Research Square

Preprints are preliminary reports that have not undergone peer review. They should not be considered conclusive, used to inform clinical practice, or referenced by the media as validated information.

Simulating Impact of Technical Efficiency of Livestock Production On Women's Empowerment in Feed The Future Zone of Bangladesh

Paresh Kumar Sarma (paresh.baures@bau.edu.bd)
Bangladesh Agricultural University Research System (BAURES)

Research

Keywords: WELI, Technical efficiency, stochastic frontier model, Livestock, Bangladesh

Posted Date: November 19th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-1036289/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Simulating impact of technical efficiency of livestock production on women's empowerment in Feed the Future zone of Bangladesh

P.K. Sarma

Dr. Paresh Kumar Sarma, Senior Scientific Officer (SG), Bangladesh Agricultural University Research System (BAURES), Bangladesh Agricultural University, Mymensingh-2202, Bangladesh, E-mail: paresh.baures@bau.edu.bd, Cell Phone: +8801712052385, Website: www.pareshsarma.com

Abstract

This study explores the impact of technical efficiency (TE) on women empowerment in livestock index (WELI) in feed the future zone of Bangladesh. Considering the livestock farming households a total of 906 data (out of 2064) were extracted from the national representative data set of the Bangladesh integrated household survey (BIHS) in 2018. The descriptive statistics, inferential statistics, Alkire Forster methodology, stochastic frontier model, and ordered probit regression modeling were applied for achieving the objective. The results found that the overall WELI score was 0.735 where about 26.65% (WELI score ≥0.80) of women were empowered. The TE score was 0.941 and 0.942 for male and 0.940 for female and male-headed households, respectively. The research revealed found that a positively significant (P<0.05) relationship between TE and WELI. Moreover, higher levels of TE are associated to reduce with the gender disparities. The researchers suggest that encouraging women to participate in livestock production is a good idea; as a result, women's empowerment has a lot of potentials to boost livestock productivity. Hence, our findings provide important evidence showing the positive impact of technical efficiency on women's empowerment and gender parity within the livestock farming household and may higher level associatively with SDGs.

Keywords: WELI; Technical efficiency; stochastic frontier model; Livestock; Bangladesh

Highlights

- To estimate the WELI and TE of livestock farming households in FTF zone of Bangladesh
- The worldwide sophisticated econometric model such as Alkire-Forster methodology, stochastic frontier production function and ordered probit regression modeling were used to data analysis.
- The overall score of WELI was 0.735 where 26.50% were empowered and 0.941 for TE.
- The TE was positively significant associated with the WELI.
- Govt. should take the appropriate programs to close the production gap and explore the technology transfer through the LES to increase the TE and WELI.

1.0 Introduction

Livestock play an important role on household income, food security and women's empowerment and gender parity within the livestock farming households (FAO 2011). It also provide to improve food production and promote consumption of animal sources protein and reducing hunger and improving household nutritional status (Zezza et al, 2016). Furthermore, livestock has significant economic value because it provides both business prospects for rural development and raw materials for industrial animal production firms (Sakarya and Uysal, 2000). On the other hand, Livestock rearing offers the greatest probable way to reduce greenhouse 30 percent gas emissions by using the several effective (Padmakuma et al., 2019).

In developing nations like Bangladesh, determining the efficiency of livestock production is a critical issue. A measure of a producer's performance is often valuable for policy purposes, and the concept of technical efficiency provides a theoretical underpinning for such a measure. Efficiency, according to Farrell (1957), refers to a farm's ability to create as much output as possible given a set of inputs. (O'Neill et al., 1999; Minviel and Latruffe, 2017; Manevska-Tasevska et al., 2014). Technical efficiency is the effectiveness with a given set of inputs is used to produce the output using one of several approaches proposed by the experts in the area to assess the TE of livestock production (Shih et al., 2004; Lambarraa et al., 2007). Women play an important role in agricultural innovation, but they face tenacious obstacles due to social and economic constraints, that prohibit them from effusively participating in agriculture (Sraboni et al., 2014). In recent decades, women's empowerment has been a topic of intense debate and thinking all across the world. Closing the gender gap in livestock production has been identified as a critical strategy for increasing livestock productivity, food security, and empowerment (FAO, 2011). Livestock can provide significant prospects for women's empowerment in impoverished countries. The women's empowerment in livestock index (WELI) is a useful tool for measuring women's empowerment. This is critical for increasing the output of livestock. For example, a woman who has the authority to decide what to grow and what inputs to apply to her plot will be more productive in the livestock industry. In addition, having access to and owning relevant technologies have a positive impact on agricultural productivity. Several studies have demonstrated the value of technology use and adoption in boosting rural farmers' empowerment and livelihood results. Asfaw et al., (2012); Gitonga et al., (2013); Mendola (2007); and Tefera et al., (2011), for example, looked at the impact of technology adoption on smallholder empowerment and livelihood outcomes in developing nations. Through a voucher-based system for purchasing and distributing agricultural supplies, these studies discovered a link between technology adoption and women's empowerment. Given the importance of women's empowerment in eliminating the gender gap in agriculture and attaining other development goals, it's critical to look into the effects of women's empowerment on technological efficiency, as well as the combined effects of technology adoption and women empowerment. The impact of the WELI's overall women's empowerment on the technical efficiency of rural women farmers is examined in this research. As a result, livestock production efficiency has a direct impact on household income and women's empowerment, particularly in Bangladesh's FTF zone. Unfortunately, very few relevant studies (Galiè et al., 2018; Akter et, al., 2013; Tung 2016; Kostlivý and Fuksová 2019 Anderson et al., 2021; Alessandro et al., 2020; Seymour 2017; Lindie et al., 2021) has been carried out to measure the relationship between WELI and TE in the global livestock sectors. To fulfill the gap, the aim of the study is to examine the impact of technical efficiency and women's empowerment within the livestock farming households in FTF zone of Bangladesh.

