Ethiopian Economics Association
(EEA)

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Policy Working Paper 16/2023

September 2023

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Acknowledgement

This study received funding from the Bill and Melinda Gates Foundation managed by the Ethiopian Economics Association (EEA). The study is conducted as part of the Global Foundational Analysis to Close Gender Profitability Gap (GPG) project under the summer school modality. We also thank Policy studies Institute for providing us the data used in this study.

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Abstract

Agriculture is the backbone of the Ethiopian economy, and empirical evidence shows that women who make up more than half of the agricultural labor force contribute less to agricultural productivity. This study investigated the gender differences in agricultural productivity and highlighted the main causes of the productivity gaps between male and female headed households. For this study, the researchers utilized the panel data of 3474 households for the analysis, of which 69% (2404) were male-headed and 31% (1070) were female-headed households. Result from the DID Method of Impact Evaluation show that female headed households were less productive by 3.7% and 2.05 quintals per hectare when measured in terms of value in birr and quintals per hectare compared to male headed households. Additionally, the results from the pooled and random effect Tobit model showed that soil fertility, sex of the household head, slope of the land, total livestock holding in TLU, extension contact, use of inorganic fertilizer, credit use, machinery use, and plantation method are among the determinants of the gender gap in agricultural productivity. Furthermore, results from the Oaxaca decomposition show that a gender productivity difference between male and female-headed households was roughly 11.2% when measured by value and 5% when measured by an area-weighted formula. The main finding of the study is that endowment effects were less likely to have a significant impact on the productivity gap than structural effects did. Differences in the unexplained characteristics of men and women may also contribute to the considerable productivity gap between male-headed and female-headed households. Therefore, working on women's empowerment to improve their structural disadvantages through various training programs that favor women or gender mainstreamed extension training programs for lowering gender productivity differentials is a possible policy option.

Keywords: Gender, Productivity, Gap, Impact, Decomposition

1. Introduction

Women make up more than half of the labor force in Sub-Saharan Africa, and they are economically vital to agricultural productivity. However, gender-based inequities in the ownership and management of financially and economically productive resources impair agricultural production and undermine efforts to increase agricultural resilience and sustainability (Tufa et al., 2022; Bello et al., 2021). Deeply rooted sociocultural norms and traditional gender roles frequently lead to unequal distribution (Drucza et al., 2020). Numerous factors, including gender relations, have an impact on crop production. On a farm, men and women may perform a variety of activities, contribute varying amounts of labor, be in charge of various crops, or manage their plots. They might have varying levels of access to both the resources needed for farming and the distribution channels for their products. The time women spend working in agriculture may be impacted by other obligations they have in the home and community (Quisumbing & Doss, 2021).

The seminal work of Quisumbing (1996) showed the gender gap in agricultural productivity and later attracted several scholars to the issue. For instance, (Arturo et al., 2014; Aguilar et al., 2015; Kilic et al., 2015; Morgado and Salvucci, 2016; Ali et al., 2016; de la O Campos et al., 2016; Drucza et al., 2020; Bello et al., 2021; Makate & Mutenje, 2021; Tufa et al., 2022; Rodgers & Akram-Lodhi, 2018; Doss, 2018) have contributed to the area by estimating the share of the endowment effect and the structural impact to explain the gender gap in productivity using the Oaxaca-Blinder decomposition technique (Oaxaca, 1973; Blinder, 1973). The Oaxaca-Blinder decomposition method has some drawbacks, including the fact that it is susceptible to specification errors, lacks a counterfactual, and overestimates the importance of the endowment effect. It may also depend on the reference group used. However, the Oaxaca-Blinder decomposition's drawbacks are addressed by the recentered influence function (RIF) decomposition (Firpo et al., 2018).

The non-linear decomposition method developed by Fairlie (1999) is a development of the linear decomposition techniques developed by Oaxaca (1973) and Blinder (1973) and is frequently used in investigations of the gender wage gap (Fortin et al., 2011). When the outcome variable is continuous, linear decomposition methods can be used to assess and explain result differences, including gender productivity differences. However, using linear decomposition techniques when outcome variables are not continuous may produce inaccurate and misleading results (Makate & Mutenje, 2021). Regasa et al. (2013) and Barenberg et al. (2011), on the other hand, employed the two-stage least squares regression model, which is unable to break down the causes of gender disparity. Moreover, the gender disparity in the agricultural productivity gap was determined using the multivariate Tobit model by Peterman et al. (2011), the log-log model by Bonis-Profumo et al. (2021), and the OLS model by Quisumbing (1995). Through the multivariate probit based on latent variables and the index, log, and OLS, which are more based on linearly restricted assumptions, they are unable to dissect the causes of gender inequality and gender difference.

Apart from numerous studies on the gender productivity gap, there is disagreement on productivity differences between men and women (Bello et al., 2021, Quisumbing & Doss, 2021; Doss, 2018; Quisumbing et al., 2014; Njuki et al., 2013). Furthermore, other researchers (Britos et al., 2022; Pierotti et al., 2022; Maisonnave & Mamboundou, 2022; Akram-Lodhi, A., 2018; Bonis-Profumo et al., 2021; Danquah et al., 2021; Makate & Mutenje, 2021; Mugisha et al., 2019; and de la O Campos et al., 2016) found the gender productivity difference is still a major concern, and an overall difference in agricultural productivity ranges between 10% and 40% in favor of men, but the majority falls between 20% and 30% depending on the countries.

But everybody agrees that increasing the economic viability of women farmers leads to better infant and child health indicators when women control additional income, as they tend to allocate more of their earnings toward the health and well-being of their children. This means that closing the agricultural gap is a proven strategy for enhancing the food security, nutrition, education, and health outcomes of children. Better-fed, healthier children learn better and become more productive citizens, and the benefits would span generations and pay large dividends in the future. A critical lens for understanding, planning for, and implementing development goals and targets is the gender gap in agriculture (Rai et al., 2019). The fulfillment of several Sustainable Development Goals, including no poverty, zero hunger, and gender equality, will be assisted by closing the yield gap between male and female-headed plots (Mugisha et al., 2019).

