SJSR Singapore Journal of Scientific Research

OPEN ACCESS

Dairy Production and Livelihood Scenario in Different Climatic Regions of Bangladesh

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ABSTRACT

Background and Objective: The dairy industry has undergone rapid structural changes and transformed into a profitable enterprise in recent years. However, many farmers still fail to recognize the critical elements determining dairy output and farm profitability. Therefore, this study aimed to identify the present scenario of dairy farming in different climatic regions of Bangladesh. **Materials and Methods:** A total of 450 farmers and 150 dairy cattle specialists from five regions (plane, hilly, coastal, flood and milk pocket areas) were interviewed using pre-tested questionnaires. Dairy farms were described as small (2-5 cows), medium (6-9 cows) and large (more than 10 cows). The collected data was summarized and analyzed using Microsoft Excel 2007 and SPSS 16.0. The differences among treatments were determined with Duncan's New Multiple-Range Test. **Results:** The highest average milk yield was 8.36 L in medium farms in the milk pocket region. The highest lactating cows in the herd were 50.82% in the medium farm of the coastal region. In the entire survey area, about 34% of the farmers for artificial insemination preferred 75% HF bull semen, the overall roughage:concentrate ratio was found 59.15:40.85 and around 86.93% of farmers utilized cow dung for fuel and agricultural land preparation. Along with floods and extremely hot weather, high prices of concentrate feed, repeat breeding, mastitis and technological knowledge were the major challenges in all regions. **Conclusion:** An area-based scenario for dairy cattle breeding, farm management techniques, feeding and technology practices, disease frequencies and climatic risks has been identified through this research, which will be effective for future research and policy development.

KEYWORDS

Climatic region, dairy cattle, livelihood, antibiotics, artificial insemination

INTRODUCTION

Dairy farming has been an integral part of agriculture for centuries, providing employment, food and nutrition to millions of people. In Bangladesh, the total cattle population is 24 million[1]. About 90% of total milk is produced from cattle[2]. The cattle genetic resources of the country comprise Native cattle, Red Chittagong cattle, Pabna cattle, North Bengal Grey cattle, Munshiganj cattle, Crossbred cattle and exotic breeds (Holstein Friesian, Sahiwal, Sindhi and Jersey)[3]. Several studies have reported that crossbred cattle are more efficient than purebred cows in the tropics[4]. Indigenous cows produced between 0.50 and 2.50 L of milk per day, whereas crosses between Holstein-Friesian, Jersey, Sahiwal and Red Sindhi

ISSN: 2152-0461 (Online)
ISSN: 1816-4919 (Print)
https://doi.org/10.3923/sjsr.2023.109.123

Received: 23 Apr. 2023
Accepted: 07 Oct. 2023
Published: 20 Oct. 2023

produced between 5 and 10 L per day[5]. The national milk production of Bangladesh has almost doubled during the last few decades. The industry still faces a big gap between requirements and domestic production. The country produced 13.07 million tons of milk in 2021-22, against a requirement of 15.67 million tons[1].

Bangladesh is one of the world's most climate-vulnerable nations, frequently facing floods, droughts, cyclones and rising temperatures. Building adaptable strategies requires an understanding of how these climatic conditions affect dairy production and livelihoods. Increased frequency of hot days, heat waves, warm periods and other extreme weather conditions (such as floods and hail) are the primary effects of climate change that have a substantial impact on animal physiology, welfare, health and reproduction and are thus relevant for livestock production[6]. Many challenges, including limited access to inputs and technology, low productivity and climate variability, prevent dairying from taking advantage of its potential. Climate variability, in particular, poses a significant threat to dairy production in Bangladesh. The country is divided into several distinct climatic zones. In the Northwest Region, for instance, the climate is semi-arid and water scarcity is a significant constraint to agriculture and livelihoods. On the other hand, the central and northern regions have more favorable conditions for agriculture, with abundant water resources and fertile soils. Production, reproduction, feeding and management practices and disease prevalence of dairy cattle are different based on climatic regions[7]. The relationship between dairy cattle production and climatic regions is complex and depends on many factors. Farmers must understand the local climate and adapt their management practices to optimize the health and productivity of their cows. Dairy cattle are usually fed a combination of roughage and concentrate feed. Different climatic conditions, such as temperature, humidity and heavy rainfall, can influence the availability and quality of forages and other feed resources. Therefore, it is essential for dairy farmers to adjust their feeding strategies according to the prevailing climatic conditions to ensure the proper nutrition and health of their animals. The disease prevalence in dairy cattle can also vary depending on the climatic region. For example, mastitis is a significant problem in all regions of Bangladesh, but it is more prevalent during the rainy season and anthrax is more prevalent in the Northern and Central Regions of Bangladesh[2]. Climatic conditions can also influence the use of antibiotics in dairy cattle. In hot and humid regions, bacterial infections are more common and therefore, the usage of antibiotics may be higher. Across the country, farmers frequently use different technologies such as artificial insemination (AI), silage preparation, routine vaccination and deworming, fodder production, etc., which improve the efficiency and profitability of dairy farming. To achieve self-sufficiency in milk production, the government is placing more emphasis on the dairy sector. Despite climate challenges, research can help find appropriate management techniques, breeds and behaviors that can thrive in particular climatic situations. Therefore, it is important to initiate diversified research strategies. This study aimed to contribute valuable knowledge that empowers dairy farmers, stakeholders and researchers to assess the impacts of varying climatic conditions on dairy production systems in distinct regions of Bangladesh and identify adaptive strategies, technologies and sustainable practices for enhancing dairy production and livelihood.

MATERIALS AND METHODS

Study area: The study was conducted in several parts of Bangladesh from July, 2021 to March, 2022. The entire country was categorized into five climatic regions (Plane, hilly, coastal, flood-prone and milk pocket areas).

Source of experimental data: To conduct the study dairy farms were categorized as small (having 2 to 5 cows), medium (6 to 9 cows) and big (having 10 or more cows). A total of 450 farms from five regions were chosen at random (90 farms in each region and 30 farms in each category) (Table 1). A survey of dairy farms was conducted to gather information using interviews and pre-tested questionnaires with 150 experts in each region, including dairy practitioners from the Department of Livestock Services (DLS) and dairy experts from the Bangladesh Livestock Research Institute (BLRI), Bangladesh Agricultural University (BAU), Milk Vita and other officials from private dairy farms (Table 1). Before the interview, all

respondents received a brief explanation of the study's nature and purposes. Each respondent was interviewed face-to-face to collect data and their responses were directly recorded on the interview schedules. The collected data from the respondents was compiled. The data were tabulated and organized as a percent value.

Parameters considered are the following:

Breeds and breeding of dairy cattle: Data were collected on the most popular breeds for AI and the major semen-producing companies in Bangladesh.

