-
	Male	222 (46.6)	254 (53.4)	1.34 (1.00-1.80)	1.38 (1.01-1.89)	0.043
Age group (years)	15-30	58 (47.9)	63 (52.1)	-	-	-
	31-45	161 (42.5)	218 (57.5)	0.80 (0.53-	0.98 (0.62-	0.914

				1.21)	1.53)	
	>45	119 (44.1)	151 (55.9)	0.86 (0.56-1.32)	1.11 (0.67-1.84)	0.687
Education level	Illiterate	265 (41.7)	371 (58.3)	-	-	-
	Primary	69 (55.2)	56 (44.8)	1.73 (1.17-2.54)	1.59 (1.05-2.41)	0.028
	Secondary	4 (44.4)	5 (55.6)	1.12 (0.30-4.21)	1.34 (0.34-5.21)	0.675
Farming experience	0-5	91 (50.6)	89 (49.4)	-	-	-
	6-10	71 (45.8)	84 (54.2)	0.83 (0.54-1.27)	0.82 (0.52-1.29)	0.387
	>10	176 (40.5)	259 (59.5)	0.66 (0.47-0.94)	0.66 (0.44-1.01)	0.055
Upazila	Austagram	51 (39.2)	79 (60.8)	-	-	-
	Itna	52 (43.0)	69 (57.0)	1.17 (0.71-1.93)	1.13 (0.67-1.90)	0.655
	Madan	60 (47.2)	67 (52.8)	1.39 (0.85-2.28)	1.20 (0.72-2.00)	0.489
	Mitamoin	54 (45.0)	66 (55.0)	1.27 (0.77-2.10)	1.16 (0.69-1.96)	0.576
	Mohongonj	57 (42.2)	78 (57.8)	1.13 (0.69-1.85)	1.09 (0.66-1.79)	0.747
	Nikli	64 (46.7)	73 (53.3)	1.36 (0.83-2.21)	1.46 (0.88-2.40)	0.139
Main income source	Livestock	13 (46.4)	15 (53.6)	-	-	-
	Livestock & Crops	325 (43.8)	417 (56.2)	0.90 (0.42-1.92)	0.88 (0.40-1.93)	0.753
Breed type	Local	172 (46.2)	200 (53.8)	-	-	-
	Crossbred	166 (41.7)	232 (58.3)	0.83 (0.63-1.11)	0.81 (0.60-1.08)	0.148
Farm type	Small	197 (45.1)	240 (54.9)	-	-	-
	Medium	107 (41.0)	154 (59.0)	0.85 (0.62-1.15)	0.85 (0.62-1.17)	0.314
	Large	34 (47.2)	38 (52.8)	1.09 (0.66-1.80)	1.12 (0.67-1.87)	0.657

Abbreviations: AOR, adjusted odds ratio; COR, crude odds ratio; CI, confidence interval.

The multivariable logistic regression analysis presented in Table 7 examined the association between farmers' socio-demographic and farm-related characteristics and their adoption of dairy farming practices in the Haor region. This analysis revealed that gender and education level were significant predictors of improved dairy farming practices in the Haor region (Table 7). Male farmers were significantly more likely to adopt improved practices compared to female farmers (AOR: 1.38, 95% CI: 1.01-1.89, p = 0.043). Similarly, farmers with primary education demonstrated significantly greater adoption of improved practices than illiterate farmers (AOR: 1.59, 95% CI: 1.05-2.41, p = 0.028). Although farmers with more than 10 years of farming experience tended to show lower adoption levels, the association was only borderline significant (p = 0.055). Other socio-demographic and farm-related variables were not significantly associated with practice adoption.

4. Discussion

The socio-demographic profile of the 770 respondents indicates that dairy farming in the Haor ecosystem is largely managed by middle-aged male farmers with limited formal education. Nearly half of the participants were between 31-45 years of age (49.22%), while men accounted for

61.82% of the respondents. This pattern reflects the prevailing socio-cultural context of rural Bangladesh, where men typically assume primary responsibility for livestock management and farm-related decision-making. Women often contribute through supportive activities such as feeding cattle, cleaning sheds, and assisting with milk handling. Similar gender distributions have been reported in several livestock studies conducted in rural Bangladesh, where male farmers generally have greater access to markets, extension services, and veterinary professionals. As a result, men are often more exposed to technical information and institutional support mechanisms. Comparable trends have been observed in agricultural systems throughout South Asia and are consistent with the findings of Bokhtiar et al. (2024), who reported that livestock production in wetland regions is largely male-dominated due to traditional gender roles and mobility constraints affecting women.

