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Women in mixed farming system and their challenges: A qualitative study in northern Bangladesh

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ABSTRACT

Women play a vital yet often overlooked role in Mixed Farming Systems (MFS) in northern Bangladesh, particularly in crop production and livestock management. Despite their active involvement, deep-rooted patriarchal norms and structural inequalities continue to restrict their participation in agricultural decision-making. This qualitative study explores both the constraints and opportunities shaping women's engagement in MFS. Data was collected through seven focus group discussions in rural communities and analyzed using a visual thematic analysis framework. Findings reveal that women face significant barriers, including limited access to quality seeds, gender-sensitive agricultural tools, knowledge of pest and disease management, and adequate veterinary services. These challenges hinder productivity and reduce household income. Nonetheless, the study identifies promising interventions such as promoting climate-resilient crop varieties, ensuring timely access to inputs like fertilizers, and enhancing livestock services through crossbreeding and improved nutritional feed, which could boost women's contributions and improve overall farm outcomes. The study underscores the importance of gender-transformative strategies to enhance women's agency and decision-making power in MFS. Although geographically focused, the findings offer valuable insights with practical implications for policymakers and development practitioners aiming to design inclusive, gender-responsive agricultural programs. Future research should broaden the scope and incorporate quantitative methods for deeper analysis.

Contribution/ Originality: This study uniquely explores women's roles in mixed farming systems in northern Bangladesh. It reveals overlooked structural barriers and actionable opportunities and highlights the need for gender-transformative strategies and localized interventions using qualitative visual thematic analysis. The study offers practical insights to inform inclusive agricultural policies and future gender-responsive development efforts in socio-economic settings.

1. INTRODUCTION

In the rural landscapes of Bangladesh, women have long served as the silent custodians of the land, working alongside men in the fields, tending crops, and caring for livestock (Biswas, Mou, Yasmin, Zonayet, & Hossain, 2022). Yet, despite their critical involvement, their contributions have traditionally been marginalized due to entrenched gender roles and societal expectations. In recent years, however, this dynamic has begun to shift. Amid growing economic pressures and the escalating impacts of climate change on agriculture, women are increasingly emerging as pivotal actors within mixed farming systems (De Pinto, Seymour, Bryan, & Bhandari, 2020). Their

deep knowledge of indigenous agricultural practices, resilience in the face of hardship, and capacity to adapt to changing conditions have become essential to the sustainability and success of these systems.

1.1. Gender in MFS

Rural women in South Asia, though often constrained by persistent gender inequalities in agriculture, demonstrate remarkable resilience and adaptability within mixed farming systems (Ahooja-Patel, 1979). Their contributions frequently undervalued and overlooked are nonetheless essential to the sustainability and effectiveness of these systems. As male outmigration increases, many women are assuming the roles of household heads, prompting significant shifts in traditional crop-sharing arrangements (Lahiri-Dutt, 2016). In Nepal, this transition has contributed to a decline in farming intensity and a reduction in livestock-related activities. Despite these evolving roles, entrenched gender norms continue to restrict women's full participation in agriculture, often minimizing the significance of their labor and decision-making (Bhawana, Sharma, & Joshi, 2020).

Understanding the relationship between women's agricultural labor and maternal and child nutrition in South Asia necessitates a nuanced consideration of factors such as seasonality, poverty, and gender dynamics (Rao, Gazdar, Chanchani, & Ibrahim, 2019). Women's involvement in the region's mixed farming systems is multifaceted, as they play a vital role in food production despite operating under difficult conditions and gender-specific constraints (Ahooja-Patel, 1979). In mixed crop–livestock systems across varying altitudes, household decision-making is typically shared between spouses in male-headed households, whereas women take primary responsibility in female-headed households. However, regional agricultural systems face numerous challenges, including the rising costs of fertilizers and seeds, crop diseases, low market prices, shortages of livestock feed, and the growing impacts of climate change particularly pronounced in lowland areas (Taha, Khan, & Smith, 2014).

Rice-based agriculture in South Asia is increasingly affected by natural disasters, climate change, and rising male outmigration challenges that disproportionately impact poor rural women (Romero-Paris, 2009). Agricultural labor is often divided along gender lines, with men typically responsible for land preparation and fertilizer application, while women play a central role in seed management, harvesting, and livestock care (Akter et al., 2017; Taha et al., 2014). Effectively addressing these gendered dynamics is essential for reducing poverty, strengthening food security, and improving family health and nutrition outcomes across rural communities (Rashid, Smith, & Khan, 2021).

In India, women are frequently excluded from agricultural training programs, extension services, and irrigation management, which significantly limits their productivity. Despite their active engagement in both crop cultivation and livestock care to support household livelihoods, many women lack access to essential skills and technical knowledge. However, participation in Self-Help Groups (SHGs) focused on skill development has shown promise in helping women overcome these barriers, enhancing their capacity and productivity in agro-based activities (Kasi, 2013). Existing data on decision-making within male-headed and female-headed households indicate that decisions in male-headed households are typically made jointly, whereas women in female-headed households often make decisions independently. However, limited research has examined whether men independently make decisions in specific agricultural activities or whether joint decision-making varies across different domains nuances that are often overlooked. Moreover, the structural constraints and sociocultural barriers that hinder women's active participation in decision-making within mixed farming systems remain insufficiently explored. This study seeks to address these gaps and contribute to a more comprehensive understanding of gendered decision-making dynamics in agriculture. This study aims to identify the key constraints and barriers that influence decision-making within mixed farming systems (MFS) in northern Bangladesh. By examining the gender dynamics that shape agricultural practices, the research seeks to generate insights that can inform policies and interventions aimed at promoting gender equity and empowering women. It highlights the challenges women face in participating fully in MFS, offering evidence-based recommendations to support more inclusive and equitable agricultural development.

