

Prediction of Animal Feeds and Fodder Availability in Bangladesh: Present Status, Challenges and Way Forward

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Abstract

This paper analyses the present status of livestock feeds and fodder in Bangladesh, maps their availability and seasonal variability, and identifies the main technical, institutional, and market challenges that constrain feed security and livestock productivity. It also outlines a practical way forward and policy directions that can strengthen feed supply chains, improve nutritional quality, and make feeding systems more climate-resilient and economically viable for farmers. Primary data were collected through a prescribed questionnaire, Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), and consultations with relevant stakeholders, government departments, research institutes, and universities. Secondary data were collected from published reports, policy documents, and research reports. The analysis showed that the availability of feeds and fodder in terms of dry matter (DM), crude protein (CP), and metabolizable energy (ME) was 49.51 million metric tons, 4.26 million metric tons, and 364.47 million megajoules (MMJ), respectively, against requirements of 89.21 million metric tons of DM, 11.34 million metric tons of CP, and 972.55 MMJ of ME. The study revealed negative balances of DM, CP, and ME for livestock. The current production capacity of the commercial feed industry, estimated at 6.55 million metric tons, can meet 84.33% of the present total requirement. Considering the existing growth of the poultry, cattle, and aquaculture industries, the projected annual compound feed requirement in 2030-31 will be 11.19 million metric tons, which could be met by only 58.49% of the present production capacity, indicating substantial future potential for the commercial feed industry. The major reason for the shortage of fodder production is the limited availability of land and seasonal fluctuations. Although farmers grow fodder and sell it in the market, they are usually reluctant to preserve it as either silage or hay. Therefore, the way forward should include promoting fodder cultivation alongside food crops to minimize land use; improving farmers' access to quality fodder seeds; providing training on fodder cultivation and feeding techniques; formulating policies to facilitate the use of *khas* land and river basins for fodder production; encouraging entrepreneurship in fodder processing, preservation, and marketing; and improving technology dissemination systems for livestock development. In addition, a strategic framework is needed to address the challenges and ensure optimum livestock productivity in Bangladesh.

Keywords: Livestock Feeds; Fodder; Feeding System; Availability; Challenges; Way Forward

Introduction

The livestock sector plays a very significant role in the national economy of Bangladesh, contributing to food and nutritional security, livelihood development, employment generation, and income augmentation. The contribution of the livestock sector to national GDP is 1.81%, with a growth rate of 3.30% in 2025-26. The GDP volume of the livestock sector is about BDT 980.09 billion at current prices, and the sector's share of agricultural GDP is 16.56% [1]. Bangladesh ranks 84th among 121 countries in the 2022 Global Hunger Index, with a score of 19.6, indicating a moderate level of hunger. According to the Bangladesh Demographic and Health Survey 2022, among children under five years of age, 24% are stunted, 22% are underweight, and 11% are wasted [2]. With a population growth rate of 1.08%, a rapidly growing population, rising food prices, and increasing awareness of nutrition, the Government of Bangladesh recognizes the importance of strengthening livestock development to meet the country's requirements for animal protein. The food revolution taking place around the world is reflected in the increasing demand for livestock products, particularly in developing countries, where livestock farming is closely linked to the advancement of the rural economy and poverty alleviation [3].

Milk, meat, and eggs are important sources of nutrition for people around the globe. The livestock industry is growing rapidly as a result of increasing investment, improved veterinary and husbandry practices, artificial insemination to enhance productivity, improved technologies and farm automation, and government financial support. Numerous new processing industries have also increased their investment in this sector. A large number of small- and medium-sized farms have become involved in the livestock industry with direct government assistance across the country. About 15.75 million metric tons of milk, 9.07 million metric tons of meat, and 250.94 million eggs were produced in Bangladesh [4]. According to the Bangladesh Household Income and Expenditure Survey (HIES) conducted by the Bangladesh Bureau of Statistics (BBS) in 2016 and 2022, daily per capita consumption of milk and meat increased from 27.3g to 34.1g and from 25.4g to 40.0g, respectively, whereas daily per capita egg consumption slightly decreased from 13.6g to 12.7g [5]. However, these consumption levels remain far below the recommended levels of milk (200 g/person/day), meat (120 g/person/day), and eggs (17 g/person/day) prescribed by ICMR and WHO [6,7].

Therefore, the Government of Bangladesh has made a clear commitment to overcoming these challenges through the National Livestock Development Policy (2007), the Five-Year Strategic Framework, the Sustainable Development Goals (SDGs) 2030, and the Bangladesh Perspective Plan 2021-2041. Meanwhile, consumption of diversified food products has increased, accompanied by lower per capita consumption of rice and increased consumption of nutritious foods such as milk, meat, eggs, and their diversified value-added products. Consequently, demand for these highly nutritious animal-source foods is expected to increase steadily, and production targets for these products have also been increased for 2041. The Bangladesh Perspective Plan 2021-2041 has set production targets of 30.0 million metric tons of milk, 12.0 million metric tons of meat, and 45,500 million eggs by 2041, against projected demand of 24.47 million metric tons of milk, 11.63 million metric tons of meat, and 45,488 million eggs [8].

Feed is one of the most important components of livestock production and productivity. Feeding is the foundation of livestock farming, and feed costs account for approximately 65 - 70% of the total cost of production. In Bangladesh, livestock feeds and fodder consist mainly of locally available feedstuffs and some imported feed ingredients [9]. Roughage feeds are mostly of local origin, including rice straw, maize stover, tree leaves, and green grasses, most of which are naturally grown on fallow land or along roadsides. In addition, some high-yielding fodder varieties, such as Napier, para, German grass, and sorghum, are cultivated on medium- and large-scale farms in urban, peri-urban, and rural areas [10].

Most rural farmers feed their ruminant livestock with naturally grown grasses that have relatively low nutritive value. A key challenge in feed supply is the high price of concentrate feeds, particularly soybean meal, as well as micronutrients, most of which are imported annually. There are several reasonably large feed industries operating in the private sector; however, the quantity of feed produced is insufficient to meet growing demand. Consequently, smallholder farmers in rural areas are often forced to operate their farms with inadequate supplies of good-quality prepared or commercial feeds.

In the case of fodder production, Bangladesh faces several challenges, including limited availability of land due to the intensity of food-crop production, poor production and management practices, and limited access to high-yielding-variety (HYV) fodder seeds. Land allocated to fodder cultivation is decreasing day by day because of rapid urbanization and industrialization. It is well established that good-quality fodder in adequate quantities is essential for dairy and other ruminant production and can also reduce feed costs for

rearing ruminant livestock. Currently, the prices of animal-source foods are increasing, partly because of the COVID-19 pandemic and the Russia-Ukraine war, as well as the associated increase in livestock feed prices. Therefore, several challenges need to be addressed to ensure sustainable animal farming and the provision of affordable animal-source foods to consumers. In light of the foregoing, a strategic framework is needed to address the challenges arising from inadequate feed and fodder resources for livestock. Such measures can increase production, reduce production costs, improve farmer profitability, and help keep animal-source foods affordable for consumers.

Objective of this Study

The objective of this study is to analyze the fodder production and demand-supply situation in the country, identify the major challenges hampering the feed and fodder supply chain, and provide recommendations to overcome these challenges.