Productive and reproductive parameters: Data were collected on several productions (average milk yield and lactation length) and reproduction (calving intervals and post-partum heat period) parameters from each farm for each lactating cow.

Feeds and feeding of dairy cattle: Data were collected on the commonly cultivated fodder (Napier, Napier pack Chong, German and maize) and the ratio of roughage and concentrate feeding in each climatic region.

Management practices in dairy farms: Data related to management practices (commonly used housing systems for dairy cattle and utilization of dairy cattle manure) in different regions were recorded.

Disease prevalence of dairy cattle: Information was collected on the prevalence of common dairy cattle diseases within the last year in each climatic region, which included repeat breeding, mastitis, Foot and Mouth Disease (FMD), anthrax, milk fever, bloat, ketosis, calf diarrhea and lumpy skin disease (LSD).

Commonly used antibiotics in dairy cattle: Information was collected from the dairy practitioners on the percentage of antibiotics that were usually taken from the nearby Upazilla Livestock Office and pharmacies prescribed for dairy cattle by the registered doctors.

Technology practices in dairy cattle production: Data were collected on the technologies practiced by dairy cattle farmers in each climatic region, which included AI, ration balancing, fodder production, silage, manure management, routine vaccination and deworming.

Risks and challenges in dairy cattle production: Information was collected regarding climate-related risks in dairy cattle production and the challenges faced by dairy cattle farmers in each region.

Statistical analysis: The data were checked for obvious inconsistencies and missing data. Data with suspicious values were excluded. Data were summarized in Microsoft Excel 2007 and analyzed using the statistical software 'SPSS-16.0'. The difference among treatments was determined with Duncan's New Multiple Range Test[7] and significance was declared when the probability was less than 5% ($p<0.05$).

Ethical considerations: Consent was obtained from all the studied participants before the data collection. The confidentiality of the studied participants was ensured throughout the study.

Table 1: Data structure of the farms and livestock experts used for the survey

	Regions					
Sources of data	Plain	Hilly	Coastal	Flood prone	Milk pocket	Total
Farms						
Small	30	30	30	30	30	450
Medium	30	30	30	30	30	
Large	30	30	30	30	30	
Livestock experts	30	30	30	30	30	150

RESULTS AND DISCUSSION

Productive and reproductive performance of dairy cattle: One of the most significant elements causing variations in dairy cow productivity is environmental variance. It has a considerable effect on the productivity, health, procreation and general well-being of dairy cows[8]. Due to regional variances, farm management, production, cow genotype, dairy product diversity and other dairy farm factors vary. The productive and reproductive performances of dairy cattle from different climatic regions of Bangladesh are shown in Table 2. A dairy farm needs at least 60% lactating cows to be profitable, but this survey revealed that the average number of milking cows was only 39.60% per farm, with the highest percentage found in medium farms of coastal regions (50.82%) and the lowest percentages being found in medium farms of hilly regions (33.88%) and large farms in plain regions (33.98%), respectively. The 305 days standard lactation length (LL) was chosen because it roughly corresponds to the period of lactation for cows that calve at intervals of 12 months.

From this survey, the average lactation length was 272.89 days, the longest lactation length on large farms in the plain region was 321.3 days and the shortest lactation length on small farms in the coastal region was 215.9 days, which was similar to the study of Miazi *et al.*[9], where the average lactation length of crossbred cows was found 246.05±6.67 days. Dairy herd production is characterized by calving periods, lactation, including pregnancy and a dry period followed by the next calving. The calving interval refers to the time interval from one calving to the next calving of the same cow. From the present results, the average calving interval was found 452.84 days, with the medium farm in the coastal area having the longest calving interval of 514.14 days and the medium farm in the flood-prone zone having the shortest of 374.41 days. These results corresponded with the findings of Famous *et al.*[10], who observed that the average calving interval of crossbred dairy cattle was 426±10 days.

Table 2: Productive and reproductive performance of dairy cattle in different climatic regions

Factors		Mean				
Location	Farm size	Lactating cattle (%)	Lactation length (days)	Calving interval (days)	Post-partum heat (says)	Average milk yield (L/day)
Hilly	Large	39.12^{b}	315.71^{a}	441.12^{b}	103.15^{a}	9.17^{a}
	Medium	33.88^{c}	262.22^{b}	476.89^{c}	147.75^{c}	7.63^{b}
	Small	40.70^{b}	235.54^{c}	451.12^{c}	128.26^{c}	6.64^{c}
Plain	Large	33.98^{c}	321.32^{a}	479.67^{c}	112.51^{b}	10.34^{a}
	Medium	35.19^{c}	273.43^{b}	479.05^{c}	103.10^{a}	8.61^{a}
	Small	37.82^{c}	236.13^{c}	479.86^{c}	114.91^{b}	9.73^{a}
Coastal	Large	41.02^{b}	292.51^{a}	508.97^{c}	95.74^{a}	8.49^{a}
	Medium	50.82^{a}	282.91^{b}	514.14^{c}	90.81^{a}	8.57^{a}
	Small	43.33^{a}	215.99^{c}	444.48^{b}	93.83^{a}	6.84^{c}
Floodprone	Large	43.68^{a}	320.73^{a}	409.57^{b}	108.82^{b}	7.08^{b}
	Medium	37.23^{c}	320.54^{a}	374.45^{a}	102.42^{a}	6.74^{b}
	Small	35.48^{c}	291.14^{a}	383.29^{a}	121.93^{c}	4.36^{c}
Milk pocket	Large	43.68^{a}	252.26^{b}	435.83^{b}	129.71^{c}	10.36^{a}
	Medium	40.44^{b}	241.47^{c}	444.16^{b}	106.60^{a}	10.54^{a}
	Small	37.60^{c}	231.92^{c}	470.13^{c}	92.85^{a}	10.23^{a}
Overall mean		39.60	272.89	452.84	110.16	8.36
SEM	Location×Farm size	0.526	0.043	3.526	0.848	0.045
Significance	Location	***	***	***	***	***
	Farm size	**	***	***	NS	***
	Location×Farm size	***	***	***	***	***

Data with different superscripts are significantly different, **Significant different ($p<0.01$), ***Significant different ($p<0.001$) and NS: Non-significant