Educational attainment among the surveyed farmers was notably low. A large proportion of respondents (82.6%) were illiterate, and only a very small fraction (1.17%) had completed secondary education. This situation reflects broader developmental challenges within the Haor basin, which is geographically isolated and frequently affected by seasonal flooding, poor transportation networks, and limited educational infrastructure. Low literacy levels restrict farmers' ability to interpret written extension materials, veterinary instructions, and technical guidelines related to improved livestock management thereby limiting the adoption of improved dairy farming practices (Ali et al., 2018; Sarif et al., 2016). Education is widely recognized as a key driver of agricultural innovation and knowledge acquisition. Farmers with higher levels of education tend to be better equipped to understand and implement advanced practices such as balanced ration formulation, vaccination schedules, artificial insemination programs, and climate-smart livestock technologies. Therefore, the high illiteracy rate observed in this study represents a significant structural barrier to improving dairy production systems in the Haor region. Similar relationships between education and the adoption of improved livestock practices have been documented by Ali et al. (2018), who found that better-educated farmers were significantly more likely to implement improved management techniques.

Although formal education levels were low, many respondents possessed substantial farming experience. More than half of the farmers (56.49%) reported having over ten years of experience in livestock farming. This suggests that much of the practical knowledge related to dairy farming in the region is acquired through hands-on experience and passed down through generations within farming households. Such experiential learning allows farmers to develop practical skills in animal observation, breeding management, and seasonal adaptation strategies. However, traditional knowledge alone may not fully address modern challenges related to nutrition management, disease prevention, and climate resilience. Integrating local knowledge with formal training and veterinary extension programs could therefore play an important role in improving the productivity and sustainability of livestock production systems in the Haor ecosystem. Naim et al. (2023) similarly emphasized that combining indigenous knowledge with scientific guidance can significantly enhance the effectiveness of smallholder livestock farming systems.

The predominance of small-scale farms (56.75%) and mixed crop-livestock production systems (96.36%) further illustrates the subsistence nature of dairy farming in the Haor basin. In this environment, livestock serves multiple functions within household livelihoods. Beyond providing milk and income, cattle also represent an important form of financial security for rural families exposed to environmental risks. The Haor ecosystem is highly vulnerable to flash floods, which frequently damage crops and disrupt agricultural production. Under these circumstances, livestock becomes a valuable asset that can provide emergency income or serve as a financial buffer during periods of crop failure. Bashar et al. (2024) similarly highlighted the critical role of livestock in supporting livelihood diversification and reducing vulnerability among farming households in flood-prone areas of Bangladesh.

A substantial variation was observed in farmers' knowledge across different aspects of dairy management. Knowledge of estrus detection was remarkably high (92.99%), suggesting that farmers have strong practical awareness of reproductive signs that directly influence breeding and herd productivity. In smallholder dairy systems, the timely detection of estrus is essential for maintaining regular breeding cycles and ensuring sustained milk production. Farmers often acquire this skill through daily observation of animal behavior and long-term experience with livestock. Similar findings were reported by Shamsuddin et al. (2007), who noted that recognition of reproductive behavior is one of the most commonly understood aspects of dairy management among smallholder farmers in Bangladesh.

However, knowledge of more technical management practices was considerably limited. Awareness of balanced ration feeding was extremely low (9.09%), while knowledge regarding deworming schedules (15.97%), vaccination protocols (18.96%), and antibiotic withdrawal periods (18.83%) was also inadequate. Balanced nutrition is widely recognized as a key determinant of milk production, reproductive efficiency, and animal health. In the absence of adequate knowledge about feed formulation and nutrient requirements, farmers often depend heavily on crop residues as the primary feed source, which may not provide sufficient protein, minerals, or vitamins required for optimal productivity. Hussain (2017) emphasized that insufficient knowledge of animal nutrition remains one of the main constraints to dairy productivity in smallholder farming systems.

