International Journal of Applied Research
Journal HP: www.intjar.com; ISSN: 2411-6610

# Seasonal changes in feeding practices, health status, and productivity of crossbred dairy cows under *bathan* and household rearing periods in Bangladesh

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**ARTICLE INFO**

**Article history**

Received: 20 April 2026
Accepted: 9 July 2026
Published: 22 July 2026

**Keywords**

*Bathan*; Feeds and feeding system; High-yielding dairy cows; Milk production; Mixed crop

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**ABSTRACT**

The *Bathan* system, located in the Sirajganj and Pabna districts of Bangladesh, plays a vital role in the country's major milk-producing area and significantly contributes to overall milk production. A longitudinal survey was conducted to assess the seasonal variation in feeding management, milk production, breeding practices, herd structure, and overall management of high-yielding dairy cows reared under both *Bathan* (extensive, natural pasture) and household (intensive, stall-fed) systems in Shahjadpur Upazila, Sirajganj, Bangladesh. A systematic questionnaire was used to gather data from 48 Bathan farmers during the fiscal year 2023–2024. Results revealed that most farmers (83%) are middle-aged and have a medium-sized herd consisting of 20 to 40 animals. All the respondents reared crossbred Holstein Friesian and Jersey cattle, and practiced 100% artificial insemination. Most farmers (84%) prefer semen with 75% exotic blood for breeding cows. Approximately 16% of the high-yielding cows in the survey area were repeat breeders. Feeding practices varied markedly between the *Bathan* and Household rearing periods. During the *Bathan* period, the majority (88.57%) of the farmers produce Hybrid Jambu (*Sorghum bicolour*; *Sorghum sudanefe*) and Black gram (*Vigna mungo*) fodder as a mixed crop. Cows tethered grazed on fodder land and received 38% less concentrate feed than during household rearing. Milk yield increased significantly ($p<0.05$) in the *Bathan* system, by 45.16% compared with the household system. Approximately 95% of the farmers reported that disease prevalence was considerably lower in the *Bathan* rearing system compared to the household rearing system. Among the challenges faced by farmers in these key milk-producing zones, low raw milk prices and high concentrate feed costs were ranked as the most severe constraints. This study provides valuable insights into optimizing *Bathan* management practices to improve productivity and resilience in smallholder dairy farms.

## 1. Introduction

The livestock sector plays an important role in Bangladesh's rural economy, contributing about 1.90% to the national GDP and nearly 16% to the agricultural Gross Domestic Product (GDP) (DLS, 2023). In addition, small-scale dairy farming containing fewer than 50 dairy cows plays an important role in the national economy and rural livelihood (Jahan & Salam, 2023) and is rapidly expanding in Bangladesh. The Sirajganj-Pabna belt is recognized as the largest milk pocket, contributing significantly to national milk production. The Baghabari milk pocket area of Sirajganj District in Bangladesh is highly concentrated with high-yielding dairy cow husbandry, producing 10-25 liters of milk. The origin of high-yielding cattle in the Indian subcontinent was initiated from this region through an early breed development program (Shahjahan, 2017). Owing to its favorable environmental conditions, agroecological location, and well-established milk marketing network, Baghabari is recognized as the largest milk pocket area in Bangladesh (DLS, 2023). Two major feeding systems prevail in this area: *Bathan* and household/stall feeding (Rahman et al., 2015). The fallow lands alongside the Boral and Gohala rivers of this milk pocket area, which serve as the main source of green fodder for dairy cows, are locally known as *Bathan*. The term *Bathan* refers to a semi-intensive system in which animals are grazed in pastures enclosed by bamboo fencing (Gupta et al., 2017). These lowlands remain inundated with floodwater from July to October and are later covered with a fertile layer of silt after the water recedes (Rahman et al., 2015). Furthermore, these lands are rich in seasonal leguminous fodders such as black gram (*Vigna mungo*) and grass pea (*Lathyrus sativa*), which germinate in the silted soil following the monsoon floods.