2. MATERIALS AND METHODS

2.1. Study Area

The study was conducted in Rangpur, Nilphamari, and Dinajpur districts, located in northern Bangladesh. Focusing on these areas enables a region-specific understanding of decision-making dynamics and women's involvement in mixed farming systems. Figure 1 FGD locations in the northern part of Bangladesh are shown in the map.

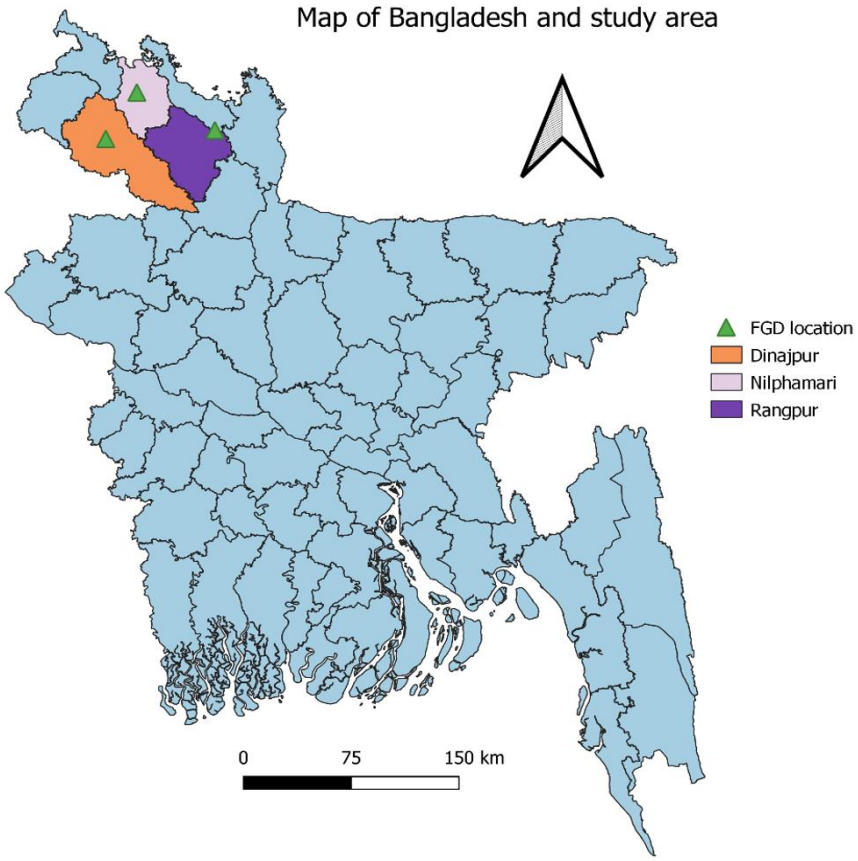

Figure 1. FGD locations.

2.2. Study Design and Sampling

This qualitative descriptive study was conducted across seven rural sites in northern Bangladesh: three in Rangpur, three in Nilphamari, and one in Dinajpur. These locations were selected to represent the broader context of Rangpur, Nilphamari, and Dinajpur districts. Site selection was based on two key criteria: (1) low levels of crop diversification, with approximately 75% of land under Boro–Fallow–T. Aman, Maize–Fallow–T. Aman, and Potato–Boro–T. Aman cropping systems; and (2) low productivity resulting from inefficient resource practices related to soil, water, timely sowing, and input use (Hoque et al., 2023; Zaman, Pramanik, Parvin, & Khatun, 2017). Site identification was carried out in coordination with field staff from regional offices in Bangladesh. The study focused on women engaged in mixed farming systems, with 130 participants purposively selected for focus group discussions (FGDs).

Table 1 presents the dates, locations (villages and districts), total number of focus group discussions (FGDs), and the number of participants interviewed across the study areas. Conducting FGDs with 130 participants across *Rangpur*, *Nilphamari*, and *Dinajpur* districts enabled the collection of in-depth insights into both existing and potential constraints and barriers influencing decision-making processes and women's participation in mixed farming systems.

Table 1. Summary of Focus Group Discussion (FGD).

Date	Locations (Village and districts)	Number of FGDs	Number of participants
02-11-2022	Khoshalpur, Dinajpur	1	18
03-11-2022	Araji Horesha, Rangpur	1	18
15-11-2022	Kalitola, Nilphamari	1	18
20-12-2022	Dupachuri, Nilphamari	1	20
20-12-2022	Gordharmapal, Nilphamari	1	20
21-12-2022	Dakhin Ramnathpur, Rangpur	1	18
21-12-2022	Shahbajpur, Rangpur	1	18
Total		7	130

2.3. Data Collection and Analysis

These interview questions aim to guide discussions with participants, exploring farming practices, decision-making, challenges, technology adoption, and perceptions of women's agricultural roles. Adjustments can be made based on the conversation's flow and context. Using semi-structured questionnaires, data was collected through seven focus group discussions (FGDs) with 15-20 participants each. To ensure fresh and diverse responses, we avoided repeating participants across groups. Each FGD lasted 60-90 minutes to allow in-depth discussion while keeping participants engaged.