Limited awareness of preventive health measures also suggests inadequate access to veterinary extension services. Preventive practices such as vaccination and parasite control are crucial for reducing disease prevalence and improving livestock performance. Nevertheless, farmers in remote wetland areas often face substantial challenges in accessing veterinary services due to geographical isolation and seasonal flooding. Similar gaps in knowledge regarding animal health management have been documented in other regions of Bangladesh where veterinary extension systems remain weak or poorly distributed (Moller et al., 2023).

The multivariable logistic regression analysis further revealed that gender, age, farming experience, and geographical location significantly influenced farmers' knowledge levels. Male farmers were more likely to demonstrate better knowledge than female farmers, which may reflect their greater involvement in livestock marketing activities and stronger interactions with veterinary professionals and extension agents. Gender-based disparities in access to agricultural information have been widely documented and may influence both knowledge acquisition and technology adoption among farmers. Godde et al. (2021) highlighted that gender inequalities in information access can significantly affect farmers' capacity to adopt improved agricultural practices.

Age also played a role in shaping knowledge levels. Younger farmers aged 15-30 years were less likely to demonstrate good knowledge compared to older farmers. This finding may reflect declining youth participation in agriculture, as many young people migrate to urban areas in search of alternative employment opportunities. Reduced involvement of youth in farming activities can weaken the transfer of traditional agricultural knowledge across generations. Similar patterns have been reported by Abbas et al. (2019), who observed decreasing youth engagement in agricultural production systems. Geographical location was another important factor influencing knowledge levels. Farmers from Mitamoin were significantly less likely to demonstrate good knowledge compared to those from Nikli. This finding highlights the uneven distribution of veterinary services, extension programs, and development interventions within the Haor region. Communities located in more remote areas often experience limited access to training opportunities and technical assistance. Kemboi et al. (2021) similarly emphasized that disparities in extension service coverage across

regions can significantly influence farmers' knowledge and productivity levels.

Despite the existence of considerable knowledge gaps, the study revealed generally positive attitudes among farmers toward improved dairy management and climate-smart livestock practices. A large proportion of respondents acknowledged the benefits of improved cattle breeds (80.8%), artificial insemination (81.9%), and balanced feeding practices (71.0%). These results suggest that farmers are receptive to technological innovations even if their practical knowledge remains limited. Positive attitudes toward innovation often represent an important foundation for the adoption of improved agricultural technologies once the necessary resources and knowledge are made available. Devadas et al. (2025) emphasized that favorable farmer attitudes toward innovation are often a key precursor to technology adoption in rural agricultural systems.

Farmers also demonstrated a high level of awareness regarding climate-related risks. Approximately 87.1% of respondents perceived climate change as a major threat to dairy farming. The Haor region frequently experiences flash floods, prolonged waterlogging, and unpredictable climatic conditions, all of which can affect feed availability, animal health, and farm infrastructure. The strong concern expressed by farmers regarding methane emissions (87.8%) and the importance of climate-smart livestock practices suggests that many farmers are increasingly aware of environmental challenges affecting livestock production. Ahamed et al. (2024) also observed that farmers living in climate-vulnerable environments often develop strong awareness of environmental risks due to their direct exposure to climatic hazards. The management practices adopted by farmers in the Haor region are therefore strongly shaped by seasonal flooding patterns. The transition from free grazing during the dry season (76.1%) to almost universal stall feeding during the rainy season (97.9%) represents a practical adaptation to the seasonal submergence of grazing lands (Sultana & Khanam, 2024).