The specific objectives of the study are

- To estimate the TE and WALI score at the household level and its determinants
- To examine the relationship between WELI and TE among the livestock farming households in the FTF zone of Bangladesh

The study's findings would imply that government action is required to establish a strong link between producers and other stakeholders, as well as to provide proper training to agricultural extension workers. The approach, which includes the conceptual model and estimating methods, the study region, and sample methods, is presented in the following section. The findings and discussion section came after that. The article concluded with conclusions and policy and practice recommendations.

2.0 Materials and Methods

2.1 Study area

The research carried out at the FTF zone in the Southern Delta region of Bangladesh. The coverage area of twenty-one districts in the southwest region of the country: Barisal, Barguna, Bhola, Jhalokati, Patuakhali, and Pirojpur in Barisal Division; Bagerhat, Chuadanga, Kushtia, Jashore, Jhenaidah, Khulna, Magura, Meherpur, Narail, and Satkhira in Khulna Division; and Gopalganj, Madaripur, Shariatpur, Faridpur, and Rajbari in Dhaka Division in Figure 1.

Figure 1. Map of Bangladesh showing the 21 districts of the study area

These areas were vulnerable to extreme shocks; thus, reiterating the need to maximize impact and strengthen resilience. This goal are aligned with the Government of Bangladesh's priorities and focuses on boosting livestock production and helping farmers diversify their production with high-value, nutrient-dense commodities. More specifically, researchers have emphasized the need for increased livestock productivity, marketability, and safe and diversified livestock product consumption.

2.2 Sources of the data

Considering the feed the future zone of the study, the secondary data of the Bangladesh Integrated Household Survey (BIHS-2018) has been collected from the International Food Policy Research Institute (IFPRI) for achieving the objectives of the study because BIHS is the most comprehensive, nationally representative household survey ever conducted in Bangladesh. The BIHS data was collected using a two-stage stratified random sampling technique with a sample size of 2064 households. Because the study's goal is to determine the influence of agricultural extension services on farm income, welfare, and WELI, particularly in livestock farming, 906 households active in livestock farming were chosen.

3 Key variables measurement

We describe the dependent and independent variables in table 1. Under the table briefly describe how major variables we constructed for the analysis in the study.

Table 1: Description of empowerment variables

Code	Level of variable	Variable Types	Expected sign	Reference
Dependent variables for intensity of use				
WELI	Women empowerment in livestock index	Composite continuous		Abebe et al., 2016; Galiè et al., 2019; USAID, 2012; WEAI et al., 2015;Alkire et al.,2012;
HDDS	Household Dietary Diversity Score (HDDS): The HDDS is a qualitative measure of food consumption that indicates access to a variety of foods in the home.	Continuous		Tambo and Wünscher 2017; Deaton 1997; Kassie et al., 2015, Shiferaw et al., 2014; Sinyolo et al., 2014; Bocoum et al., 2014; Wossen et al., 2019;
Key explanatory variables				
TA	Percentage of technology adoption of i^{th} household	Continuous	+	Wossen et al., 2017; s Anderson and Feder, 2007; Wossen et al., 201
Lincome	Last month household income in TK	Continuous	+	Hansen and Duveskog (2012); Maltitz et al.,2021; Babatunde el al., 2007
ICT	1 if farmers access any service like mobile, internet/computer/radio/TV and zero otherwise.	Dummy	+/-	Nwafor 2020; Meena and Singh (2013)
HWF	Household welfare measuring adult per head expenditure in TK	Continuous	+/-	Mekbib · 2017; Gebregziabher 2015
HWI	Household wealth index	continuous	+/-	Mutisya et al., 2016
TE	Technical efficiency of livestock production of farmers households in the FtF zone using the stochastic frontier method	Composite continuous	+	Adeyeye et al., · 2019 ; Achandi and Kidane 2019
Herd Size	The number of livestock (cattle, cow, bulk, goat and lamb)	Continuous	+	Jago and Berry (2011)
HAge	Households' head age in a complete year	Continuous	+/-	Langyintuo and Mulugetta 2005; Arene and Anyaeji 2010
Hedu	Level of household head education in year	Continuous	+/-	Abay and Assefa, 2004; Salasya et al. 2007, Alene and Manyong, 2007
Main occupation	Main occupation is a dummy variable referring 1 (one) if farmers are engaging in livestock farming and 0 (zero) otherwise	Dummy	+/-	Hameed et al., · 2019; Neethi and Sailaja 2018
Hsize	Number of family member	Continuous	+/-	Liberio 2012, Idrisa 2012; Jayne et al., 2005; Deininger, 2003

Household Dietary Diversity Score (HDDS): HDDS is the snapshot of a family's capacity to access a range of foods based on their financial situation (Kennedy et al., 2013; Headey and Ecker 2014). It was once employed as a proxy for food access in the home which was developed by FANTA (Swindale and Bilinsky 2006). The score was computed by adding up the number of days in the previous seven days that households consumed at least one item from each of the 12 food groups (Sibhatu and Qaim 2018). The range of HDDS's is zero to twelve.

the HDDS indication is written like this:

$$\mathrm{HDDS}\ (0-12)=\sum(\mathrm{A}+\mathrm{B}+\mathrm{C}+\mathrm{D}+\mathrm{E}+\mathrm{F}+\mathrm{G}+\mathrm{H}+\mathrm{I}+\mathrm{J}+\mathrm{K}+\mathrm{L})\ \ldots\ldots.(\mathrm{v})$$

The HDDS indicator is calculated over a 7-day recall period using 12 food groups: A. cereals; B. Pulses; C. Fruits D. Edible oil; E. Vegetables F. Meat, eggs and milk; G. Fruits; H. Fish (large); I. Fish (small); J. Spices; K. Drinks and beverages; L. Other foods prepared outside home. The values for A to L can be "0" or "1".

Household Wealth Index (HWI): Principal component analysis (PCA) creates a composite variable wealth index which was includes household land, assets, and productive assets, as well as home amenity ownership indicators. Among the vital commodities are a car, motorcycle, bicycle, radio, gas cooker, sewing machine, bed, and cell phone, as well as livestock (Mutisya et al., 2016). Formally, the wealth index for household i is the linear combination;

$$Y_i=\alpha_i\left(\frac{X_1-\overline{X_1}}{S_i}\right)+\alpha_2\left(\frac{X_2-\overline{X_2}}{S_2}\right)+\cdots+\alpha_k\left(\frac{X_k-\overline{X_k}}{S_k}\right)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(\mathrm{vi})$$

Where, $\overline{X_k}$ and S_k are the mean and standard deviation of asset X_k , and α represents the weight for each variable X_k for the first principal component.

