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# Livestock farming and women empowerment in rural Bangladesh: a mixed method approach

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## Abstract

**Background** In Bangladesh, livestock farming is not only a major source of animal protein, but it also provides opportunities for women to contribute to household income. Therefore, this study was undertaken to identify the empowerment status of women livestock farmers, factors influencing women's participation in livestock farming and its impact on women's empowerment.

**Methods** The study was conducted in the Mymensingh district (administrative unit) of Bangladesh, due to the active participation of women in livestock farming activities. A total of 200 women were surveyed between May to November 2018. Additionally, prior to the final survey, 02 Focus Group Discussions (FGDs) were performed to gain insight into the context of the study areas. Furthermore, a total of 12 semi-structured in-depth interviews were performed with 12 experienced women livestock farmers to collect data regarding the challenges they encounter in livestock farming. Women empowerment was measured using four domains: decision-making process, ownership of assets, social and political awareness, and freedom of mobility. Descriptive statistics, and Heckman's endogenous treatment effect model were applied to analyze the data.

**Results** The results revealed that majority (75%) of women who are involved in livestock farming had a medium level of empowerment. Women's decision to participate in livestock farming was positively influenced by farm size, knowledge, extension contact, and training. According to the average treatment effect on the treated (ATT) value, the empowerment status of women is 16 points higher among participants in livestock farming compared to non-participants. Furthermore, women in rural areas face several obstacles such as economic issues and inadequate marketing facilities, which may prevent them from engaging in livestock farming.

**Conclusions** Educating women through raising awareness and providing training is warranted because there is a notable disparity in the empowerment status of women who are and are not involved in livestock farming. This will help women improve their social awareness, decision-making capacity, and mobility. Livestock initiatives that encourage women's involvement could be generated by various rural-focused organizations.

**Keywords** Endogenous treatment effect model, Livestock farming, Women decision making power, Women empowerment

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## Background

Livestock farming is an important sub-sector of the Bangladesh's agriculture-based economy. It is a major source of income for rural people in Bangladesh as well as a key supplier of animal protein (Rahman et al. 2014). More than 10 million people are employed in the livestock sector, which accounts for around 12% of the country's GDP (Chowdhury et al. 2016). Livestock farming provides excellent opportunities for enhancing family earnings through women participation and thereby increase their empowerment status (Bairwa 2013; Galie et al. 2022). Women are mainly involved in activities such as, herding, collection of forage, animal sheds cleaning, bathing, watering the animals, feeding, gutter cleaning, dung cake making, utensils cleaning, milking, and marketing (see Fig. 1) (Shafiq 2008; Singh et al. 2017; Bhauria and Singh 2019; Akram et al. 2019; Rahman et al. 2020). Through earnings from this sector, these activities serve as a source of social, financial, and natural wealth, which may contribute to women's empowerment (Akter et al. 2018). Livestock present a unique opportunity for rural women to access and control productive resources, unlike land and machinery (Galiè et al. 2015; Njuki and Sangina 2013). By promoting gender equity—ensuring equal life outcome by addressing the diverse needs, resources, and power dynamics between men and women—livestock systems can contribute to overall gender equality, fostering a fair and inclusive society (Galiè et al. 2019).

Women empowerment is a broad term and multi-faceted concept (Chaudhry and Noshseen 2009, 2012; Wright and Annes 2016; Leder et al. 2017; Sharaunga

et al. 2019) including the "power to" change one's situation, the capacity to "power with" others, and the ability to develop and nourish "power inside" oneself (Oxaal and Baden 1997). It is the woman's ability to exert control over her own life, body, and environment which frequently emphasized on rights to decision-making, economic independence, and legal protection against all sorts of discrimination (Astutik et al. 2020). Empowerment of women is not only desirable for a nation's development, but it is also crucial for poverty reduction and economic progress (Sohail 2014). It also pivotal for upholding democratic and human rights, reducing gender inequality that challenges traditional norms and stereotypes, promotes equal access to resources, advocates for women's rights, and encourages their participation in decision-making processes. Through creating supportive environments that sustain gender equality, leading to lasting empowerment for women (Kabeer 1999; Cornwall and Rivas 2015). Women's participation in livestock farming is viewed as one approach for women's empowerment through increasing the income (Herrero et al. 2013; Bain et al. 2018). In addition, food and nutrition security and shock resilience may all be improved through livestock production (Varjakshapanicker et al. 2019). According to Grace (2005) livestock production activities can help women to earn money which in turn act as their bargaining tools and increase their decision-making power in all aspects of their life.

Globally, livestock farming plays a crucial role in empowering women by offering economic opportunities, asset ownership, skill development, social status, and decision-making power. In sub-Saharan Africa and



**Fig. 1** Involvement of women in livestock farming

South Asia, Kristjanson et al. (2014) observed that livestock farming could generate substantial income, which enhances women's economic independence and ensures children's education, healthcare, and nutrition. Jadoun et al. (2021) investigated the contribution of livestock-based Self-Help Groups (SHGs) on women's empowerment in India. They found that participation in SHGs significantly enhanced women's empowerment, both socially and economically, by fostering entrepreneurial ventures. Sharma et al. (2020) also concluded in their study that goat and dairy farming shows a positive impact on tribal women economic empowerment in Madhya Pradesh of India. Similarly, Ambreen et al. (2024) indicated that engagement in livestock activities notably boosted women's empowerment, particularly in economic and social realms in Pakistan. They experienced heightened access to income, greater influence in decision-making, and enhanced social standing. Based on a comprehensive analysis of case studies from 13 countries, Galie et al. (2022) proposed that all domains of women empowerment need to converge for women to achieve empowerment through livestock. Bain et al. (2020) proposed that women's empowerment and gender equity were positively influenced by owning dairy cows, based on insights gained from in-depth interviews. Furthermore, several previous studies (Jamatia et al. 2020; Kumar et al. 2021) suggested that small scale dairy has significant contribution in women empowerment through providing additional source of income and employment in India. A study conducted by Ahmed et al. (2021) suggested that poultry rearing had a great contribution on women empowerment and increased their decision-making skills in Bangladesh. However, most of these studies used only descriptive statistics to achieve their study's objectives. A few studies (Yasmin and Ikemoto 2015; Islam et al. 2019) suggested that women in rural areas who engaged in small-scale dairy farming reported higher levels of self-esteem, a wider social support network, and a greater sense of independence because of enhanced empowerment status. However, a variety of constraints, including a lack of resources, limited access to market-related information, and unequal power relations among family members as well as in the community, prevent women from engaging in livestock farming (Islam et al. 2019). As a result, it is critical to identify the factors influencing women's livestock farming participation and its impact on their empowerment status in developing countries such as Bangladesh to develop appropriate policies to improve women's empowerment.

The previous discussion indicated that although there is a growing body of information on the relationship between women's empowerment and livestock, there is still a need for further empirical research to fully

understand the impact of livestock farming on women's empowerment. Given the circumstances, this study aimed to determine the state of empowerment among women who are livestock farmers. It also sought to identify the factors that influence their decision to engage in livestock farming, assess the impact of livestock farming on women's empowerment, and examine the challenges faced by women in this field. Therefore, the present study aims to provide answers to the following research questions: What is current empowerment status of the women livestock farmers? What are the determinants of the decision to participate in livestock farming by women farmers? What is the impact of livestock farming on women empowerment? and What are the challenges that women livestock farmers encounter in the case of livestock farming?