Despite its long-standing reputation as the leading milk pocket in Bangladesh, the Baghabari area is currently facing several problems that threaten the sustainability of high-yielding dairy cow

***Cite this article:*** *Sultana, N., Hossain, A.-A., Alam, U. S., & Islam, M. T. (2026). Seasonal changes in feeding practices, health status, and productivity of crossbred dairy cows under bathan and household rearing periods in Bangladesh. International Journal of Applied Research, 12(1), 43–53. https://doi.org/10.5281/zenodo.21637481*

production. The number of active dairy farmers and total milk collection has been declining in recent years, mainly due to rising feed prices, scarcity of green fodder, and low farm-gate milk prices (Benarjee, 2025). Milk Vita's Baghabari plant, which previously collected nearly 200,000 L of milk per day, now collects only about 20,000–30,000 L daily—reflecting reduced productivity and farmer participation (Dey, 2021). The number of High-yielding dairy farmers is shrinking due to the shortage of fodder land in *Bathan*. These seasonal and system-based variations must be understood to develop appropriate management strategies and policy interventions for the milk pocket area. Moreover, identifying the challenges faced by smallholder dairy farmers is crucial for maintaining the sustainability of the *Bathan* system.

Therefore, this study aims to evaluate the seasonal variation in feeding management, milk production, reproductive performance, herd structure, and overall management of high-yielding crossbred dairy cows reared under *Bathan* and household systems in Shahjadpur Upazila, Sirajganj. Results from this study will bring valuable insights for improving dairy management practices, strengthening farmers' resilience, and encouraging Bangladesh's dairy industry to grow sustainably.

## 2. Materials and Methods

### 2.1. Study design

This study used a longitudinal within-subject design in which the same individually identified cows were monitored over two management systems: the *Bathan* grazing period and the family stall-feeding period. Each cow acted as its own control, allowing direct comparison of outcomes between the two settings. To guarantee consistent identification during the two periods, animals were tracked using ear tags and farm records. Individual-level data on disease incidence, nutrition, reproduction, and milk yield were gathered. While health and reproductive events were recorded using organized farmer logbooks and, when available, veterinary records, milk production was measured daily and then averaged on a weekly basis.

### 2.2. The study area

Reshambari Bathan and Potazia Bathan, situated inside Potazia Union in Shahjadpur Upazila of Sirajganj District, Bangladesh, are physically positioned at roughly 24.15° N latitude and 89.56° E longitude. It is characterized by a low-lying floodplain, riverine grassland, and alluvial soil that support seasonal grazing for dairy cattle (**Figure 1**).

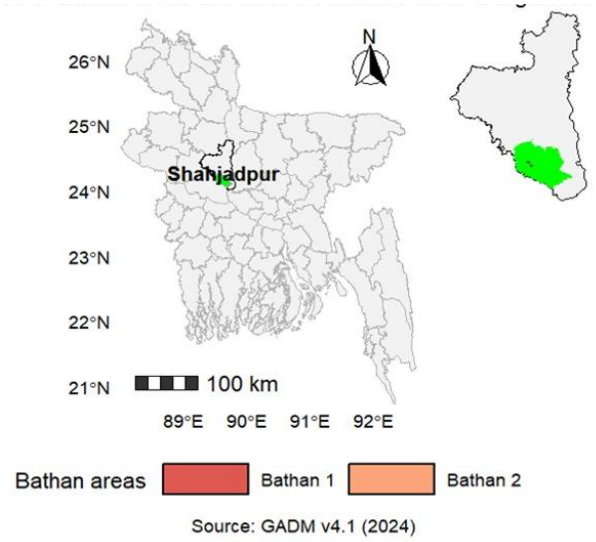


**Figure 1:** Study area map

### 2.3. Climatic condition

The area experiences a hot and humid environment. From April to August *Bathan* area is submerged in water. The temperature ranges between 12°C in winter and 38°C in summer. The land is roughly 10-22 meters above sea level, which significantly affects animal husbandry practices. The relative humidity in this area generally ranges between 75% and 90%, and the average annual rainfall is approximately 2,184 mm (BPDB 2025).

### 2.4. Tools and time of data collection

As indicated above, the main purpose of the base line survey was to generate evidence on the demo graphs of the selected farmers who reared the animal both on farm and on *Bathan* area, livestock population status, its feeding system, breeding system, health status, waste management status, and facing challenges etc. are the main tools for the survey and question was pretested before data collection. All the required data were collected at two key seasonal time points, such as pre-monsoon (December/2023) and post-monsoon (July/2024).

### 2.5. Study population and sample size

The study comprised 48 livestock farmers who had at least five nursing dairy cows and expertise in managing their herds under both the *Bathan* and

home systems. A total of 503 high-yielding dairy cows were included, and all selected animals had been exposed to both management regimes within the same herd, allowing for within-animal comparisons. Variables describing production, health and reproduction were recorded at the individual cow level and the cow was the major unit of study. Cows, however, were nested inside farms and this hierarchical structure was taken into account in the analytical method by accounting for farm-level clustering, thus avoiding biased standard errors due to non-independence of observations. The unit of analysis varied depending on the variable of interest. Farmer-level variables (e.g., socioeconomic characteristics, management practices, and constraints) were analyzed at the farm level (n = 48). Animal-level variables (e.g., milk yield, reproductive performance, health outcomes) were analyzed at the individual cow level (n = 503).