Reversing the existing situation is a must for policymakers by implementing a combination of economic and behavioral reforms to achieve sustainable development goals, and it is hard to achieve sustainable development goals without increasing the productivity of women, who make up 50% of the population (Women, 2015). In doing so, gender analysis in agriculture sheds light on how socially constructed roles and duties influence a wide range of choices, from agricultural production and processing to market involvement to consumer choice and well-being results (Quisumbing and Doss, 2022). This study has been conducted for several pertinent reasons. Firstly, even though the above-mentioned studies contribute to the body of literature, none of the studies evaluated the gender gap using data collected from the same household at various times to account for time-invariant characteristics. In addition, empirical research on gender productivity in Ethiopia is extremely limited, and it receives little academic support. Consequently, the general objective of the study was to analyze the gender productivity gap and identify the determining factors of the gap in Ethiopia, specifically to examine the gender discrepancy in agricultural productivity and identify the sources of the gender differential in agricultural productivity. This research work would be unique in using panel data and applying a different econometric model from previous studies, which aims to fill an empirical gap on the magnitude and sources of the gender gap in Ethiopia by employing nationally representative data that were collected from regions of high resource potential. As a result, this study examined factors that account for the gender productivity gap using the Difference in Difference (DID) method of impact evaluation and the random effect Tobit model to capture the impact of unobserved heterogeneity between male-headed and female-headed households. Additionally, the researchers used Oaxaca and RIF Oaxaca decomposition to evaluate the source of the difference at a disaggregated level. The remaining sections of this work are as follows: section two is about methodology of the study; the third section deals with results and discussion; and the final section is concerned with the conclusion and recommendations.

2. Methodology of the Study

2.1 Type and Source of Data

The study was based on secondary data that were collected in 2017 and 2019 for PSI's AGP II baseline study and midline evaluation. This data is multi-topic and collected from representative households across the high-potential woreda in the country. This data contains detailed agricultural production parameters covering the size of land, characteristics of land, crop production, crop commercialization, agricultural production and technologies, livestock, non-farm activities, crop harvest, extension, and access to infrastructure. The AGPII baseline data includes both the treatment and control groups, whereas the AGP-II midline data only includes the treated group. Only 50% of the baseline sample was used to gather the midline data. For this study, the researcher utilized the panel households on both the baseline and midline surveys since the purpose of the paper is to compare the gender productivity gap between male-headed households and female-headed households that benefit equally from the AGP II program. Thus, the panel households were kept and used for analysis, whereas the control group and households are excluded. In line with this, 3474 households are used for the analysis, of which 69% (2404) are male-headed households and 31% (1070) were identified as female-headed households.

2.2 Method of Data Analysis

Before detailed productivity gap determination, crop productivity was measured using two methods. The first is an output-area-based estimation by dividing output produced per hectare of land. It was calculated as follows:

$$YI_i = \sum_{i=1}^{n} y_{ij} * \frac{a_{ij}}{A_{ij}} \quad \textbf{(1)}$$

Where Y_i is the overall yield of household i, and $i = 1, 2, \ldots, n$; y_{ij} is the per hectare yield of crop j, and $j = 1, 2, \ldots, M$ in household; a_{ij} is the area of crop j of household i; and, A_{ij} is the total cropping area of household i.

The second method was calculated by dividing the output value by the input cost per hectare. It has been calculated as follows:

$$Y\text{i} = \frac{\sum_{i=1}^{N} P_{ij} Q_{ij}}{\sum_{i=1}^{N} C_{ij} X_{ij}} \quad \textbf{(2)}$$

Where, Y_i is the overall yield of household i, and $i = 1, 2, \ldots, n$; pij is the price of per hectare output of crop j for ith household head, Qij is the quantity of output produced for crop j of household I, Cij is the cost of input j for ith household and Xij is the quantity of input j for an ith household.

The traditional approach to measuring and modeling disparities in technical efficiency between men and women in agricultural productivity involves the estimation of production functions that model the greatest output produced from the set of inputs given the technology accessible to the household (Peterman et al., 2011). The gender gap has been studied in the literature using different approaches. Some research has focused on differences in resource endowments to explain this phenomenon. A common method in this literature consists of testing the allocative efficiency of the distribution of certain inputs such as fertilizer or pesticide between male-headed households and female-headed households by regressing these inputs against households' observable characteristics and a variable identifying the head's gender (Larson et al. 2015; Doss and Morris 2000). These inputs are considered inefficiently allocated assuming decreasing marginal returns when the coefficient of the gender variable is statistically significant. On the other hand, several other studies have tried to explain the gender productivity gap through differences in technical efficiency. Most of these studies regress the yields on the observable characteristics of a pooled sample of male-headed households and female-headed households by including the gender of the head, which accounts for the differences in technical efficiency. Following Ali et al. (2016), before looking into the elements that can contribute to potential male-female productivity differences, the study first assessed the existence and size of the gender productivity gap using a standard methodology in the empirical literature.

$$Y_{ih} = \beta Z_{ih} + \gamma G_{ih} + \mu_{ih} + \epsilon_{ih} \qquad \textbf{(3)}$$

where, Y_{ih} is the log of yield (crop output per planted area) or value of yield for ith household h βZ_{ih} is the vector of covariates including land characteristics, log of agricultural input per planted area (chemical, organic, labor, etc.), crop varieties and farmer characteristics, γG_{ih} is the binary variables capturing the gender of household head, μ_{ih} is fixed effect that captures all time invariants characteristics of the household. And this model extended to panel data and crop-fixed effects. The DID model of impact evaluation was then used to capture the gender gap in agricultural productivity. Each model's specification details are listed below, one by one. The difference-in-differences (DiD) design takes into account any difference between genders over a given period. Following this (Fredriksson and Oliveira, 2019), the impact analysis was maintained as follows:

$$DiD = \left(\left(\bar{y}_s\text{=treatment, t=After - } \bar{y}_{\text{s=treatment, t=Before}}\right) - \left(\bar{y}_s\text{=Control, t=After - } \bar{y}_{\text{s=Control, t=Before}}\right)\right) \qquad \textbf{(4)}$$

Where y is the outcome variable, the bar represents the average value (averaged over households, typically indexed by i), the group is indexed by s (because in many studies, policies are implemented at the household level), and t is time. Algebraically, the equation of DID is represented as follows:

$$y_{it} = \alpha_T + \beta X_{it} + \mu_i + \varepsilon_{it} \qquad \textbf{(5)}$$

where Y_{it} is the program outcome of interest (yield, revenue, etc.) for household i at time t, T is a dummy variable taking the value one for the year of post-intervention and zero otherwise, X is a vector of exogenous variables including household characteristics that may affect the outcome of interest, α and β (a vector) are population parameters to be estimated, μ_i denotes time-invariant unobserved household-specific heterogeneities, and ε_{it} denotes an error term that is assumed to be identically and independently distributed. Our variable of interest is T which shows the average gender yield gap given y_{it}. The before-and-after comparison assumes that if the program had never existed, the program development outcome (yield, revenue) for program participants would have been the same as their preprogram situation. In addition to capturing the unobserved heterogeneity between female-headed households and male-headed households, gender productivity gap determinants were analyzed using the random effect Tobit regression using household panel data. Regression model with panel-level random effects specified as follow:

$$y_{it} = x_{it}\,\beta + v_i + \varepsilon_{it}$$

Where $i = 1..n$ Panels and $t = 1 \ldots n_i$ the random effect v_i are i.i.d.. $N(0, \sigma_v^2)$) and ε_{it} are i.i.d N(0, σ_ε^2σ) independently of v_i. The observed data represent possibly censored versions of yit.