Methodology

The present study was conducted using primary data collected through a prescribed questionnaire, Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), and consultations with relevant stakeholders, government departments, research institutes, and universities. Different categories of stakeholders participated in the study. The study team collected their opinions using a pre-designed, structured questionnaire at the beginning of the consultations, followed by open discussions on the relevant subjects. Secondary data were collected from published reports, policy documents, and research reports.

The study also analyzed the existing situation regarding feed and fodder demand, availability, and requirements using an Excel spreadsheet according to the procedure described by FAO [11]. Nutrient requirements were projected using the method described by Rothman-Ostrow, *et al.* [12]. The study summarized information on needs and aspirations, policy support, gaps and challenges, and possible ways forward to meet the future demand for livestock feeds and fodder and to support sustainable livestock production.

Results

Traditional fodder production and utilization of crop residues

Ruminant farmers are aware of the benefits of producing and feeding good-quality fodder to animals to increase production and reduce feed costs. However, they face many challenges in growing fodder and maintaining a continuous supply throughout the year. Commercial, medium-, and large-scale farmers grow high-yielding fodder on their own land to feed their livestock. Some of them also preserve fodder as silage for use during lean periods. Consequently, the major sources of green grass for livestock are grazing on fallow land and the cut-and-carry system, using naturally grown grasses from roadsides, crop-field boundaries, and fallow land.

These naturally grown grasses generally have low nutritional value and low biomass yields. Because of the severe shortage of green grass, rural livestock farmers primarily supply rice straw as the major roughage source for their ruminant livestock. Uddin, *et al.* [13] reported that the proportion of rice straw in animal rations was substantially higher (46 - 67%) than that of green grass (23 - 33%) and concentrates (8 - 17%). Except under intensive production systems, dairy cattle are generally underfed in terms of total daily dry matter (DM) intake compared with the recommended amount of 10 kg DM/day, based on 3.5% of their live weight [14]. This is mainly due to the high price of concentrates, inadequate availability of green fodder, and, above all, the strong influence of seasonal variation on fodder availability.

The influence of seasonal variation on green grass availability and milk production has also been observed in Bangladesh. The highest fodder availability and milk production occur during winter and spring because, immediately after the monsoon, farmers cultivate fodder on their own fallow land as well as along riverbanks, resulting in abundant fodder availability during these periods. The lowest fodder availability and milk production are observed during the monsoon because much of the cultivable land becomes inundated.

In Bangladesh, integrated rice-forage production systems have been found in some areas. These systems can help prevent the loss of soil nutrients and increase rice production. One method involves cultivating fodder during the Rabi season on land that remains fallow for two months between two crops in areas where two crops are cultivated annually. Another option is to grow *Lathyrus sativus*, a legume fodder, as a relay crop alongside *Aman* rice. Both integrated rice-fodder production systems have been found to be promising because they do not compete with rice production and can improve soil fertility by up to 8% and rice production by up to 13%. Feeding the resulting fodder to dairy cows increased milk yield by 20 - 25% [15].

In South Asia, including Bangladesh, India, Nepal, and Pakistan, approximately 14.6 million hectares of ricefallow land could potentially be used for establishing leguminous forages without interfering with crop production. A typical fresh herbage yield from common grass weeds associated with lowland rice is 16 t/ha, of which approximately 63% is consumed by livestock, mainly *Echinochloa crus-galli*, *E. colona*, *E. crusgavonis*, and *Leptochloa chinensis* [16]. In rain-fed lowland rice systems, Medrano [17] reported dry matter yields from weeds of 2.03 t/ha, of which 60% were grasses. Rice bunds also contribute to feed availability and have the potential to produce forage-legume dry matter yields of 5 - 50 kg/100 m²/year [18] and grass dry matter yields of more than 10 t/ha/year [19].

Utilization of crop residues

The utilization of crop residues through chemical and biological treatments to improve the nutritional quality of cereal straw has been reviewed extensively by Devendra [20] and has also been practised in Bangladesh. Chemical treatment, particularly urea treatment, has been an effective method for improving the nutritive value of straw. A successful fattening ration for indigenous, old, and emaciated bullocks was developed using rice straw, roadside grass, and urea-molasses. Different methods of urea feeding were tested in growing and lactating animals and breeding bulls. Molasses was added to improve the palatability of crop residues and increase their energy content through the preparation of urea-treated rice straw or urea-molasses-treated straw [21].

Chemical treatment of straw with urea was found to be effective in increasing the nitrogen content and digestibility of straw, promoting better growth responses in calves, and increasing milk production in dairy cows. The author also observed that growing indigenous calves weighing 50 kg could gain 0.2 - 0.3 kg/day when fed urea-treated straw, compared with 0.2 kg/day when fed a protein meal or green fodder [21]. Milking cows could produce 5 litres of milk on a similar diet. Animals fed an ammoniated-straw-based diet showed a significant increase in live weight (33%) in growing animals and milk yield (14%) in indigenous cows.

Azolla was used as a supplement to urea-treated straw in the ration of growing cattle. Jackfruit leaves and mander leaves were also used as supplements to urea-treated straw, together with urea and poultry excreta, in ruminant rations. Feeding silage prepared from rice straw mixed with banana plants and leaves to growing bull calves helped maintain body weight. Supplementation of rice-straw-based rations with sweet potato leaves or arail grass was also suggested as a suitable ration for bull calves.

Present status of feed and fodder production and availability

Provision of adequate quantities of good-quality feed to livestock is a prerequisite for increasing livestock production [22]. Accurate assessment of total feed requirements, production, availability, and supply gaps for dry matter (DM), crude protein (CP), and metabolizable energy (ME) are important parameters for understanding a country's overall livestock feeding situation.

Estimation of the feed balance on a DM basis provides information on annual feed availability and demand. However, estimating the feed balance is challenging because it requires substantial data on the total livestock population, different age categories, the proportions of dairy and non-dairy cattle, specific nutrient requirements, feed production and availability, chemical composition, and the volume of feed ingredients imported and exported [23].

The total production and availability of feed resources are presented in table 1. Feed resources available in Bangladesh for livestock include dry roughages such as straw, stover, bagasse, and haulms from legume crops; green grass, including non-cultivated indigenous grasses, crop-field weeds, roadside and embankment grasses, cultivated fodder; legumes, non-leguminous and perennial grasses from fallow lands and forests; and vegetable and fruit by-products such as banana leaves and potato leaves. Among concentrate supplements, agro-industrial by-products such as rice bran, wheat bran, oil cakes, and molasses are commonly available feed ingredients. In practice, however, livestock feeding is mainly based on crop residues and by-products of cereals, oilseeds, and pulses [14]. Table 1 indicates that Bangladesh produces approximately 130 million tons of fresh matter, equivalent to approximately 103 million tons of dry matter. Of this amount, 49.51 million tons of DM, 4.26 million tons of CP, and 364.47 million MJ of ME are available for livestock. However, these amounts are lower than the total requirements of DM, CP, and ME, which are 89.21 million metric tons, 11.34 million metric tons, and 972.55 million MJ, respectively, as shown in table 3. Meanwhile, Uddin and Akter [23] reported that the availability of feed was 119 million tons of fresh matter, of which 109 million tons were available for livestock, feed use. A total of 44.08 million tons of DM, 3.32 million tons of CP, and 244 million MJ were produced.