### 2.6. Methods of data collection

A pretested questionnaire was used to gather data from respondents after an in-person interview. Both the interviewer and the respondents were given a clear explanation of the study's goal prior to data collection. As a thank you for their invaluable time and involvement in the data collection process, farmers received an honorarium. Dairy farming issues were assessed using a variety of scoring methods. A four-point rating system was employed, with 0 denoting not at all, 1 denoting some extent, 2 denoting average extent, and 3 denoting large extent. Each item on the scale received a score of 3, 2, 1, and 0. Each respondent's overall score was determined by aggregating the points they earned on each item. The following formula was used to construct a Problem Index (PI) to assess the severity of problems:

$$PI = N_{ge} \times 3 + N_{ae} \times 2 + N_{se} \times 1 + N_{na} \times 0$$

According to the PI Problem Index, $N_{ge}$ represents the number of respondents who experienced a problem to a large extent, $N_{ae}$ represents the number of respondents who experienced a problem to an average extent, $N_{se}$ represents the number of respondents who experienced a problem to some extent, and $N_{na}$ represents the number of respondents who did not experience a problem at all. Based on the respondents' PI, eight issues were prioritized.

### 2.7. Determination of Nutrient Composition of Cultivated Grasses

Nine representative samples of each cultivated forage grass were collected randomly for nutrient composition analysis. The samples were analyzed to determine dry matter (DM), crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), and lignin contents. All samples were prepared and analyzed following the standard procedures described by AOAC (1990).

### 2.8. Statistical Analysis

First, Microsoft Excel was used to extract the gathered data. R software (version 4.5.0) was used to analyze the data, and Microsoft Excel Version 16 (Microsoft, Redmond, WA, USA) was used to generate and express descriptive statistics as mean ± standard error. A paired t-test was applied to compute milk yield between *Bathan* and household feeding periods since measurements were obtained from the same cows. At $p < 0.05$, differences were deemed statistically significant.

## 3. Results

### 3.1. Socio-economic attributes of the respondents

The socioeconomic traits of the survey participants are displayed in Table 1. The findings reveal that most farmers are middle-aged, with a mean age of under 50. Notably, most elderly farmers were unwilling to rear cattle because it required hard labor. Most respondents had a medium-sized family, followed by small families with a family size of up to 4.

**Table 1:** Socio-economic characteristics of the respondents

| Parameter | Categories | Respondents (n=48) | | Mean | SE |
|---|---|---|---|---|---|
| | | Number | (%) | | |
| Age | Young (18-35) | 3 | 7 | 45.9 | 1.06 |
| | Middle (36-55) | 40 | 83 | | |
| | Old (>55) | 5 | 10 | | |
| | Small (up to 4) | 13 | 27 | | |

| | | | | | |
|---|---|---|---|---|---|
| Family Size (No. of members) | Medium (5 to 8) | 30 | 63 | 5.89 | 0.38 |
| | Large (Above 8) | 5 | 10 | | |
| Land size (hectares) | Landless (<0.02) | 0 | 0 | 0.55 | 0.09 |
| | Marginal (0.02-0.2) | 14 | 29 | | |
| | Small (0.21-1) | 23 | 48 | | |
| | Medium (1.1-3) | 9 | 19 | | |
| | Large (>3) | 2 | 4 | | |
| Herd size (No. of animals) | Small (<20) | 9 | 18 | 26.46 | 1.26 |
| | Medium (21-40) | 35 | 73 | | |
| | Large (>40) | 4 | 9 | | |
| Occupation | Agriculture + Cattle Farming | 26 | 54 | - | - |
| | Cattle Farming | 12 | 25 | | |
| | Cattle Farming + Business | 7 | 15 | | |
| | Cattle Farming + Others | 3 | 06 | | |
| Year of Experience (Livestock Farming) | Low (up to 10) | 3 | 06 | 19.32 | 0.86 |
| | Medium (11-20) | 27 | 57 | | |
| | High (>20) | 18 | 37 | | |
| Annual Income (BDT) | Low (up to 250000/-) | 28 | 59 | 2,51,666 | 10661.01 |
| | Medium (251000-400000/-) | 13 | 27 | | |
| | High (>400000/-) | 7 | 14 | | |

*BDT: Bangladeshi Taka; n: Number of respondents; SE: Standard Error*

### 3.2. Cattle genotype and breeding practice

The genotypes of cattle and their breeding practices are shown in Table 2. The results indicate that all of the farmers reared crossbred animals. Among the crossbred, the majority were Holstein Friesian (HF) crosses, and the remaining were Jersey crosses. Most of the farmers preferred 75% blood level of semen straw for artificial insemination.