The study contributes to the existing literature in two ways: first, the majority of researchers considered only one aspect of livestock farming (small-scale dairy farming, or poultry rearing, or goat farming). Very few researchers have considered overall livestock farming and its impact on women empowerment in Bangladesh. This study examines the overall livestock farming and its influence on the empowerment of women. Furthermore, most of the prior research utilized simple statistical techniques or conducted case studies to accomplish their goals. This study utilized a rigorous econometric model to ascertain the causal impact of livestock farming on the empowerment of women. The study will provide insights into the role of livestock farming in empowering women by fostering economic benefits, social status, decision-making, and skill development. Additionally, the study will highlight the importance of the sector in promoting gender equality and improving the overall well-being of women in farming communities. The article is divided into five sections. The first and second sections depicted the introduction and methodology. The third and fourth sections focused on the results and discussion on factors influencing women's participation in livestock farming and its impact on empowerment. The final section of the article discusses the conclusions and recommendations.

## Methods

### Study areas and sampling technique

The study followed a multistage sampling procedure. First, Mymensingh district (administrative unit) was selected purposively. Mymensingh is one of the major livestock producing district in Bangladesh and women actively participate in different types of livestock farming such as goat rearing, small scale dairy farming, poultry farming, and duck farming (Islam et al. 2016, 2019; Kumar et al. 2018; Modak et al. 2019). Second, one sub-district, namely Mymensingh Sadar, was selected from

the district for face-to-face surveys due to the active involvement of women in livestock related activities (Roy et al. 2017). This selection was based on the review of relevant literature and consultation with experts. Third, after consulting with sub-district level livestock officer, two villages were purposively selected. These selected villages are suitable for livestock farming and many households are engaged in small scale livestock farming (Kumar et al. 2018; Modak et al. 2019; Hossain 2020). Notably, women in these selected villages were involved in small-scale livestock farming. Despite the risks of physical injuries from handling animals, financial challenges in acquiring and maintaining livestock, and potential health issues from close animal contact, they managed these tasks independently. Meanwhile, men participated in various other income-generating activities, including working as rickshaw (a three-wheeler vehicle) pullers, carpenters, painters, masons, bicycle repairers, farmers, and more. Women in these villages received livestock rearing training from the sub-district livestock office, as well as some financial assistance from non-governmental organizations (NGOs) to purchase livestock. According to sub-district livestock officer, a total of 556 women were actively engaged in livestock farming. A list of these women was obtained from the sub-district livestock office. Yamane's formula (Eq. 1) was used to determine the minimum sample size for this study (Yamane 1967). This formula is widely used by other researchers (Hussain and Thapa 2012; Zulfiqar and Thapa 2016; Roy et al. 2021).

$$n = \frac{N}{1 + N(e^2)}, \quad (1)$$

where  $n$  is the minimum sample size,  $N$  is number of population (556), and  $e$  is the precision level, which was set at 10% (0.10). Several studies suggested that precision level can be customized due to limitations in resources (Kabir et al. 2022; Rahman et al. 2022). Furthermore, the central limit theorem can be applied to a reasonable sample size because the population we are studying is reasonably harmonious. Therefore, we set the precision level at 10%. Equation (1) provided the minimum sample size of 85. However, we surveyed a total of 100 women, equally divided between two villages, each having at least 1 year of experience in raising at least one type of livestock. To validate and compare the findings, another 100 women from other villages who were not involved with livestock farming were also surveyed.

#### Data collection

In accordance with Creswell (2014), this study utilized exploratory sequential mixed methods, which consisted of two phases. In the first phase, a qualitative approach

was used to explore the opinions of respondents. During this phase, two focus group discussions (FGDs) were conducted to gain a deeper understanding of women's participation in livestock farming and their level of empowerment. A group of 10 women, each with a minimum of 8 years of experience in livestock farming, were chosen for each FGD. A trained and skilled facilitator led the FGDs, which were audio-recorded with notes taken on the important issues. The discussions, held at the school premises, lasted for 60 min in the local *Bangla* language. A non-structured questionnaire was used to gather data, with the basic guidelines on what kinds of information the facilitator should collect. Participants did not have prior acquaintance with the facilitator. The facilitator explained the study objectives to the participants, emphasizing a focus on gathering perspective on women's empowerment. Information was gathered regarding various aspects of women's empowerment, including participation in decision-making, freedom of movement, asset ownership, and political and social awareness. We actively listened to the live FGDs, repeatedly reviewed the audio recordings, and read the important notes. Afterwards, we transcribed the FGDs so that we could pick out the respondents' opinions. The information gathered from FGDs is also utilized in formulating interview schedule for conducting face-to-face interviews. The interview schedule was firstly prepared in English and then translated into the local *Bangla* language. Three enumerators were hired and trained for the collection of data. From May to November 2018, a face-to-face survey was conducted to collect data on various aspects of women's empowerment among both livestock participants and non-participants women. Furthermore, semi-structured in-depth interviews were conducted with 12 women farmers who had at least 08 years of livestock farming experience, to get detailed information about constraints in livestock farming. The interview schedule includes various aspects of women's empowerment: women's participation in household and farm-level decision-making, their extent and areas of movement in different public places, their ownership and control over various household assets, and their awareness of social and political activities.

#### Analytical techniques

The collected data was cleaned for error detection and omission. The random utility (RU) theory was used to determine the factors influencing women's participation in livestock farming. Following RU theory, drivers of participation in livestock farming can be estimated using the following equation:

$$Z_i^* = \beta k X_i + u_i, \quad (2)$$

where  $Z_i^*$  is the latent variable representing the difference between utility gain from participation in livestock farming,  $\beta_k$  is the parameters to be estimated,  $X_i$  is the independent variables, and  $u_i$  is an error term. In this study we applied probit regression to assess the relationship expressed in Eq. (2). The following empirical model was used to identify the factors affecting women participation in livestock farming:

$$Z = \beta_0 + \sum_{i=1}^{10} \beta_k X_i + u_i, \tag{3}$$

Where  $Z$  is participation status (1 if involved with livestock farming),  $X_i$  are the independent variables,  $\beta_s$  are parameters to be estimated and  $u_i$  is error term. The marginal effect was also calculated to estimate the effect on the likelihood of achieving each of many outcomes rather than the effect on a single conditional mean (Cameron and Trivedi 2009).

Following Abdallah et al. (2019), the impact of livestock farming on women empowerment can be estimated using the following equation:

$$Y_i = \beta \cdot iX_i + \gamma D_i + v_i, \tag{4}$$

where  $Y_i$  is women empowerment,  $D_i$  = participation status,  $v_i$  is the error term.