The availability of DM and CP in the present study differs from the findings of Uddin and Akter [23], indicating that feed and fodder production has not increased sufficiently to meet the requirements of the growing livestock population. This may be partly due to the predominant use of land for crop production. The availability of DM, CP, and ME is also lower than the requirements reported by other researchers [14,24].

Feed resources	Production, fresh (‘1000’ M tons)	Production, DM (‘1000’ M tons)	DM availability to livestock (‘1000’ M tons)	CP availability to livestock (‘1000’ M tons)	ME availability to livestock (1000 MJ)
1. Crop residues					
Rice straw	48890.4	44490.26	26694.16	1121.15	154826.13
Wheat straw	1410.5	1283.56	641.78	20.54	4043.21
Maize straw	8232	7491.12	4494.67	166.3	34159.49
Potato leaves	16481.63	4120.41	3708.37	467.29	33748.9
2. Oil seed cakes/meals	996	906.36	815.72	295.29	9217.64
3. Pulses	425	382.5	344.25	32.36	2581.88
4. Grains					
Rice	37608	33471.12	669.42	55.56	11714.85
Wheat	1085	965.65	96.57	12.17	1689.98
Maize	4116	3663.24	366.32	34.43	5971.02
Other cereals	1.247	1.085	0.108	0.01	1.68
5. Grain by products					
Rice polish	2256.48	2030.83	203.08	38.99	4163.14
Rice bran	3760.8	2030.83	304.62	43.25	4812.99
Wheat bran	217	190.96	15.28	2.44	172.66
Broken rice	127.5	110.93	8.87	0.71	150.79
Pulses bran	531.25	478.13	26.3	5.05	284.04

Imported grains and feed additives	1928.63	1697.19	1697.19	339.44	18669.0
6. Other by products					
Sugarcane tops	833.25	416.63	312.47	15.31	2499.76
Sugarcane bagasse	933.24	466.62	349.97	6.3	2344.8
Molasses	166.65	128.39	102.71	2.05	1119.54
Banana leaves	1230.74	172.3	53.41	5.69	453.99
7. Grasses/others					
Green grass	34650	8316	8316	1580	68856.0
Sweet potatoes	280	196	78.4	3.14	713.44
Mango kernel	303.75	212.63	212.63	13.61	2275.14
Total	166465.07	113222.74	49512.70	4261.08	364470.07

Table 1: Total feed production and availability (DM, CP and ME) to livestock in Bangladesh.

Source: Annual Report of Department of Agriculture Extension, 2021-22 (with some modifications), By-products of all crop residues are determined based on extraction factors and harvesting loss.

Animal feed and nutrient requirements for livestock

The existing populations of different ruminant species, classified according to age and sex, were converted into livestock units based on a constant body weight. The requirements for DM, CP, and ME were then calculated according to the procedure described by Rothman-Ostrow, *et al.* [12]. Based on the current cattle and buffalo populations, nutrient requirements were estimated and are presented in table 2. The present total requirements for DM, CP, and ME were 89.21 million tons, 11.34 million tons, and 972.55 million MJ, respectively. In contrast, the availability of DM, CP, and ME was 49.51 million tons, 4.26 million tons, and 364.47 million MJ, respectively. These figures clearly indicate a negative feed balance for DM, CP, and ME (Table 3).

Huque and Sarker [25] reported that the availability of DM and ME was 32.34 million tons and 250.22 million MJ, respectively, which was considerably lower than the present estimates. The deficits in DM, CP, and ME were 44.51%, 62.44%, and 62.43%, respectively. Huque and Sarker [25] also reported DM and ME deficits of 56.20% and 54.70%, respectively. The increase in DM availability may be partly attributable to increased maize production in Bangladesh in recent years [14].

An important factor is the mismatch between biomass production and supply. Most fibrous crop residues are produced during the monsoon season, when sun-drying—the main method of preserving crop residues—is difficult. Consequently, farmers are unable to make sufficient quantities available for their animals during the dry season [25]. Collection, processing, preservation, and value addition of crop residues could increase their availability to livestock. Furthermore, as shown in table 2, the projected DM, CP, and ME requirements for cattle and buffalo in 2041 are 111.39 million tons, 15.27 million tons, and 1,266.66 million MJ, respectively. This situation clearly demonstrates the importance of increasing feed and fodder production and cultivation in Bangladesh.

Compound feed production: Demand, supply, and future projections

Commercial feed industries in Bangladesh play a significant role in producing quality feed for poultry, livestock, and fish. However, the volume of production is insufficient to meet current demand and, unless production increases, will not be sufficient to meet future

Species	Year	No of Animals (M)	No of Live-stock unit (M)	Ave. LW (kg)/h	DM (MMT) /Year	CP (MMT) /Year	ME (MMJ) / Year
Cattle	2021-22	24.70	17.29	250	55.22	5.52	414.15
Buffalo	2021-22	1.51	0.88	300	3.37	0.34	252.94
Sheep	2021-22	3.75	7.81	12	1.54	0.185	13.08
Goat	2021-22	26.77	55.77	12	10.99	1.32	93.41
Poultry	2021-22	375.65	469.56	2	18.09	3.98	198.97
Total	2021-22				89.21	11.34	972.55
Cattle	2041 (Projected)	27.81	19.47	250	62.18	6.22	466.37
Buffalo	2041 (Projected)	1.66	1.16	300	4.45	0.44	333.42
Sheep	2041 (Projected)	5.24	10.91	12	2.15	0.258	18.27
Goat	2041 (Projected)	30.20	62.91	12	12.40	1.49	105.40
Poultry	2041 (Projected)	633.34	791.67	2	30.21	6.86	343.20
Total	2041 (Projected)				111.39	15.27	1266.66

Table 2: Present requirements (2021-22) and future projection of nutrients for livestock by 2041.

Source: Projected nutrients are calculated by the method described by Rothman-Ostrow, et al. [12]; M: Million; LW: Live Weight; MMT: Million Metric Ton; MMJ: Million Mega Joule.

	Dry Matter (MMT)	Crude Protein (MMT)	Metabolizable Energy (MMJ)
Availability	49.51	4.26	364.47
Requirement	89.21	11.34	972.55
Balance	-39.70	- 7.08	- 608.08
Availability (%)	55.49%	37.56%	37.47%

Table 3: Feed balance, availability and requirement of livestock in Bangladesh.

Source: Based on present availability data (DLS, 2022); MMT: Million Metric Ton; MMJ: Million Mega Joule.

demand. Only a portion of consumers, particularly large livestock farms, can purchase or afford commercial feeds, partly because of limited production and partly because of high prices. According to FAO [26], China and India together account for 40% of the global feed market. Bangladesh is the fifth-largest producer of feed, but its share of the global feed market is only 1.5%. Feed accounts for more than 50% of the market cost of animal-source proteins, including fish and meat [27].