**Table 2:** Cattle genotype and breeding practice (n=503)

| Parameters | Category | | Frequency | Percentage (%) |
|---|---|---|---|---|
| Cattle genotype | Local | | 0 | 0 |
| | Crossbred | HF | 412 | 82 |
| | | Jersey | 91 | 18 |
| Repeat breeder | - | | 81 | 16 |
| Service type | Natural Mating | | 0 | 0 |
| | Artificial Insemination (AI) | | 503 | 100 |
| Semen blood level | 50%-62.5% | | 0 | 0 |
| | 75% | | 419 | 84 |
| | 87.5% | | 51 | 11 |
| | 100% | | 33 | 5 |

*HF: Holstein Friesian; n: Number of animals*

### 3.3. Feeding system

The feeding system in the *Bathan* and Household period is shown in Table 3. Concentrate supplementation was significantly lower ($p<0.05$) in the *Bathan* period compared with the Household feeding period. Straw was the main source of roughage during the Household period, whereas ad libitum mixed grass was supplied in *Bathan* periods.

**Table 3:** Feeding system during the *Bathan* and Household period

| Parameters | Feeding System | | |
|---|---|---|---|
| | *Bathan* period (Mean ± SE) | Household period (Mean ± SE) | P-value |
| Roughage (kg/cow/day) | Ad libitum supply of mixed grass | 6.81±1.05 (straw) | - |
| Concentrate (kg/cow/day) | 5.28±0.84 | 8.37±1.80 | <0.001 |
| Feeding method | Tethered grazing | Stall feeding | - |

*Highly significant: p = (0.000-0.001); Significant: p = (0.001- 0.01); NS: Non-significant (p > 0.05); SE: Standard Error*

### 3.4. Composition of ingredients in the concentrate combination

Table 4 shows the makeup of the concentrate mixture given to the cows. The finding showed clear differences in feeding practices between the *Bathan* and Household periods. Ready feed and DCP were supplied only in the Household period. Statistically significant seasonal variation was observed in wheat bran, maize husk, and soybean meal.

**Table 4:** Seasonal variation in concentrate feed ingredients

| Parameters | Respondents using ingredient, n/N (%) | Amount of feed ingredient fed to animals in different seasons (kg/day/head) | | |
|---|---|---|---|---|
| | | *Bathan* period (Mean ± SE) | Household period (Mean ± SE) | P-value |
| Wheat bran | 100 | 2.21 ± 0.076 | 2.65 ± 0.091 | <0.001 |
| Maize husk | 72 | 2.26 ± 0.110 | 2.83 ± 0.145 | <0.01 |
| Soybean meal | 86.6 | 1.87 ± 0.123 | 2.34 ± 0.161 | 0.026 |
| Khesari bran | 26.6 | 0.50 ± 0.031 | 0.610 ± 0.120 | 0.28 |
| Rice Polish | 26.6 | 1.45 ± 0.026 | 1.62 ± 0.196 | 0.067 |
| Til Oil cake | 80 | 1.23 ± 0.14 | 1.44 ± 0.162 | 0.330 |
| Ready Feed | 62 | - | 1.06±0.120 | - |
| Gram Husk | 33 | 0.50 ± 0.025 | 0.92 ± 0.093 | 0.06 |
| Lentil bran | 66 | 0.50 ± 0.19 | 0.77 ± 0.09 | 0.08 |
| DCP | 86 | - | 0.100 ± 0.013 | - |

*DCP: Di Calcium Phosphate; Highly significant: p = (0.000-0.001); Significant: p = (0.001- 0.01); NS: Non-significant (p > 0.05); SE: Standard Error; Ready feed: Completed pelleted feed*

### 3.5. Mixed grass production and Nutritional composition

Figure 2 displays the production of mixed grass in the survey area. The results revealed that the majority of the farmers produce hybrid Jambu (*Sorghum bicolour*; *Sorghum sudanefe*) and Black gram (*Vigna mungo*) fodder as a mixed crop. The rest of the farmers produce mixed fodder with Hybrid Jambu (*Sorghum bicolour*; *Sorghum sudanefe*) and Grass pea (*Lathyrus sativa*).