Furthermore, in the literature, different methodologies have been used by Ali et al. (2016), Bonis-Profumo et al. (2021), Bello et al. (2021), Pierotti et al. (2022), Britos et al. (2022), Maisonnave and Mamboundou, (2022) to examine the gender gap in agricultural productivity between male-headed households and female-headed households. This analysis also follows a similar approach to the previous empirical works (i.e., Peterman et al., 2011; Aguilar et al., 2015; de la O Campos et al., 2016; Quisumbing & Doss, 2021; Tufa et al., 2022) and employs the extended Oaxaca-Blinder decomposition technique (Oaxaca, 1973; Blinder, 1973). The standard Oaxaca decomposition (Oaxaca, Blinder 1973) used in this analysis and the equation that has been used to decompose is as follows:

$$\mathrm{Q_m} - \mathrm{Q_f} = \mathrm{b_m}(\mathrm{X_m} - \mathrm{X_f}) + (\mathrm{b_m} - \mathrm{b_f})\mathrm{X_f} \qquad \textbf{(6)}$$

Where$\mathrm{Q_m}$, and $\mathrm{Q_f}$, represent the mean yields of male-headed households and female-headed households respectively. $\mathrm{b_m}$, and $\mathrm{b_f}$, are estimated output coefficients of male-headed households and female-headed households farmers, and X_m, and X_f, are mean levels of endowments and inputs of male-headed households and female-headed households farmers. That is, the overall average male-female yield gap can be decomposed into the portion due to differences in input endowments, $(X_m - X_f)$ evaluated using male coefficients; the other portion is attributable to differences in the returns, or output elasticity $(b_m - b_f)$, that male-headed households and female-headed households get for the same endowment or input application.

lastly, to overcome the weakness of Oaxaca and Blinder 1973 the authors use the RIF decomposition method (Rios-Avila, 2020). RIF's decomposition is an improved extension and refinement of the standard Oaxaca–Blinder (1973) decomposition techniques. RIF provides the detailed contributions of individual covariates to aggregate decomposition (Rios Avila, 2020). Following Rios Avila (2020), and Tufa et al., (2022) the researchers assume that $f_{y,x,g}(Y_i X_i G_i$ is a joint distribution function that describes all relationships between household productivity (y) and head of the household characteristics X; as well as the sex of the household head. The joint probability distribution function and cumulative distribution of Y conditional on (G) can be expressed as:

$$f^{g}_{Y,X}\,(Y,X) = f^{g}_{Y|X}(Y|X)\; f^{g}_{x}X \quad \textbf{(7)}$$

$$f^{g}_{Y,}(y) = \int f^{g}_{Y|X}(Y|X)d\; f^{g}_{x}{}_{X} \quad \textbf{(5)}$$

Where superscript g indicates the density of conditional on G= g with g϶[0,1]. To analyze the difference in productivity between male head households (g=0) and female head household (g=1) for a given distributional statistics v the cumulative conditional distribution of Y can be used to calculate the agricultural productivity gap.

$$\Delta v = v_{1-}v_0 = v(F^1_Y) - v(F^0_Y) \quad \textbf{(8)}$$

$$\Delta v = v(f^{g}_{Y,}(y) = V(\int F^1_{Y|X}(Y|X)d\; F^1_x - vV(\int F^0_{Y|X}(Y|X)d\; F^0_x\, X \quad \textbf{(9)}$$

Equation 2 shows that the difference in the statistics Δv arises from the difference in the distribution of Xs $(d\; F^1_x(X) \neq\; d\; F^0_x(X))$ and the difference in relationships between Y and $(F^1_{Y/X}(Y/X)d\; F^1_x \neq F^0_{Y/X}(Y/X)d\; F^0_x X$. To decompose the overall productivity gap caused by the structural effect the researcher obtains the counterfactual using the VC (Rios Avila 2020).

$$v_c = v(F_Y^c) = \text{v}\left(\int F_{Y|X}^0(Y|X)d\,F_x^1\,(X)\right) \quad \textbf{(10)}$$

The gap in distribution statistic v can be disaggregated into two effects: the endowment Δv_x and structural Δv_s effects, as follows:

$$\Delta v = (v_1 - v_c) + (v_c - v_0) \quad \textbf{(11)}$$

We use the semi-parametric reweighting procedure to identify the counterfactual distribution $F_{Y|X}^0(Y|X)d\,F_x^1\ (X)$ based on the observed data. According to Rios Avila (2020), although we cannot directly observe the distribution of outcomes and characteristics, the researchers can approximate the counterfactual distribution by multiplying the observed distribution of characteristics $d\,F_x^0(X)$ with a factor $\omega(X)$ thus representing the distribution $F_x^1(X)$. Therefore, the counterfactual function in the equation can be rewritten as:

$$\mathrm{F_Y^c} = \int \mathrm{F_{Y|X}^0(Y|X)d\,F_x^1\,(X)} \cong \int \mathrm{F_{Y|X}^0(Y|X)d\,F_x^0}\,\omega\mathrm{(X)} \quad \textbf{(12)}$$

The reweighting factor $\omega(X)$ can be identified using the Bayes rule as follows:

$$\omega\mathrm{(X)} = \frac{\mathrm{d\,F_X^1(X)}}{\mathrm{d\,F_X^0(X)}} = \frac{\mathrm{dF_{X|G}(X|G=1)}}{\mathrm{dF_{X|G}(X|G=0)}} = \frac{\mathrm{dF_{X|G}(X|G=1)}}{\mathrm{dF_G(G=1)}} = \frac{\mathrm{dF_G(G=0)}}{\mathrm{dF_{G|X}(G=0|X)}} = \frac{1-\mathrm{P}}{\mathrm{P}}\,\frac{\mathrm{P(T=1|X}}{1-\mathrm{P(T=1|X}} \quad \textbf{(13)}$$