Feed producers can contribute to greater sustainability in the livestock sector by improving the quality of animal-source foods while reducing costs to consumers. The feed-milling industry can simultaneously contribute to Bangladesh's long-term food security, employment generation, and poverty reduction. At present, there are 294 registered commercial feed mills [28] in the country, almost all of which are privately owned. These mills produce approximately 6.55 million tons of commercial feed annually, comprising 4.15 million tons of poultry feed, 0.70 million tons of dairy feed, and 1.70 million tons of fish feed [29]. These figures are broadly consistent with the findings of Kamal and Jashim [27], who reported annual production of 4.7 million tons. To reduce the price of commercial feeds, feed

manufacturers should increase the use of locally available ingredients. High-quality ingredients such as soybean meal could potentially be produced on a contract-farming basis. This could create a mutually beneficial situation for producers and consumers and accelerate industrial feed production and livestock development in the country.

Annual feed requirements, availability, and projections for 2030-31 are shown in table 4. The table shows that annual commercial feed supply in 2010-11 was 2.76 million tons, equivalent to 60.28% of total national requirements. In 2020-21, commercial feed production was sufficient to meet 84.33% of total national requirements. These data indicate an increasing capacity to meet national feed demand. Considering the existing growth rates of poultry, livestock, and fish production, the estimated annual compound feed requirement in 2030-31 will be 11.19 million tons, whereas current production capacity would meet only 58.49% of the total national requirement.

Particulars	Year		
	2010-2011	2020-2021	2030-2031
Broiler PS	255,500	724,200	1,450,000
DOC (broiler)	858,000	2,050,000	2,850,000
Layer PS	19,710	46,360	595,200
DOC (layer)	1,357,070	2,219,500	3,050,000
Cattle	1,300,312	1,126,937	1,152,487
Fish	800,000	1,600,000	2,100,000
Total feed required (MT)*	4,590,592	7,766,997	11,197,687
Industrial compound feed supply (MT)	2,767,440	6,550,000	-
Availability (%)	60.28	84.33	58.49% by current production capacity

Table 4: Annual feed requirements and commercial feed supply with projection by 2031.

*Broiler PS - 140 g/bird/day (average); Broiler DOC-3 kg/bird up to marketing; Layer PS-120 g/bird/day; Layer DOC-110 g/bird/day; Cattle -Av. body wt. 250 kg (@1% concentrate DM and 5% as compound manufactured feed); Fish-Data from personal communication and Bangladesh Poultry Industries Central Council [30], MT: Metric Ton; DOC: Day Old Chicks; PS: Parent Stock.

Import of feed ingredients

The major ingredients required for feed production include maize, soybean, rapeseed, corn gluten meal, distillers dried grains with soluble (DDGS), fish meal, and bone meal. These ingredients are largely imported, and the government provides tax waivers for importing feed ingredients in bulk. This contributes to maintaining the cost of raw materials used in feed manufacturing. Raw materials account for up to 70% of the total cost of feed production. The remaining costs are associated with production, transportation, and packaging. As demand for feed increases, demand for major raw materials also continues to rise.

Bangladesh is not self-sufficient in producing these raw materials. Local producers rely heavily on imports from countries such as Brazil, India, and the United States. In addition, micro-ingredients such as vitamin premixes, amino acids, and other nutritional premixes are almost entirely imported [27]. In the present study, major feed ingredients, including maize, soybean meal, fish meal, corn gluten meal, DDGS, and feed additives, amounting to approximately 2 million tons, are imported annually at a cost of around USD 944 million [31].

Land allocation for fodder production

Land shortage is a major constraint to fodder production faced by livestock farmers. However, the situation has gradually been changing, with increasing allocation of land for fodder cultivation. Over the past decade, there has been steady growth in the number of

large dairy farms under private ownership. These farms cultivate good-quality, high-yielding-variety (HYV) fodder on their own land to meet their requirements. Therefore, the allocation of land for fodder production is gaining momentum [23].

The total area used for fodder production, potentially available land, and actual land use are presented in table 5. The highest dry matter yield is obtained from Napier grass, including its hybrid varieties, which is cultivated throughout the country. Uddin and Akter [23] found that farmers mainly use hybrid Napier Pakchong, a relatively new variety in Bangladesh that has been spreading rapidly at the farm level because of its high production per unit of land. Fodder production among small and marginal farmers is generally not a common practice. Instead, farmers mainly feed their cattle using tethering systems on fallow land, roadside grass, and cut-and-carry systems [23].

Green fodder production is not well synchronized and largely depends on individual farmers' decisions. Land scarcity is a major constraint that prevents farmers from allocating sufficient land to fodder production. Despite these constraints, fodder production is increasing, and farmers are becoming more interested in cultivating fodder. The average land size of a typical dairy farm in Bangladesh is approximately 0.3 ha per farm, including homestead land. At present, farmers mainly cultivate approximately 1-10% of their arable land for partial fodder production [32].

Name of Fodder*	Characteristics			Area	Potentially available			Allocation	Actually used		
	D M yield	CP	ME	Area	DM	CP	ME	As fed	DM	CP	ME
	t/ha/Y	g / kg DM	MJ / kg DM	1 0 0 0 ha	1000MT	1 0 0 0 MT	1 0 ⁹ MJ	(%)	1 0 0 0 MT	1 0 0 0 MT	1 0 ⁹ MJ
Napier	50.24	102	8.3	3.3	164.4	16.8	1.4	100	164.4	16.8	1.4
Para	12.8	108	8.1	0.7	8.4	0.9	0.1	100	8.4	0.9	0.1
German	15.7	85	8.2	0.7	10.3	0.9	0.1	100	10.3	0.9	0.1
Dall	11.15	67	8.1	0.7	7.3	0.5	0.1	100	7.3	0.5	0.1
Maize	10	71	9.4	1.0	9.8	0.7	0.1	100	9.8	0.7	0.1
Cowpea	3	180	9.8	0.3	1.0	0.2	0.0	100	1.0	0.2	0.0

Table 5: Area under fodder production and its potential contribution to nutrient availability.

Source: IDRN feed database [33]. *Napier, *Pennisetum purpureum*; Para, *Brachiaria mutica*; German, *Echinochloa spp.*; Dall, *Hymenachne amplexicaulis*; Maize, *Zea mays*; Cowpea, *Vigna unguiculata*.

Geographical locations for fodder production

In some areas, particularly the milk-pocket areas of Madaripur, Munshiganj, Rangpur, Sirajganj, and Tangail, where small-scale dairying, cattle fattening, and milk-marketing facilities are prevalent, fodder production is gaining popularity as a source of income and employment [34]. Outside the major milk-pocket areas, fodder cultivation exclusively for feeding dairy cows began in 2008 in the chars (river basins) of northern districts, including Sirajganj, Bogura, Gaibandha, Kurigram, and the chars of Jamalpur [35]. Many farmers in these areas grow fodder for both their own livestock and the market. Common HYV fodders grown in the milk-pocket and char areas include Napier, German grass, Jumbo grass, maize, sorghum, Bajra, Khesari, and black gram. In addition, each Agro-Ecological Zone (AEZ) supports a wide variety of native grasses. There are common as well as unique grass species in each AEZ. The 30 AEZs of Bangladesh have considerable potential for fodder production (Figure 1).