Table 3: Major semen-producing companies in Bangladesh

Organization/Company	Genotype
Department of Livestock Services	50%HF, 62.5%HF, 68.75%HF, 75%HF, 87.5%HF, 100%HF, SL50%×F50%, SL100%, NBG Local, RCC, Local100%
Milk Vita	HF cross and Jersey 100%
ACI Limited	75%HF, 87.5%HF, 93.75%HF, 100% HF, 87.5%SL, 100%SL, RCC
SOJAG Dairy farm	75%HF, 62.5%SL, 87.5%HF
EJAB Alliance Ltd., Thakurgaon	50%HF, 75%HF, 100%HF, 75%SL, 87.5%SL, 100%SL
BRAC Bull and Buck Station	50%HF, 75%HF, 87.5%HF, 100%HF, 50%SL, 75% SL, 87.5% SL, 81.25%SL, RCC
LalTeer Livestock Department	75%HF, 87.5%SL, 93.75%HF, 75%SL, 96.88%SL, RCC100%, Local 100%, MED50%
American Dairy Ltd.	50%HF, 75%HF, 100%HF, SL100%, Munshigonj, RCC, Local, Local NBG, Pabna, Murrah

Source: Personal communication

The term "post-partum heat period" describes a situation in which cows have not been seen or reported to be in estrus for several weeks following calving, frequently until the conclusion of the voluntary (elective) waiting period in dairy cattle, which is the period between calving and the next estrus and conception[11]. Cows must conceive on average 83 days (60-90 days) after calving, with a gestation duration of 282 days, to maintain a 365 days calving interval. During this time, the uterus goes through involution and prepares for the subsequent pregnancy. From this study, it is found that the average post-partum heat period was 110.16 days, with the highest being 147.75 days in the medium farm of the Hilly region and the lowest being 90.81 days in the medium farm of the Coastal region. It was found that the average postpartum periods of the HF×J and HF×L crosses were 66.6 and 60.8 days[12], respectively. These results did not agree with their findings. Another report found that the Frisian cow had the shortest post-partum heat phase at 86.52 days[5].

From the survey, the highest daily milk yield of 10.51 L/day was found in medium farms in the milk pocket region and the lowest of 4.36 L/day was found in medium farms in the milk pocket region. The average daily milk yield was 8.36 L/day. In another study, it was found that the average daily milk yield of the high-yielding crossbred cow was 7.68 L/day[13].

Majorsemen-producing companies in Bangladesh: Artificial insemination services were thought to be a key way to undertake cross-breeding to improve the current reproductive performance of cow breeds[14]. Artificial insemination (AI) research dates back more than 200 years. Major semen-producing companies in Bangladesh with different genotypes are shown in Table 3.

Both public and private organizations in Bangladesh have been operating artificial insemination (AI) services on a commercial basis, while the autonomous organization offers AI services as part of their research and extension plan. The Department of Livestock Services (DLS), a basic agency functioning under the Ministry of Fisheries and Livestock, conducts all government cattle breeding efforts. In this survey, it is found that, along with DLS, Milk Vita, ACI Animal Genetics, BRAC Bull and Buck Station, SOJAG, Dhamrai, Dhaka, EJAB Alliance Ltd., Thakurgaon, LalTeer Livestock Department, American Dairy Ltd., etc., were the leading semen producing companies (Table 3) approved by the government that was operating in remote areas to improve livestock productivity.

Frequency percentage of the most popular breed for AI in Bangladesh: Through the utilization of superior genetic bulls, AI promotes genetic and financial gains. The frequency percentage of the most popular breed for AI in the different climatic regions of Bangladesh was found that 34% of farmers prefer the semen of a 75% Holstein Friesian (HF) bull to inseminate their dairy cattle, 20% prefer 100% HF, 16% prefer 50% HF, 5% prefer 62.5% HF and only 3% prefer 87.5% HF to inseminate their dairy cattle. Other preferable breeds were 100 % Sahiwal (SL) (14%), 50% SL (4%) and Jersey (4%). The study found that most farmers prefer the semen of HF, in particular 75% HF, to inseminate their dairy cattle. Their preference for HF crossbred might be due to the comparatively high milk production compared to other genotypes.

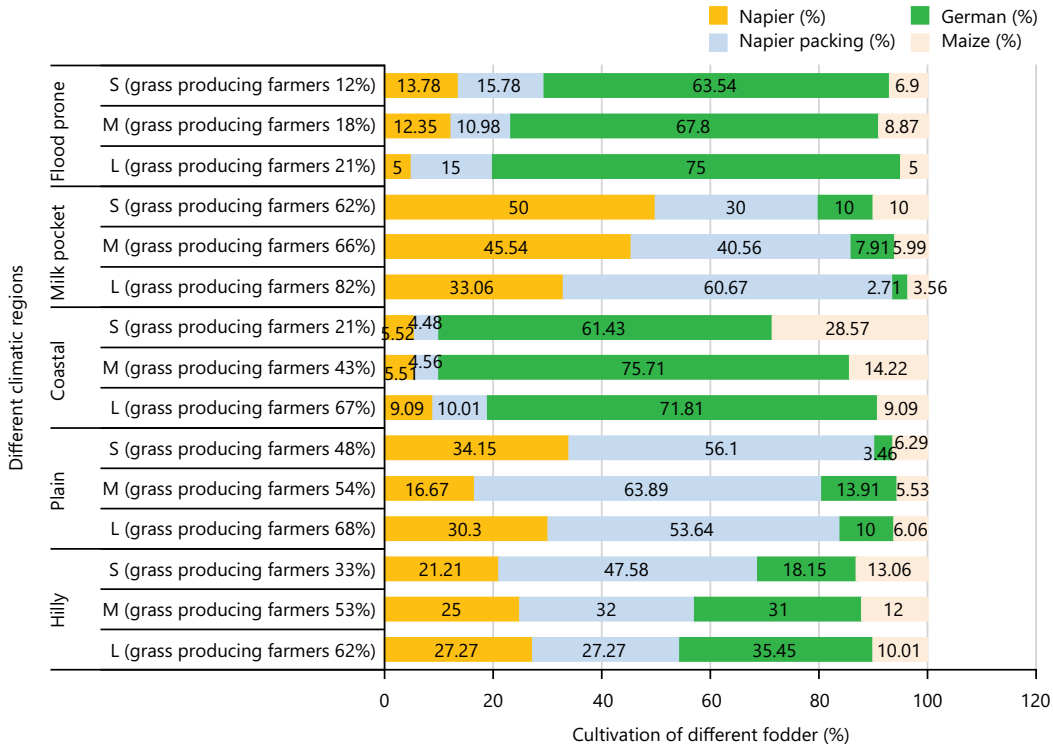

Fig. 1: Frequency of high-yielding fodder cultivated in different regions

It was reported that the HF cross cows had the highest milk yield (7.4 L/day) in comparison to other crossbreds under field conditions in Bangladesh[15]. Another study declared that HF crossbred breeding bulls have a significantly higher libido and better sperm quality than Brahman and RCC[16]. It was stated that compared to other genotypes of breeding bulls, the HF×L crossbred produced better quality semen based on semen volume, sperm motility, sperm concentration and percentage of dead sperm[17]. It was recommended that 100% Friesian, 50% SL and 50% HF crossbreds had better performance in the dimensional characteristics of spermatozoa[18].