The analysis of factors influencing farmers' attitudes revealed that geographical location was the only significant predictor. Farmers from Madan and Mitamoin exhibited significantly more positive attitudes toward improved dairy farming practices compared to those from Austagram. This variation may reflect differences in local development initiatives, NGO activities, or the availability of agricultural extension services across Upazilas. Community-level institutional engagement often plays an important role in shaping farmers' perceptions and willingness to adopt improved practices. Islam et al. (2021) similarly reported that localized institutional support can strongly influence farmers' attitudes toward agricultural innovations. Interestingly, education did not show a statistically significant relationship with farmers' attitudes. Even farmers with limited formal education expressed favorable views regarding improved dairy practices. This suggests that attitudes may develop through community interaction, peer learning, and observation of successful farmers rather than formal schooling alone. Sarma and Islam (2025) noted that social learning processes within rural communities often play a significant role in shaping farmers' perceptions and behavior toward agricultural innovations.

The analysis of farm management practices revealed that dairy production systems in the Haor region remain largely traditional. Housing structures were primarily kacha or semi-pucca with mud floors, indicating limited financial capacity among farmers to invest in improved infrastructure. Poor housing conditions can increase disease risks, particularly during the monsoon season when excessive moisture and inadequate drainage create favorable conditions for pathogen growth. Mostari and Ali (2025) reported that inadequate livestock housing significantly contributes to disease outbreaks such as Foot and Mouth Disease in flood-prone environments. Feeding practices were also heavily dependent on traditional feed resources, particularly crop residues, which were used by 96.1% of farmers. The extremely limited use of silage (3.9%) indicates that modern feed preservation technologies are rarely adopted in the region. During the rainy season, when

grazing lands are submerged, farmers frequently experience severe feed shortages. Such nutritional deficiencies can negatively affect milk production, weaken immune responses, and increase susceptibility to disease. Alam and Rahman (2024) highlighted that feed scarcity during flood periods remains one of the most critical constraints affecting dairy productivity in wetland ecosystems.

Preventive health management was identified as one of the weakest aspects of dairy farming practices in the study area. More than 92% of farmers reported that their animals were not up-to-date with vaccination schedules, and deworming practices were also infrequent. The discrepancy between farmers' positive attitudes toward vaccination and their limited implementation suggests the presence of systemic barriers. These barriers may include vaccine unavailability, inadequate cold-chain infrastructure, high service costs, and difficulties accessing veterinary services during the flood season. Islam and Mahmud (2025) emphasized that logistical and infrastructural challenges often limit the effectiveness of veterinary service delivery in remote wetland areas. Another critical concern identified in the study was the widespread use of antibiotics without sufficient knowledge of appropriate withdrawal periods. Such practices can pose serious public health risks by contributing to antimicrobial resistance and the presence of antibiotic residues in milk. Hossain et al. (2022) warned that the uncontrolled use of antibiotics in livestock production is an emerging public health issue in Bangladesh and many other developing countries.

Overall, the results of this study highlight a complex interaction between knowledge, attitudes, and practices among dairy farmers in the Haor region. While farmers generally demonstrate positive perceptions toward improved livestock practices and climate-smart strategies, significant knowledge gaps and structural limitations hinder the effective implementation of these practices. Addressing these challenges will require strengthened extension services, targeted farmer training programs, improved veterinary infrastructure, and the promotion of locally adapted climate-smart livestock technologies. Enhancing institutional support and encouraging community-based knowledge sharing will be crucial for improving the resilience, sustainability, and productivity of dairy farming systems in Bangladesh's vulnerable Haor ecosystems.

5. Conclusion

The findings highlight the need for targeted extension programs in the Haor region, particularly focusing on balanced feeding, vaccination schedules, and responsible antibiotic use. Community-based training and mobile veterinary services could help overcome geographical barriers caused by seasonal flooding. Strengthening climate-resilient livestock management strategies may also improve dairy productivity and farmer resilience. This study reveals an important gap within the dairy farming community of the Haor region: although farmers show positive attitudes toward modern farming practices and climate-resilient strategies, significant deficiencies remain in technical knowledge and the adoption of improved management practices. While awareness of basic reproductive management, such as estrus detection, was very high, knowledge of balanced ration feeding, vaccination protocols, and proper deworming was very limited. As a result, traditional management practices still dominate, including low vaccination coverage and widespread misuse of antibiotics.