The FGDs focused on gathering women's views on decision-making and identifying barriers they face in mixed farming systems in northern Bangladesh. Initially in English, the interview guides were translated into Bengali to ensure clarity and ease of communication. Participants gave consent before the interview, and discussions were recorded with their permission. We explained the study's objectives and assured participants of confidentiality to encourage open and honest participation, particularly on sensitive topics.

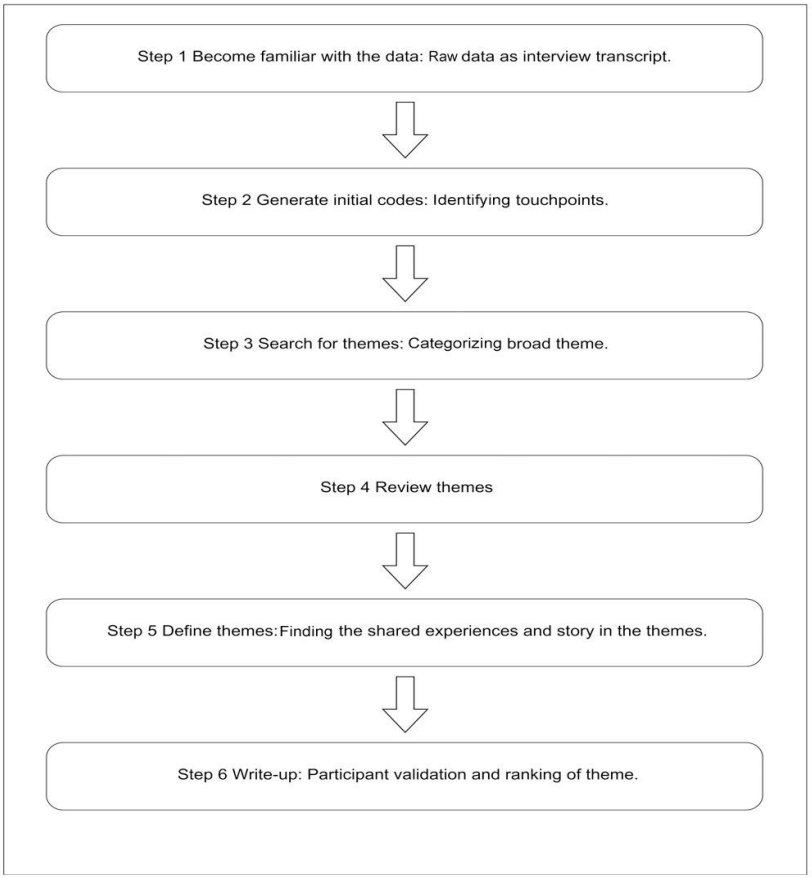

Figure 2. Visual representation of thematic analysis adopted from Braun & Clarke's six-phase framework.
Source: Maguire and Delahunt (2017).

After fieldwork, all interviews and field notes were transcribed in Bangla, translated into English, and uploaded to Atlas. Ti[1], a computer-aided qualitative data analysis software. This platform organized, managed, and analyzed the data efficiently through coding and categorization, enabling pattern exploration. The analysis followed Braun and Clarke's (2006) thematic framework, shown in Figure 2, outlining six phases of data analysis.

We began by organizing the data systematically. Using open coding based on the study's objectives, we extracted codes from responses to each question, applying the same codes across all seven FGDs. The software consolidated these codes, grouping them into broader themes. These themes addressed the mixed farming system (MFS), participation in MFS activities, new technologies, challenges, and ways to improve the system.

The themes were designed to align with the research questions, focusing on farming systems' characteristics, decision-making, crop and livestock choices, and constraints faced by women. The final analysis highlighted the barriers women face in engaging more actively in mixed farming and offered recommendations for addressing these challenges.

Table 2 shows the preliminary codes and themes identified from different questions on the objectives.

Table 2. Preliminary codes and themes.

Theme: General crop and livestock category **Codes** What crops and livestock are grown in this area, Land category, How many seasons are considered?	**Theme: Selection criteria of crop and livestock variety** **Codes** Variety of crops and livestock, Causes for selection, Considering environmental issues, Merits of growing/keeping them.
Theme: Decision to participate in crop production **Codes** Figure out crop production activities, Who is the primary decision-maker for crop activities, Men and women, participation in activities.	**Theme: Decision to participate in livestock and poultry rearing** **Codes** Figure out livestock and poultry rearing activities, Who is the primary decision-maker for livestock activities, Men and women participate in livestock.
Theme: Women in new technologies or a variety **Codes** New crop variety, New livestock variety consider, Advantages of the new variety on livelihood, Problem faced by new variety, Adaptation practice of new variety.	**Theme: Major constraints and barriers faced by women** **Codes** Knowledge gap of technology, Information gap about good quality seeds, Lack of knowledge about livestock disease, Inadequate knowledge about livestock nutrition, Ignore homemade compost
Theme: Potential causes for significant constraints **Codes** Male domination in attending training and agricultural organization. Proper training of farm organizations, Women's cultural dependency on men, Ignoring homemade compost, Habits for giving first aid themselves.	**Theme: Top priority issues to solve** **Codes** Irrigation for crops, Home seeds, Availability of fertilizer, Harvesting machine, Cross breeds from local breeds, Availability of veterinarian, Nutritious feeds.