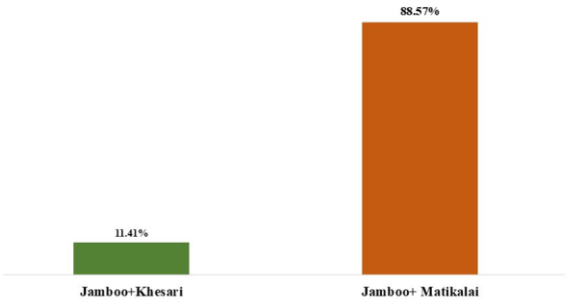


**Figure 2:** Types of mixed fodder cultivated at *Bathan* land

Table 5 displays the nutritional makeup of mixed grass. The dry matter (DM) and lignin content of the two forage combinations differed significantly ($p < 0.05$).

**Table 5:** Nutritional composition of cultivated mixed grass at 40 days of cutting

| **Parameters** | **Jambu+Matikalai (Mean±SD)** | **Jambu+ Khesari (Mean±SD)** | **P-value** |
|---|---|---|---|
| Dry Matter (DM)% | 19.56±1.65 | 20.43±1.21 | 0.010 |
| Crude protein (%) | 18.71±6.20 | 19.68±1.96 | 0.760 |
| ADF (%) | 35.58±3.24 | 37.98±2.64 | 0.059 |
| NDF (%) | 55.05±8.22 | 62.78±5.51 | 0.055 |
| Lignin (%) | 6.55±0.32 | 10.74±1.59 | 0.041 |

*ADF: Acid Detergent Fiber; NDF: Neutral Detergent Fiber; SD: Standard Deviation; Highly significant: p = (0.000-0.001); Significant: p = (0.001- 0.01); NS: Non-significant (p > 0.05).*

### 3.6. Milk production

Table 6 demonstrates the milk production during *Bathan* and household feeding. On average, milk yield under *Bathan* feeding increased by 45.16% compared to the household.

**Table 6:** Milk Production (Liter) during the *Bathan* and Household feeding period

| Household period (Mean± SD) | *Bathan* periods (Mean± SD) | Percentage increase (%) | P-value |
|---|---|---|---|
| 14.40 ± 2.84 | 20.50 ± 2.67 | 45.16 ± 15.86 | <0.001 |

*SD: Standard Deviation; Highly significant: p = (0.000-0.001); Significant: p = (0.001- 0.01); NS: Non-significant (p > 0.05).*

The peak milk production scenario of the high-yielding cows is shown in Table 7. The majority of farmers who kept cows produced milk in the range of 15 to 20 liters. Cows producing 36 to 40 liters of milk are less than one percent in these survey areas.

**Table 7:** Peak milk production scenario of High-Yielding cows of the responders

| Peak milk production (L/day) | Frequency (n=503) | Percentage (%) |
|---|---|---|
| 15-20 L | 330 | 65.60 |
| 21-30 L | 145 | 28.82 |
| 31-35 L | 24 | 4.77 |
| 36-40 L | 04 | 0.79 |

*L: Liter; n: Number of animals*

### 3.7. Health condition of cows

The health status of high-yielding cows is shown in Table 8. The farmer-reported disease occurrence is considerably lower in the *Bathan* rearing system than in the household rearing system. Deworming was practiced by all farmers in the survey areas, but regular vaccination was not performed by one-fifth of the farmers.

**Table 8:** Health status of cows

| Parameters | Category | Frequency (n=48) | Percentage |
|---|---|---|---|
| Farmer-reported disease occurrence at *Bathan* periods | Increased | 03 | 5 |
| | Decreased | 45 | 95 |
| Regular Vaccination | Yes | 39 | 80 |
| | No | 09 | 20 |
| Regular Deworming | Yes | 48 | 100 |
| | No | 0 | 0 |

*n: Number of animals*

### 3.8. The reproductive and productive characteristics of crossbred cows

Table 9 displays the crossbred cows' reproductive and productive performance. The mean conception rate was 2.142±0.845 services per conception, which suggests most cows conceived within two or three services.

**Table 9:** Productive and reproductive attributes of crossbred cows

| **Parameters** | **Mean ± SE (n)** |
|---|---|
| Conception rate (service/ conception) | 2.142±0.845 (503) |
| Return to heat after missed conception (days) | 23.42± 0.695(503) |
| Postpartum heat periods (days) | 66.57± 1.67 (503) |
| Lactation length (days) | 226.85± 4.09 (212) |

*SE: Standard Error; n: Number of animals*

### 3.9. Challenges faced by dairy farmers (n=48)

To assess the intensity of the challenges encountered by farmers in high-yielding dairy cattle farming, a Problem Index (PI) was computed. This index made it possible to determine the magnitude of each problem and rank them accordingly, as presented in Table 10.