Socio-demographic factors such as gender, age, farming experience, and geographical location significantly influenced farmers' knowledge and practice adoption. Male farmers and those with moderate farming experience showed relatively better knowledge and practices, while certain sub-regions exhibited lower knowledge levels. These disparities are further intensified by the environmental challenges of the Haor ecosystem, particularly seasonal flooding, along with limited access to technical knowledge and veterinary services. To improve the resilience and productivity of the dairy sector in the Haor region, interventions should focus on

strengthening localized extension services, promoting climate-resilient infrastructure, implementing gender-inclusive training programs, and improving veterinary support systems. Such efforts will help smallholder farmers adopt improved management practices, enhance livestock productivity, and support sustainable dairy development in this vulnerable ecosystem.

Acknowledgements

The authors would like to express his sincere gratitude to the farmers of the haor areas for their cooperation and participation, and to the Upazila livestock offices of Nikli, Itna, Mitamoin, Austagram of Kishoreganj district and Madan, Mohanganj of Netrokona districts whose guidance and assistance were instrumental in data collection.

Limitations of the study

This study has several limitations. Its cross-sectional design restricts causal interpretation, while the reliance on self-reported data may have introduced recall bias. The use of purposive sampling may limit the generalizability of the findings. Seasonal variations were not assessed comprehensively, and no direct farm observations or laboratory verification were conducted. In addition, women's contributions may have been underrepresented, and the limited educational diversity among respondents may have influenced the responses and constrained the breadth of perspectives captured.

Policy implications and implementation

Building a resilient dairy sector in the Haor region requires coordinated, context-specific interventions. Government agencies, NGOs, and local communities should strengthen livestock extension and veterinary services through localized training and mobile veterinary units, particularly in remote, flood-prone Upazilas. Training should emphasize vaccination, balanced feeding, disease prevention, and responsible antibiotic use. Investment in climate-resilient infrastructure including elevated cattle sheds, community fodder-storage facilities, flood-tolerant fodder crops, improved water sources, and appropriate manure management is also essential. Policies should further promote women's participation in dairy farming and expand access to livestock insurance, credit, and other financial support mechanisms.

Recommendations

Priority should be given to integrated extension programs, strengthened veterinary coverage, and climate-smart dairy practices tailored to local conditions. Community-based training, mobile services, flood-proof infrastructure, year-round fodder availability, and improved financial protection can enhance farm productivity and resilience. These measures would support a more sustainable dairy sector while contributing to food security and the economic well-being of vulnerable farming communities.

Conflict of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics statement

This study adhered to ethical standards and received approval from the research ethics committee of the Animal Welfare and Experimentation Ethics Committee (AWEEC) of Bangladesh Agricultural University. The approval was granted on January 10, 2025, under approval number AWEEC/BAU/2025(2)/82(a). Informed consent was obtained from all participants, guaranteeing their voluntary participation, protection of their rights and confidentiality of their data. The ethical approval and consent procedures

implemented in this study demonstrate our dedication to responsible and ethical research practices, ensuring the welfare and well-being of the participants.

References

Abbas, Q., Hu, Y., & Ullah, A. (2019). Dairy Production under Climatic Risks: Perception, Adaptation and Determinants of Adaptation Decisions. International Journal of Environmental Research and Public Health, 16(20), 4036. https://doi.org/10.3390/ijerph16204036

Ahamed, J. U., Rahman, M. M., & Islam, M. S. (2024). Impact of agricultural intervention on income and employment in the Haor region of Bangladesh. Urban Agriculture & Regional Food Systems, 9(1), e70001. https://doi.org/10.1002/uar2.70001

Alam, S., & Rahman, M. M. (2024). Alternative cropping and feeding options to enhance dairy productivity in Bangladesh. Journal of Agricultural Science, 162(2), 145-158. https://doi.org/10.1080/27685241.2023.2290046

Ali, S., Kashem, M. A., & Aziz, M. A. (2018). An overview of socio-economic and farming systems status of farmers' in the Haor area under Sunamganj district. Asian Journal of Advances in Agricultural Research, 7(2), 1-10. https://doi.org/10.9734/AJAAR/2018/42145

Bashar, M. K., Hassan, M. R., & Sultana, N. (2024). Assessment of GHG emissions in dairy production systems of Bangladesh. Journal of Advanced Veterinary and Animal Research, 11(3), 664-674. https://doi.org/10.5455/javar.2024.k816