Frequency of high-yielding fodder cultivation: Crops that are grown primarily for animal feed are referred to as fodder crops. Bangladesh suffers from a severe dearth of green fodder and grazing areas for large ruminants. In the present study, the frequency of the cultivation of high-yielding fodders is shown in Fig. 1. The highest percent of fodder producing farmers (82%) were found in the large farms of milk pocket areas and the lowest in the small farms of flood-prone regions (12%). A suitable species of fodder crop that could be grown in abundance and kept as hay and silage to feed the animals during times of scarcity has recently piqued the interest of livestock producers. In addition to the many types of fodder that are being experimentally grown in Bangladesh, hydroponic fodder has also been tested. There are currently many different kinds of fodder available in Bangladesh. The most common of them are Napier, Napier pack Chong, German, maize, etc., because of their greater productivity and simple cultivation methods.

A study found that, the majority of fodder producers (72.72%) relied on Napier production for their livelihood, while 83.33% of intermediaries depend on the selling of fodder[19]. In Bangladesh, winter is thought to be a lean time for the development of popular fodder such as Napier and Para. German grass, however, thrives in lowland environments. In the research area, it was discovered that milk pocket locations are where Napier and Napier pack Chong cultivation is most prevalent, whereas flood-prone and coastal regions are where German grass is most prevalent. A small amount of maize is cultivated more or less everywhere.

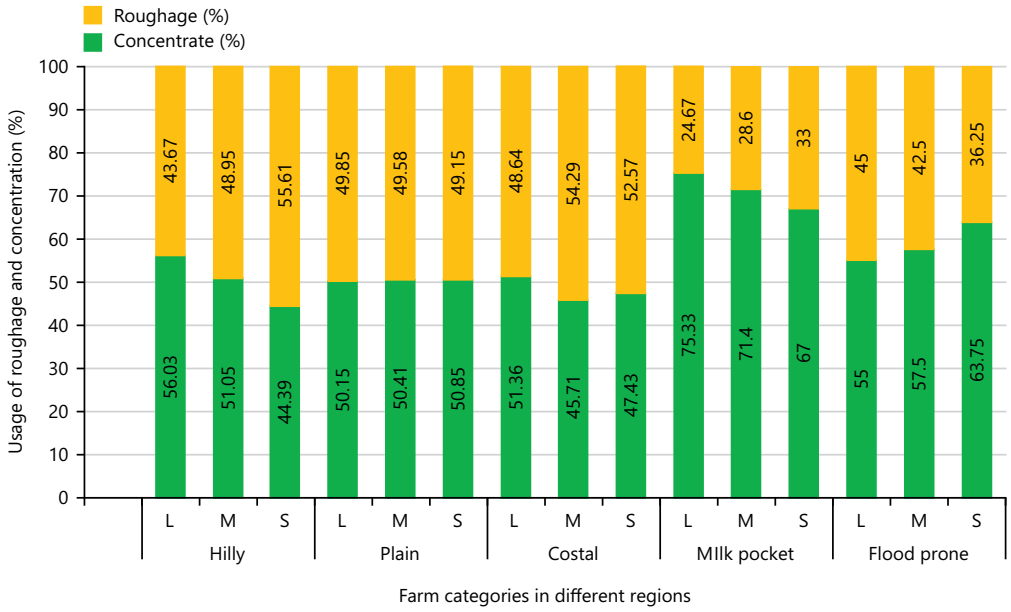

Fig. 2: Roughage to concentrate ratio in the feeding practices of dairy cattle in different climatic regions
S: Small, M: Medium and L: Large

Roughage to concentrate ratio in the feeding practices of dairy cattle: The ratio of roughage and concentrate feeds in dairy cattle feeding in the different climatic regions of Bangladesh is shown in Fig. 2. The study found that the roughage and concentrate ratios in the large, medium and small category dairy farms of the hilly, plain, coastal, milk pocket and flood-prone regions were as follows: 56.03:43.67, 51.05:48.95 and 44.39:55.61, 50.15:49.85, 50.41:49.58 and 50.85:49.15, 51.36:48.64, 45.71:54.29 and 47.4352.57, 75.33:24.67, 71.4:28.6 and 67.33, 55:45, 57.5:42.5 and 63.75:36.25, respectively. On a dry matter basis, the appropriate roughage concentrate ratio for high-yielding dairy cattle should be 60:40. From this study, it was revealed that in the milk pocket and flood-prone regions, farmers used a low percentage (25-45%) of concentrate feed to feed their dairy cattle, but in the hilly, plain and coastal regions, farmers used almost 50% concentrate feed, which may have increased their feed cost. A study found that the cost of feeding increased when the roughage concentrate ratio was reduced from 60:40 to 50:50[20]. An experiment suggested that cows producing 12-14 kg of milk per day could be best maintained on a diet consisting of 70% high-quality roughage and 30% concentrate, which differed from the present findings[21].

Technology practices: Farmers in Bangladesh typically aren't encouraged to employ all of the latest technologies for dairy production. However, high levels of technological adoption have a direct influence on milk production, household income, revenue creation, poverty reduction, the supply of animal protein and the development of the dairy industry. The technologies adopted by the farmers in different regions are shown in Fig. 3. It was observed that relatively few dairy farmers have adopted new technology and a significant portion of them are practically uninformed of better management techniques. Other than grazing, those whose superior technology, management strategies and production techniques produce more milk than those who don't[22]. Though the percentage was very high in the case of artificial insemination, the picture was completely different in the case of other technologies. In the study area, it was found that on average, 88.87% of the farmers practice artificial insemination for breeding their cattle. This rate was highest in large farms in the coastal region (94.45%) and lowest in small farms in the milk pocket region (78.11%), which was similar to the study of Quddus[23], stated that farmers employed AI, quality feeds, veterinary care and routine vaccination, while these percentages were 70, 50, 71.6 and 56.7% in semi-urban dairy farming, respectively. From the study, it was revealed that the highest percentage of farmers (78.18%) practiced ration balancing and high-yielding fodder production on large farms in the milk pocket region. The rate of silage-making was very low, averaging 17.26% in all regions. Manure