However, selection bias may occur if latent variables influence the error terms in Eqs. (3) and (4). Controlling selection bias from observable sources is possible by incorporating a set of variables into the model (Danso-Abbeam et al. 2018). However, it is difficult to control selection bias from unobservable factors by introducing variables. Consequently, measuring the impact using Eq. (4) by ordinary least square (OLS) can produce biased results. This study employed Heckman’s endogenous treatment effect model to circumvent this issue

(Heckman 1976, 1978). Heckman’s endogenous treatment effect model is an expansion of his two-stage model (Danso-Abbeam et al. 2018). In Heckman’s endogenous treatment effect model, the dependent variable in the selection equation becomes one of the independent variables in the outcome equation. Heckman’s endogenous treatment effect model can be utilized only when the correlation between the two error terms is greater than zero (Heckman 1979; Hoq et al. 2021). The first stage of Heckman’s endogenous treatment effect model is a probit model as specified in Eq. (2), and the second stage is OLS regression used to estimate the impact of livestock farming. The endogeneity was examined through a Wald test. An instrument is considered valid if it influences involvement in livestock farming but does not directly impact the outcome variable (women empowerment). The study utilized information source, specifically extension contact, as an instrumental variable (Hossain and Karim 2020). One can acquire information on livestock farming, which may influence their decision to adopt it, by contacting extension agents. Nevertheless, it does not exert any direct impact on the dependent variable (women empowerment). The instrumental variable was validated using a Pearson correlation test (Ma and Wang 2020).

**The variables**

The independent variables for this study were selected based on previous studies (Debnath et al. 2019; Akter et al. 2021; Nath and Athinuwat 2021). Table 1 provides a summary of these independent variables. In this study, the empowerment of women is the outcome variable. Various authors have measured the status of women’s empowerment using a variety of dimensions (Ackerly 1995; Hashemi et al. 1996; Biswas and Kabir 2004; Mahmud et al. 2012; Nessa et al. 2012; Alkire et al.

**Table 1** Description of the independent variables used in the model

Independent variables	Description	Expected sign
Age (years)	Age of the respondent in years	±
Education (years)	Total years of schooling of the respondent	+
Household size (number)	Total number of family members	–
Farm size (ha)	Total area of farm in hectare	+
Knowledge on livestock farming (score)	A series of questions regarding livestock farming were asked. Each correct, partially correct, and incorrect answer receives a score of 3, 2, 1, and 0. Finally, the respondent’s total knowledge score was calculated	+
Livestock farming experience (years)	Total number of years involved in livestock farming related activities	+
Annual household income (USD)	Total amount of household annual income from both farm and non-farm sources	+
Training (days)	Total number of days attended in training programs on livestock farming	+
Credit (USD)	Total amount of money borrowed by the respondent	+
Extension contact (number)	Frequency of contact with extension agents during last one month	+

2013; Malapit and Quisumbing 2015; Nath and Athinuwat 2021). This study, however, followed and adapted the dimensions used by Nessa et al. (2012) and Nath and Athinuwat (2021). Nessa et al. (2012) employed this scale to assess the impact of microcredit on the empowerment of women, whereas Nath and Athinuwat (2021) applied this scale to test the level of women’s empowerment in organic farming. We opted for this scale due to its straightforwardness and suitability in the context of Bangladesh. Four dimensions were used to collect data on the empowerment of women: participation in the decision-making processes, ownership of assets, political and social awareness, and freedom of movement. We measure women’s empowerment through these four dimensions that we see as indicators of the broadening of women’s choices and freedoms in decision-making, enabling them to take actions that can shape their life outcomes. These dimensions were selected because we feel that in the context of Bangladesh, they capture the essence of women’s empowerment, reflecting women’s fundamental rights within the family, society, and nation as depicted in various literature. Women’s participation in the decision-making processes within the household indicates their empowerment and autonomy within the family unit, moving away from traditional male-dominated roles. This inclusion can result in a fairer allocation of resources and responsibilities, encompassing areas such as education, healthcare, general family well-being, and aspects related to livestock. Women’s ownership of assets within the household indicates their economic empowerment and independence within the family unit. This shift towards more balanced gender dynamics

allows women to have control over resources like income, land, housing, or livestock. Such ownership can enhance financial stability and security for them, their children, and their families, significantly impacting their overall well-being. In addition, women’s political and social awareness reflects their understanding of societal issues and their ability to engage in political and social activities. It signifies the willingness to participate in decision-making processes, advocate for their rights, and contribute to community development. This awareness is crucial for promoting gender equality, empowering women, and creating more inclusive and just societies. In Bangladesh, a society with traditional male dominance, women often encounter constraints on their freedom to move about freely. Such restrictions can reveal deeper gender inequalities and their restrictions on women’s rights and opportunities. Their ability to move independently reflects their autonomy, empowerment, and access to livestock resources, employment, healthcare, and involvement in social and political spheres. In total, 28 statements were utilized to assess empowerment across four dimensions, with seven statements for each dimension. A modified 4-point Likert scale with weights of 3, 2, 1, and 0 was used (Table 2). Respondents were asked to rate each dimension on a modified 4-point Likert scale ranging from 0 to 21. Each dimension was categorized into three levels based on these scores: low (0–7), medium (8–15), and high (> 15). The total empowerment scores therefore ranged from 0 to 84, categorizing them into four levels based on these scores: very low (0–20), low (21–40), medium (41–60), and high (61–84). In addition, the Total Observed Score of a Statement (TOSS)

**Table 2** Measurement procedure of TOSS for each dimension

Dimension	Scale (4-point)	Formula
Participation in decision-making processes	3—fully own decision 2—decision mainly taken by discussing with husband 1—joint decision (all family members), and 0—no power of decision	$TOSS = (DM_o \times 3) + (DM_h \times 2) + (DM_j \times 1) + (DM_n \times 0)$ Where, $DM_o$ = No. of respondents indicating fully own decision, $DM_h$ = No. of respondents indicating decision mainly taken by discussing with husband, $DM_j$ = No. of respondents indicating joint decision, $DM_n$ = No. of respondents indicating no power of decision
Ownership of assets	3—high 2—medium 1—low, and 0— not at all	$TOSS = (O_h \times 3) + (O_m \times 2) + (O_l \times 1) + (O_n \times 0)$ Where, $O_h$ = No. of respondents indicating high, $O_m$ = No. of respondents indicating medium, $O_l$ = No. of respondents indicating low, $O_n$ = No. of respondents indicating not at all
Political and social awareness	3—high, 2—medium, 1—low, and 0—not at all	$TOSS = (AW_h \times 3) + (AW_m \times 2) + (AW_l \times 1) + (AW_n \times 0)$ Where, $AW_h$ = No. of respondents indicating high, $AW_m$ = No. of respondents indicating medium, $AW_l$ = No. of respondents indicating low, $AW_n$ = No. of respondents indicating not at all
Freedom of movement	3—frequently, 2—occasionally, 1—seldom, and 0—not at all	$TOSS = (F_f \times 3) + (F_o \times 2) + (F_s \times 1) + (F_n \times 0)$ Where, $F_f$ = No. of respondents indicating frequently, $F_o$ = No. of respondents indicating occasionally, $F_s$ = No. of respondents indicating seldom, $F_n$ = No. of respondents indicating not at all

This table is partially adopted from Nath and Athinuwat 2021

**Table 3** Socio-economic characteristics of the respondents

Silent features	Women participants			Non-participants		
	Observed score range	Mean	Standard deviation	Observed score range	Mean	Standard deviation
Age (years)	17–65	30.72	9.59	17–70	32.39	9.69
Education (years)	0–10	5.78	3.19	0–9	4.37	2.68
Household size (number)	2–11	5.03	1.63	2–15	6.58	3.12
Livestock farming experience (years)	2–21	11.66	5.57	0	0	0
Farm size (ha)	0.01–0.56	0.082	0.1	0–0.47	0.06	0.08
Annual household income (USD)	262–5552	1817	87.23	274–2105	1550	54.48
Training (days)	0–90	27.26	17.17	0	0	0
Credit (USD)	0–2705	368	36.25	0–2000	426	34.80
Extension contact (number)	0–25	16.19	4.53	0–18	7.13	5.03
Knowledge on livestock activities (score)	1–25	15.01	4.88	1–13	5.56	3.16

was computed for each dimension of empowerment (Nath and Athinuwat 2021). The TOSS score could range from 0 to 300.