3. RESULTS

The research findings from the field data are presented in three key areas: (1) women's participation in mixed farming systems (MFS); (2) major constraints and barriers hindering women's active involvement in MFS; and (3) potential strategies for enhancing women's roles within these systems. This section addresses both general categories, such as crop and livestock production and specific aspects including breed selection and decision-making related to participation in various agricultural activities.

[1] https://atlasti.com/

3.1. Socioeconomic Conditions of Participants

Table 3 presents the socioeconomic characteristics of participants from the three districts of *Rangpur*, *Nilphamari*, and *Dinajpur*. These characteristics are categorized into three areas: demographics, farm assets, and household assets, providing an overview of the participants' livelihood conditions. The average age of participants was 36 years, ranging from 23 to 70 years. Most participants had completed only up to eight years of schooling, reflecting the lower literacy rates in northern Bangladesh compared to other regions. Correspondingly, the average household size was five members, which exceeds the national average of four (Bangladesh Bureau of Statistics (BBS), 2022). The table also shows the participants involved in mostly off-farm and on-farm activities for their livelihood, with an average income of BDT 100,915.40 (USD 921.50), which is relatively lower than the national average of BDT 270,414 (USD 2,469.26) (Bangladesh Bureau of Statistics (BBS), 2022). Overall, socioeconomic indicators such as literacy rates and income levels in the study areas are below the national averages for Bangladesh.

Table 3. Socio-economic conditions of participants in the northern part of Bangladesh (n=130).

Variable	Mean	Std. dev.	Min.	Max.
Demographics age	36.00	8.67	23	70
Education (Completed year)	8.00	2.93	2	18
Family size	5.00	1.19	3	9
Farm land (Bigha)	4.00	2.17	1	20
Occupation (On-farm=1, Off-farm=2 and Both=3)	2.15	0.99	1	3
Household assets				
Cattle	2.23	0.73	1	5
Goats	3.84	1.22	1	8
Chicken	4.98	1.45	2	10
Ducks	4.74	1.80	2	10
Income	100915.40	45051	40,000	310,000

In addition, we found that all participants belonged to male-headed households, were married, and were actively involved in crop production and livestock rearing. At the same time, aquaculture activities were not prioritized for commercial purposes; households occasionally engaged in them for family consumption. Livestock ownership was common across households, with nearly every household possessing, on average, 2 cattle, 4 goats, 5 chickens, and 5 ducks to use in their crisis or vulnerable situations, especially when they have flooded, and crops are damaged.

3.2. Women's Participation in the Mixed Farming System

3.2.1. Common Mixed Farming System Characterizations

This section explores the common crops, livestock, and aquaculture patterns in the *Rangpur*, *Nilphamari*, and *Dinajpur* regions.

Table 4 shows cropping patterns are set based on the cropping seasons, which are divided into three types, namely Kharif-1 (March 16 - June 30), Kharif-2 (July 1 - October 15), and Rabi (November 15 - March 15). In Kharif-2, participants have cultivated Aman rice, short-duration biofortified Aman rice, Blackgram, and Indian spinach. Most participants reported cultivating Boro rice, maize, potato, mustard, maize/leafy vegetables, short-duration mustard, carrot (70 days to harvest), wheat, sweet corn, or baby corn in the Rabi season. After the Rabi season, they cultivate baby corn, sweet corn, or relayed sweet gourd, Boro rice (biofortified), sorghum (fodder), groundnut, maize, jute or Aus rice, pearl millet (fodder), chili, brinjal, or okra, among others. In Kharif-2, they cultivated four types of crops: short-duration biofortified Aman rice, maize/leafy vegetables, sorghum (fodder), and leafy vegetables such as green pea and field pea. In these three regions, the general livestock breeds included cows, goats, horses, chickens, ducks, and pigeons. The aquaculture varieties comprised Rui (Labeo rohita), Catla (Labeo

catla), Mrigal (Cirrhinus cirrhosis), Kalibaos (Labeo calbasu), Bighead carp (Hypophthalmichthys nobilis), and Tilapia (Oreochromis niloticus), among others.

Table 4. District-wise, the major farming system.

#		Rangpur	Nilphamari	Dinajpur
1	Crops	Fallow-Aman-Maize, Aman-Tobacco-Jute, Aman-Potato-Boro, Aman-Mustard-Boro, Jute-Aman-Vegetables	Aman-Boro-Fallow, Aman-Tobacco-Jute, Aman-Potato-Boro Aman-Potato-Maize	Aman-Potato-Maize, Aman-mustard-Boro, Fallow-Aman-Vegetables
2	Livestock	Cows, Goats, Chickens, Ducks, Pigeons, Horses.	Cows, Goats, Chickens, Ducks	Cows, Goats, Chickens, Ducks,
3	Aquaculture	Rui (Labeo rohita), Catla (Labeo catla), Mrigal (Cirrhinus cirrhosis), Kalibaos (Labeo calbasu), Bighead carp (Hypophthalmichthys nobilis), Tilapia (Oreochromis niloticus), etc.	Rui (Labeo rohita), Catla (Labeo catla), Mrigal (Cirrhinus cirrhosus), Kalibaos (Labeo calbasu), Bighead carp (Hypophthalmichthys nobilis), Tilapia (Oreochromis niloticus), etc.	Rui (Labeo rohita), Catla (Labeo catla), Mrigal (Cirrhinus cirrhosis), Kalibaos (Labeo calbasu), Bighead carp (Hypophthalmichthys nobilis), Tilapia (Oreochromis niloticus), etc.