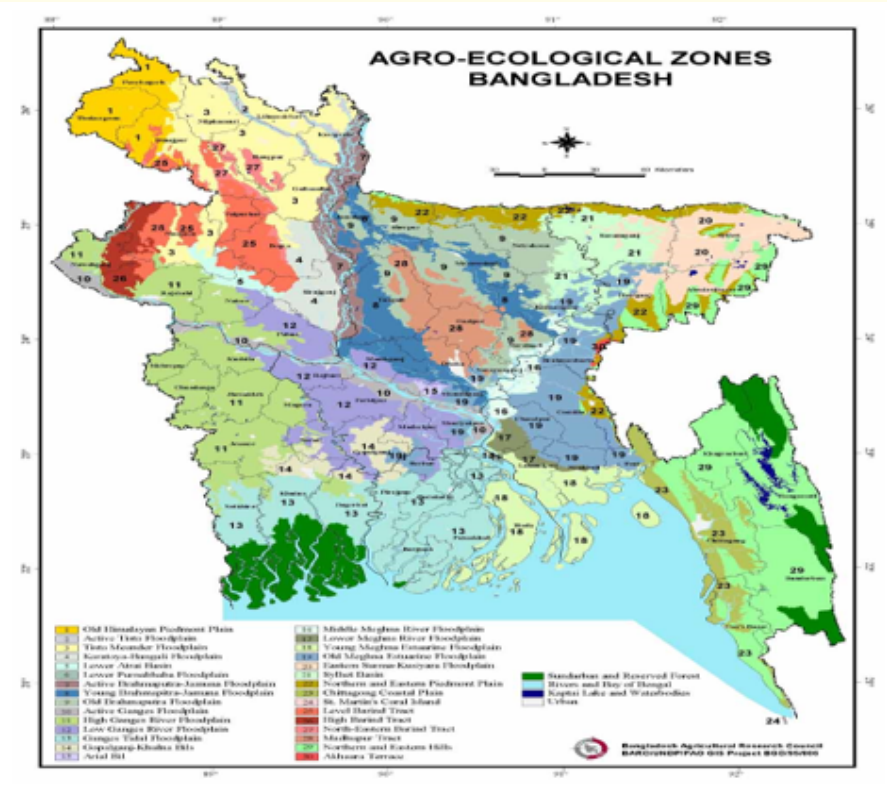


Figure 1: Agro-ecological zones (AEZs) in Bangladesh.

Sarker, *et al.* [36], in a study of fodder resources in several AEZs of Bangladesh, reported approximately 48 types of indigenous grasses in river-basin areas. Islam, *et al.* [37] identified 51 indigenous grasses that were important for fodder conservation. The ten most widely available local green grasses are presented in table 6. *Durba* was identified as the most widespread and popular local green grass, occurring throughout the year and being found in all surveyed areas, consistent with the findings of Rahman, *et al.* [38].

*Rank	Local name	Taxonomical name	AEZ	Regions where available (Districts)
1	<i>Durba</i>	<i>Cynodom dactylon</i>	1, 4, 7, 12	Most of the surveyed areas
2	<i>Badla</i>	<i>Cyperu srotundus</i>	4, 7, 12	Rajshahi, Faridpur, Tangail, Jamalpur
3	<i>Kawn</i>	<i>Setaria italica</i>	1, 11	Kushtia, Kurigram,
4	<i>Shama</i>	<i>Echinochlo acolonom</i>	4, 12	Rajshahi, Faridpur, Jamalpur, Kushtia
5	<i>Khesari</i>	<i>Lathyrus sativus</i>	1, 7	Serajganj, Tangail, Jamalpur, Kushtia, Kurigram
6	<i>Gamma</i>	<i>Tripsacum dactyloides</i>	7, 12	Faridpur, Tangail, Jamalpur, Kushtia
7	<i>Ura</i>	<i>Imperata cylindrica</i>	12	Faridpur, Kurigram
8	<i>Gobra</i>	<i>Paspalum comersoni</i>	1, 4, 7	Jamalpur, Bogura, Kurigram
9	<i>Hama</i>	<i>Echinochlo acolonom</i>	12	Faridpur, Tangail, Kurigram
10	<i>Maskalai</i>	<i>Phaseolus mungo</i>	7, 12	Serajganj, Faridpur, Jamalpur

Table 6: List of available indigenous grasses under different areas and AEZs of Bangladesh.

*Rank based on availability; AEZ, Agro Ecological Zone. Source: Sarker, *et al.* [36].

Seasonal availability of indigenous grasses

The majority of native grasses are readily available during the dry season, from March to June, while some grasses, such as *Durba*, *Badla*, *Kawn*, and *Shama*, are available throughout the year. The winter season provides greater access to some fodder species, including *Kawn*, *Khesari*, and black gram.

Market scenario of commercial feeds and fodder

There is no organized or well-structured marketing system for either the purchase of feed and fodder inputs or the sale of outputs. Therefore, business owners sell commercial feeds through dealers, who then sell them to contract growers, or through wholesale agents who supply retailers. Industry players may occasionally develop monopolistic practices because of the substantial shortage of commercial feed relative to demand. In addition, feed dealers may increase their earnings by taking advantage of contract farmers. Bangladesh is a net importer of wheat, soybean, and maize. Hundreds of firms are involved in importing wheat and maize from abroad. In the case of soybean, the majority of imports are handled by a small number of firms. Three types of importers operate in the core feed-ingredient value chain: sole importers, large feed millers, and national millers. The subsequent links in the value chain include dealers, feed entrepreneurs, feed-mixing service providers, retailers, and farmers.

Green-grass production and marketing are gaining popularity in selected regions of the country. The northern region, particularly Sirajganj and Bogura, and the southern region, particularly Satkhira, are examples of areas where fodder marketing is developing. Although entrepreneurship in the production and commercialization of green fodder has developed in a number of areas, the majority of farmers (85%) grow green fodder for their own livestock, mainly dairy cattle and, to a lesser extent, beef cattle. Approximately 12% of farmers produce fodder for their own use and also sell it to other livestock farmers, while the remaining 3% are primarily involved in green-fodder production for direct sale in the market as a source of income [39].

The development of the fodder market is important for enhancing dairy and beef cattle production in Bangladesh. Fodder marketing has considerable potential in urban, peri-urban, and rural areas. The foddermarketing channel involves several actors, including fodder producers and entrepreneurs, seed companies, seed dealers, farmers, and local livestock officers.

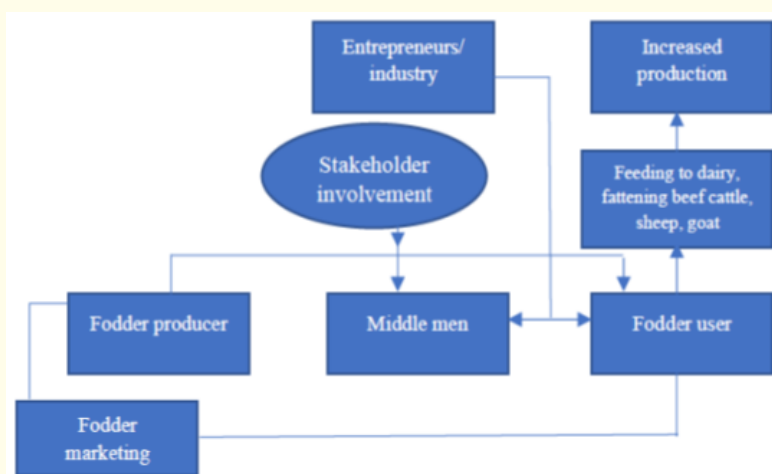


Figure 2: Development of fodder market and entrepreneurship in Bangladesh. Source: Uddin and Akter [23].