Technical efficiency (TE): The technical efficiency was produced by using stochastic Frontier Analysis modeling. The range of TE was 0 to 1 with 1 (one) meaning the signifying a completely efficient farm (Farrell, 1957). Technical efficiency is defined as a set of factors measured using a certain way in relation to a group of companies, and any change in these specifications will affect the measure (Farrell, 1957). It assesses a company's ability to maximize the value of a set of inputs. In any such metric, this is unavoidable. However, given these qualifications, it functions as a natural and satisfactory measure of efficiency (Farrell, 1957). For measuring technological efficiency, three quantitative methodologies have been developed: parametric non-parametric based on Data Envelopment Analysis (DEA), and productivity indices based on growth accounting and index theory principles (Coelli et al, 1988). Stochastic Frontier Analysis

(SFA) and differential equation analysis are the most extensively used methods (DEA). Both methods use the efficient frontier to calculate the firm's technical efficiency. The SFA approach requires that the frontier production function be specified in a functional form. To generate a piece-wise frontier that encircles a set of observations, the DEA technique employs linear programming. The most efficient frontier is the one with the best results among the farmers. The DEA method has the advantage of allowing for simultaneous examination of several inputs and outputs, as well as varied units of measurement for inputs and outputs. Furthermore, DEA allows for scale efficiency computation; nevertheless, SFA has a distinguishing advantage over DEA in that it allows for scale efficiency calculation. Aigner et al. (1977) and Meeusen and ven den Broeck (1977) proposed the stochastic frontier model at the same time (1977). It incorporates a random term to represent noise, as opposed to a deterministic model.

The following is the model for the ith farm:

$$In(Y_i) = \int (X_i, \beta) \; + \; V_i - U_i \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where

Y_i Is the observed output quantity of the ith farm

$\int$ is the production function

X_i is a vector of the input quantities used by the farm

β is a vector of parameters to be estimated

v_i is an error term, independent and identically distributed (iid) with, $N(0, \sigma_v^2)$ u_i is a non-negative random error, accounting for efficiency, iid, with $N(0, \sigma_u^2)$, truncated to zero to ensure non-negativeness.

The variance is parameterized by substituting Battese and Corra (1977) and Battese and Coelli (1995) with σ 2vu and σ2μ with

$$\delta^2 = \sigma_u^2 \; + \; \sigma_{vu}^2 \text{ and } \lambda = \frac{\sigma_u^2}{(\sigma_{uv}^2 - \sigma_u^2)} \text{-----------------------------}()$$

Where, $0 \leq \lambda \leq 1$, with the value equal to 1 indicating that all the deviations from the frontier are due entirely to technical inefficiency (Coelli, Rao, and Battese, 1998).The technical efficiency of the household can be defined as:

$$TE = \frac{E\left(\frac{Y_i}{U_i}, \quad X_i\right)}{E\left({}^{Y}\!/_{u_i} = 0, \; X_i\right)} = e^{-u_i}$$

Where;

A rice farmer's expectation is E. Thus, given the value of V_i-U_i evaluated at the highest likelihood estimates of the parameter in the model, the measure of technical efficiency is based on a conditional expectation given by Equation (8), where the expected maximum value of Y is conditional on ui=0 (Battese and Coelli, 1988). The metric TE_i has a range of zero to one, and the overall mean technical efficiency of households is estimated to be as follows:

$$\boldsymbol{TE = \left\{\frac{1 - \emptyset\left[\sigma_u - \left({}^{u}\!/_{\sigma_u}\right)\right]}{1 - \emptyset\left({}^{u}\!/_{\sigma_u}\right)}\right\} e^{-u+(0.05)\sigma_u^2}}$$

Where; $\emptyset$ is the standard normal variable's density function.

$\text{Technical inefficiency} = 1 - \text{TE}_\text{i}$

Women empowerment in livestock index (WELI): In this study empowerment of women was measured by empowerment in the livestock index (WELI). WEAI is the latest index developed in 2012 by OPHI as a direct indicator of economic empowerment and gender parity at the household and individual level (Alkire et al., 2013; and Yang and Stanley, 2012). Because empowerment is a dynamic and multifaceted concept, a single indicator is insufficient to assess it. As a result, the (Alkire et al., 2013) multidimensional measure of empowerment was used in this study. The Alkier-Foster multidimensional measure of empowerment can be used to show women's progress across ten indicators and five empowerment areas. The WELI and its components of empowerment are presented in this paper: (1) agricultural production decisions; (2) nutrition decisions; (3) resource access and control; (4) income control and use; (5) access to and control of opportunities; and (6) workload and control over own time. WEAI uses weighted five domains and ten indicators to assess empowerment in a multidimensional approach, allowing for breakdown and comparison across domains. WEAI combines two sub-indices with arbitrary weights of 90 and 10%, respectively: five domains of empowerment (5DE) and gender parity index (GPI).

As a result, the adequacy status of an individual is determined in each indicator by multiplying the variable by their stated weight and comparing it to the insufficiency cutoff. Once, Individual adequacy score and inadequacy cutoff are computed, and the total disempowerment index (M_0) is calculated using weighted indicators (Alkire et al., 2012; and Alkire et al., 2013). The disempowerment of women is broken down into indicators and domains to show how each one contributes to the overall disempowerment of women. Empowerment in five domains is a counterpart of disempowerment which is computed as

$$5\mathrm{DE} = 1 - \mathrm{M}_0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Where, M_0 is the overall disempowerment score, while 5DE is measured using ten indicators with their respective weights. Each sign indicates whether or not a person has acceptable achievement in that area. Another unique component of WEAI is the Gender Party Index (GPI), which compares women's and men's empowerment across the 5DEs in the same household.