Table 4 shows cropping patterns are set based on the cropping seasons, which are divided into three types: Kharif-1 (March 16 - June 30), Kharif-2 (July 1 - October 15), and Rabi (November 15 - March 15). Overall, participants from FGD mentioned that in the Aman season, they cultivate Sharna types, BR 11, and BRRI dhan34. In the Boro season, they mostly cultivate BRRI dhan28, BRRI dhan29, BR16, Hira-2, and Janakraj. Other crops include jute, maize, tobacco, mustard, potato, leafy vegetables, vegetables, groundnut, chili, fodder, green peas, garlic, and onion. In these three regions, the primary livestock types are cow, goat, horse, chicken, duck, pigeon, etc. On the other hand, aquaculture types are mostly Rui (Labeo rohita), Catla (Labeo catla), Mrigal (Cirrhinus cirrhosis), Kalibaos (Labeo calbasu), Bighead carp (Hypophthalmichthys nobilis), Tilapia (Oreochromis niloticus), etc.

3.3. Causes of Selecting the Crop Variety

This section examines the factors influencing crop variety selection among participants in the study area, including land quality, water availability, seasonality, crop yield, and market demand. While highland areas are available in certain regions, they present challenges due to water scarcity for irrigation. As a result, participants increase irrigation efforts to support crops grown on highlands to mitigate this limitation. Given that rice is a water-intensive crop, maize and other vegetables are preferred for cultivation on highlands during the winter season. Conversely, rice is predominantly grown in the lowlands of Dinajpur and Nilphamari, where irrigation water requirements are relatively lower. Aman rice is typically cultivated in mid-high to highland areas relying on rainfed irrigation.

Crop selection is also strongly influenced by expected yield and market prices. Maize is favored over wheat for highland cultivation due to its significantly higher yield potential maize yields approximately 40–50 mounds per bigha (33 decimals) compared to just 15 mounds for wheat. Moreover, maize requires less irrigation, enabling multiple cropping cycles on the same land, which increases overall production and income. This explains the widespread preference for maize cultivation among farmers.

Participants employ crop diversification strategies to maximize land productivity and income generation by growing multiple crops such as Aman rice, tobacco, and jute on the same plots. The high market price of tobacco, reaching BDT 3,000 (approximately USD 27.58) per mound, further incentivizes farmers to cultivate tobacco. Additionally, tobacco manufacturers provide financial incentives to encourage continuous tobacco production in the region.

3.4. Causes for Selecting a Livestock Breed

The significance of livestock rearing, especially among respondents from Dinajpur, Nilphamari, and the flood-prone areas of Rangpur, underscores a strategic adaptation to local environmental challenges and livelihood demands. Livestock rearing is notably more prevalent in flood-affected regions compared to other areas. Given the severe financial hardships faced by these communities, livestock serves as a crucial pillar in sustaining household incomes. Annual flooding disrupts crop production, positioning livestock rearing as a resilient alternative for securing both food supply and economic stability.

In this context, livestock, particularly cattle, goats, and horses, fulfill a dual role for households in the flood-affected zones of Rangpur. These animals are regarded as valuable assets, representing both wealth and a source of financial security, enabling families to meet expenses during times of need. Beyond economic benefits, livestock also provide practical advantages, such as facilitating the transportation of crops and goods, with horses playing a vital role in mobility within these regions.

Among the 150 participants, one woman shared her experience with in-house livestock management: "*In my household, I have two cows and two goats. This year, I have acquired one calf and two chevon from these cows and goats, contributing to our wealth growth. Moreover, I sell cow milk daily. If 1.5 kilograms of milk are produced, we consume half a kilogram at home, and the remaining 1 kilogram is sold. The amount of milk produced varies on different days. The money earned from selling milk is consistently used to purchase notebooks and pens for my children.*"
(Age: 32, Village: *Dupachuri*, District: *Nilphamari*).

3.5. Decision to Participate in Farming System Activities

The study aims to identify key decision-makers responsible for various farming system activities, including crop production, livestock, and poultry rearing activities. It provides valuable insights into the dynamics of agricultural decision-making within households in the study area. Table 5 shows land preparation, crop seed selection, pest and disease control, harvesting, marketing, and financial/credit management. Table 6 highlights the primary decision-maker in livestock and poultry planning, rearing, processing, and credit management activities. Additionally, we examined the involvement of both men and women in these activities. Generally, in Bangladesh's northern region, men and women actively participate in agricultural work. However, the decision-making process varies in different farming activities. It depicts the individuals who are accountable for decision-making and the participation of both men and women in farming activities focusing on major crop cycle stages.

Table 5. Decision on various crop production activities.