Fodder preservation and marketing

Bangladesh is producing increasing quantities of green fodder, but production is still insufficient to meet demand. In addition to typical seasonal shortages, natural disasters such as floods, droughts, cyclones, and other hazards may further reduce fodder availability. A consistent supply of high-quality feed is necessary to maintain livestock productivity throughout the year. Therefore, livestock farmers should be encouraged to conserve green fodder to address both seasonal shortages and shortages resulting from natural disasters.

Among the various methods of green-fodder preservation, farmers commonly prepare hay and silage. Crops suitable for silage production generally include non-leguminous fodder crops rich in soluble carbohydrates, such as maize, oats, sorghum, pearl millet, and cultivated grasses. The principal raw material for silage production is good-quality green fodder, particularly maize. Because of the shortage of green fodder in Bangladesh, adoption of silage-making technology remains relatively low, although awareness among livestock farmers is increasing. Two major types of silage production are practised in Bangladesh: production for own consumption and commercial production. A small number of entrepreneurs operate silage-production businesses on a commercial basis (Figure 3). Automated baled silage-making equipment is also available in Bangladesh, indicating potential for increased adoption of silage technology in the near future. However, wider adoption will require dissemination of silage preparation technologies in a more user-friendly and convenient manner.

Khandarker and Uddin [40] reported that concrete silo pits are an effective technology for preserving silage for longer periods and can provide a cost-effective method of silage preparation. Another study by Saifullah and Uddin [41] comparing different silage-preparation methods concluded that preparation of silage using plastic drums was highly effective. Good-quality silage can also be prepared from maize using traditional bamboo systems in rural areas. This approach is cost-effective and can optimize feed intake and rumen fermentation [42].



Figure 3: Commercial silage making process in Bangladesh.

Challenges of feeds and fodder production Scarcity of land for fodder production

Land shortage is a major constraint to fodder production among smallholder farmers. It has been reported that the area of cultivable land decreases by approximately 1% annually. Under these circumstances, alternative approaches and means must be identified to increase fodder production and mitigate the fodder shortage.

Changes in cropping patterns

Leguminous fodders are rich sources of protein and are used as green fodder for feeding ruminants and for making hay for use during the lean season. The development of new high-yielding varieties (HYVs) of rice and other crops, together with the introduction of

intensive food-cropping systems, has resulted in regular changes in cropping patterns. The expansion of rice cultivation during winter has contributed to a significant decrease in the production of legumes for fodder, resulting in a reduction in the land available for fodder production.

Lack of fodder availability during seasonal lean periods

Fodder is not uniformly available throughout the year. Naturally occurring green grasses and other fodders grow abundantly during the rainy season. Non-leguminous fodders grow well during the rainy season, whereas legumes generally perform better during winter. The yield of perennial non-leguminous fodders is considerably higher than that of legumes. The growth of perennial fodders is highest during the rainy season but becomes very slow during winter. Therefore, land shortages and changes in cropping patterns, together with seasonal variation; result in good fodder availability during the rainy season but fodder scarcity during winter.

Lack of quality fodder seeds/cuttings

HYV fodder seeds are generally imported from countries such as Australia, India, and others. Farmers have limited access to the small number of companies that import these seeds. Consequently, although many farmers are interested in cultivating HYV fodders, they frequently encounter difficulties in obtaining highquality fodder seeds and cuttings.

Poor knowledge of farmers regarding HYV fodder cultivation

Most high-yielding fodders were introduced into Bangladesh from other countries and therefore require specific management and harvesting techniques. Farmers require training and demonstrations to cultivate these fodders successfully. In rural areas, it is common to find farmers operating medium-sized dairy farms without adequate knowledge of planting hybrid Napier cuttings or sowing fodder seeds to achieve higher yields. Therefore, in addition to providing high-quality fodder seeds and cuttings, farmers need training on improved fodder-production practices to increase the adoption of HYV fodder cultivation in the country.

Research and development on feeds and fodders for climate disaster-prone areas

Bangladesh is one of the country's most vulnerable to the effects of climate change. Major climate-related disasters include floods, cyclones, tidal surges, saline intrusion, and heavy rainfall. Floods and heavy rainfall affect almost all low-lying areas of the country, while other disasters particularly affect coastal areas. Climate-related disasters adversely affect agricultural crops, including livestock fodder. Fodder production is particularly severely affected by saline intrusion. In saline-affected areas, very little fodder can be grown, resulting in serious shortages of feed and reduced livestock productivity.

Lack of good-quality concentrate feeds

Proper growth and development of animals depend largely on the nutrient content of the feed supplied to them. Concentrates comprise cereal grains and their by-products, oilseeds and their by-products, and animal by-products. However, the use of concentrates creates direct competition between humans and livestock for food resources. Moreover, processing techniques applied to different grains may reduce their nutritional value. This situation contributes to the importation of concentrate feed ingredients for livestock production. There are very few industries in Bangladesh that process concentrate feed ingredients and micronutrients. As a result, a large proportion of the micronutrients used in commercial feed is imported, and their quality needs to be properly monitored and controlled.

Poor knowledge of farmers regarding improved feeding practices/systems

The appropriate feeding system for livestock depends on several factors, including the type, age, size, health status, and purpose of livestock rearing. However, there are some general feeding practices that can be followed to ensure healthy growth and productivity. Many livestock farmers do not have adequate knowledge of appropriate feeding practices. They may not fully understand the nutritional

requirements of their animals or how to provide a balanced diet. This can result in under nutrition, low productivity, and increased susceptibility to disease.

Lack of commercialization of feeds and fodder

Production of pasture and fodder can be profitable, as demonstrated by gross-margin analysis. The commercialization of feeds and fodder can be enhanced by small-scale fodder producers through increased productivity using high-yielding varieties, reduced production costs, improved quality and safety, and greater market opportunities.

Poor transfer and adoption of skills/technologies

High-yielding fodder-crop seed and germplasm banks are generally unavailable at the district and upazila levels. Technologies for utilizing non-conventional feedstuffs, such as slaughterhouse waste, crop residues, and food-processing waste, have not yet been adequately developed. Very limited efforts have been made to train farmers in HYV fodder production. The shortage of green fodder is largely caused by limited land availability, insufficient extension activities, and the lack of fodder seed banks.

Increasing feed prices

Increasing livestock feed prices are a serious concern for farmers, feed manufacturers, and livestock professionals. During the last decade, feed prices have increased substantially, placing a burden on farmers, livestock-product producers, and consumers. Because of increases in feed prices, many small-scale poultry farmers have discontinued their businesses. The high price of concentrate feed has become one of the major constraints to the growth of the livestock industry. Therefore, reducing feed prices to an affordable level for farmers is a critical challenge for the livestock sector.