Bayazid, A. A., Harun, A. B., Billah, M. M., & Meher, M. (2025). Impact of flood on livestock farming and a possible solution to reduce the suffering of livestock in the Haor region of Bangladesh. Journal of Research in Veterinary Sciences, 18(1), 45-58. https://doi.org/10.30539/jrvs.2025.18.1.45

Bokhtiar, S. M., Islam, M. S., & Rahman, M. M. (2024). Constraints and Opportunities of Agricultural Development in Haor Areas of Bangladesh. Agriculture, 14(2), 17. https://doi.org/10.3390/agriculture14020017

Chowdhury, T., Ahmed, J., Hossain, F. M. A., & Hossain, M. T. (2023). Knowledge, attitudes and biosecurity practices among the small-scale dairy farmers in Sylhet district, Bangladesh. Veterinary Medicine and Science, 9(5), 2312-2321. https://doi.org/10.1002/vms3.1199

Das, S. C., Mahbubul, M., Ferdows, J., & Islam, M. T. (2025). The current scenario, challenges, and possible mitigation practices of livestock production potentials in the Haor ecosystem of Bangladesh: A review. Journal of Advanced Veterinary and Animal Research, 12(4), 1379-1395. https://doi.org/10.5455/javar.2025.l998

Devadas, S., Hossain, M. T., & Rahman, M. M. (2025). Knowledge, attitudes and practices on antimicrobial use and resistance among livestock farmers in Bangladesh. Preventive Veterinary Medicine, 238, 106500. https://doi.org/10.1016/j.prevetmed.2025.106500

Famous, M., Baset, M. A., Uddin, M. N., Hossain, M. N., & Islam, M. O. (2021). Dairy Buffalo Production and Management Systems in Haor Areas of Sylhet in Bangladesh. Turkish Journal of Agriculture - Food Science and Technology, 9(8), 1524-1529. https://doi.org/10.24925/turjaf.v9i8.1524-1529.4343

Godde, C. M., Mason-D'Croz, D., Mayberry, D. E., Thornton, P. K., & Herrero, M. (2021). Impacts of climate change on the livestock food supply chain; a review of the evidence. Global Food Security, 28, 100488. https://doi.org/10.1016/j.gfs.2020.100488

Hassan, M. R., Sultana, S., Sultana, N., & Hosen, A. (2023). Dairy Production and Livelihood Scenario in Different Climatic Regions of Bangladesh. Singapore Journal of Scientific Research, 13(1), 109-123. https://doi.org/10.3923/sjsr.2023.109.123

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2010). Multivariate data analysis, 7th Edn. Hoboken.

Hossain, M. T., Rafiq, K., Islam, M. Z., Chowdhury, S., Islam, P., & Rahman, M. M. (2022). A Survey on Knowledge, Attitude, and Practices of Large-Animal Farmers towards Antimicrobial Use, Resistance, and Residues in Mymensingh Division of Bangladesh. Antibiotics, 11(4), 442. https://doi.org/10.3390/antibiotics11040442

Hussain, S. G. (2017). Identification and Modeling of suitable cropping systems and patterns for saline, drought and flood prone areas of Bangladesh. Bangladesh Journal of Agricultural Research, 42(3), 451-465. https://doi.org/10.3329/bjar.v42i3.32692

Islam, M. O., Famous, M., & Baset, M. A. (2021). Socioeconomic status of dairy buffalo farmer in Haor of Sylhet. Turkish Journal of Agriculture - Food Science and Technology, 9(8), 1524-1529.

https://doi.org/10.24925/turjaf.v9i8.1524-1529.4343

Islam, M. S., & Mahmud, M. A. A. (2025). Assessment of knowledge, attitudes, and practices on vaccine usage among large ruminant farmers in the rangpur division of Bangladesh. Preventive Veterinary Medicine, 236, 106476. https://doi.org/10.1016/j.prevetmed.2025.106476