Mathematically

$$\mathrm{WEAI} = 0.90(5\mathrm{DE}) + 0.10(\mathrm{GPI}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

Where,

5DEs is the degree of empowered women, and GPI is the relative empowerment of women in the household, according to the WEAI index of gender empowerment in agriculture index. The weights assigned to the indexes are 0.9 and 0.1. The WELI is defined as the percentage of domains in which women have sufficient power in the livestock index. STATA was used to create all of the indexes, along with their associated sub-indexes.

2.4 Ordered probit regression on technical efficiency

Simultaneous equation modeling is an alternative approach used in economic analysis. The ordered probit regression model was used to examine the impact of TE of livestock production on novel empowerment indicators WELI. The functional form of the ordered probit regression expressed the following ways;

$$\Pr\left(outcome_j = i\right) = \Pr(K_{i-1} < \beta_1 X_{1j} + \beta_2 X_{2j} \pm \cdots + \beta_k X_{kj} + u_j \leq k_i$$

The more specifically

$$Y_1 = \beta_0 + \beta_1 Y_2 + \beta_2 X_1 + \beta_3 X_2 + \beta_4 X_3 + \beta_5 X_4 + \beta_6 X_5 + \beta_7 X_6 + U_1 \ldots\ldots\ldots\ldots..(x)$$

Where,

Y_1 and is the dependent variables

X_1 ………. X_n are the vectors of covariance

U_1 and U_2 are the error terms

3.0 Results and Discussion

3.1 Descriptive Statistic

The average WELI score of livestock farmers who participated in extension services was 0.77, which was higher than the non-participant (0.73). Technical efficiency (TE) (0.94) and percentage of technology adoption (44.85), wealth index (0.07), and average herd size (2.47) were also higher than the non-participant (0.73). The Wilcoxon Rank-Sum Test is a nonparametric test of the null hypothesis (H_0), which states that a randomly chosen value from one population is equally likely to be less or higher than a randomly chosen value from another community. The non-parametric variant of the two-sample t-test is a common description. The WELI showed a statistically significant difference (P0.01) between participants and non-participants in agricultural extension activities. In agricultural extension efforts, there was a significant ($P<0.01$) difference in the percentage of technology adoption between participants and non-participants.

Table-2 Descriptive Statistic of targets variables

Variables	Non-participants			Participants			Wilcoxon rank-sum test
	Mean	CV	SD	Mean	CV	SD	
Women's empowerment in livestock index (WELI)	0.7350	0.1704	0.0044	0.7720	0.1272	0.0106	0.0019
Technical efficiency (TE)	0.9413	0.0023	0.0001	0.9416	0.0019	0.0002	0.1777
Technology adoption (TA)	37.6829	0.5416	0.7127	44.8505	0.4179	2.0212	0.0010
Household wealth index (HWI)	-0.0073	-137.9604	0.0352	0.0664	14.1380	0.1012	0.0094
Head size of the household	2.2695	0.6188	0.0490	2.4651	0.5555	0.1477	0.1561

3.2 Mean efficiency score of livestock farmers

The sample size used for the analysis, as well as the mean, standard deviation, and range of anticipated technical efficiency and inefficiency scores, are shown in Table 3. The average technical efficiency is expected to be around 94.13 percent. This demonstrates that farmers are working close to the border. The average technological inefficiency is 5.87 percent, indicating that farmers are operating below the technology frontier. This also means that farmers have the opportunity to increase their performance through technological advancements. The technical efficiency scores among farm homeowners range from a minimum of 93.11 percent to a high of 95.12 percent, as shown in Table 3. This gap indicates that farmers have room to enhance their efficiency.

Table 3: Average efficiency and inefficiency scores of livestock farming households

Variables	Mean	Std. Dev	Min	Max
Technical efficiency	0.9413	0.0021	0.9311	0.9512
Inefficiency	0.0587	0.0021	0.0488	0.0689

3.2 Women's empowerment in livestock index

The women's empowerment in livestock index measure used in this study are based on the women's empowerment in agriculture index (WEAI) developed by Alkire et al., 2009). WELI is a survey based index measures empowerment considering 5(five) domains (production decision-making, control over resources, control over income, leadership, and time allocation) and 10(ten) indicators within the livestock sectors (Galiè 2013a). WELI is an aggregate measures with two sub-indices namely five domains of empowerment (5DE) and gender parity index (GPI). Table 4 shows the sub-indices of overall WEAI scores at the study site, along with a breakdown of male and female achievement. According to the 5DE, only 37.09 percent of women are empowered at an 80 percent achievement level, with a shocking 62.91 percent of women not yet empowered. The not yet empowered women have an average inadequate achievement in 29 percent of domains. The women's disempowerment index (M_0) is 0.290 and 5DE is 0.710. The overall WEAI for the study area is 0.735 and is a weighted average of the 5DE sub-index value of 0.710 and GPI sub-index of 0.955.

Table 4: Women empowerment in Agriculture Index: Scores for the study site

Indicator	**Women**	**Men**	**Difference**
5DE (1-M0)	**0.710**	**0.658**	**0.052**
Disempowerment score (1-5DE)	0.290	0.342	-0.052
N (number of observations)	906	906	
Percent of women achieving empowerment (1-H)	37.09	23.40	-13.69
Percentage of women not achieving empowerment (H)	62.91	76.60	13.69
Mean 5DE score for not yet empowered women (1-A)	0.632	0.604	-0.028
Mean Disempowerment score (1-5DE) for not yet empowered women (A)	0.368	0.396	0.028
GPI Score (1-HGPI*IGPI)	**0.955**		
N (number of dual adult households)	906		
Percentage of women achieving gender parity (1-HGPI)	71.08		
Percentage of women NOT achieving gender parity (HGPI) percentage	28.92		
Average Empowerment gap (IGPI)	0.045		
WEAI Score (0.9*5DE +0.1*GPI)	**0.735**		

The respondents were divided into three quartiles based on their WELI scores to compare how dimensions and indicators affect WELI scores. They were separated into three groups of 906 households each after being graded on their WELI scores. The WELI scores for these three groups, as well as their makeup, are shown in Figure 2. As a result, 5.64 percent of respondents with the lowest WELI scores are found in the first quartile (0.50). Only 35.47 percent of livestock farming households achieve gender equality since women's empowerment is 0.80 and their position is between 0.80 and 1.00. The WELI is a standardized measure of women's empowerment in the cattle industry. Through technological and institutional breakthroughs that increase farm output, empowering the poorest farmers, particularly rural women, is a proven strategy to achieve gender equality while decreasing or eliminating hunger and poverty (UN Women et al. 2012). Galiè 2013a; FAO 2011). Goal 5: Gender equality and women's empowerment are important human rights that are also important for a long-term future.