**Table 10:** Rank order of problems faced by dairy farmers of this area

| **Serial Number** | **Problems** | **Total Score** | **Rank Order** |
|---|---|---|---|
| 01 | Lack of training facilities | 108 | 3rd |
| 02 | Low price of row milk | 144 | 1st |
| 03 | High price of concentrate feed | 141 | 2nd |
| 04 | Heat stress/ high environmental temperature | 88 | 6th |
| 05 | Repeat breeding/ disease condition of cows | 98 | 4th |
| 06 | High vaccine price | 65 | 7th |
| 07 | Lack of capital | 34 | 8th |
| 08 | Lack of knowledge of balanced ration formulation | 90 | 5th |

## Discussion

Our present study evaluated the total existing scenario of cows reared by the *Bathan* farmers throughout the year. The *Bathan* farmers in the milk-producing areas, such as Sirajganj district in

Bangladesh, typically relied on rearing high-yielding dairy cattle. The development of milk processing industries, such as the Milk Producing Co-operative Union (Milk Vita), Pran Dairy, and Iglu Dairy, and the scope of production of fresh grass in the *Bathan* land are reasons for rearing High-yielding dairy cows in these areas. The husbandry of high-yielding cows in the area was initiated by the renowned poet Rabindranath Tagore, who allocated approximately 1200 acres of *Bathan* land to local farmers and introduced high-yielding dairy bulls for crossbreeding with indigenous cows in the 1890s. The family size of the respondents in these areas ranged from 3 to 17, with an average of 5.89, which was higher than that of the national average of 3.89 (BBS, 2025). Almost similar findings were reported by Rakib et al. (2021) in their studies. Most of the respondents (73%) had a medium-sized herd, consisting of 21-40 animals. These findings are in agreement with the survey results of Shahjahan (2017), who stated that 67% of the farmers in the *Bathan* area of Shahjadpur upazila were middle-scale farming holding 20 milking cows. Only a few (10%) of large farmers were found in this study. However, according to the farmers' opinion, the number of large dairy farmers rearing more than 40 cattle is shrinking day by day. The average livestock farming experience of the respondents was 19.32 years. The majority (57%) of the respondents had medium livestock rearing experience, where 37% respondents had also vast rearing experience of more than 20 years. A similar observation was made by Rana et al. (2020). The majority of farmers (54%) were engaged in agriculture and cattle farming, according to Table 1. Among the respondents, one-quarter of the whole reared high-yielding cattle only as a main occupation. However, the number of sole cattle farming farmers is decreasing day by day. Farmers are not achieving the desired profit from rearing cattle alone as they once did. Therefore, most of them are involved in other sectors, such as agriculture and business. In contrast to the findings of Sarma et al. (2014), highly educated, unemployed individuals are more likely to be attracted to livestock farming for profitability.

All the farmers practiced Artificial insemination (AI) for servicing cows. Our study confirmed the survey results of Shahjahan (2017), which found that no natural breeding was practiced in the *Bathan* area. The results of our present study differ slightly from those of Islam (2010), who reported that about 79% of the artificial insemination was identified in crossbreed cattle in Shahjadpur Upazila, Sirajganj. Traditionally, rearing bulls for breeding purposes has been decreasing remarkably, highlighting a complete shift from traditional natural mating practices to modern breeding technologies within the *Bathan* system. About 16% of the cows experienced conception failure after more than 5 successive services. Similar findings were reported by Islam et al. (2017), who found that about 29% of repeat breeder cows were in the Baghabari milk pocket areas. Cows with more than 50% HF genetics were found to be repeat breeders at the farmer's house in the *Bathan* areas (Ali et al., 2021). Most farmers (84%) used semen with 75% exotic blood for breeding cows. According to farmers' opinions, 75% blood was more sustainable; no farmers were found who used 50-62.5% exotic blood in breeding high-yielding dairy cows in the survey area. In our study area, there are numerous Artificial Insemination (AI) workers who are employed by various government and non-government organizations, such as Milk Vita, BRAC, Lal Teer, American Dairy Limited (ADL), and the Department of Livestock Services (DLS). These AI workers emphasize the importance of supplying high-quality semen doses to farmers. They also advise farmers on the appropriate proportion of semen types to use. According to their opinion, maintaining a stock containing about 75% semen from elite bulls is highly beneficial. The price of semen straws typically ranges from 300 to 500 BDT. Likewise, cows HF 75% × L show better performance in age at first calving (AFC) and age at first heat (AFH) than 50%, 62.5% (Azad et al., 2023). In contrast, higher blood levels (75-87.5%) did not show any benefit in adjusting potential cost for tropical small holder farmers (Rahman et al., 2024).