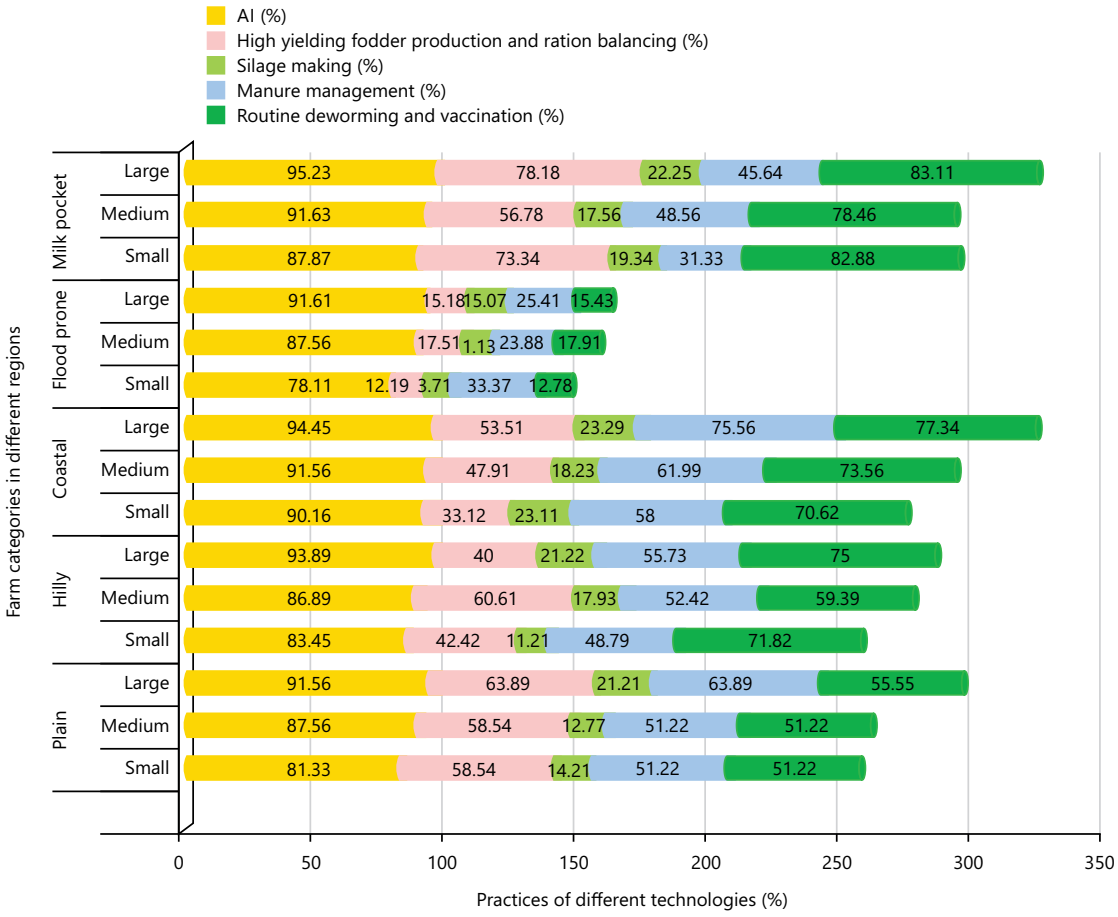

Fig. 3: Technology practices in different regions

management and routine vaccination were also gaining popularity day by day and the average rates were 46.47 and 58.41%, respectively. Data from different regions revealed that farmers in the milk pocket region were the most technology-practicing and the least in the Flood Prone Region. A study observed that the degree of technological adoption by smallholder dairy farmers is suboptimal and heavily influenced by their education, agricultural background, financial situation and extension support of the farmer[23]. The socioeconomic environment greatly affects how technologies are adopted and every adoption study's particular adoption process is determined by these elements.

Utilization of manure: The findings indicated that the majority of farmers who raise cattle and buffalo chose solid storage systems for managing their waste. About 35% of the stored manure was utilized for fertilizing land, 47% was used to prepare fuel for burning, 8% was composted and the other 10% was entirely squandered[24]. In the targeted area, about 34.15% of the farmers used their animal manure to prepare burned fuel using dung cakes and dung sticks and 31.78% stored it in solid form to use as needed. About 12% of farmers used management strategies for anaerobic digestion, 9% utilized their liquid slurry; and only 3.5% used manure for direct sale. Others, 9.57% of farmers, left their manure in unused condition. Collecting livestock manure for open stacking storage and drying for culinary materials by the farmer is a common practice at small holding farms in Bangladesh.

Therefore, it is reasonable to assume that Bangladesh would benefit greatly if the whole volume of livestock dung produced could be handled through an anaerobic digestion system. Manure is a rich resource, but due to its traditional management methods, it poses a hazard to the environment and public health[25]. Bangladeshi farmers commonly practice; solid dung storage, fuel burning and open removal of liquid slurry which is responsible for environmental pollution. Therefore, strategic initiatives should be taken for the proper management and utilization of livestock manure.