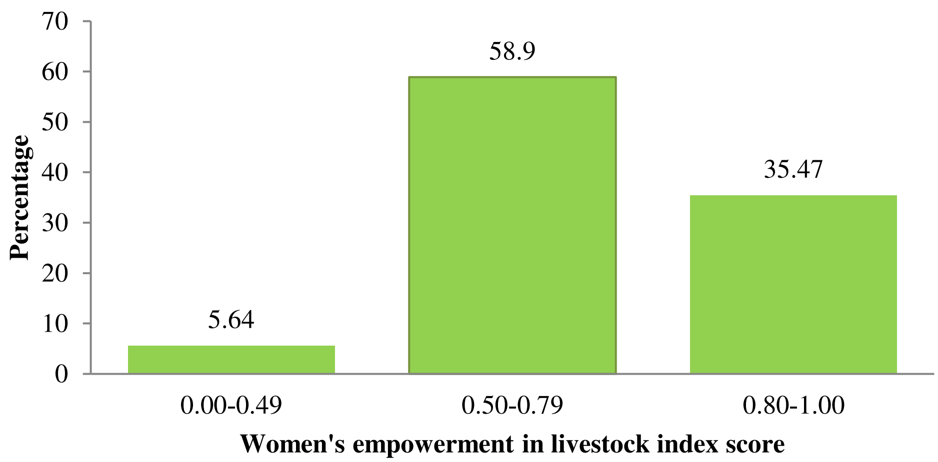

Figure 2: Present status of women's empowerment of livestock farmers

3.5 Association between technical efficiency and women's participation

To examine the relationship between the ordinal dependent variable and independent variables is used in the ordered probit model expressed the equation (x). The estimated mean of TE was 0.837. The Pseudo R2 was 0.0399, Prob>chi2 was 0.000 indicated the will fit the model. The TE has been positively significant ($P<0.01$) associated with the WELI, technology adoption, herd size, age, and main occupation it meaning that farmers who received technology were more TE (Table 5) . Technical efficiency improved with women empowerment and herd size. While our finding agrees with the previous studies (Benjamin and Hamdiyah 2020; Mayen et al.,2009; Nathan et al., 2021; Geffersa et al.,2019; Achandi 2019) and opposite with (Ugbagbe et al.,2017). The result has also established the importance of technology adoption in reinforcing women's empowerment to improve technical efficiency in livestock farming which was correlated with the Adeyeye et al., 2019. The factors that affect technical efficiency are household health index, ICT, last month income, and family size.

$\widehat{TE} = -0.2989 + 0.7109WELI + 0.0100TA + 0.2124ICT + 0.0300HWI +$
$0.4813Herdsize + 0.0001Lincome + 0.0096\text{Age} + 0.2177\text{occupation} + 00.0115\text{Edu} +$
$0.0309\text{Hsize} + 0.0410\text{HDDS}$…………..(x)

Table 5: Ordered probit regression on Technical efficiency

Variables	Coef.	Std. Err.	z	P>z	[95% Conf. Interval]	
WELI	0.7109	0.2760	2.580	**0.010**	0.1700	1.2518
TA	0.0100	0.0018	5.430	**0.000**	0.0064	0.0136
ICT	0.2124	0.2401	0.880	0.376	-0.2582	0.6830
HWI	0.0300	0.0347	0.870	0.386	-0.0379	0.0980
Herdsize	0.4813	0.0289	16.640	**0.000**	0.4246	0.5380
Lincome	0.0001	0.0001	0.970	0.334	0.0000	0.0000
Age	0.0096	0.0027	3.600	**0.000**	0.0044	0.0148
Occupation	0.2177	0.0734	2.960	**0.003**	0.0738	0.3616
Education	0.0115	0.0086	1.340	0.181	-0.0053	0.0284
Hsize	0.0309	0.0217	1.420	0.155	-0.0117	0.0735
HDDS	0.0410	0.0408	1.010	0.314	-0.0389	0.1209
/cut1	-0.2989	0.6193			-1.512653	0.914821
/cut2	-0.0806	0.5898			-1.23661	1.075424
/cut3	0.0725	0.5752			-1.054793	1.199826
Number of observation	= 904					
LR $chi^2(11)$	= 490.32					
Prob > chi^2	= 0.0000					
Pseudo R^2	= 0.0399					
Log likelihood	= -5893.8256					

The positive relationship between HDDS and TE it meaning that high technical efficient farmer has more food secured which was similarities with (Zinab and Kehinde 2019; Khuda et al., 2006). The results delivered useful understanding into the role of technology adoption, herd size, age, and occupation as the factors of household TE and women empowerment status.

3.6 Mechanism of the impact of TE on WELI

The path model shows the relationship between variables in Figure 3. The entire path diagram showed the TE has a relationship with the WELI, herd size, and technology adoption. The casual relationship has revealed if one occurrence causes another variable. The correlation between two variables means they are interlinked with each other. If two variables have a causal link, it must correlate them.