Where p is the proportion of the head of the household in group $G = 1$ and $P(G = 1|X)$is the conditional probability of the household head with characteristics X being the part of group 1. This implies the counterfactual distribution of the $F_{Y|X}^c$, can be identified by estimating the reweighting factor $\omega(X)$ using the parametric methods to estimate the conditional probability of $P(G = 1|X)$. After reweighting the factors of counterfactual statistic v_c the researcher estimates RIF regression for each group and counterfactual as follows:

$$\mathrm{v_1} = \mathrm{E(RIF(y_i, v(F_Y^1)))} = \mathrm{\overline{X}^{1\prime}\,\beta^1)} \quad \textbf{(14)}$$

$$\mathrm{v_0} = \mathrm{E(RIF(y_i, v(F_Y^0)))} = \mathrm{\overline{X}^{0\prime}\,\beta^0)} \quad \textbf{(15)}$$

$$\mathrm{v_c} = \mathrm{E(RIF(y_i, v(F_Y^0)))} = \mathrm{\overline{X}^{c\prime}\,\beta^c)} \quad \textbf{(16)}$$

Therefore, after some mathematical tricks, the final decomposition components were defined as
Follows:

$$\Delta v = \underbrace{(\overline{X}^{c} - \overline{X}^{m})'^{\beta_m}}_{\Delta v_x^p} + \overline{X}^{c} \underbrace{(\acute{\beta}_c - \acute{\beta}_m)}_{\Delta v_x^e} + \overline{X}^{f\prime} \underbrace{(\acute{\beta}_f - \acute{\beta}_c)}_{\Delta v_s^p} + \underbrace{(\overline{X}^{f'} - \overline{X}^{c})'\acute{\beta}_c}_{\Delta v_s^e} \qquad \textbf{(17)}$$

The components of Δv_x^p +Δv_x^e resemble the Oaxaca-Blinder aggregate endowment effect and Δv_s^p+Δv_s^e resemble the aggregate structural effect. Δv_x^p and Δv_s^p represent pure endowment and structural effect. Δv_s^e and Δv_x^e asses the overall fitness of the model.

A clean version of the data has been prepared primarily before doing analysis. To determine the productivity gap between male- and female-headed households over different periods and groups, the DID model was employed. Then, the random effect Tobit model was used to determine the determinants of productivity differences among female and male-headed households. Finally, the Oaxaca Blinder decomposition and the RIF's Oaxaca decomposition were used to identify the magnitude and source of the gender productivity differential.

2.3 Variables of interest and definition

Table 1: Variables of interest and definition

Variables of Interest	Definition of Variables	Exp. Sign
Dependent variable		
Log of crop productivity	The logarithm of crop productivity, the ratio of gross output divided by area in hectares, and gross output value divided by input value	
Independent Variables		
Age of household head	Age of a farmer in years	-
Marital status	Marital status of a farmer (Married =1 and single= 0)	+
Sex of the household head	Sex of the farmer (male=1 and female=0)	+
Educational level	Education level of the farmers in years	+
Family size	Family size	+
Livestock ownership	Livestock owned measured by TLU	+
Access to credit	Farmers' access to credit (1 if has access to credit and 0 otherwise)	+
Access to extension service	Access to extension service (1 if farmer has access and 0 otherwise)	+
Use of chemical fertilizer	Use of chemical fertilizer (1 if the farmer has used it and 0 otherwise)	+
Farm size	Area of farmland (hectares)	-
Market access	Access to market (1 if farmer has access and 0 otherwise)	+
Soil fertility status	Takes 1 if a farmer perceived that the soil is fertile and 0 otherwise	+
Irrigation access	Access to irrigation (1 if the farmer has access and 0 otherwise)	+
Topography of plot	Takes 1 if a farmer perceived that plot is flat and 0 otherwise	+
Average distance to plots	Distance from home to a plot in walking distance in a minute	-
Multiple crops produced	Number of crop types produced by a farmer (1 if farmer produced one crop and 0 otherwise)	-
Planting method	Takes 1 if a farmer used row planting and 0 otherwise	+
Mechanization	Takes 1 if a farmer used mechanization and 0 otherwise	+

3. Result and Discussion

3.1 Sample Households' Characteristics

In this section, various continuous socio-demographic and socio-economic variables were tested for significant mean differences among male and female household heads included in the sample. Accordingly, the major significant variables are presented as follows:

The mean education level of the respondents was 2.36, showing the lower education level of farm households. There was a positive and significant relationship of 1% significance between the sex of the household head and education level. The female household head group (n=1070) has a mean education level of 2.12 (SD=3.16). By comparison, the male group was associated with a numerically higher education level of 2.46 (SD=3.5). Thus, male household heads were associated with statistically higher mean education levels (Table 2).

The mean livestock ownership measured in Tropical Livestock Units (TLU) was 3.84. Female-headed households have a mean livestock ownership of 2.81, while male-headed households have a mean of 3.85. Thus, there is a significant livestock ownership difference between male-headed and female-headed households at a 5% significance level (Table 2). As most of the land preparation is done by animal draught power, the contribution of livestock ownership to production and productivity is unquestionable. Moreover, ownership of livestock increases the probability of using manure in crop production, which would contribute to soil fertility improvement. Since land preparation and soil fertility management practices contribution to crop productivity is high, livestock ownership is expected to have a significant impact on the gender agricultural productivity gap.

Table 2: Descriptive result for continuous variables

Variables	Male (N=2404)		Female (N=1070)		Total sample (N=3474		t-value
	Mean	St. Dev.	Mean	St. Dev	Mean	St. Dev	
Age	45.650	14.23	45.87	14.38	45.72	14.27	0.42
Education (years)	2.468	3.53	2.12	3.17	2.36	3.43	23.71***
Land size (ha)	1.621	1.56	1.60	1.42	1.62	1.52	0.32
Family size	5.584	2.09	5.50	2.18	5.56	2.11	1.04
Livestock owned	3.850	1.39	2.81	1.36	3.84	1.38	4.55**

The sample was composed of both male- and female-headed households. From the total sample respondents, 2404 (69%) were male household heads and 1071 (31%) were female household heads. Most of the sample household heads were married, and of these married household heads, 69 percent were male and 31 percent were female. However, the difference in terms of the marital status between the two groups was not statistically significant (Table 3).

From the total sample of households, 78.64 percent perceived that their land was fertile soil, and the remaining perceived it was not. The difference in terms of soil fertility and the status of plots among the two groups was significant at a 5% level of significance (Table 3). The possible reason could be that most soil and water conservation activities with soil fertility management are primarily practiced by the male household head, and the use of chemical fertilizer by women farmers is affected by various socio-economic statuses. As shown in the table below, the difference in terms of the use of chemical fertilizer among the two male and female household heads was significant at a 1% level of significance.