In the study area, two different feeding periods were found: the *Bathan* and the Homestead. In the *Bathan* period, cattle are allowed to graze freely on natural pasture. Cattle are kept in this area for about 5 months (Nov-March). Cattle were mainly maintained on ad libitum mixed grass available from communal grazing lands, with an average concentrate supplementation of 5.28 ± 0.84 kg per cow per day. After the floodwater recedes from the *Bathan*, farmers sow Jambu grass seeds mixed with black gram or grass pea on the silted soil. Typically, they use a 1:2 seed ratio of Jambu grass to black gram or grass pea. The cows are usually brought back to the *Bathan* 40–45 days after sowing, when the forage becomes suitable for grazing. A temporary shelter was provided to the animals for the night. During the daytime, animals were tethered

and grazing on the fodder land. During the *Bathan* period, high-yielding cows received approximately 38% less concentrate feed than under household rearing conditions. In the *Bathan* period, cattle primarily depended on natural grazing, and concentrate feeding served only as a supplementary nutrient source. Similar findings are reported by Shahjahan (2017).

On the other hand, during the household period (April to October), animals were fully confined under stall-feeding management. At this time, cows were supplied with an average of 8.37 kg of concentrate feed per day, along with ready feed to meet their higher nutritional demands. In contrast to the *Bathan* period, rice straw constituted the only source of roughage during this lean season, with an average daily intake of 6.81 kg per cow. Wheat bran was the common concentrate ingredient reported by all respondents (100%), supplied to the cows during *Bathan* and Household feeding periods. However, an average of 50% of wheat bran used by the *Bathan* dairy farmers was reported by Shahjahan (2017). This shift in feeding practices between the two periods reflects the seasonal variation in feed resource availability, where the abundance of natural pasture during the *Bathan* period is replaced by reliance on stored and purchased feed at the homestead (Rahman et al., 2015).

The majority (65.60%) of high-yielding cows produced between 15-20 liters of milk per day, followed by 28.82% produced 21 to 30 liters of milk, while only a small percentage, less than one percent, achieved over 36 liters. The number of high-yielding cows in this milk pocket area is decreasing. However, milk production depends on several factors, including breed or genetics, environment, and the interaction between genetics and environment (Bednarski & Kupczyński, 2024). The crossbreds, such as Holstein Friesian (HF) or Jersey, that produce 40 liters or more of milk, have the genetic potential for 100% exotic blood. These temperate breeds are more comfortable producing at low environmental temperatures. But at high environmental temperatures in Bangladesh, especially in April to June, high-yielding cows cannot sustain their production in traditional farming. Feed intake of high-yielding cows decreases with increasing temperature from the thermo-neutral zone and drops sharply above 30°c of cows (Chanda et al., 2017). Negative energy balance in cows leads to weight loss and a decline in milk production, resulting in significant economic losses for farmers. According to Habiba et al. (2025), a short period of heat can still have a strong impact on HF crossbreds, which are more susceptible to heat stress than many other breeds, thereby negatively affecting the income of dairy farmers in Bangladesh.

On average, milk yield under *Bathan* feeding increased by 45.16% compared to the household. A significant improvement in milk production, from approximately 5 to 6 liters in *Bathan* feeding compared to household feeding, was reported by all farmers. Although, milk yield was significantly higher during the *Bathan* period than during the household period but this finding should be interpreted with caution. The *Bathan* and household management periods were in different seasons, therefore the observed difference in milk yield might have been affected not only by the rearing system but also by seasonal factors such as ambient temperature, heat stress, forage availability, feed quality and stage of lactation. The *Bathan* period was associated with relatively cooler conditions and greater availability of green mixed fodder, while the household period occurred during warmer months when heat stress and limited forage availability might reduce feed intake and milk production. The present results thus suggest a strong association between *Bathan*-season management and higher milk yield, but should not be taken as proof of a direct causal effect of the *Bathan* system alone. Essentially, animals are provided with an adequate amount of green mixed fodder, which meets all essential energy and protein requirements, potentially increasing milk production. Mixed forage (e.g., grass + clover) fed ad libitum significantly increased dry-matter intake and milk yield in Holstein cows (Johansen, 2017). The higher production performance of *Bathan* cows can be ascribed to better grazing opportunities and access to ad libitum highly nutritious mixed green fodder. Grazing-based lamb produces higher milk than stall feeding due to better feed intake (Hossain et al., 2022). In addition, the *Bathan* periods coincide with the winter seasons in our study area, and the ambient temperatures are comparatively lower than the household periods, in which crossbred cows feel more comfortable in production. Reduced heat load and favorable microclimate help crossbred animals achieve better productivity (Bernabucci et al., 2014). However, contrasting results were reported by Shahjahan (2017) found no significant difference in peak milk production of cows reared in the *Bathan* and the Household period.