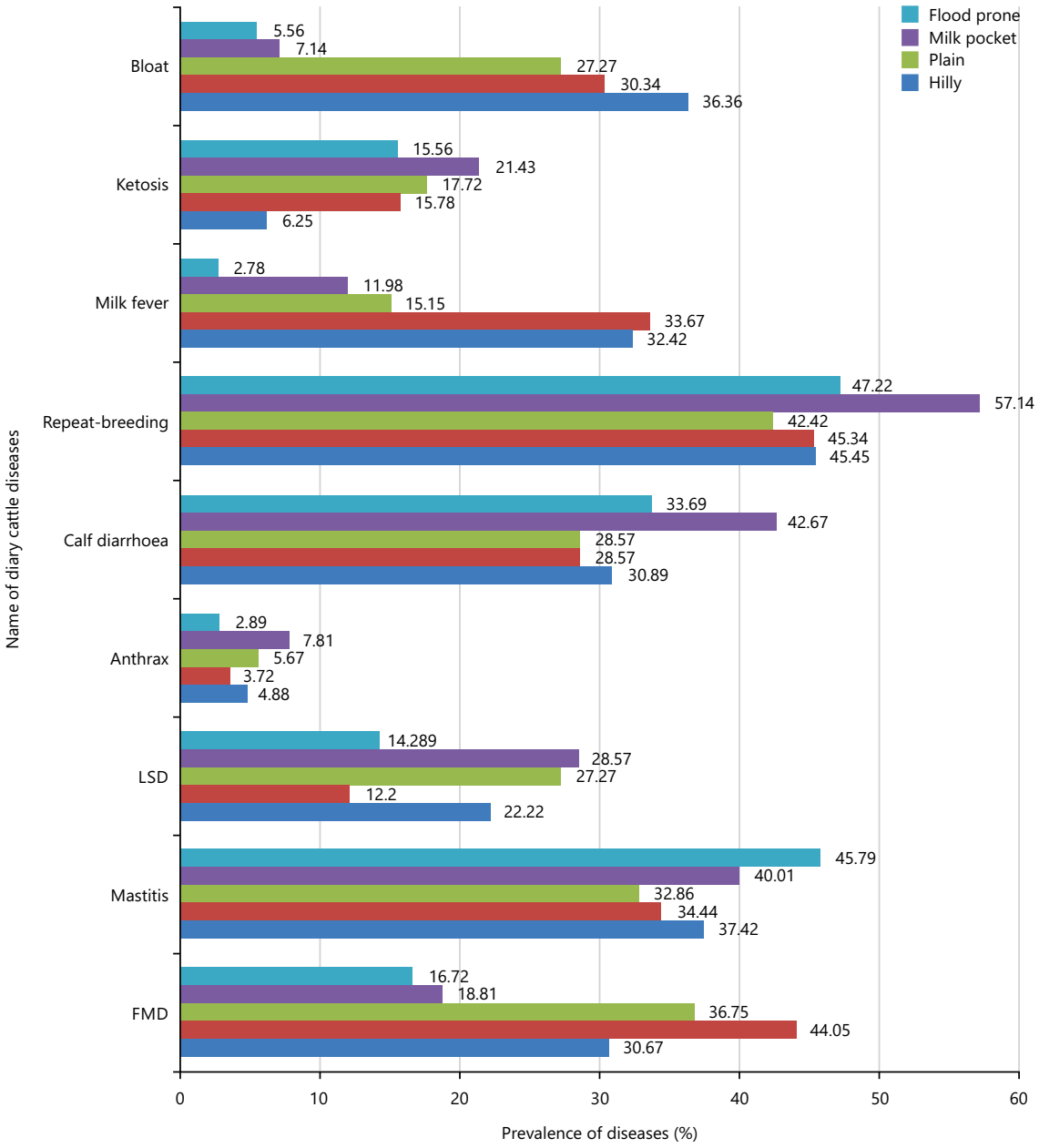

Fig. 4: Prevalence of common dairy cattle diseases in the last year in different climatic regions

Disease prevalence in dairy cattle: The frequency percentage of the prevalence of common dairy cattle diseases in different climatic regions of Bangladesh is shown in Fig. 4. The selected farmers in each region were asked about the prevalence of diseases in their dairy cattle in the last year. Based on their answers, the result revealed that in the entire five regions, repeat breeding and mastitis were the two most frequently occurring diseases, which were in agreement with the findings[26]. However, another study observed the occurrence of repeat breeding at only 5.7% in the Sirajganj district of Bangladesh, which was much lower than the present study[27]. In another experiment conducted in the Sirajganj district of Bangladesh, the incidence of mastitis was found to be 78.2% and repeat breeders were 17.10%, which differs from the present study[28]. Another result in the Chittagong Region revealed that among the tested cow's overall prevalence of mastitis was 34.2%, which was similar to the current study findings[29]. In an experiment conducted in Rajshahi, the overall prevalence of FMD was found to be 25.07%, which is almost similar to the present finding[30]. The differences among the findings of different authors may be due to the variations in the locations and management practices followed by the farmers.

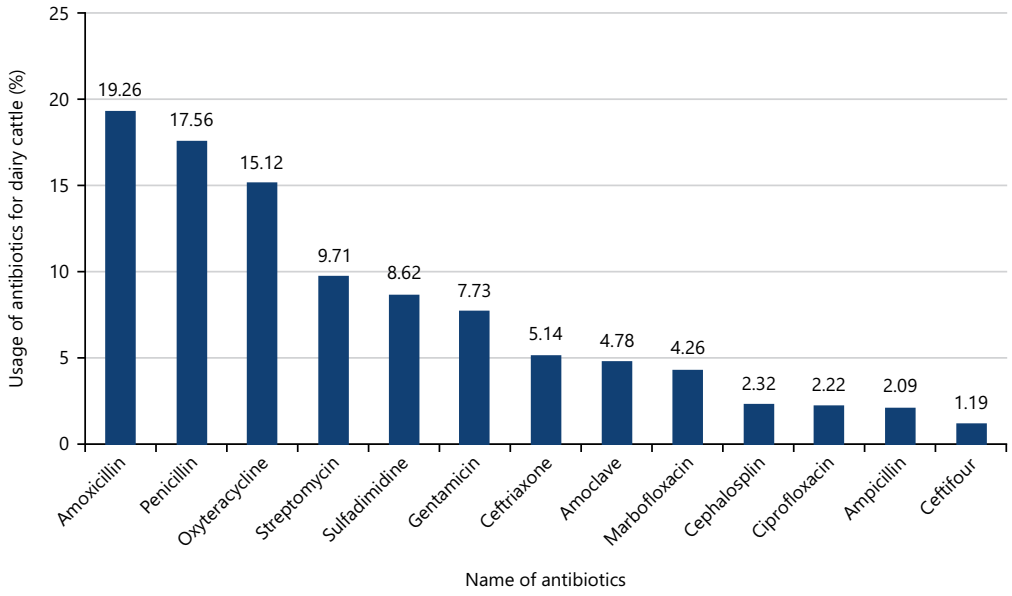

Fig. 5: Percentage of different antibiotics used for dairy cattle in Bangladesh

Usage of antibiotics for dairy cattle in Bangladesh: The percentage of antibiotic usage for cattle prescribed by registered doctors in Bangladesh. Dairy practitioners and experts from different regions of the country were asked for data on the usage of antibiotics as shown in Fig. 5.

The percentages of the most frequently used antibiotics were as follows: Amoxicillin (19.26%), penicillin (17.56%), oxytetracycline (15.12%), streptomycin (9.71%), sulfadimidine (8.62%), gentamicin (7.73%), ceftriaxone (5.14%), amoclave (4.78%), marbofloxacin (4.26%), cephalosplin (2.32%), ciprofloxacin (2.22%), ampicillin (2.09%) and ceftifour (1.19%). The study revealed that amoxicillin, penicillin and oxytetracycline are the most commonly used antibiotics for cattle in our country. Though there have been many studies regarding the usage of antibiotics, residue limits of antibiotics in milk and meat and health hazards related to antibiotics, as per my knowledge, there has not been any study regarding the percentage of the usage of antibiotics for cattle prescribed by registered doctors in Bangladesh to compare current study findings with.

Housing systems in different regions of Bangladesh: Good animal's housing can be made comfortable by the arrangement. It maintains the health of the animal, reduces medical costs and improves milk production. The housing systems for dairy cattle in different regions of Bangladesh are shown in Fig. 6. From the survey, it was found that single row, brick-floor, tin-roof housing was most commonly practisedin small farms in the coastal region (41.1%), double-row, brick-floor, tin-roof housing was mostly practised in large farms in the milk pocket region (57.78%) and conventional housing systems were most common in small farms in the prone region, (77.78%).