Table 3: Summary of a categorical variable group of female and male household head

Variables	Female (N=1070)	Male (N=2404)	Pearson χ 2
Married household heads (Yes %)	30.70	69.30	0.023
Perceived fertile soil (Yes %)	65	66	2.13**
Perceived flat plot topography	80	78	1.53
Grow multiple crops (Yes %)	53	48	0.41
Used improved seed and row planting method (Yes %)	12	15	11.04***
Have extension contacts (Yes %)	24	65	1.76
Used machine harvesting (Yes %)	7	9	2.68*
Have irrigation access (Yes %)	13	13	0.20
Have credit access (Yes %)	47	45	0.11
Have market access (Yes %)	25	25	0.80
Used fertilizer on crops (Yes %)	67	68	4.08***

Despite the importance of appropriate agricultural technologies, such as improved seed, for improving the productivity of crop production, the use of improved seed with row planting and the application of mechanization is low among farmers. The proportion of female-headed households using improved seed and planting methods was 12 percent significantly lower than that of 15 percent of male-headed households. From this, the contribution of female household heads was minimal, showing significant differences between the two groups in the use of improved seed and row planting. Similarly, there is a significant difference between male and female household heads in the use of mechanization, especially machine use for crop harvesting. The proportion of female-headed households using machine harvesting was 7 percent, significantly lower than that of 9 percent of male-headed households (shown in Table 3 above).

Generally, the descriptive comparison revealed that female-headed households are significantly cultivating less fertile land, have weak use of improved seeds and row planting methods, poorly apply chemical fertilizers, lack credit access, and are more likely to be using mechanization technologies than male-headed households.

3.2 Crops production and productivity difference among male and female-headed households

Major cereal crops produced were maize, teff, wheat, sorghum, barley, and wheat, based on their area coverage and contribution to producers' food security and economy. The mean area covered by cereal crops of the total sample households was 0.76 ha. There was a positive and significant relationship between the sex of the household head and cultivated land coverage at a 5% significance level. The female-headed households have a mean of 0.69 ha, which is lower than the males (0.75 ha) (Table 4 below). The mean harvested of male and female-headed households is statistically and significantly different at a 5 percent significance level. Female-headed households harvested a lower mean harvest (10.05 q/l) than males of 12.27 q/l in a production season. There was a statistically significant difference in the production and harvest of crops between the two groups. The lower harvest and comparatively higher input costs of female-headed households contributed to lower output values compared to the male-headed households.

This can be revealed by the fact that male household heads earned on average 13,819 birr in a production season, which is higher than female-headed households of 12,203 birr, and the difference was statistically significant at a 5% significance level. In this study, crop productivity has been measured in both output and input costs and output and area coverage. In both estimation methods, female-headed households showed lower productivity levels than male-headed households. For instance, male household head output-area-based productivity on average was 16.258

q/l per ha in the main production season, which is higher than female-headed households of 15.0362 q/l, and the difference in crop productivity between the two groups is statistically significant at the 1% significance level (Table 4).

Table 4: Crops production and productivity difference among male and female-headed households

Variables	Male (N=2404)		Female (N=1070)		Total sample (N=3474)		t-value
	Mean	SD	Mean	SD	Mean	SD	
Crops area	0.75	0.75	0.71	0.66	0.74	0.72	2.213**
Production (ql)	12.26	19.51	10.05	12.56	11.58	17.69	4.00***
Input cost (birr)	9841.4	19019	8973.8	11430.	9574.	17049	1.67*
Output value (birr)	13819	27663.2	12203.	18040	13321	25104	2.05**
Productivity (value-based)	1.64	1.03	1.46	0.83	1.58	0.97	4.93***
Productivity (area based)	16.26	11.92	15.04	9.91	15.88	11.35	3.15***
Average distance to plots (minutes)	16.22	17.57	16.22	16.56	16.27	17.26	0.10

3.3 Productivity improvement based on DiD measurements

The difference in difference estimation strategy was used to calculate the gender productivity gap between male and female-headed households in the years 2016/2017 and 2019, following the AGPII baseline data and the AGPII midline data.

Table 5: Productivity improvement based on DID

Year	Sex of household head	Log productivity measured in value	Log Productivity measured in area based
2017	Female	1.36	14.78
	Male	1.52	15.05
2019	Female	1.58	15.33
	Male	1.78	17.65
Female difference		0.22	0.55
Male difference		0.26	2.60
Difference in difference		0.037	2.05

As presented in Table 5, female-headed household productivity improved by 0.22, measured by the output- input method, and by 0.548 quintals based on the output-area-based measurement. The male-headed household productivity improved by 0.26, measured by the output- input method, and by 2.6 quintals based on the output-area-based measurement. The difference in difference measured for the two groups was 3.75% measured by the output- input method and 2.05 quintals based on the output-area-based measurement. This result showed improvement in both groups due to AGP program intervention; however, male-headed households' improvement has been considerably higher than female-headed households.

3.4 Determinants of household heads' Agricultural Productivity

Factors affecting household head productivity were further examined through the Tobit regression model. For both value-based and area-based regressions, various sets of explanatory variables were found to be significant. The sex of the household head, soil fertility status, extension contact, and credit use were found to have a positive and significant effect on productivity. A flat topography, more livestock ownership, the use of improved seed and row planting, the use of chemical fertilizer, and machine for harvesting affected productivity positively and significantly. The researchers estimated the random effect Tobit model, which strengthens the result from the pooled Tobit model. The output from the random effect Tobit model includes the overall and panel-level variance components rho, and we have tested the difference between the two models using the likelihood-ratio test, which is included at the bottom of the output. When rho is zero, the panel-level variance component is unimportant, and the panel estimator is not different from the pooled estimator. In our case, we reject the null hypothesis that there are no panel-level effects and go for the random effect, and the random-effects model is calculated using quadrature, which is an approximation whose accuracy depends partially on the number of integration points used. We checked this using the quadchk command to see if changing the number of integration points affected the results, and we confirmed no impact. The results of the random effect show that, given the unobserved heterogeneity under the random effect Tobit model, unobserved household characteristics are the cause of the gender gap in agricultural productivity.