Activities	Who is the primary decision-maker	Who participates
Seed selection for crops	Male	Both males and females contribute to seed management, with female contribution being greater than that of males.
Land preparation for crop	Male	Male contribution is more than female, but females are partially involved
Pest and disease control	Male	Male
Harvesting	Male	Both male and female (But male contribution is more than female)
Processing	Both male and female	Both male and female (But female contribution is more than male)
Marketing of crops	Male	Male
Financing/ Credit management	Male	Males participate most of the time, but partially females are involved

Table 6. The decision to participate in livestock and poultry activities.

Activities	Who makes decisions	Who participates
Planning	Males control large-sized livestock, and females control small-sized livestock and poultry.	Both males and females participate in livestock, and only females participate in poultry.
Rearing and processing	Both male and female	Females participated more than males.
Financial management	Both male and female	Both male and female

3.6. Women in New Technologies

This section emphasizes the adoption of new technologies and innovative agricultural practices among farmers in northern Bangladesh. These advancements exemplify the farmers' proactive efforts to enhance productivity, promote sustainability, and adapt to changing environmental conditions.

The introduction of improved crop varieties, such as hybrid seeds, enables greater resilience against diverse environmental stresses. Concurrently, the incorporation of crossbred cattle in place of indigenous breeds represents a significant innovation aimed at boosting livestock productivity and optimizing breeding outcomes. Additionally, farmers employ home composting techniques to improve soil fertility while reducing reliance on commercially available chemical fertilizers.

Most participants acknowledged the modest yet impactful initiatives of organizations working in the northern area of Bangladesh. One key initiative has been the promotion of premium-quality rice cultivation. Traditionally, farmers cultivated BRRI dhan28 and 29 varieties; however, they have been encouraged to transition to BRRI dhan50 (commonly known as Bangla Mati).

This shift in rice cultivation is closely associated with the Auto Rice Mill industry. Previously, BRRI dhan28 paddy sold for BDT 30–32 (USD 0.27–0.29) per kilogram, whereas Bangla Mati commands a higher market price of BDT 40 (USD 0.37) per kilogram.

Some respondents shared their experiences cultivating new rice varieties and hybrid cows, stating, *"Now, we are breeding crossbred cows from domestic breeds, which have more milk production. We have also started planting a rice variety called Bangla Mati. Previously, the yield for the paddy BRRI dhan28 and BRRI dhan29 I planted was 30-32 mounds per bigha, but with Bangla Mati, it has increased to 40 mounds per bigha, and the price is significantly higher relative to BRRI dhan28 and BRRI dhan29."* (Age: 36, village: *Khoshalpur*, District: *Dinajpur*).

In the case of maize, a variety named 951 was grown earlier. However, maize faced recurring lodging issues, which decreased yields. Consequently, they have now switched to cultivating the 750 variety instead for higher yields.

3.7. Significant Constraints and Barriers to Active Participation of Women Farmers in Mixed Farming Systems

In this section, Table 7 summarizes the key constraints and barriers faced by women within mixed farming systems, as expressed through their own experiences and perspectives.

These challenges underscore the urgent need for targeted interventions and support mechanisms aimed at bridging knowledge gaps, improving access to resources and information, and strengthening women's capacity to effectively manage agricultural activities, thereby promoting sustainable livelihoods in the study area.

In the northern region, women's limited exposure to modern agricultural technologies and practices is frequently attributed to multiple factors, including entrenched patriarchal family structures, restricted access to agricultural education and extension services, reliance on male family members, and traditional gender roles.

Table 7. Significant constraints, barriers, and potential causes for these constraints.

Constraints and barriers	Potential causes
Lack of knowledge about technology and machinery	Males were rarely permitted to participate in training, farmer organizations, or extension systems.
Information gap about good quality seed	Women needed to be adequately trained by agricultural organizations.
Lack of adequate knowledge about livestock feed and disease.	Women's dependency on the male members of the family
Proper knowledge gap about homemade compost	Women need help understanding the need for homemade compost and the production process.
Lack of identifying proper poultry disease	They usually contact a nearby veterinary medicine dealer first and do not need to consult any veterinarian doctor.

Case 1. Inability to identify crop disease.

One of the participants expressed her experience with the inability to accurately identify crop diseases.

"We are planting brinjal. I suddenly saw that the brinjal plant was getting soft. I cannot understand what is causing it. I am giving different pesticides and insecticides based on advice from neighbors and peers, but it is not working. The plants are dying."

(Age: 43, Village: *Araji Horesha*, District: *Rangpur*).

Case 2. New insect attack on crops.

Participants said crop production requires large amounts of pesticides and fertilizers, resulting in less profit due to the higher costs involved. On the other hand, the number of rats is comparatively higher than before and is growing. If any crop is planted, rats cut down those plants and damage them fully.

A member of the respondents described their experience of insect attack in crops, saying.

"I went to the field three days ago to see what a beautiful paddy is. Peace of mind when you see the paddy field. But after three days, I saw that the plants were all white. Insects are cutting down all the plants. I am applying pesticides BDT2000-3000 (18.43 USD - 27.65 USD) to cultivate one bigha of land. Even then, the insects are damaging the plants. This is called Brown Plant Hopper (BPH) insects (Nilaparvata lugens). These insects eat the young leaves of rice and maize."