**Results**

**Socio-economic characteristics of respondents**

Table 3 displays the socio-economic characteristics of the respondents. The findings revealed that women involved in livestock farming tend to be younger than those who are not. Livestock farming participants have higher education, and smaller household size than their counterparts. The annual household income is also higher for women involved in livestock farming compared to their counterparts. Participants in livestock activities possess greater training experience, have more frequent contact with extension services, and exhibit a higher level of knowledge regarding livestock compared to non-participants.

**Overall empowerment status**

Table 4 reveals that the majority of participating women (75%) had a medium level of empowerment, while 61% of non-participating women had a low level of empowerment. The significant t-value (8.342\*\*) indicates that a significant difference exists between these two groups of women in terms of participation in decision-making, freedom of movement, asset ownership, and political and legal awareness. It demonstrates the empowerment gains made by women farmers, allowing them to focus on their own perspectives, needs, and demands.

**Dimensions of women empowerment**

**Participation in decision making processes**

The participation of women in decision-making and control over their own lives are the most essential indicators

**Table 4** Overall empowerment status of women based on four dimensions

Empowerment status	Women participants		Non-participants	
	Number	%	Number	%
Very low (0–20)	3	3	7	7
Low (21–40)	8	8	61	61
Medium (41–60)	75	75	30	30
High (61–84)	14	14	2	2
Mean	49.48		38.15	
SD	11.12		12.88	
t-value	8.342***			

\*\*\*Indicates significance at 1% level

**Table 5** Women’s participation in decision making processes

Decision making status	Participating women		Non-participants	
	Number	%	Number	%
Low (0–7)	16	16	51	51
Medium (8–15)	76	76	43	43
High (> 15)	8	8	8	8
Mean	12.82		9.71	
SD	3.88		3.85	
t-value	5.694***			

\*\*\*Indicates significance at 1% level

of women empowerment, as it demonstrates their status and dignity within the family (Kabeer 1999). The majority of livestock-rearing women farmers (76%) had a medium level of participation in the decision-making processes, whereas 51% of non-participating women reported a low level of participation (Table 5). The significant t-value

**Table 6** Rank order of statements about participation in decision-making processes

Decisions	Extent of participation in decision-making processes				TOSS	Rank order
	Fully own decision	Decision taken by discussing with husband	Joint decision (All family member)	No power of decision		
Child schooling	65	25	5	5	250	1
Selection and buying of livestock	50	20	20	10	210	2
Buying clothes for own and others	45	25	23	7	208	3
Buying household furniture and other necessities	43	27	15	15	198	4
Birth spacing	25	45	20	10	185	5
Family get-together	20	25	44	11	154	6
Child marriage	19	22	50	9	151	7

TOSS total observed score of a statement

**Table 7** Women's status on ownership of assets

Ownership status	Participating women		Non-participants	
	Number	%	Number	%
Low (0–7)	10	10	54	54
Medium (8–15)	57	57	43	43
High (> 15)	33	33	3	3
Mean	13.95		9.77	
SD	4.40		3.71	
t-value	7.259***			

\*\*\*Indicates significance at 1% level

(5.694\*\*) indicates that these two groups differ significantly in their participation in decision-making. The TOSS value makes it easier to determine their level of participation in the decision-making processes regarding their day-to-day lives, their children's education, the well-being of other family members (Table 6). Women are most involved in decisions regarding the education of children, followed by the selection and acquisition of livestock.

**Ownership of assets**

Possession of assets is crucial for women to demonstrate their position in the family and participation in decision-making (Akram 2018). According to Table 7, 57% of women involved in livestock farming owned a medium level of assets, while 54% of non-participating women owned a lower level of assets. The statistically significant t-value (7.259) indicates that there is a significant difference between the two groups. The TOSS value suggests that the majority of female livestock farmers have the ability to possess their own money and allocate it for their own purposes (Table 8).

**Political and social awareness**

It is revealed from Table 9 that women engaged in livestock raising have a moderate level of understanding regarding their political and social rights, while their counterparts demonstrate a lower level of awareness. The TOSS score suggests that "Speaking out against child marriage" was ranked as the top decision, while "voting for the preferred candidate" came in second place (Table 10). The findings are in line with the findings of previous study conducted by Swain and Wallentin (2012).

**Table 8** Rank order of statements about ownership of assets

Item of assets ownership	Extent of ownership				TOSS	Rank order
	High (3)	Medium (2)	Low (1)	Not at all (0)		
Own income is spent on one's own	63	27	10	0	253	1
Invested money on livestock farming	59	23	14	4	237	2
Spending own money for child education	55	25	19	1	231	3
Saving money for future	52	26	21	1	229	4
Taking loan from NGOs or other sources	39	23	26	12	189	5
Use of borrowed money	27	29	32	12	171	6
Ownership of mobile phone	21	25	30	24	143	7

TOSS total observed score of a statement



**Table 9** Women’s participation in political and social awareness

Political and social awareness status	Participating women		Non-participants	
	Number	%	Number	%
Low (0–7)	3	3	60	60
Medium (8–15)	71	71	40	40
High (> 15)	26	26	0	0
Mean	14.12		9.30	
SD	3.21		3.12	
t-value	10.774***			

\*\*\*Indicates significance at 1% level

**Table 11** Women’s status regarding freedom of movement

Status of freedom of movement	Participating women		Non-participants	
	Number	%	Number	%
Low (0–7)	47	47	68	68
Medium (8–15)	50	50	32	32
High (> 15)	3	3	0	0
Mean	9.16		7.22	
SD	2.64		3.21	
t-value	3.528***			

\*\*\*Indicates significance at 1% level

**Freedom of movement**

In terms of freedom of movement, 50% of women involved in livestock farming had a medium level of freedom, whereas the majority of non-participating women (68%) had a lower level of freedom. In terms of mobility, there is a significant difference between these two groups of respondents (Table 11). The TOSS value indicates that women livestock farmers are able to visit health centers and relatives’ houses (Table 12), supporting findings by other studies (Nath and Athinuwat 2021).

**Factors affecting women’s participation in livestock farming**

Table 13 reveals that, of the 10 independent variables, household size negatively influenced the decision to engage in livestock farming. The negative coefficient of household size indicates that an increase in household size decreases the likelihood of livestock farming participation. On the other hand, knowledge, experience, training and extension contact played a positive role in the decision to engage in livestock farming. The positive coefficient of training, for example, indicates that providing women with additional training will enhance their likelihood of participating in livestock farming. These findings are consistent with the findings of several

previous studies (Shekhar et al. 2019; Kumar et al. 2021; Sharifzadeh and Abdollahzadeh 2021).