Table 6: Pooled and Random Effect Tobit model result on the Determinants of gender gap on productivity

Variables	Productivity (value-based)						Productivity (area based)					
	Pooled Tobit Model Result			Random Effect Tobit Model Result			Pooled Tobit Model			Random Effect Tobit Model Result		
	Coeff.	Marginal effect	z-value	Coeff.	Marginal effect	z-value	Coeff.	Marginal effect	z-value	Coeff.	Marginal effect	z-value
Age	0.000	0.000	-0.24	0.00	-0.000	-0.010	0.001	0.0006	0.71	.001	0.001	0.86
Sex of household head	0.094	0.095	6.17***	.097	0.097	6.380***	0.044	0.0443	1.77*	.046	0.046	1.85*
Education	0.003	0.003	1.24	.002	0.002	1.010	0.003	0.0031	0.86	.003	0.003	0.73
Marriage	0.015	0.015	0.83	.014	0.014	0.800	0.036	0.0363	1.21	.036	0.036	1.20
Soil fertility	0.041	0.041	2.64***	.033	0.033	2.190**	0.134	0.1342	5.31***	.128	0.128	5.07***
Slope	0.051	0.051	2.87***	.042	0.042	2.410**	0.012	0.0122	0.42	.004	0.004	0.13
Av. distance to the plots	0.001	0.000	-1.10	000	0.000	0.250	-0.001	-0.0006	-0.82	0	-0.000	-0.03
Livestock holding unit (TLU)	0.014	0.014	2.78***	.007	0.007	1.360	0.004	0.0038	0.45	-.003	-0.003	-0.36
Family size	0.001	0.001	0.20	.001	0.001	0.380	-0.011	-0.0109	-1.97**	-.01	-0.010	-1.88**
Land size	0.002	0.002	0.39	0	0.000	0.050	-0.011	-0.0106	-1.34	-.012	-0.012	-1.54
Growing multiple crops	-0.019	-0.019	-1.27	-.035	-0.035	-2.430**	0.016	0.0155	0.65	0	-0.000	-0.02
Extension contacts	0.049	0.049	3.35***	.042	0.042	2.940***	0.104	0.1042	4.33***	.098	0.098	4.09***
Plant method (impr. seed)	0.056	0.056	3.71***	.026	0.026	1.680	0.032	0.0320	1.28	.003	0.003	0.10
Mechanization	0.027	0.027	1.00	.032	0.032	1.220	0.161	0.1607	3.63***	.166	0.166	3.76***
Fertilizer use	0.098	0.098	6.93***	.105	0.105	7.510***	0.024	0.0235	1.02	.03	0.030	1.29
Irrigation access	-0.002	-0.002	-0.08	.004	0.004	0.170	0.039	0.0392	1.12	.044	0.044	1.26
Credit use	0.051	0.051	3.56***	.008	0.008	0.560	-0.089	-0.0885	3.76***	-.128	-0.128	-5.23***
Market access	0.021	0.021	1.30	-.004	-0.004	-0.280	0.042	0.0424	1.58	.018	0.018	0.65
Constant	0.028		0.57	.1	1.35		2.375		29.52	2.441		25.17

Mean dependent var = 0.331	/sigma_u = 0.050	Mean dependent var = 2.559	/sigma_u = 0.059
SD dependent var =0.471	/sigma_e = 0.00	SD dependent var = 0.673	/sigma_e = 0.00
Pseudo r-squared = 0.044	Rho = 0.03	Pseudo r-squared = 0.016	Rho = 0.013
Number of obs = 3269	LR test of sigma_u=0: chibar2(01) = 90.14	Number of obs = 3269	LR test of sigma_u=0: chibar2(01) = 27.14
Chi-square = 173.991	Prob >= chibar2 = 0.000	Chi-square = 106.176	Prob >= chibar2 = 0.000
Prob > chi2 = 0.000		Prob > chi2 = 0.000	
Akaike crit. (AIC) = 3863.628		Akaike crit. (AIC)= 6621.374	
Bayesian crit. (BIC) = 3985.473		Bayesian crit. (BIC)= 6743.219	

*** p<.01, ** p<.05, * p<.1

Among the observed variables, soil fertility and extension contact are the main factors accounting for the gender gap in agricultural productivity in all scenarios under consideration (See Table 6). Credit use and family size showed an unexpected negative sign. However, it might be due to the fact that household heads with larger families borrowed and utilized their credit for consumption smoothing rather than using it for applying productivity-improving technologies such as improved seed, fertilizer, and others. The finding is consistent with some prior findings that revealed the main causes of the gender gap, pinpointed as gender differences in access to and use of agricultural inputs and related investments in land and improved technologies, market and credit access, human and physical capital, and informal institutional constraints affecting farm management and marketing of agricultural outputs. For instance, compared to male-headed households, plots managed by women were found to be on average 37.5% less productive in Malawi (Tufa et al., 2022), 34.9% less productive in Uganda (Ali et al., 2016), 25% less productive in Malawi (Kilic et al., 2016), 23.4% less productive in Ethiopia (Aguilar et al., 2015), 20 % less productive in Mozambique (Morgado & Salvucci, 2016), and 11% less productive in Nigeria (Bello et al., 2021). The main causes of the gender gap in these studies have been pinpointed as gender differences in access to and use of agricultural inputs, tenure security, and related investments in land and improved technologies; market and credit access; human and physical capital; and informal institutional constraints affecting farm and plot management and marketing of agricultural produce.

3.5 Oaxaca Blinder decomposition for the gender gap in crop productivity

The study found a modest difference in crop productivity between female-headed and male-headed households of 11.5%. However, the productivity difference is lowering up to 5% when measured through the output to cropping area. After accounting for observed household head characteristics, the unexplained difference in yield between male and female-headed households is 10.5% and 4.9% in output value to input cost conversion and output to area productivity measurement, respectively. Female-headed households cultivate smaller areas of crop production in a context with strong inverse returns to the planted area, giving them a net endowment advantage of 0.6%. Crop yields in male-headed households are about 4.9-10.5% more productive than yields on farms in female-headed households. The structural component of the gap is larger than the endowment component, suggesting that even if women possess the same characteristics as men and are provided equal access to productive resources, the productivity difference will continue unless the returns to the resource endowed improve. Some prior studies similarly revealed that the gender productivity gap is driven majorly by differences in returns to resource endowment or structural effects between male- and female-headed households (for instance, Tufa et al. (2022) in Malawi, Kilic et al. (2016) in Uganda, Ali et al. (2016) in Uganda, and Bello et al. (2021) in Nigeria). Female-headed households' showed a structural disadvantage and an endowment advantage. For instance, Tufa et al. (2022) showed females a structural disadvantage of 23.1% and an endowment advantage of 8.2%); Ali et al. (2016) revealed an unexplained yield difference between male and female farmers to be 30.4% after taking into account observed parcel characteristics and unobserved household, community, season, and farmer factors,

Further analysis by the Oaxaca-Blinder decomposition method revealed that some factors contributing to the female household head productivity gap were livestock ownership, the use of improved seed and row planting methods, and fertilizer application. See Table 7 below.