The prevalence of E. coli was found significantly higher ($p= 0.002$) in cattle under intensive farming

(84%) than in cattle on *Bathan* (56%) (Gupta et al., 2017), which confirms our results. But dissimilar results were found by Sarker et al. (2013), who stated that animals are more susceptible to surgical disease in *Bathan* grazing. Regular deworming was performed by all the farmers in our survey area. About 80% of the farmers regularly follow the vaccination schedule for their cattle, and almost all farmers administer major vaccines such as LSD and FMD in our study area. All farmers believed that cows' health is better under the *Bathan* periods. During this period, cows exhibit regular estrous cycles, and the conception rate is also considerably higher compared to the household rearing period. Similarly, about 95% farmers used anthelmintics every three months, and about 78% farmers of Shahzadpur vaccinated their animals (Munsi et al., 2016).

These values are in line with the findings of Sarker et al. (2014), where conception rates in crossbred cows generally range between 1.8 and 2.5 services per conception, but show dissimilarity with the findings of (Shahjahan 2017), who found the conception rate of 1.62 in this area. In our survey area, the postpartum heat periods and lactation lengths of high-yielding dairy cows were 66.57±1.67 and 226.85±4.09 days, respectively. Lactation length may vary with the management system ( Rahman et al., 2017). The average lactation length of HF crossbred cows in Bangladesh was 232.2 days, as reported by Rahman et al. (2017), which aligns with our study results. The postpartum heat periods of the cows in our survey were lower than those reported by Rahman et al. (2017), who found the average postpartum heat period of FH crossbred cows was 117 days. The low price of raw milk and the high price of concentrate feed stand 1$^{st}$ and 2$^{nd}$ ranked, indicating the severe problems among the problems faced by the respondents in these milk pocket areas. Lack of training facilities for farmers, the number of repeat breeder cows, and lack of knowledge of the ration formulation are moderately severe among the problems. Recorded predominant breeder bulls and increasing milk price will strengthen the overall dairying in the Baghabari milk pocket regions (Shahjahan, 2017). Similarly, feed cost represents an important factor, and beyond the price ranges that farmers can afford (Khan et al., 2009), which confirms the results of our study.

## Conclusion

The *Bathan* dairy production system holds an essential component of Bangladesh's major milk-producing region, offering clear benefits over intensive household rearing. This study shows that *Bathan*-based management provides higher access to grazing resources, reduces feeding costs, and improves overall herd performance. Milk production was considerably higher in the Bathan system, while disease prevalence was greatly lower, indicating both economic and health advantages for farmers. However, farmers rely heavily on crossbred cattle and artificial insemination, and reproductive challenges such as repeat breeding persist. Therefore, specific interventions such as improving feed resource availability, promoting fodder conservation, ensuring affordable inputs, and strengthening breeding services are crucial for enhancing productivity and profitability. Overall, the *Bathan* period demonstrates strong potential as a cost-effective method of dairy production, and with appropriate policy and technical support, it can considerably contribute to improved livelihoods, food security, and the long-term growth of the dairy sector in Bangladesh.

## Declarations

### Ethical approval

Our study used a basic survey and collected a few pieces of personal information. All data were kept confidential, securely stored, and anonymized before analysis.

### Authors Contribution

N.S.: Conceived the idea, led the research design, coordinated writing. A.H.: Data collection, curation, analysis, and writing the original draft. U.S.A.: Data collection, curation, analysis, writing the original draft, and reviewing the final manuscript draft. M.T.S.: Data collection, curation, analysis.

### Funding

This research received no financial support from others and was conducted at the author's own cost.

### Conflict of interest

The writers affirm that they have no conflicting interests.

### Acknowledgement

The employees of the Bangladesh Livestock Research Institute (BLRI) regional station in

Sirajganj helped with this study. The authors would like to sincerely thank the *Bathan* dairy farmers and the employees of the BLRI regional station in Sirajganj for their kind assistance.

## Data availability

On reasonable request, the corresponding author will provide data created and/or analyzed during this work.

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