This was quite similar to the study of Hossain *et al.*[31], where he found that 10% of farmers furnish half of the buildings, while the remaining 90% keep their cattle in tin sheds and straw sheds. According to the kind of floor, 60% of the farmhouses had semi-paved (brick) floors, while the remaining 40% had unpaved floors (data not indicated). Farmers made the most open houses (77.5%), whereas just 22.5% made closed or semi-closed houses.

Climate-related risks for dairy cattle farming in Bangladesh: The global food chain depends heavily on livestock, but dangers associated with climate change might put both production and availability at risk. Increasing temperatures, changing precipitation patterns, droughts, floods, riverbank erosion, salinity

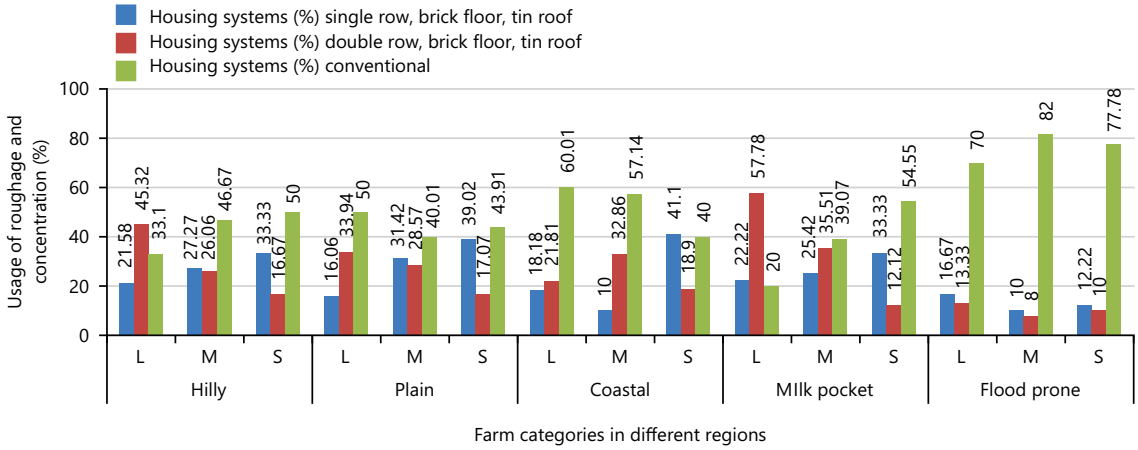

Fig. 6: Dairy cattle housing practisedin different climatic regions

and other natural disasters like cyclones are to blame for decreasing the quantity and quality of fodder and water, reducing livestock growth and reproduction, spreading diseases and endangering animal genetic resources. A saltwater intrusion into farmland and freshwater caused by sea level rise, on the other hand, is expected to cause Bangladesh to submerge, severely hurting agriculture and animal output, especially in coastal districts.

Over 200 rivers run through Bangladesh and experts predict that as a result of shifting climatic trends, floods will continue to exceed normal ranges[32]. The typical flood lasted one month. Amounting to 34.48% of Bangladesh's geographical area, flood hazards range from moderate to severe[33]. The likelihood of flooding was low or extremely low in 43.88% of sites and in 22.65% of locations, respectively[34]. In the present study, the farmers of the coastal, milk pocket and flood-prone regions suffered the most from water logging, which was also responsible for spreading contagious diseases.

Climate-related risks for dairy cattle farming in Bangladesh are shown in Fig. 7. The majority of Bangladesh's northwestern area is still experiencing severe drought. Approximately 5.8, 8.4 and 38% of sites in Bangladesh were classified as fairly sensitive to drought for animal production, very sensitive to drought for animal production and extremely susceptible to drought for animal production, respectively[34]. From the survey, it was found that found that large farms in the coastal (41.67%) and milk pocket regions (38.7%) are more affected by drought than the other regions.

The amount and frequency of rainfall have a significant impact on the pasture and water supplies. According to research, temperature and precipitation variations in Bangladesh over the past year have been more pronounced than they were 30 years ago[16]. In the Haor area of Bangladesh, 95.63 percent of residents, according to a survey[35] showed a rising trend in temperature during the previous 10 years. On the other hand, 56.25 and 29.38% of respondents, respectively, said that the area's rainfall had decreased and risen. From our study, we found that hilly and plain regions suffer most from high ambient temperatures, while flood-prone and coastal regions are mostly affected by excessive rainfall, which is also responsible for flooding. In the study it was found that, tornadoes and salinity were most common in the coastal region.

According to this study, our country's temperature is rising and rainfall patterns are changing. As a result, salinity, drought and flood severity are all increasing. Additionally, the greatest detrimental effect of global warming on cattle is seen to be heat stress. It inhibits the animals' ability to develop, produce milk and meat and reproduce. It has been discovered that the best methods for adapting and mitigating the effects