Table7: Log Value of productivity Oaxaca Decomposition by Gender of household heads

Aggregate decomposition	Log productivity by value decomposition		Log productivity by area-based decomposition	
	Coefficient	P-value	Coefficient	P-value
Male-headed households' productivity(log)	0.365	0.000	2.575	0.000
Female-headed households' productivity(log)	0.255	0.000	2.525	0.000
Difference in productivity	-0.111	0.000	-0.050	0.046
Explained Portion of Difference	-0.006	0.247	-0.001	0.886
Unexplained Portion of Difference	-0.105	0.000	-0.049	0.049

Detail Decomposition Based on Value-Based Productivity Measurement

The RIF Oaxaca approach is used to decompose the productivity gap between male and female-headed households into a component that can be explained by variations in productivity determinants and a part that cannot be explained by such group differences. The results of RIF decomposition are shown in the table below. The major findings revealed that households with female heads were, on average, 11.1% less productive than households with male heads. The Oaxaca decomposition result revealed that the method of applying fertilizer, the number of livestock held, and the usage of machinery were the factors that contributed to the lower production of families with female heads. Access to credit, TLU, extension, planting method, fertilizer use, soil fertility, and slope, in contrast, make the male-headed household more productive.

Table 8: Detail decomposition based on Value Based Productivity measurement

Variables	RIF regression group 1 (Female)		RIF regression group 1 (Male)	
	Coef.	**z-value**	**Coef.**	**z-value**
Age	-0.001	-0.840	0.000	0.000
Education	0.004	0.830	0.001	0.460
Marriage	0.050	1.250	0.001	0.030
Soil fertility	0.047	1.410	0.042	2.050***
slope	0.062	1.560	0.062	2.660***
distance	0.001	0.550	-0.001	-1.500
TLU	0.026	2.270**	0.012	1.730*
Family size	0.006	0.800	0.002	0.340
Land size	0.012	1.080	-0.001	-0.180
Multiple crops	-0.055	-1.730*	-0.019	-0.990
extension	0.018	0.540	0.056	2.890***
Planting method	0.094	2.790***	0.048	2.370***
Mechanization use	0.042	0.740	0.044	1.190
Fertilizer application	0.160	4.870***	0.100	5.470***
Irrigation access	0.034	0.740	-0.002	-0.070
Credit access	0.008	0.260	0.059	3.070***
Market access	0.015	0.420	0.019	0.870
_cons	-0.122	-1.130	0.112	1.770
	RIF mean: 0.3653		RIF means: .25471	
	Number Of obs = 1,019		Number Of Obs. = 2250	
	Prob >F = 0.000		Prob >F = 0.000	
	R-squared = 0.055		R-squared = 0.037	

From Table 8 above, one can understand that Access to agricultural extension services, the technique of applying fertilizer, the number of livestock held, and the usage of machinery were the factors that contributed to widening the gap, suggesting that less attention may be given to women in agricultural extension programs, technology adoption, and asset holding. Lad size, multiple crop planting, and irrigation access are factors that close the gender productivity gap, even though they are not statistically significant. Beyond this, access to all other socioeconomic characteristics contributes to the gender gap, even if they are not statistically significant. For the male-headed household, soil fertility, the slope of the land, extension, planting method, technique of fertilizer application, and credit access contribute 34% of gender differentials, whereas for the female-headed household, fertilizer application plays the major role in gender differentials, followed by planting method and total livestock unit.

Detail Decomposition Area-Based Productivity Measurement

The productivity gap between households with male and female heads was calculated using the area-weighted productivity. According to the findings, households headed by women are 5% less productive than households headed by men. Similar to the last instance, the use of mechanization, soil extension, and soil fertility were all factors in the production differential. On the other hand, factors like soil fertility, marriage, credit access, market access, extension, planting method, mechanization use, and fertilizer application method all helped male-headed households produce more. Family size, however, has a detrimental impact on the productivity of male-headed households since the larger the family, the more they exploit their land using family labor and the less productive the land is. Therefore, farms run by households with male heads produce around 11.2% more than farms run by households with female heads. The finding is consistent with other prior studies that found nearly the same productivity gap among male and female households 4-40% in Uganda (Kilic et al., 2015); 11% in Nigeria, (Bello et al., 2021). However, the gender productivity gap estimated is lower than some other studies who revealed less productivity of women with a gap on average of 37.5 % in Malawi (Tufa et al., 2022), 34.9 % Uganda (Ali et al., 2016), 25% in Malawi (Kilic et al., 2016), 23.4% in Ethiopia (Aguilar et al., 2015), 20 % in Mozambique (Morgado & Salvucci, 2016) and Mahajan, (2019) of 45%. The major reason for that might be due to some policy and project interventions that contributed to women's empowerment and female headed households' productivity improvements in the last years including the AGP program, for instance.

Table 9: Detail decomposition based on area-based approach

Variables	RIF regression group (Female)		RIF regression group (Male)	
	Coef.	z-value	Coef.	z-value
Age	0.001	0.770	0.000	0.290
Education	-0.004	-0.570	0.005	1.210
Marriage	-0.061	-1.200	0.076	2.060**
Soil fertility	0.139	3.260***	0.133	4.240***
slope	-0.001	-0.020	0.008	0.230
distance	-0.001	-1.110	-0.000	-0.460
TLU	0.018	1.230	-0.003	-0.340
Family size	-0.010	-1.110	-0.013	-1.870*
Land size	-0.023	-1.600	-0.005	-0.510
Multiple crops	-0.039	-0.960	0.036	1.220
extension	0.145	3.470***	0.094	3.180***
Planting method	-0.062	-1.430	0.072	2.370***
Mechanization use	0.199	2.750***	0.144	2.570***
Fertilizer application	-0.063	-1.500	0.055	1.970
Irrigation access	0.034	0.580	0.048	1.100
Credit access	-0.057	-1.410	-0.103	-3.530***
Market access	0.015	0.330	0.055	1.680*
_cons	2.513	8.140	2.391	24.740
	Distributional Statistic: mean Sample Mean RIF mean: 2.5251 Number Of obs = 1,019 Prob >F = 0.000 R-squared = 0.044 Root MSE = 0.631		Distributional Statistic: mean Sample Mean RIF mean: 2.5747 Number Of Obs. = 2250 Prob >F = 0.000 R-squared = 0.037 Root MSE = 0.676	