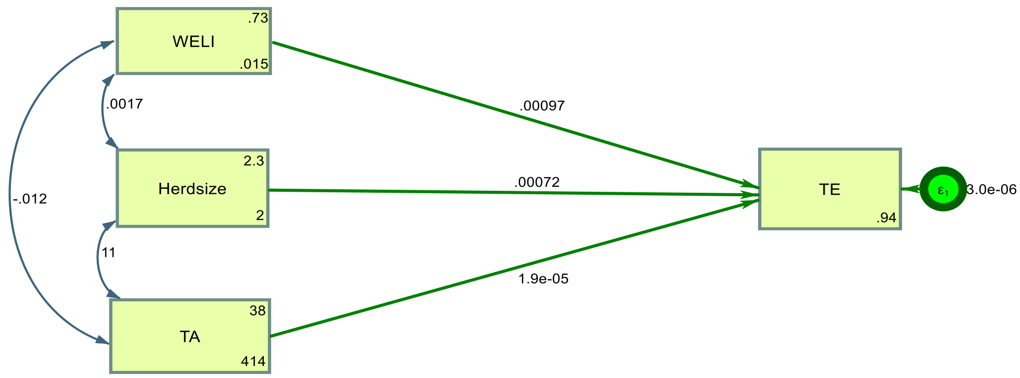

Figure 3: Casual relationship among the target variables

Finally, there is a need to conduct intervention-based prospective studies to gain a more accurate understanding of the causal relationships among these variables. Across all three types of programs technology transfer, increasing herd size and technical efficiency were the strong evidence exits on pathways of impact on women empowerment in the particular region.

4.0 Conclusion and policy implication

In this research, we look at the relationship between technology efficiency (TE) and women's empowerment in the livestock index (WELI). I calculate TE by using stochastic frontier production function model and WELI score by the Alkier Forster methodology and ultimate objective achieve by using order probit regression model. The research revealed that strong evidence because it positively significantly associated between TE and WELI among the livestock farming households in the study areas. The researchers show that the women's disparity would be reduced by increasing a 2.2% of technical efficiency. The results indicate that TE is a maybe good indicator to improve women's empowerment of livestock farming households. The study was also found that the importance of technology adoption in reinforcing women's empowerment to improve technical efficiency in livestock. Therefore, more research should be conducted to search and identify areas contextually peculiar to women. Though Bangladesh Government was lunch livestock extension services in the year 2013 to boost livestock production it needs to explore everywhere all over the country and also exploring ways of utilizing mass media to supplement the work of extension agents through extensive use of information and communication technology and providing access to mobile phone services to farmers are also recommended to improve the efficiency of farmers and women empowerment. The policy marker and different stakeholders need to more emplace to increasing technical efficiency for achieving SDGs 2 and 5.

5.0 Declarations

Data Availability Statement

The dataset analyzed in the study available from the Harvard dataverse: https://dataverse.
harvard.edu/dataset.xhtml? persistentId=doi:10.7910/DVN/QPBCQB

Declaration of interest statement

The writers have stated that they have no conflicts of interest.

Funding

This research has not any external funding

Authors' contributions

PKS has been generated the idea, research design, data collection, analysis and writing the manuscript.

Acknowledgements

The authors are grateful to anonymous reviewers for their insightful remarks and ideas on a previous draft of this paper.

6. References

Abay, A., Assefa, A, 2004. The Role of Education on the Adoption of Chemical Fertilizer under different Socioeconomic Environments in Ethiopia. *Agricultural Economics,* 30, 215-228

Abebayehu Girma Geffersa., Frank W. Agbola., Amir Mahmood, 2019. Technology adoption and technical efficiency in maize production in rural Ethiopia, *African Journal of Agricultural and Resource Economics Volume* 14(3):184-201

Achandi, E.L., Kidane, A., Hepelwa, A, 2018. Technical efficiency: A study of smallholder rice farmers in Kilombero district, Tanzania.

Adeyeye O., Ogunleye, A.S., Akinola, A.A., Reed, H., Didier, A., Wineman, A.,Bamire, A.S., Abdoulaye, T,2019. Women's Empowerment and Technical Efficiency: What Role for Technology Adoption in Nigeria?, Annual Meeting, July 21-23, Atlanta, Georgia 291799, Agricultural and Applied Economics Association.

Aigner, D., Lovell K., Schmidt P,1977. Formulation and Estimation of Stochastic Frontier Production Function Models. *Journal of Econometrics,* 6(1), 21-37.

Akudugu, 2012. Estimation of the Determinants of Credit Demand by Farmers and Supply by Rural Banks in Ghana's Upper East Region, *Asian Journal of Agriculture and Rural Development*, 2(2), 179-190

Alessandro De Pinto., Greg Seymour., Elizabeth Bryan., Prapti Bhandari,2020. Women's empowerment and farmland allocations in Bangladesh: evidence of a possible pathway to crop diversification, *Climatic Change*, https://doi.org/10.1007/s10584-020-02925-w

Alkire S., Meinzen-Dick R., Peterman A., Quisumbing A., Seymour. G., Vaz A, 2013. The women's empowerment in agriculture index. *World Development*, 52, 71–91

Anderson J R., Feder G., 2007.Agricultural extension', in R.E. Evenson & P. Pingali (eds.), Handbook of agricultural economics, vol. 3, Agricultural development: Farmers, farm production, and farm markets, p. 2343–2378, Elsevier, Amsterdam.

Arega Alene., V Manyong, 2007. The effects of education on agricultural productivity under traditional and improved technology in northern Nigeria: an endogenous switching regression analysis, *Empirical Economics*, 32(1)

Arene C., Anyaeji J., 2010. Determinants of Food Security among Households in Nigeria. *Pakistan Journal of Social Sciences*, 30, 9-16.

Asfaw S., Shiferaw B., Simtowe F., Lipper L, 2012. Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. *Food Policy*, 37, 283–295

Ayu Pratiwi., Aya Suzuki, 2020. Does training location matter? Evidence from a randomized field experiment in Rural Indonesia, *Agricultural and Food Economics*, 8(3), https://doi.org/10.1186/s40100-019-0146-4

Bakhsh Khuda., Ahmad Bashir., Hassan Sarfraz, 2006. Food Security Through Increasing Technical Efficiency, *Asian Journal of Plant Sciences,* 5(6); DOI:10.3923/ajps.2006.970.976

Battese G.E., Coelli T.J, 1995. A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data. *Empirical Economics*, 20,325-332.