Climate change effects and environment

Bangladesh is considered one of the country's most vulnerable to climate change because of its geographical location, economic dependence on agriculture, and recurrent natural hazards [43]. Three regions of Bangladesh are particularly affected by climate change: the coastal region in the south, the drought-prone area in the northwest, and the flood-prone area in the central part of the country. Climate change can exacerbate these problems by increasing temperatures and changing rainfall patterns, which can affect the quality and availability of livestock feed. The most important impacts of climate change on the ruminant livestock sector include reduced grazing areas, fodder shortages, reduced growth, and decreases in milk and meat production. The reduction in grazing areas is partly caused by saline intrusion resulting from storm surges and cyclones. Fodders generally cannot grow in saline soil or water, except for certain salt-tolerant species. Consequently, severe shortages of livestock feed are common in these areas.

Limited access to credit for fodder production

Fodder production requires financial investment because of labour requirements for land preparation, sowing seeds or planting cuttings, intercultural operations, harvesting, and other activities, as well as the cost of purchasing seeds and cuttings. Therefore, access to credit is essential for farmers to invest in feed and fodder production. However, many smallholder farmers in Bangladesh face significant difficulties in accessing credit, which limits their ability to invest in fodder production and processing.

Competition between human and animal agriculture

There is direct competition between humans and livestock for food resources. More specifically, livestock feeds, particularly the grain components of concentrates, include maize, wheat, soybean, *Lathyrus*, chickpea, and other crops that are also used as human food. Therefore, with increasing population pressure and limited land availability, there will be little scope for expanding livestock feed production unless it becomes more profitable than food-crop production. It should also be noted that livestock fodder and other feed production require land, water, and soil nutrients, which may create additional competition with human food production. This situation is

unlikely to be reversed in the near future unless Bangladesh achieves greater self-sufficiency in food-grain production and livestock feed and fodder production becomes more profitable for farmers.

Post-harvest losses of feeds, fodder and by-products

Post-harvest losses of feeds, fodder, and their by-products are significant and have a considerable impact on the total availability of livestock feeds and fodder. According to a study conducted by FAO, annual postharvest losses of feeds and fodder in Bangladesh are estimated at approximately 5-10%, while losses of byproducts may reach up to 20%. Straw and other crop residues are also used as fuel and for other purposes. It is estimated that 30-40% of total straw and crop residues are used for fuel and other purposes. The major causes of post-harvest losses in feeds and fodder include inadequate harvesting and storage facilities, lack of proper drying and preservation techniques, and pest and disease infestations. By-products such as rice bran, wheat bran, and oilseed cakes are not always properly collected, stored, or processed, resulting in spoilage and reduced nutritional quality [26].

Way forward

To enhance feed and fodder production and improve feeding practices in the livestock sector, several strategies should be implemented. The following measures are proposed for improving feed and fodder production, preservation, marketing, and utilization are discussed in the below section.

Intensify fodder cultivation

Farmers should be encouraged to allocate dedicated land for HYV fodder cultivation. Local DLS offices should take initiatives to facilitate this process and ensure farmers' access to the necessary inputs and logistics, including good-quality fodder seeds and cuttings. To increase production per hectare, farmers need access to current agronomic techniques, improved fodder varieties, and appropriate training. It is essential to ensure year-round fodder production and supply sufficient quantities to productive cattle. Therefore, alternative methods of fodder production, such as hydroponics and vertical farming, should also be promoted where appropriate.

Develop entrepreneurship in fodder production and preservation

The low level of fodder production in Bangladesh, combined with the dominance of traditional practices and limited knowledge regarding the quality of preserved fodder, are major reasons why fodderpreservation technologies have not yet been widely adopted by smallholder farmers. Many large and medium-sized farms also prefer to feed green fodder to productive animals rather than preserve it. Consequently, fodder availability varies throughout the year. Several measures should be implemented to address this issue, including increasing farmers' awareness, promoting higher fodder production, fostering the development of fodder-related enterprises, and facilitating the marketing of both preserved and green fodder. Farmers should be encouraged to cultivate non-leguminous crops for silage and leguminous crops for hay. The preservation of silage and hay will help ensure access to feed during lean periods and support livestock productivity.

Fodder cultivation with minimum use of land

Due to the annual loss of approximately 1% of cultivable land, fodder cultivation with minimum land requirements is becoming increasingly important. This can be achieved through integrated rice-forage production systems that prevent the loss of soil nutrients and may increase rice production. The government may identify areas with unfavorable conditions for conventional crop production and riverbasin areas and coordinate among relevant ministries to utilize these areas for HYV and *Bathan* fodder production. Enhancing forage production through the careful use of available resources—including tree plantations, embankments, roadsides, *khas* land, and char areas—requires intensive research and development. Farmers in different agro-climatic regions should be informed about special HYV maize and sorghum varieties developed specifically for fodder production.

Create market facilities for green and preserved fodder

Many actors, from producers and processors to farmers, are involved in the fodder supply chain. Establishing an effective system to ensure adequate supply and distribution of high-quality feed throughout the country is essential, particularly by connecting areas with abundant fodder resources to areas where fodder is scarce. Contract farming between fodder processors and farmers, as well as leasing small farmers' land to larger producers, could provide additional support to private entrepreneurs. Neighborhood fodder banks or cooperatives should be promoted to ensure a steady supply of high-quality fodder during periods of scarcity. A centralized information system should also be developed to monitor feed production, supply networks, quality assurance, and market prices for feeds and preserved fodder.

Alternative means to reduce concentrate feed costs

The high cost of feed needs to be reduced to a manageable level to accelerate livestock development. This is challenging because numerous factors influence feed prices, particularly when feed ingredients are imported from other countries. The Government of Bangladesh may continue to consider appropriate fiscal measures, including import-duty adjustments, where necessary. For ruminants, greater use of high-quality locally available concentrates and fodder, including locally produced fish meal and soybean meal, may help reduce feeding costs. For poultry and other non-ruminant livestock, efforts should be made to increase domestic production of expensive imported feed ingredients. DLS should take the lead in coordinating with relevant government agencies and policymakers to support these initiatives.

Enforcement of the feed act for quality feed marketing

Animal feed quality, safety, and marketing directly affect livestock health and production. Therefore, effective enforcement of the Animal Feed Act, 2010, is essential. The Act seeks to protect livestock farmers' interests by ensuring that animals receive safe and wholesome feed while improving the quality of feeds and fodder. Key elements include regulatory authority, feed registration and licensing, quality control and standards, and complaint-handling procedures. DLS is responsible for implementing and enforcing the Feed Act. Feed manufacturers and importers are required to register their products with DLS before marketing them. The government should develop an action plan and establish a strong monitoring mechanism to coordinate with relevant government agencies and stakeholders in the livestock sector and ensure effective enforcement of the Feed Act for quality feed production and marketing.

Enhance R&D for salt- and flood-tolerant fodder development

Research should be intensified to develop or identify fodder varieties capable of tolerating floodwater and salinity, similar to efforts undertaken in the crop sector. This is particularly important for cattle farmers operating in coastal areas. Furthermore, efforts should be made to identify and evaluate indigenous grasses and fodder species that may possess salt tolerance. Promising species should subsequently undergo field validation trials.