The RIF Oaxaca decomposition reveals that the structural effect outweighs the endowment effect in terms of the percentage of gaps attributable to variations in observed household factors. As a result, the structural component of the difference is greater than the endowment component. According to this finding, performance gaps will still exist even if women share the same traits as men and have equal access to both productive resources and policy variables. The above result reveals that given equal access to resources, there is still a difference between male-headed and female-headed households, where soil fertility, extension service, and mechanization use together contribute 48% to gender differentials. From Table 9 above, one can simply trace that the male-headed household has more access to the endowment, which helps strengthen the structural characteristics that result in gender differentials. Prior studies had also explored the relevant contributions of the resource endowment effect versus the returns to resource and structural effects of the gender gap in productivity. Some of the author's conclusions have been that the gap is driven by differences in resource endowment between male- and female-headed households, rather than returns to resource endowment. For instance, Aguilar et al. (2015) in Ethiopia, Kilic et al. (2016) in Malawi, Makate, and Mutenje (2022) in Malawi, Makate and Mutenje (2022) in Tanzania showed 13.4 %, 82%, 70.3%, and 94% of this difference in productivity gap is explained by observable characteristics, or resource endowment respectively. Many of these studies suggest that estimates of the gender productivity gap become smaller after disparities in access to productive resources and personal traits are taken into account. Others revealed that the gap is driven primarily by differences in returns to resource endowment and structural effects between male- and female-headed households. For instance, Tufa et al. (2022) in Malawi, Ali et al. (2016) in Uganda, and Bello et al. (2021) in Nigeria showed that 23.1%, 30.4%, and 77.6 % of the difference in productivity gap are explained by unobservable characteristics or returns to resource endowment, respectively. If women's farms have more access to agricultural resources, they may produce 20%–30% more yields (Tambo et al., 2021) compared to what they were producing before. However, other authors argue that the productivity gap would persist even if women shared the same characteristics as men, had equal access to resources for generating income, and were taken into account when making policy decisions (World Bank, 2014; Bello et al., 2021; Kilic et al., 2016). The gender gap shrinking inside the family may provide women with more power, enhancing their access to productive inputs, increasing their responsibility for decision-making and bargaining power, and enhancing their ability to make their own decisions that are in their economic interest (Danquah et al., 2022; Mugisha et al., 2019). It has been shown that the gender difference in agricultural productivity is related to either the gender of the household head or the gender of the person who manages the farm at home, utilizing data and outcomes at the household level (Tufa et al., 2022). When compared to men, who have fewer responsibilities at home, women, particularly those who have children, spend less time on farming operations due to concerns about domestic chores, child care, and other duties. Women are time-constrained in rural communities because they manage the household and care for the children full-time. This is especially true when it comes to attending training for the extension service and taking care of domestic duties at the same time. Lack of extension results in the inability to adopt new technology in farming. Consequently, farm production may decline, and farm output may be lower. In addition, a positive coefficient for the extension variable indicates that the variable has contributed favorably to the widening of the gender performance gap. This could be because extension services are not sufficiently addressing the information needs of women.

4. Conclusion and Recommendations

Ethiopian agricultural policies have been in place for many years, with an emphasis on increasing agricultural productivity, ensuring food security, and reducing poverty. The sector is also seen as playing a key role in the economy. However, gender disparities that disproportionately disadvantage women are present in the nation's agricultural productivity. The availability of productive resources, low rates of technology adoption, economic incentives, and general well-being were all examples of gender-based disparities. Therefore, the success of policy initiatives aimed at empowering women depends on having a solid understanding of the scope and causes of gender productivity inequalities. Based on these important factors, this study investigated the gender differences in agricultural productivity and highlighted the main causes of the productivity gaps between households led by men and women. By measuring the production differences between households with male and female heads in Ethiopia, this study aims to add to the conversation on gender productivity differences in the agricultural sector. Employing RIF Oaxaca-Blinder decomposition, the results from the study showed a gender performance (productivity) difference between male-headed and female-headed households of roughly 11.2% when measured by value and 5% when measured by an area-weighted formula. The main finding of the study is that endowment effects were less likely to have a significant impact on productivity gap than the structural effects did. Differences in the unexplained characteristics of men and women may also contribute to the considerable productivity gap between households headed by men and women.

The RIF's decomposition demonstrated that, although male headed and female headed households have equal access to resources, there are still unmeasured differences preventing women from maximizing their resource usage. This study shows that to support women's emancipation and address the underlying reasons for gender differences in productivity outcomes, efforts to close the gender productivity gap should go beyond ensuring that everyone has access to resources. Such initiatives might, for example, involve the use of gender transformative strategies that aim to improve women's negotiation and decision-making abilities while also addressing the gender norms and power dynamics that prevent women from utilizing and benefiting from the resources, they have access to. The significance of structural impacts in accounting for the gender productivity gap highlights the need for policies and agricultural development programs that take into account the underlying mechanisms generating gender productivity gaps rather than focusing only on agricultural production aspects.

The findings of this study have significant policy implications for policy targeting. To effectively plan and carry out gender-responsive policies and project interventions, development professionals and policymakers would use the study's findings on the gender gap in agricultural productivity. Consequently, it would be crucial for the ministry of women's affairs to concentrate on women's empowerment to improve their structural disadvantages and increase the returns of resource utilization through various training programs that favor women or gender mainstreamed extension training programs for lowering gender productivity differentials in close collaboration with the Ministry of Agriculture. To this end, achieving gender equality in agriculture or significantly reducing its current magnitude through addressing gender gaps in access to modern production inputs (chemical fertilizer, improved seed, mechanization equipment), extension, and financial literacy, as well as improving the levels of human and social capacity building, could result in other non-negligible indirect gains in addition to gains in production, consumption, and poverty reduction.

Limitations of This Paper and Areas of Further Research

Despite the use of panel data for analysis and the two years (2017 and 2019) of national-level cross-sectional data, the study used household-level crop production and productivity data. The limitations of the household-level data compared to pilot-level data might have disregarded women's contributions to farms in households headed by men. The influence of the structural or unexplained component of the agricultural productivity gap, which is far larger than the endowment component in this analysis, was not thoroughly investigated by the researcher. Therefore, the influence of unexplained or structural effects on productivity differences arising from only being female and assuming that they had equal access to endowment was not adequately considered by the researchers in this analysis. Consequently, future studies on the subject should concentrate more on the structural effects of gender differences between female-headed and male-headed households.

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