Battese, G.E., Corra, G.S, 1977. Estimation of a Production Frontier Model with Application to the Pastoral Zone of Eastern Australia. *Australia Journal of Agricultural Economics*, 21, 169-179

Benjamin Tetteh Anang., Hamdiyah Alhassan., Gideon Danso-Abbeam., Fatih Yildiz, 2020. Estimating technology adoption and technical efficiency in smallholder maize production: A double bootstrap DEA approach, *Cogent Food & Agriculture,* 6(1), DOI: 10.1080/23311932.2020.1833421

Beshir Hussien., Bezabih Emana., Kassa Belay., Haji Jema, 2012. Economic efficiency of mixed crop-livestock production system in the north eastern highlands of Ethiopia: the Stochastic Frontier *Approach, Journal of Development and Agricultural Economics* 1(1):10-20

Bocoum I., Dury S., Egg J., Herrera J., Prevel Y, 2014. Does monetary poverty reflect caloric intake? *Food Security*, 6(1), 113–130.

C. Leigh Anderson., Travis W. Reynolds., Pierre Biscaye., Vedavati Patwardhan., Carly Schmidt, 2021. Economic Benefits of Empowering Women in Agriculture: Assumptions and Evidence, *The Journal of Development Studies*, 57(2), 193-208, DOI: 10.1080/0022 0388.2020.1769071

Derek Headey; Olivier Ecker (2014). Rethinking the Measurement of Food Security: From First Principles to Best Practice, *Food Security*, 5(3),327-343, DOI: 10.1007/s12571-013-0253-0

Esther Leah Achandi, 2019. Women empowerment, technical efficiency and market participation: a study of smallholder rice farmers in Kilombero district, Tanzania, PhD thesis, University of Dar es Salaam, http://publication.aercafricalibrary.org/bitstream/handle/123456789/1984/Esther%20Final%20Thesis%20_September%202019-signed.pdf?sequence=1&isAllowed=y

FAO, 2011. The State of Food and Agriculture, Rome, FAO.

Farrell, Michael, 1957. The Measurement of Productivity Efficiency. *Journal of the Royal Statistics Society*, 120(3), 253–90

Friis-Hansen E., D Duveskog., 2012. The empowerment route to well-being: An analysis of farmer field schools in East Africa. *World Development*, 40 (2), 414–427.

Galiè A., Teufel N., Korir L,2019. The Women's Empowerment in Livestock Index. *Social Indicators Research,* 142, 799–825. https://doi.org/10.1007/s11205-018-1934-z

George Battese., Tim J. Coelli,1988. Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data, *Journal of Econometrics,*38(3),387-399,DOI:10.1016/0304-4076 (88)90053-X

Gitonga Z M., De Groote H., Kassie M., Tefera T, 2013. Impact of metal silos on households' maize storage, storage losses and food security: An application of a propensity score matching. *Food Policy,* 43, 44–55

Gordana Manevska-Tasevska,. Helena Hansson., Mette Asmild., Yves Surry, 2021. Exploring the regional efficiency of the Swedish agricultural sector during the CAP reforms multidirectional efficiency analysis approach, *Land Use Policy*, 100, https://doi.org/10.1016/j.landusepol.2020.104897

Jago J G., Berry D P, 2011. Associations between herd sizes, rate of expansion and production, breeding policy and reproduction in spring-calving dairy herds. *Animal,* 5(10), 1626–1633

Justice A Tambo., Tobias Wünscher, 2016. Building farmers' capacity for innovation generation: Insights from rural Ghana, *Renewable Agriculture and Food Systems*, 1-15

Kassie M., Teklewold H., Marenya P., Jaleta M., Erenstein O, 2015. Production risks and food security under alternative technology choices in Malawi: Application of a multinomial endogenous switching regression. *Journal of Agricultural Economics*, 66(3), 640–659.

Kebede T, Berhane G, Gebru M, 2014. Technical efficiency in teff production by small scale farmers in Tigray. *Ethiopian Journal of Economics,* 4(10), 85–97,DOI: 10.22004/ag.econ.259394.

Kennedy ,2011. Guidelines for Measuring Household and Individual Dietary Diversity

Kibrom T Sibhatu., Matin Qaim, 2018. Farm production diversity and dietary quality: linkages and measurement issues, *Food Security,*10(42), DOI: 10.1007/s12571-017-0762-3