**Impact of livestock farming on women empowerment**

Using a second-stage OLS model, the impact of women’s participation in livestock farming on their empowerment is examined. Before continuing with model estimation, the Variance Inflation Factor (VIF) was calculated to determine the presence of multicollinearity. The calculated VIFs (mean VIF: 1.42) were less than the threshold value of 10, indicating that multicollinearity was not a problem (Maddala 1992). The statistically significant lambda values indicate that the sample contains a selection bias. The result of the Wald test indicates that the null hypothesis of no correlation between the selection equation error term and the outcome equation error term can be rejected, thereby justifying the use of Heckman’s endogenous treatment effect model (Table 14). The results of the endogenous treatment effect model indicate that women’s empowerment was significantly affected by their participation in livestock farming. According to the ATT, the status of women’s empowerment is 16 points higher among livestock farming participants than among non-participants. The results are consistent with other research that suggested that livestock farming has

**Table 10** Rank order of statements about political and social awareness

Items of political and social awareness	Extent of awareness				TOSS	Rank Order
	Frequently	Occasionally	seldom	Not at all		
Raising voice against child marriage	67	21	12	0	255	1
Casting vote to the preferred candidate	63	19	17	1	244	2
Taking immediate action against any injustice or violence	57	24	9	10	228	3
Taking part in the discussion about the current state of the country	52	29	6	13	220	4
Assisting relatives in case of emergency	49	31	7	13	216	5
Marriage registration	39	33	9	19	192	6
Helping people in case of flood or fire	35	31	15	19	182	7

TOSS total observed score of a statement

**Table 12** Rank order of statements about freedom of movement

Items of mobility	Extent of mobility				TOSS	Rank order
	Frequently	Occasionally	Seldom	Not at all		
Visit to health care center	48	41	8	3	234	1
Visit to relatives' house	42	34	12	12	206	2
Visit to neighboring village	38	33	24	5	204	3
Visit to Upazila livestock office	39	29	22	10	197	4
Visit to Upazila Union Office	32	33	21	14	183	5
Visit to municipality office	19	34	31	16	156	6
Visit to capital city	15	30	30	25	135	7

TOSS Total Observed Score of a Statement

**Table 13** Determinants of participation in livestock farming via first stage of endogenous treatment effect model

Variable	Coefficients	Robust SE	z-value
Age	- 0.016	0.023	- 0.710
Education	0.046	0.100	0.450
Household size	- 0.184**	0.074	- 2.480
Farm size	7.551***	2.702	2.790
Knowledge	0.346***	0.063	5.520
Livestock farming experience	0.239***	0.059	4.080
Annual household income	0.002	0.004	0.410
Training	0.186**	0.076	2.430
Credit	- 0.001	0.006	- 0.240
Extension contact	0.080*	0.049	1.630
Constant	- 5.285***	1.112	- 4.750
Wald Chi-square	283***		
No. of observations	200		

SE indicates standard errors; \*, \*\* and \*\*\* indicate significant at 10%, 5% and 1% level, respectively

**Table 14** Impact of livestock farming on women empowerment via second stage of endogenous treatment effect model

Variable	Women empowerment	
	ATT	SE
Livestock farming	16***	3.45
Control variable	Yes	-
Rho	0.501**	0.216
Sigma	9.345***	0.489
Lambda	4.601**	2.066
Wald test	3.57**	-
Mean variance inflation factor	1.42	-

SE indicates standard errors; - indicates not applicable; \*\*, and \*\*\* indicate significant at 5%, and 1% level, respectively; The second stage of the endogenous treatment effect model incorporates all of the independent variables listed in Table 1. Because our primary goal is to assess the impact of livestock farming, we only reported on the livestock farming coefficient

the capacity to boost women’s empowerment (Bain et al. 2018; Galie et al. 2022).

**Constraints faced by the women livestock farmers**

Women interviewed had several limitations in livestock production activities, which were influenced by diverse components of their community and lives. The majority of the challenges were related to the availability of funds, resources, knowledge-acquisition methods, and marketing channels.

The majority of the women stated that a lack of available capital prevented them from getting into or staying in the livestock farming business. Most of the family members were employed in low-skilled occupations such as day laborers, rickshaw pullers, construction workers, carpenters, and shop owners. Consequently, there were sometimes insufficient funds to provide food for everyone. When it comes to investing in their livestock, they frequently lack the financial resources necessary. In some instances, they obtain loans from non-governmental organizations with high interest rates. During FGDs and in-depth interviews, respondents elaborated on this theme as follows: “I borrowed some money from a local NGO and the interest rate on the money is so high. To avoid further hassle, I need to promptly pay the requested sum. If I didn’t pay back the money, they threatened to take my belongings”. As a result, it is extremely challenging for them to keep raising livestock. Lack of access to market information is another major constraint faced by women farmers. To determine the correct price of a product, it is essential to have market information. The majority of women possessed mobile phones but did not have internet access. Therefore, they are unaware of the current prices of livestock products on the market. During the in-depth interviews as well as FGDs respondents stated that “I have a mobile phone, but I don’t know how to use the internet to obtain price-related market information.” Previous research also indicated that women’s

lack of access to market information was a significant barrier to their economic empowerment in Pakistan (Aslam et al. 2013).

## Discussion

The involvement of women in livestock farming has a substantial impact on their life and is considered a means of empowering women by enhancing their income. The study evaluated the impact of livestock farming on women's empowerment and identified constraints in livestock farming activities. The descriptive statistics suggested that younger women exhibit a greater inclination towards engaging in livestock farming. This inclination may be influenced by several aspects, including physical capability, willingness to adopt novel approaches, and the availability of resources. Moreover, higher education empowers individuals to acquire a more profound comprehension of the difficulties associated with livestock rearing and equips them with the capacity to proficiently handle the obstacles. The higher household income of women engaged in livestock farming empowers them to enhance their quality of life, facilitates more investments in farming, and fosters empowerment. The descriptive statistics also showed that women with more training experience and regular interaction with extension services demonstrate a proactive attitude in seeking information and resources to improve livestock operations, resulting in a greater level of knowledge enrichment.

The findings indicate a substantial disparity in the level of empowerment between women engaged in livestock farming and those not engaged in livestock farming. By selling eggs, milk, chicken, duck, pigeon, goat, and other farm animals, they are able to produce their own income to support their requirements. Akter et al. (2018) also found that a significant proportion (50%) of individuals in Bangladesh possessed a moderate level of empowerment because of engaging in income-generating activities such as poultry rearing, livestock management, and post-harvest activities.

The assessment of empowerment across four dimensions reveals that women are mostly engaged in child education when it comes to decision-making processes. Previous research also indicated that women are primarily involved in household decisions regarding livestock husbandry and child education (Sumy et al. 2021). Women farmers earned money from raising livestock, which they put toward the education of their children and family expenses. During FGD, one respondent stated that "I had a strong desire to continue my education, but my father forced me to marry at a younger age due to my family's terrible financial situation. However, I understood the value of education. Consequently, I've decided

to help my children with their education. So that they experience no difficulties in their daily lives."

The assets ownership related findings indicate that women are able to acquire the items necessary to meet their needs (such as buying new clothes for themselves and investment on farming). During FGD, participants stated, "I have enough money to spend on my own purposes, and I have invested my earnings to expand my livestock farming." Spouses also encourage women to invest money in purchasing additional livestock since it allows them to expand their household revenues, reducing the financial burden on them.