(Age: 39, Village: *Dakhin Ramnathpur*, District: *Rangpur*).

A member of the respondents stated that, regarding the rat attack.

"I came to know about it from one army personnel when I was young. Army personnel said the rat was abandoned in Cholan beel areas and frequently damaged crops. Now I see these rats are in the crop field in our area."

(Age: 50, Village: *Kalitola*, District: *Nilphamari*).

Case 3. Availability of fertilizer.

While producing crops, participants said that fertilizer is a mandatory element for obtaining profit in crop production. Some respondents shared their experiences when they went to collect fertilizer; they said.

"For optimal growth and yield, providing nourishment at the right moment is crucial. However, giving it in the afternoon instead of feeding it in the morning is not good for health. It is the same with plants. They will not produce good crops if you don't apply it at the right time. Some days ago, I went to the market to get fertilizer in the morning and returned in the afternoon but did not get any fertilizer from the fertilizer dealer. After two days of rotation, when I got fertilizer, it was 5 kg instead of 10 kg required, with which the crop was not produced well."

(Age: 29, Village: *Shahbajpur*, District: *Rangpur*).

3.8. Cases from Livestock Rearing

Case 1. More diseases attack livestock, and there is a failure to maintain livestock health.

Participants said that cow disease is more common than before. Also, if you keep ducks and chickens at home, they all die from fowl pox (Avipoxvirus). Besides, in the case of cattle and goat rearing, they cannot provide enough nutritious feed. With nutritious feed, their health will improve.

Participants expressed their opinions when they faced food shortages in cattle rearing, saying,

"We cannot properly feed the cattle and goats. There is a little straw and some grass from the fields. We cannot give other nutritious feed; it dries them up, and they barely survive."

(Age: 53, Village: *Dupachuri*, District: *Nilphamari*).

3.9. Identify Top Priority Issues to Solve from Women's Perspective

Table 8 summarizes the top priority issues identified by participants in addressing the challenges faced in mixed farming systems. These expectations reflect the aspirations of women farmers to access resources, support services, and opportunities that enable them to overcome constraints, improve productivity, and enhance their livelihoods in the agricultural sector.

Table 8. Identifying top priority issues.

Farming system	Top priority to solve
Crops	Irrigation: It is better to address the issue of how to select and produce crops with limited irrigation effectively.
	Own seeds: Own seeds can provide a good yield of crops.
	Fertilizer: Fertilizer is available at the right time and at a fair price for crop cultivation.
	Harvesting machines: Ensure that threshing and plowing machines are equally gender-sensitive.
Livestock and poultry	Breed: Crossbreed cattle are produced from native breeds.
	Availability of doctor: Doctor's availability and willingness to treat cows and goats properly.
	Nutritious feeds: Producing sufficient nutritious feeds or fodder without purchasing them for cattle.

3.10. Implications for Mixed Farming System Intervention on Women's Participation

This section highlights several strategies to enhance and empower women's roles within mixed farming systems, particularly in a male-dominated society characterized by restrictive social norms. First, agricultural organizations should be encouraged to actively promote women's participation while engaging men in community dialogues to foster inclusive support. Second, targeted training on agricultural technologies and machinery should be delivered by women trainers, alongside the promotion of home composting through tailored educational programs. Third, there is a pressing need for increased training focused on livestock disease management and the nutritional value of animal products. This includes raising awareness about livestock diseases and providing clear guidance on response measures, facilitated through accessible veterinary videos designed to reach and educate women farmers effectively.

4. DISCUSSION

Studies in South Asia and Ethiopia highlight distinct gender roles in agriculture, with men often leading tasks such as land preparation, pesticide application, and marketing. At the same time, women handle crop establishment, weeding, harvesting, and post-harvest activities (Akter et al., 2017; Taha et al., 2014). This study explores the mixed farming system in northern Bangladesh, focusing on farming practices, decision-making, technology adoption, and the challenges women face in participation. In regions like Gopalganj, the introduction of mixed cropping in lowland areas has improved economic conditions (Shaibur, Husain, Mollah, & Mow, 2019). In Jashore's Beel Kapalia, coping strategies such as floating agriculture and mixed farming support alternative livelihoods (Shaibur, Rizvi, Islam, & Shamsunnahar, 2019). Similarly, the Coastal Bhola District employs mixed farming to

adapt to environmental challenges and enhance livelihoods (Ishtiaque, Alam, & Rahman, 2020). In northern Bangladesh, areas such as Rangpur, Nilphamari, and Dinajpur also practice mixed farming to improve socio-economic conditions and adapt to climate change impacts such as floods, droughts, and extreme temperatures.

In northern Bangladesh, women adopt innovative strategies such as new crop varieties, crossbreeding cows, and homemade composting to enhance productivity and livelihoods. By adopting new technologies, rural women can increase crop yields (Sarker, Salam, & Firdaus, 2024; Singh, Prasad, & Reddy, 2013). Like adopting high-yielding breeds, livestock extension services can boost farm income and reduce gender gaps (Alemayehu & Kebede, 2015; Sarma, Alam, Begum, & Sayem, 2024). Crop diversification, such as rice-shrimp farming in Southwest Bangladesh, offers women new opportunities beyond traditional roles (Akber, Islam, Rahman, & Rahman, 2022). Participation of rural women of mixed agriculture is influenced by various factors, including demographics, experience, workload, and resource access (Fami, 2006). In Southern Ethiopia, female-headed households adopt fewer improved maize varieties than male-headed ones, particularly when decisions are made jointly (Gezimu, Abera, & Abebe, 2019). In contrast, studies from Myanmar, Thailand, Indonesia, and the Philippines show that women have equal access to productive resources and greater control over household income (Akter et al., 2017). In Ecuador, landownership forms impact decision-making, with gender differences based on roles and rights (Jennifer, Martinez, & Perez, 2015).