Mitigation of climate change effects on and by livestock

Climate affects livestock growth rates, milk and egg production, reproductive performance, morbidity and mortality, as well as feed availability. At the same time, livestock production contributes to climate change through greenhouse-gas emissions. Research is therefore needed to identify locally appropriate mitigation and adaptation strategies, particularly in relation to feed and fodder supply, feeding practices, and policies that encourage the adoption of environmentally sustainable production systems.

Exploration of forage-based feeding systems

The major greenhouse gases associated with animal agriculture include methane and nitrous oxide. Methane is mainly produced through enteric fermentation and manure management and has a substantially greater global-warming potential than carbon dioxide [45].

Consequently, several nutritional strategies for mitigating enteric CH₄ emissions have been studied and developed. Among the available options, improved forage quality and precision livestock feeding are promising approaches for reducing enteric methane emissions.

Animal performance is closely related to the efficient utilization of forage combined with appropriate nutritional management. Such approaches can increase animal production while contributing to methane reduction efforts. In recent decades, grass-based diets have received increasing attention because they can combine pasture ecosystem services with livestock production. Important ecosystem services include biodiversity, improved forage quality, reduced requirements for mineral nitrogen fertilization through the use of legumes, reduced associated N₂O emissions, and carbon sequestration in pastures.

Use of river basins for fodder production

In Bangladesh, char lands (riverine islands) periodically emerge from riverbeds as a result of accretion. The riverine islands of Bangladesh can be divided into five sub-areas associated with the Jamuna, Brahmaputra, Padma, Upper Meghna, and Lower Meghna rivers (Figure 4). Using GIS technology, newly emerging char lands can be identified and their potential for fodder cultivation can be assessed. Under the Char Livelihood Programme (CLP), funded by DFID, char lands in the northern districts of Sirajganj, Bogura, Gaibandha, and Kurigram were brought under fodder-production activities. HYV fodders were introduced, and farmers continue to cultivate these grasses for feeding their livestock as well as for fodder marketing. Therefore, there is considerable potential for expanding HYV fodder cultivation across suitable char lands in Bangladesh.

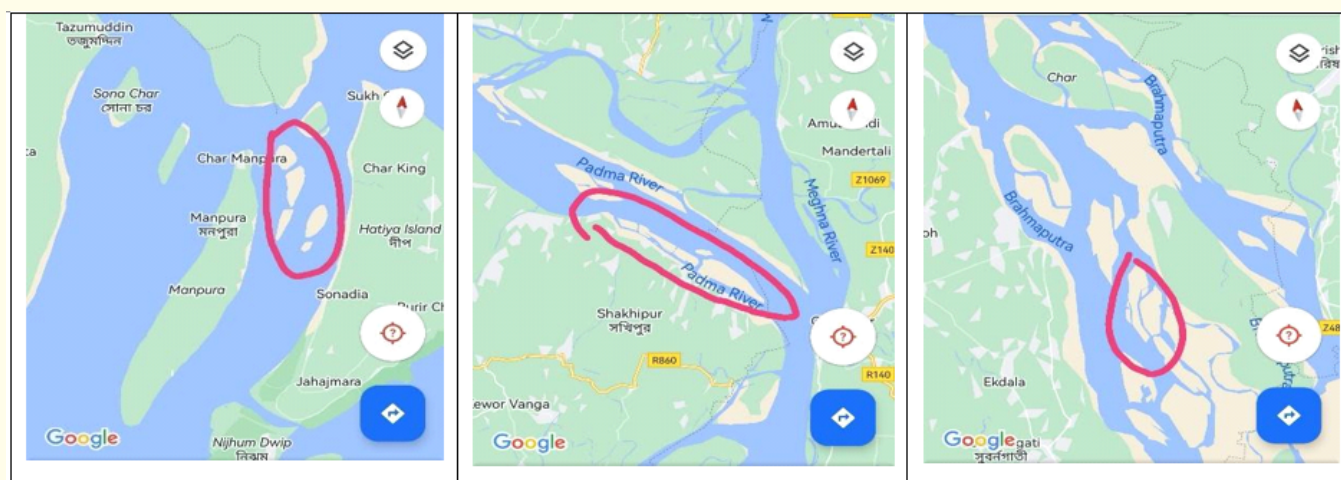


Figure 4: River basin areas for fodder production in Bangladesh.

Simplify credit facilities for fodder farmers

Access to finance is crucial for small-scale farmers and feed producers seeking to invest in the feed and fodder sector. The government should work with financial institutions to improve access to credit for smallholder farmers. DLS should work closely with financial organizations to develop suitable credit mechanisms for farmers engaged in fodder production. Improved access to finance will help farmers invest in feed and fodder production and processing, thereby improving the quality and quantity of livestock products.

Improve the dissemination system for adoption of skills and technologies

The Department of Livestock Services (DLS) has an important role to play in improving the dissemination and adoption of modern techniques and technologies related to feeds, feeding, and fodder processing. DLS has a nationwide grassroots-level infrastructure comprising trained technical and sub-technical staff, including Livestock Extension Officers (LEOs) and Livestock Service Providers (LSPs). These personnel can be effectively utilized to disseminate feed and fodder technologies, distribute fodder seeds, demonstrate HYV fodder cultivation at the upazila level, and organize training for farmers on fodder production, processing, and feeding systems.

Use of ICT in feed and feeding systems

Modern digital systems have not yet been fully integrated into fodder production and marketing. The primary objective of the government's Digital Bangladesh initiative is to develop and apply ICT across all aspects of agriculture. However, ICT adoption has progressed more rapidly in the crop sector than in the livestock sector. The Livestock and Dairy Development Project (LDDP), implemented under DLS, has demonstrated how ICT can be used for dairy and livestock development. Development of balanced diets is essential for increasing the production of milk, meat, and eggs, and feeding management is one of the most important aspects of livestock farming. Excel-based and modelling-based tools can be used to formulate balanced and economical rations, demonstrating the potential of ICT applications in livestock feeding.

Conclusion

The agricultural economy of Bangladesh depends substantially on livestock, which provides an important source of food and income for the population. However, the adverse effects of climate change have contributed to feed and fodder shortages, creating challenges for livestock productivity and animal health. For sustainable livestock production, the availability of high-quality and well-balanced feed is essential. Greater attention is therefore required to produce and distribute nutritionally adequate feeds and fodder that meet the specific requirements of different livestock species. Several factors, including limited water availability, restricted land resources, and competition between food crops and fodder crops for available land, frequently constrain fodder production. Climate variability can further affect fodder growth and availability.

Diversification of fodder crops can help reduce the effects of changing weather patterns and ensure a more stable supply of high-quality feed throughout the year. Feed and fodder production systems should therefore be made more resilient to climate change and environmentally sustainable. This requires the selection of fodder crops that can tolerate changing climatic conditions and the adoption of climate-smart feeding strategies. Increased fodder production can be achieved by improving access to fodder markets and ensuring the availability of high-quality seeds, fertilizers, incentives, and other necessary inputs. Appropriate use of *khas* land for fodder production is one potential option. Appropriate government policies should be implemented to support sustainable fodder production, reduce input costs, and strengthen research, extension, and technology-transfer services for the livestock sector.

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