Social and political awareness is a crucial indicator of women's empowerment because it demonstrates women's ability and willingness to advocate for their rights. The TOSS value indicates that women livestock farmers are conscious of their rights and have demonstrated strong opposition to injustice or violence. Child marriage in Bangladesh is a prominent problem that is worsened by economic insecurity and poverty, leading to several social challenges for women (Asadullah et al. 2021). During FGDs respondents mentioned that "Livestock farming enables us to attain a prominent status within our family and community mostly as a result of the revenue that is received from this activity". Due to their position in the family, certain participants possessed a heightened awareness of the problems at hand. As a result, they vocally opposed child marriage and actively resisted all types of injustice. Furthermore, they have developed an interest in political matters and exercise their right to vote for their favored candidate. Respondents reported that no social or familial pressures influenced their decisions. Swain and Wallentin (2012) found that heightened political consciousness played a crucial role in empowering women in India and fostering their involvement in public advocacy and legal initiatives.

The results also indicated that women engaged in livestock farming possess greater ability to move to other places compared to their counterparts. The respondents reported that in the past, they had to seek financial assistance from family members in order to access healthcare facilities. Nevertheless, because of engaging in livestock farming, women have gained the capacity to generate income, which in turns may allow them to have mobility to some extent for personal endeavors. In addition to livestock farming, the evolution of social and cultural norms in recent times may also facilitate their mobility in public spaces. By being mobile, individuals can expand their viewpoint, enhance their autonomy, and improve their abilities to communicate (Nath and Athinuwat 2021). Previous research has also suggested that mobility allows women in Bangladesh to gain new perspectives, experiences, and self-assurance, as well as to protest

the negative comments that impede their advancement (Banu et al. 2001).

The findings of factors influencing participation in livestock farming suggested that family size negatively influenced participation decision. This may be because, in addition to housekeeping duties, women in Bangladesh are responsible for caring for their non-working children and other duties (Haque 2020). To reap the benefits of livestock farming, however, women must be heavily involved in livestock management activities. However, due to larger family sizes, women are unable to participate frequently in livestock farming. During the in-depth interview, one respondent mentioned that “Every day I wake up at 5:00 a.m., after completing prayer I must start preparing food for all family members, and all day I am engaged in various household activities. If I could manage my time, I would raise more domestic animals and make more money for myself”.

The farm size played a positive role in determining participation. One of the economic indicators of households is the size of their farms. The households with larger farms may have a greater income, which they invest in the purchase of livestock and agricultural activities. Knowledge, experience, and training also played a positive role in the decision to participate. Training enables them to comprehend their farm challenges quickly. Training is essential to bring about desired changes and update respondents’ knowledge, which they can use to reduce their farming problems (Sharifzadeh and Abdollahzadeh 2021). Respondents received various training (poultry rearing, beef fattening, goat farming, management of livestock diseases etc.) from the Department of Livestock Service. According to respondents, these training courses are very beneficial to their farming activities. In India’s Koderma district, Shekhar et al. (2019) found that training had a significant impact on backyard poultry farming. As a result, they can utilize all of these in their livestock farming, thereby increasing their contribution to the family’s income, which may enhance women’s empowerment. Additionally, prior research has indicated that educating women through training can increase their knowledge and have a positive effect on women’s empowerment (Kabir 2012; Cinar and Kose 2018). Effective livestock extension services appeared to be a significant issue in Bangladesh, where millions of households rely on animal farming. Extension services can be an effective way to reach farming households, particularly women, which may increase their livestock farming efficiency and productivity.

The impact analysis suggested that livestock farming positively impacted women empowerment. As a result of raising livestock, women now have the financial means to provide for their own basic needs, as well as those of their

families. In addition, livestock farming necessitates women’s participation in a variety of training and demonstration programs, which has the potential to raise their level of technical, legal and social awareness, which in turn may give them more agency in the household’s financial, asset, and mobility decisions and thus further increase their empowerment. Nevertheless, it is a fact that in Bangladesh, men hold a position of power in society, and a patriarchal culture limits the freedom of women and undermines their worth in several ways. Therefore, all the four domains of women empowerment need to converge for women to achieve empowerment through livestock.

## Conclusion

Women’s small-scale livestock farming can be a significant route to improved livelihoods and higher incomes, thereby empowering women. This study was conducted to assess the impact of livestock farming on women’s empowerment in Bangladesh. Compared to women who are not involved in livestock farming, women who are involved in livestock farming have a greater sense of empowerment. Livestock farming helps women increase their decision-making power, asset holding, social and political awareness, and consequently their level of empowerment. Multiple factors such as knowledge, extension contact, and training, positively influenced the decision of women to participate in livestock farming. As a result, government and non-government sectors can play a crucial role in enhancing the knowledge and skills of women farmers in livestock farming, thereby boosting their empowerment status. To assist women livestock farmers, the government should enhance access to livestock-related information by expanding extension services. The study found that livestock farming positively impacted women empowerment. Nevertheless, all the four selected domains of empowerment must converge for the entire benefit to be realized. Women farmers could be educated and supported through mentorship programs to increase their awareness and decision-making power and thereby enhancing empowerment. Different organizations working in rural areas could develop livestock interventions that facilitate the participation of women. Despite generating relevant depictions of livestock farming and women’s empowerment, this study is limited by its small sample size and limited geographical extent.

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## Author contributions

TDN collected and analyzed the data and wrote the original draft of the manuscript. MSR analyzed the data and review and edit the manuscript. AB

collected data and wrote the original draft of the manuscript. RAJ collected data and wrote the original draft of the manuscript.

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### Availability of data and materials

The datasets are available from the corresponding author on reasonable request.

### Declarations

#### Ethics approval and consent to participate

The Review Committee of the Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh, Bangladesh, granted ethical approval. Each respondent provided verbal informed consent after being informed about the objectives of the study. Respondents' participation in the study was entirely voluntary. Respondents had the option to refuse or end the interview at any time.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare that they have no competing interests.