In our study, we observed a similar trend. The decision-making process in mixed farming in northern Bangladesh reflects complex gender dynamics within households. Men typically lead decisions on crop production, while women contribute significantly to processing and, to a lesser extent, livestock and poultry management.

In rural Africa, women often manage a significant portion of livestock, such as sheep, goats, and poultry, and their sale during financial crises helps ensure family food security (Sekaran, Lai, Ussiri, Kumar, & Clay, 2021). Similarly, in northern Bangladesh, women are key in dairy and income management (Hasan, Haq, & Abdullah, 2023). Women also play crucial roles in livestock management, processing, and marketing (Patel, Patel, Patel, Patel, & Gelani, 2016). Bangladesh's participation in agriculture has gradually increased compared to men (Jaim & Hossain, 2021). However, in a study from Uganda, Ghana, and Bangladesh perspectives, women face constraints in climate-smart agricultural practices, such as limited access to information, financial resources, and societal norms (Jost et al., 2016).

This study identified several barriers to women's participation in the mixed farming system, including information gaps, limited resources, and household decision-making dynamics. Empowering women through education, training, and access to extension services can improve their agricultural management skills. Women spend a significant amount of time on livestock management, often buying feed with their husbands' support, but they lack knowledge about the nutritional value of the feed.

Participants highlighted key issues women face in crop production and livestock management. Addressing these challenges requires focused interventions to improve women's access to information, resources, and decision-making power.

Women often face restrictions in accessing training and extension programs, with limited decision-making power within households due to sociocultural norms and gender inequalities (Hasan et al., 2023; Paris, 2002). In Uganda, women are often limited to cultivating low-return crops, though crop diversification could offer significant benefits (Peterman, Quisumbing, Behrman, & Nkonya, 2011). Information-seeking behaviors positively influence farming decisions (Füsun Tatlıdil, Boz, & Tatlidil, 2009; Kabir, Rainis, & Azad, 2017; Mazvimavi & Twomlow, 2009). In Bangladesh, women's media use significantly impacts post-harvest processing choices, and they have multiple sources of farming knowledge (Kabir, Afroz, Alam, & Rahman, 2023).

The study highlights pathways to enhance women's participation in mixed farming by addressing entrenched social and structural barriers. Women's exclusion from farmer organizations, extension systems, and credit networks remains pervasive. Agricultural organizations must promote equitable involvement of both genders and

provide training through female trainers, emphasizing gender-sensitive approaches to technology and machinery use. Additionally, awareness programs on livestock diseases and nutrition supported by accessible veterinary video resources—are essential. Although families encourage women's agricultural engagement, they often restrict their access to marketing channels, limiting women's economic empowerment.

4.1. Limitations of the Study

This study has several limitations regarding data collection and analysis. Firstly, interviews were conducted exclusively with women participants, and data were gathered and recorded solely from their perspectives; the perceptions of male family members were not captured or analyzed. Secondly, the data were not subjected to statistical validation, as the findings are based primarily on qualitative case study analysis. To obtain more comprehensive and robust insights, future research should incorporate perspectives from both men and women and employ quantitative methods to validate and complement qualitative findings.

5. CONCLUSION

This study explores women's involvement in agriculture within the mixed farming systems of northern Bangladesh, emphasizing the significant barriers they face. A primary challenge is the lack of skills related to farming technologies, which restricts their active participation. While men predominantly lead decisions regarding women's roles in farming, joint decision-making is more common during post-harvest activities. Despite these dynamics, both men and women contribute extensively across various agricultural tasks, reflecting a blend of traditional gender roles and evolving practices.

Women's limited knowledge spans farming technologies, machinery use, access to quality seeds, pest and disease management, fertilizer availability, and livestock nutrition. To overcome these challenges, women prefer cultivating crops that require less irrigation, accessing affordable inputs, utilizing gender-sensitive equipment, and receiving veterinary care. They balance agricultural work alongside household responsibilities, underscoring the need to acknowledge their contributions while addressing practical constraints.

Although women participate in household decisions related to crop and livestock management, men ultimately hold control over women's engagement in these activities. To foster greater inclusion, agricultural organizations should implement gender-transformative approaches, including community dialogues and targeted training programs to enhance women's decision-making power and resource accessibility. Promoting women's participation through female-led training on technology and livestock management, supplemented by veterinary educational videos, can significantly empower rural women within mixed farming systems.

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Institutional Review Board Statement: The study involved minimal risk and followed standard ethical guidelines for social science fieldwork. Formal approval from an Institutional Review Board was not required due to the nature of the study. The study was done following basic ethical guidelines and principles. Informed verbal consent was obtained from all participants, and all data were anonymized to protect participant confidentiality.
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
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