Kamal, M. M., Bhuiyan, M. M. U., Parveen, N., & Shamsuddin, M. (2014). Risk factors for postpartum anestrus in crossbred cows in Bangladesh. Turkish Journal of Veterinary and Animal Sciences, 38(2), 151-156. https://doi.org/10.3906/vet-1301-31

Kemboi, E., Khan, M. A. S., & Rahman, M. M. (2021). Yield gap in milk production is considerable in Indian Himalayan state of Meghalaya. Journal of Dairy Research, 88(3), 285-292. https://doi.org/10.1017/S002202992100056X

Moller, K., Rahman, M. M., & Islam, M. S. (2023). Livestock and aquaculture farming in Bangladesh: Current challenges and potential opportunities. Cogent Food & Agriculture, 9(1), 2241274. https://doi.org/10.1080/23311932.2023.2241274

Mostari, M. P., & Ali, M. Z. (2025). Farmer's Knowledge, Attitude and Practice toward Lumpy Skin Disease in Bangladeshi Cattle: A KAP Study. Advances in Animal and Veterinary Sciences, 13(7), 1606-1619. https://doi.org/10.17582/journal.aavs/2025/13.7.1606.1619

Naim, Z., Asaduzzaman, M., Akter, M., & Islam, M. S. (2023). Impact of climate change on livestock production in Bangladesh-A review. Bangladesh Journal of Animal Science, 52(2), 65-78. https://doi.org/10.3329/bjas.v52i2.65311

Rahman, M. C., Sarkar, M. A. R., Kabir, M. J., & Rahaman, M. S. (2025). Vulnerability and adaptation in flood-prone ecosystems of Bangladesh: a case study of rice farming households. Discover Sustainability, 6, 84. https://doi.org/10.1007/s43621-025-00848-z

Sarif, S. M. K., Kabir, M. H., Sultana, S., & Hossain, M. A. (2016). Socioeconomic conditions, agricultural practices and communication status of the vulnerable Haor people in Bangladesh. American Journal of Rural Development, 4(5), 101-107. https://doi.org/10.12691/ajrd-4-5-1

Sarma, P. K., & Islam, M. S. (2025). Assessing the impact of the dairy lead farmer approach on household food security in rural Bangladesh. Journal of Agriculture and Food Research, 19, 100286. https://doi.org/10.1007/s44279-025-00286-5

Sarma, P. K., Rashid, M. H., & Islam, M. S. (2025). Understanding farmer's knowledge, attitudes, and practices towards adopting livestock interventions for food and nutrition security in Bangladesh using latent class analysis. Scientific Reports, 15, 9628. https://doi.org/10.1038/s41598-025-96283-1

Shamsuddin, M., Hossein, M. S., Siddiqui, M. A. R., & Bhuiyan, M. M. U. (2007). Use of milk progesterone radioimmunoassay and computer applications for community based reproductive health services in smallholder dairy farms of Bangladesh. IAEA-TECDOC, 1571, 16-28.

Shaver, P. R., & Wrightsman, L. S. (1991). Measures of personality and social psychological attitudes (Vol. 1). Elsevier.

Sima, N. K., Akter, M., Hoque, M. N., & Islam, M. T. (2023). Reproductive management of dairy cows: An existing scenario from urban farming system in Bangladesh. Journal of Animal Reproduction and Biotechnology, 38(4), 215-222. https://doi.org/10.12750/JARB.2023.38.4.215

Sultana, M. N., Uddin, M. M., & Peters, K. J. (2016). Socio-economic determinants of milk production in Bangladesh: an implication on on-farm water use. Livestock Research for Rural Development, 28(1), 1-14. http://www.lrrd.org/lrrd28/1/sult28001.html

Sultana, N., & Khanam, J. S. (2024). Present feeding management practices and socio-economic conditions of dairy farmers in selected areas of Bangladesh. African Journal of Agricultural Research, 19(1), 12-25. https://doi.org/10.5897/AJAR2023.16478

Uddin, M. T., Hossain, N., & Dhar, A. R. (2019). Business prospects and challenges in Haor areas of Bangladesh: Business prospects and challenges in Haor areas. Journal of the Bangladesh Agricultural University, 17(3), 406-411. https://doi.org/10.3329/jbau.v17i3.40665