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### References

- Abdallah A, Ayamga M, Awuni JA. Impact of agricultural credit on farm income under the Savanna and Transitional zones of Ghana. *Agric Finance Rev.* 2019;79(1):60–84.
- Ackerly BA. Testing the tools of development: credit programmes, loan involvement, and women's empowerment. *IDS Bull.* 1995;26(3):56–68.
- Ahmed S, Begum M, Khatun A, Gofur MR, Azad MT, Kabir A, Haque TS. Family Poultry (FP) as a tool for improving gender equity and women's empowerment in developing countries: evidence from Bangladesh. *Eur J Agril Food Sci.* 2021;3(2):37–44. <https://doi.org/10.24018/ejfood.2021.3.2.251>.
- Akram N. Women's empowerment in Pakistan: its dimensions and determinants. *Soc Indic Res.* 2018;140(2):755–75. <https://doi.org/10.1007/s11205-017-1793-z>.
- Akram MB, Iqbal A, Qaisar K. Role of rural women in livestock production in district Pakpattan, Pakistan. *J Agric Res.* 2019;57(2):127–34.
- Akter A, Ahmad N, Jaafar WMW, Zawawi DB, Islam M, Islam MA. Empowerment of women through entrepreneurial activities of self-help groups in Bangladesh. *J Int Bus Manage.* 2018;1(1):1–15.
- Akter A, Hoque F, Rahman MS, Kiprop E, Jahan MS, Geng X. Determinants of adoption of homestead gardening by women and effect on their income and decision making power. *J Appl Hort.* 2021;23(1):59–64.
- Alkire S, Meinzen-Dick R, Peterman A, Quisumbing A, Seymour G, Vaz A. The women's empowerment in agriculture index. *World Dev.* 2013;52:71–91. <https://doi.org/10.1016/j.worlddev.2013.06.007>.
- Ambreen DPZU, Malik N, Usman M, Sardar N. Assessing women empowerment through livestock activities in rural Faisalabad. *Pakistan Remit Rev.* 2024;9(2):2611–9.
- Asadullah MN, Islam KMM, Wahhaj Z. Child marriage, climate vulnerability and natural disasters in coastal Bangladesh. *J Biosoc Sci.* 2021;53(6):948–67.
- Aslam S, Latif M, Aslam M. Problems faced by women entrepreneurs and their impact on working efficiency of women in Pakistan. *Middle-East J Sci Res.* 2013;18(8):1204–15.
- Astutik E, Efendi F, Sebayang SK, Hadisuyatmana S, Has EMM, Kuswanto H. Association between women's empowerment and diarrhea in children under two years in Indonesia. *Child Youth Serv Rev.* 2020;113: 105004.
- Bain C, Ransom E, Halimatusadiah I. Weak winners' of women's empowerment: the gendered effects of dairy livestock assets on time poverty in Uganda. *J Rural Stud.* 2018;61:100–9.
- Bain C, Ransom E, Halimatusadiah I. Dairy livestock interventions for food security in Uganda: what are the implications for women's empowerment? *Rural Sociol.* 2020;85(4):991–1020.
- Bairwa KC, Varadan RJ, Jhahria A, Meena DK. An economic appraisal of livestock sector in India. *Indian J Anim Res.* 2013;47(2):105–12.
- Banu D, Farashuddin F, Hossain A, Akter S. Empowering women in rural Bangladesh: Impact of Bangladesh rural advancement committee's (BRAC's) programme. *J Int Women's Stud.* 2001;2(3):30–53.
- Bhadauria P, Shingh R. Women empowerment through livestock-based enterprises. National conference on women empowerment through agro-entrepreneurship for livelihood security, Society for integrated development of agriculture, veterinary and ecological sciences, 07–08 February, 2019, New Delhi, India, pp. 127–135, 2019.
- Biswas TK, Kabir M. Measuring women's empowerment: Indicators and measurement techniques. *Soc Change.* 2004;34(3):64–77. <https://doi.org/10.1177/004908570403400305>.
- Cameron AC, Trivedi PK. *Micro-econometrics using stata*. Revised. College Station: Stata Press; 2009.
- Chaudhry IS, Nosheen F. The determinants of women empowerment in Southern Punjab Pakistan: an empirical analysis. *Eur J Soc Sci.* 2009;10(2):216–29.
- Chaudhry IS, Nosheen F, Lodhi MI. Women empowerment in Pakistan with special reference to Islamic viewpoint: an empirical study. *Pakistan J Soc Sci.* 2012;32(1):171–83.
- Chowdhury QMK, Hossain M, Ahmed J, Shykhat CA, Islam MS, Hasan M. Impact of climate change on livestock in Bangladesh: a review of what we know and what we need to know. *Am J Agric Sci Eng Technol.* 2016;3(2):18–26.
- Cinar K, Kose T. The determinants of women's empowerment in Turkey: a multilevel analysis. *South Eur Soc Pol.* 2018;23(3):365–86. <https://doi.org/10.1080/13608746.2018.1511077>.
- Cornwall A, Rivas AM. From 'gender equality and 'women's empowerment' to global justice: reclaiming a transformative agenda for gender and development. *Third World Quarterly.* 2015;36(2):396–415.
- Creswell JW. *A concise introduction to mixed methods research*. SAGE Publications. 2014.
- Danso-Abbeam G, Ehiakpor DS, Aidoo R. Agricultural extension and its effects on farm productivity and income: insight from Northern Ghana. *Agric Food Sec.* 2018;7:74.
- Debnath D, Rahman MS, Acharjee DC, Latif WU, Wang L. Empowering women through microcredit in Bangladesh: an empirical study. *Int J Fin Stud.* 2019;7(3):37. <https://doi.org/10.3390/ijfs7030037>.
- Galiè A, Mulema A, Mora Benard MA, Onzere SN, Colverson KE. Exploring gender perceptions of resource ownership and their implications for food security among rural livestock owners in Tanzania, Ethiopia, and Nicaragua. *Agric Food Secur.* 2015;4:1–14.
- Galiè A, Teufel N, Korir L, Baltenweck I, Webb Girard A, Dominguez-Salas P, Yount KM. The women's empowerment in livestock index. *Soc Indic Res.* 2019;142(2):799–825. <https://doi.org/10.1007/s11205-018-1934-z>.
- Galiè A, Najjar D, Petesch P, Badstue L, Farnworth CR. Livestock innovations, social norms, and women's empowerment in the global south. *Sustainability.* 2022;14(7):3741. <https://doi.org/10.3390/su14073741>.
- Grace J. Who owns the farm? rural women's access to land and livestock. Afghanistan Research and Evaluation Unit (AREU). 2005.
- Haque T. Exploring uncounted contribution of women in Bangladesh: barriers, implications and opportunities. *Pakistan J Gen Stud.* 2020;13:267–90.
- Hashemi SM, Schuler SR, Riley AP. Rural credit programs and women's empowerment in Bangladesh. *World Dev.* 1996;24(4):635–53.
- Heckman JJ. The common structure of statistical models of truncation, sample selection and limited dependent variables and a simple estimator for such models. *Annals Econ Soc Meas.* 1976;5:475–92.
- Heckman JJ. Dummy endogenous variables in a simultaneous equation system. *Econometrica.* 1978;46:931–59.