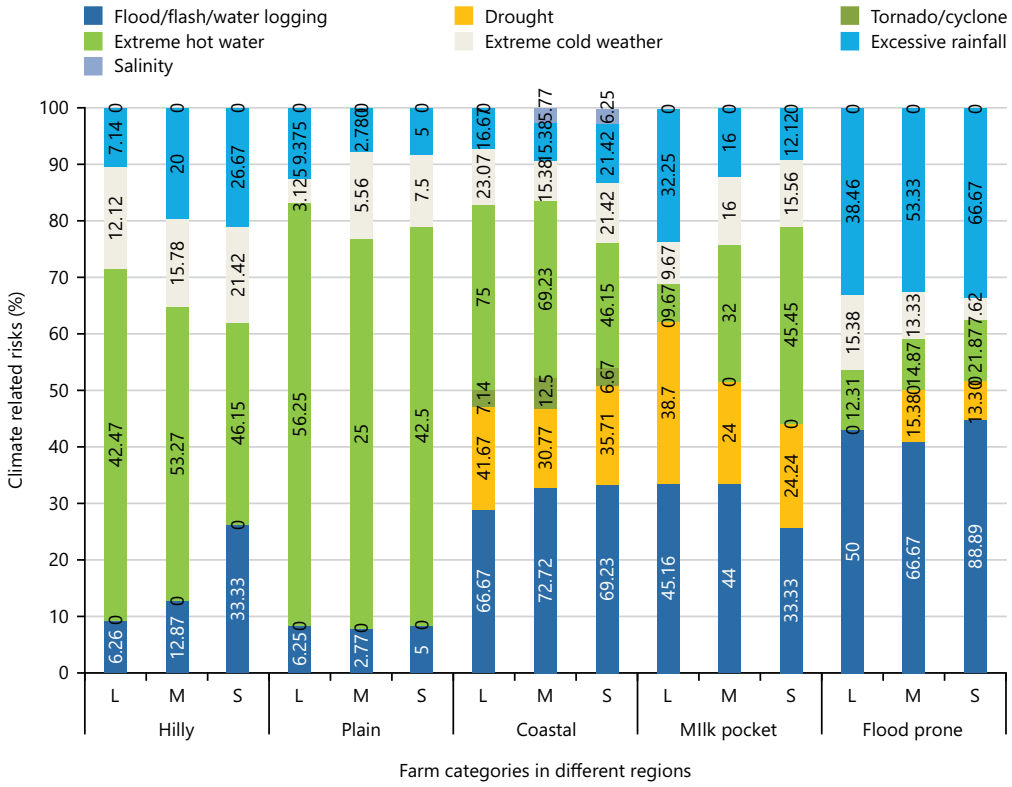

Fig. 7: Climate-related risks for dairy cattle farming in Bangladesh

of climate change on livestock include the adoption of local breeds and integrated agricultural systems, the construction of hazard-proof housing and the modification of feeding techniques. Policies on breed selection and livestock management should be put into place in accordance with the various climatic areas.

Major challenges for dairy farming: This study revealed that high prices of concentrate feed, low milk prices, lack of pure water and repeat breeding were the major challenges in every region. Mastitis, lack of high-yielding breeds, technological knowledge, product diversification etc. were also common challenges that are shown in Fig. 8. A study found that if everything else is equal, dairy producers make less money when feed prices are higher than the price they get for their milk[36]. Farmers mostly rely on concentrate feed items, which are more expensive, because roughage is scarce in the area.

In terms of modern farm management, 80% of farmers lack adequate training, while just 20% are skilled in the dairy industry. Other factors include the adoption of current technology (80%), high feed prices and a shortage of high-producing fodder (70%), illnesses including infertility (40%), mastitis (30%) and a lack of high-yielding breeds (30%).

This study analyzed the implications of existing climatic conditions of different regions in Bangladesh on dairy farming and identified the variations in productive and reproductive performances, feeding practices, disease prevalence, breeding, management and technology practices in different climatic regions. This study also revealed the major challenges and climate-related risks faced by dairy farmers and serves as a foundation for further research and development activities focused on climate change and dairy production. The study recommends future research on breeding and management practices suitable for different climatic conditions, development of climate-resilient feeding systems and exploring suitable innovative technologies for enhancing milk production and quality. Region-specific dairy cattle breeds,

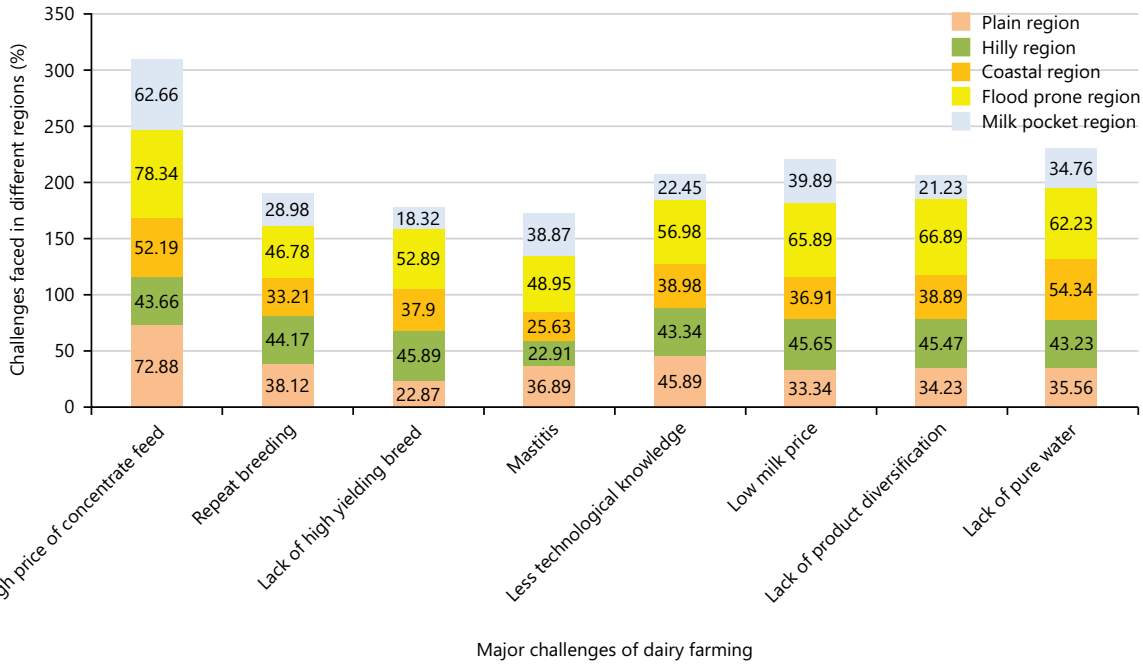

Fig. 8: Major challenges of dairy farming in different regions

fodder varieties, cultivation patterns, disease management and rearing practices need to be taken into consideration for successful dairy farming in Bangladesh. The findings of this study will have significant implications for policymakers and researchers working in the fields of agriculture, climate change and rural livelihoods in Bangladesh and other similar contexts. The study will also contribute to the ongoing debate on climate change adaptation and food security in Bangladesh and help to identify strategies to promote climate-resilient dairy production and livelihoods.

CONCLUSION

This research has identified the area-based scenario for dairy cattle breeding, farm management, feeding and technology practices, disease prevalence and climate-related risks for small, medium and large-scale dairy farming in Bangladesh. The study also revealed the productive and reproductive performances of dairy cattle, a popular breed for artificial insemination, in different climatic regions and found that dairy cattle from milk pocket regions produced the highest milk and farmers preferred 75% Holstein Friesian for artificial insemination. The usage and knowledge of technologies like artificial insemination, ration balancing, fodder production, manure management, routine deworming and vaccination, etc. are increasing over time in all regions. Lack of high-yielding breeds, high feed costs, low milk prices and less farming and technological knowledge are the major challenges for dairy farmers. The study focused on the dairy production and livelihood scenarios in different climatic regions of Bangladesh, which would be an asset for further research and policymaking.

SIGNIFICANCE STATEMENT

Although there had been much research conducted on dairy farming in Bangladesh, there was no climate-specific research. The study has identified the major differences and scopes for an area-based dairy farming system in the case of small, medium and large-scale dairy farming in Bangladesh, which would be an asset for further research work and policy making. The study found that dairy farming practices were region-specific and the overall management, challenges and production systems were different based on region. So, further research specific to different climatic regions is needed to enhance the dairy production system in Bangladesh.

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