Kidanemariam Gebregziabher, 2015. The impact of agricultural extension on households' welfare in Ethiopia, *International Journal of Social Economics,* 42(8):733-748, DOI: 10.1108/IJSE-05-2014-0088
Kostlivý V., Fuksová Z, 2019.Technical efficiency and its determinants for Czech livestock farms. *Agricultural Economics – Czech,* 65,175–184.
Lambarraa F., Serra T., Gil J M., 2007. Technical efficiency analysis and decomposition of productivity growth of Spanish olive farms. *Spanish Journal of Agricultural Research*, 5(3), 259-270
Lambarraa, Fatima1., Kallas Zein., 2007. Subsidies and technical efficiency: An application of stochastic frontier and Random-effect Tobit models to LFA Spanish olive farms, Paper prepared for presentation at the 113th EAAE seminar" A resilient European food industry and food chain in a challenging world" Chania, Crete, Greece, date as in September 3-6, 2009
Lindie V Maltitz., Yonas T Bahta.,2021. Empowerment of smallholder female livestock farmers and its potential impacts to their resilience to agricultural drought, *AIMS Agriculture and Food*, 6(2), 603-630. DOI: 10.3934/agrfood.2021036
Manevska-Tasevskaa Gordana., Helena Hanssonc., Ewa Rabinowiczb, 2014. Input saving possibilities and practices contributing to more efficient beef production in Sweden, *AgriFood Economics Centre working paper*, https://www.agrifood.se/Files/AgriFood_WP20141.pdf
Maurice Mutisya., Moses Ngware., Caroline W Kabiru., Ngianga-Bakwin Kandala, 2016. The effect of education on household food security in two informal urban settlements in Kenya: a longitudinal analysis, *Food Security* 8(4), DOI: 10.1007/s12571-016-0589-3
Mayen Carlos., Balagtas Joseph., Alexander Corinne, 2009. Technology Adoption and Technical Efficiency: Organic and Conventional Dairy Farms in the United States. *American Journal of Agricultural Economics,* 92. 181-195. 10.1093/ajae/aap018.
Meena M., Singh Krishna M, 2013. Impact of Self Help Groups on Attitudes of Members (September 10, 2013). *Indian Journal of Agricultural Sciences*, 83(9).971-976.
Meeusen W., J van den Broeck, 1977. Efficiency Estimation from Cobb-Douglas Production Functions With Composed Error, *International Economic Review* 18, 435-444.
Mendola M.,2007. Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh, *Food Policy*, 32(3), https://doi.org/10.1016/j.foodpol.2006.07.003.
Million Tadesse., Getahun Degu, 2001. Review of On-Farm Research and Adoption Studies on Maize in Southern Ethiopia, Awassa Agricultural Research Center, Ethiopia.
Minviel., Latruffe, 2017. Effect of public subsidies on farm technical efficiency: a meta-analysis of empirical results, *Applied Economics*, 49 , pp. 213-226
Mutisya M., Ngware M W., Kabiru C W, 2016.The effect of education on household food security in two informal urban settlements in Kenya: a longitudinal analysis. *Food Security* 8, 743–756(2016).https://doi.org/10.1007 /s12571-016-0589-3
Nathan D DeLay., Nathanael M., Thompson James R Mintert, 2021. Precision agriculture technology adoption and technical efficiency, *Journal of Agricultural Economics*, https://doi.org/10.1111/1477-9552.12440
Nwafor C, 2020. An Integrated Conceptual Framework for ICT-based Market Information Source Adoption among Smallholder Farmers., DOI: 10.20944/preprints202003.0163.v1).
Padmakumar Varijakshapanicker Sarah., Mckune Laurie Miller., Saskia Hendrickx., Mulubrhan Balehegn., Geoffrey E Dahl., Adegbola T Adesogan, 2019. Sustainable livestock systems to improve human health, nutrition, and economic status, *Animal Frontiers,* 9(4), 39–50, https://doi.org/10.1093/af/vfz041
Sakarya E., Uysal G. 2000. Measures to be considered in the livestock sector during the European Union/Turkey nomination process. Agriculture Congress; Kızılcahamam, Ankara. Turkey
Saleem A., Ali F., Khattak R M., Quraishi M I, 2014. Impact of Farm and Farmers Characteristics on Repayment of Agriculture Credit. *Abasyn Journal of Social Sciences*, 4(1)
Sasidhar PVK, Suvedi M, 2015. Integrated contract broiler farming: an evaluation case study in India. Mod Ext Advis Serv. www.meas.illinois.edu. Accessed 1 June 2018
Seymour G, 2017. Women's empowerment in agriculture: Implications for technical efficiency in rural Bangladesh. *Agricultural Economics* 48,513–522
Shiferaw B., Kassie M., Jaleta M., Yirga C, 2014. Adoption of improved wheat varieties and impacts on household food security in Ethiopia. *Food Policy,* 44, 272– 284, https://doi.org/10.1016/j.foodpol.2013.09.012
Shih H S., C H Wang., E S Lee., 2004. A multiattribute GDSS for aiding problem-solving. Math. Comput. Model., 39,1397-1412.
Sinyolo S., Mudhara M. Wale E, 2014. Water security and rural household food security: empirical evidence from the

Mzinyathi district in South Africa. *Food Science*, 6, 483–499.https://doi.org/10.1007/s12571-014-0358-0
Smith L C., Subandoro A, 2007. Measuring food security using household expenditure surveys. Food security in practice technical guide series. Washington, DC: International Food Policy Research Institute
Sraboni E Malapit H., Quisumbing A, 2014. Women's empowerment in agriculture: What role for food security in Bangladesh? *World Development*, 61, 11-52, DOI: 10.1016/j.worlddev.2014.03.025
Suzanne O'neill., Alan Matthews, 2001. Technical Change and Efficiency in Irish Agriculture, *The Economic and Social Review*, 32(3), 263-284
Swindale A., Bilinsky P, 2006. Household Dietary Diversity Score (HDDS) for Measurement of Household Food Access: Indicator Guide Washington, DC: Food and Nutrition Technical Assistance Project, Academy for Educational Development
Tefera T., Kanampiu F., De Groote H., Hellin J., Mugo S., Kimenju S., Beyene Y., Boddupalli P M., Shiferaw B., Banziger M, 2011. The metal silo: An effective grain storage technology for reducing post-harvest insect and pathogen losses in maize while improving smallholder farmers' food security in developing countries. *Crop Protection*, 30, 240 – 245
Tung D T, 2016. Measuring the technical efficiency of livestock production in Vietnam, *Outlook on Agriculture*, 45(2), 132–139. DOI:10.1177/0030727016650771
Ugbagbe., Omadachi Ogbodo., Tahirou Abdoulaye., Alpha Kamara., Joseph Mbavai., Oyakhilomen Oyinbo, 2017. Profitability and Technical Efficiency of soybean production in Northern Nigeria. *Tropicultura,* 35, 203–14
Wossen T., Abdoulaye T., Alene A., Feleke S., Menkir A., Manyong V, 2017. Measuring the impacts of adaptation strategies to drought stress: The case of drought tolerant maize varieties. *Journal of Environmental Management*, 203, 106– 113. https://doi.org/10.1016/j.jenvman.2017.06.058
Wossen T., Alene A., Abdoulaye T., Feleke S., Rabbi I Y., Manyong V, 2019. Poverty reduction effects of agricultural technology adoption: The case of improved cassava varieties in Nigeria. *Journal of Agricultural Economics*, 70(2), 1-16. https://doi.org/10.1111/1477-9552.12296
Yang M., Stanley T D, 2012. Micro-credit and income: A literature review and meta-analysis, *Bulletin of Economics and Meta-Analysis*,18(2).http://www.hendrix.edu/maer-network/default.aspx?id=15206,.
Zainab Oyetunde-Usman., Kehinde Oluseyi Olagunju, 2019. Determinants of food security and technical efficiency among agricultural households in Nigeria, *Economics,* MDPI, file:///C:/Users/Dell% 20Vostro/ Downloads /economies-07-00103.pdf