- Heckman JJ. Sample selection bias as a specification error. *Econometrica*. 1979;47(1):153–61.
- Herrero M, Grace D, Njuki J, Johnson N, Enahoro D, Silvestri S, Rufino MC. The roles of livestock in developing countries. *Animal*. 2013;7(1):3–18.
- Hoq MS, Raha SK, Hossain MI. Welfare impact of market participation: the case of rice farmers from wetland ecosystem in Bangladesh. *Environ Chall*. 2021;5: 100292.
- Hossain MM. Livelihood improvement of farmers through cattle fattening of Mymensingh District: a socio-economic study. *J Agric Food Environ*. 2020;1(3):1–5.
- Hossain M, Karim A. Impact assessment of solar mini-grid, solar irrigation and improved cooking stove projects of IDCOL. Final Report, Bangladesh Institute of Development Studies, Dhaka, Bangladesh, 2020.
- Hussain A, Thapa GB. Smallholders' access to agricultural credit in Pakistan. *Food Secur*. 2012;4:73–85.
- Islam MA, Howlider MAR, Alam MA, Heyamet MA, Debnath M. Present status, problem and prospect of duck farming in rural areas of Mymensingh district, Bangladesh. *Asian J Med Bio Res*. 2016;2(2):202–12.
- Islam MR, Kabir SL, Islam MS. Women's empowerment through small-scale dairy farming in Bangladesh: a study on some selected areas of Mymensingh district. *Asian-Australas J Food Saf Secur*. 2019;3(2):85–95.
- Jadoun YS, Chadda A, Singh J, Kansal SK, Singh A. Women empowerment through livestock based self-help groups. *Int J Livest Res*. 2021;11(6):1–10.
- Jamatia K, Ray MN, Payeng S, Bora L, Johari M, Roy DRK. Perceived empowerment of tribal women through livestock enterprises in Tripura. *J Entomol Zool Stud*. 2020;8(4):401–4.
- Kabeer N. Resources, agency, achievements: reflections on the measurement of women's empowerment. *Dev Change*. 1999;30(3):435–64.
- Kabir MS, Hou X, Akther R, Wang J, Wang L. Impact of small entrepreneurship on sustainable livelihood assets of rural poor women in Bangladesh. *Int J Econ Fin*. 2012;4(3):265–80.
- Kabir MH, Biswas S, Rahman MS, Islam MS, Tan ML. Determinants of vegetable growers' knowledge and willingness to adopt botanical pesticides. *Int J Pest Manage*. 2022. <https://doi.org/10.1080/09670874.2022.2066733>.
- Kristjanson P, Waters-Bayer A, Johnson N, Tipilda A, Njuki J, Baltenweck I, Grace D, MacMillan S. Livestock and women's livelihoods: a review of the recent evidence. ILRI Discuss Paper. 2014;20:209–33.
- Kumar A, Chae BJ, Bhuiyan AKFH, Sarker SC, Hossain MM. Goat production system at Mymensingh district in Bangladesh. *Bangladesh J Ani Sci*. 2018;47(1):13–20.
- Kumar M, Dahiya SP, Ratwan P. Backyard poultry farming in India: a tool for nutritional security and women empowerment. *Bio Rhythm Res*. 2021;52(10):1476–91.
- Leder S, Clement F, Karki E. Reframing women's empowerment in water security programmes in Western Nepal. *Gend Dev*. 2017;25(2):235–51.
- Ma W, Wang X. Internet use, sustainable agricultural practices and rural incomes: evidence from China. *Austral J Agric Resour Econ*. 2020;64(4):1087–112.
- Maddala GS. Introduction to econometrics. 2nd ed. New York: Macmillan Publishing Company; 1992.
- Mahmud S, Shah NM, Becker S. Measurement of women's empowerment in rural Bangladesh. *World Dev*. 2012;40(3):610–9. <https://doi.org/10.1016/j.worlddev.2011.08.003>.
- Malapit HJL, Quisumbing AR. What dimensions of women's empowerment in agriculture matter for nutrition in Ghana? *Food Policy*. 2015;52:54–63. <https://doi.org/10.1016/j.foodpol.2015.02.003>.
- Modak M, Chowdhury EH, Rahman MS, Sattar MN. Waste management practices and profitability analysis of poultry farming in Mymensingh district: a socioeconomic study. *J Bangladesh Agric Uni*. 2019;17(1):50–7.
- Nath TD, Athinuwat D. Key factors of women empowerment in organic farming. *GeoJournal*. 2021;86(6):2501–20. <https://doi.org/10.1007/s10708-020-10211-6>.
- Nessa T, Ali J, Abdul-Hakim R. The impact of microcredit program on women empowerment: evidence from Bangladesh. *OIDA Int J Sust Dev*. 2012;3(9):11–20.
- Njuki J, Sanginga PC, Editors. Women, livestock ownership and markets. New York, USA: Earthscan USA/International Development Research Centre, Canada. 2013.
- Oxaal Z, Baden S. Gender and empowerment: definitions, approaches and implications for policy. Bridge, Institute of Development Studies: University of Michigan. 1997.
- Rahman S, Begum IA, Alam MJ. Livestock in Bangladesh: distribution, growth, performance and potential. *Livest Res Rural Dev*. 2014;26(10):233–8.
- Rahman KM, Hossain MJ, Rana MS. Livestock and poultry rearing by small-holder farmers in haor areas in Bangladesh: impact on food security and poverty alleviation. *Bangladesh J Agric Econ*. 2020;41(1):73–86.
- Rahman MS, Sujon MHK, Acharjee DC, Rasha RK, Rahman M. Intensity of adoption and welfare impacts of drought-tolerant rice varieties cultivation in Bangladesh. *Heliyon*. 2022;8(5): e09490.
- Roy PK, Haque S, Jannat A, Ali M, Khan MS. Contribution of women to household income and decision making in some selected areas of Mymensingh in Bangladesh. *Progr Agric*. 2017;28(2):120–9.
- Roy D, Datta A, Kuwornu JK, Zulficar F. Comparing farmers' perceptions of climate change with meteorological trends and examining farm adaptation measures in hazard-prone districts of northwest Bangladesh. *Environ Dev Sust*. 2021;23(6):8699–721.
- Shafiq M. Analysis of the role of women in livestock production in Balochistan. *Pakistan J Agric Soc Sci*. 2008;4:18–22.
- Sharaunga S, Mudhara M, Bogale A. Conceptualization and measurement of women's empowerment revisited. *J Hum Dev Capab*. 2019;20(1):1–25.
- Sharifzadeh MS, Abdollahzadeh G. The impact of different education strategies on rice farmers' knowledge, attitude and practice (KAP) about pesticide use. *J Saudi Soc Agric Sci*. 2021;20(5):312–23. <https://doi.org/10.1016/j.jssas.2021.03.003>.
- Sharma S, Thakur KS, Singh DV. Role of self help groups on women economic empowerment. *Paideuma J*. 2020;13:35–43.
- Shekhar S, Ranjan R, Singh CV, Singh RK. Evaluating impact of training on backyard poultry farming among landless and small farmers of Koderma district. *J Community Mobilization Sustain Dev*. 2019;14(3):543–6.
- Singh PK, Sankhala G, Singh PK, Manjusha J. Role of rural women in rearing of Gangatiri cattle in Uttar Pradesh. *Ruminant Sci*. 2017;6(1):109–12.
- Sohail M. Women empowerment and economic development-an exploratory study in Pakistan. *J Bus Stud Q*. 2014;5(4):210.
- Sumy MC, Islam MM, Huda FA. Women's participation in small ruminant rearing and household decision making process at Banskhali Upazila in Chattogram District. *J Bangladesh Agric Univ*. 2021;19(1):128–33. <https://doi.org/10.5455/JBAU.26333>.
- Swain BR, Wallentin FY. Factors empowering women in Indian self-help group programs. *Int Rev Appl Econ*. 2012;26(4):425–44. <https://doi.org/10.1080/02692171.2011.595398>.
- Varijakshapanicker P, Mckune S, Miller L, Hendrickx S, Balehegn M, Dahl GE, Adesogan AT. Sustainable livestock systems to improve human health, nutrition, and economic status. *Anim Front*. 2019;9(4):39–50.
- Wright W, Annes A. Farm women and the empowerment potential in value-added agriculture. *Rural Soc*. 2016;81(4):545–71.
- Yamane T. Statistics. In: An introductory analysis. 2nd edn. New York: Harper and Row; 1967.
- Yasmin S, Ikemoto Y. Women's empowerment through small-scale dairy farming in selected areas of Bangladesh. *Asian Soc Sci*. 2015;11(26):290.
- Zulficar F, Thapa GB. Is "Better cotton" better than conventional cotton in terms of input use efficiency and financial performance? *Land Use Policy*. 2016;52:136–43.

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