



# Food Poverty, Vulnerability, and Food Consumption Inequality Among Smallholder Households in Ghana: A Gender-Based Perspective

Kwabena Nyarko Addai<sup>1</sup> · John N. Ng'ombe<sup>2</sup> · Omphile Temoso<sup>3</sup>

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## Abstract

We examined gender-based household welfare differences in Ghana among smallholder households. We measured disparities in welfare outcomes (food poverty, vulnerability, and food consumption inequality) across male and female household heads and identified the set of covariates influencing them. The study utilizes a dataset from a farm household survey undertaken in Northern Ghana from October to December 2018. A multistage sampling approach was adopted in selecting 900 farm households. The Oaxaca–Blinder mean and Recentered Inference Function decomposition techniques highlighted the sources of gender differentials in household welfare outcomes. The findings indicate a significant gap in food consumption expenditure per capita and household dietary diversity scores between male- and female-headed households, and these gaps are as high as 28.2% and 18.1%, respectively. However, there are no statistically significant differences in vulnerability to food poverty between male- and female-headed households. The Lorenz curves confirm inequality in gendered households' food consumption expenditure and dietary diversity scores. This study highlights the existence of systemic female-headed household vulnerability to food poverty in Ghana. This study provides significant evidence of the need for policymakers to address food systems' structural deficiencies and inequalities with gender in mind.

**Keywords** Food consumption expenditure · Dietary diversity · Vulnerability to food poverty · Inequalities · Gender differentials

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✉ Kwabena Nyarko Addai  
knaddai@gmail.com

<sup>1</sup> Department of Agricultural Economics, University of the Free State, Bloemfontein, South Africa

<sup>2</sup> Department of Agribusiness, Applied Economics and Agriscience Education, North Carolina Agricultural and Technical State University, Greensboro, NC, USA

<sup>3</sup> UNE Business School, University of New England, Armidale, NSW 2351, Australia

## 1 Introduction

The 2007–08 food price crisis and subsequent price spikes in 2010–2011 profoundly affected the world's deprived persons, aggravating and drifting the masses into poverty and gravely threatening their right to food (Oxfam, 2019; WFP, 2009). Smallholders and women (60% of the world's chronically hungry persons in 2009) were the most highly impacted groups (Scott-Villiers et al., 2016; WFP, 2009). The United Nation's food, agriculture, and health agencies estimate that the total number of hungry persons globally jumped to 10 million by 2019 (FAO et al., 2020). In all these, research suggests that female smallholders are the most severely impacted and continue to be far from attaining and achieving their human right to adequate food (Botreau & Cohen, 2020). The global community has responded by implementing various interventions and tools (see Botreau & Cohen, 2020, p.75). Still, financing has not been at par with the problems and is inadequate. Policies have fallen short in addressing the world food system's systemic shortages and inequalities instead of the usual rhetoric (Botreau & Cohen, 2020). A decade down the lane, the already precarious situation is worsened by the COVID-19 global pandemic, causing a rise in hunger and poverty. Bidisha et al. (2021) indicated that the socio-economic conditions of the currently poor or vulnerable-to-be-poor might be worsened by the COVID-19 pandemic. As COVID-19 ravages on, it exposes the links between gender inequality, food insecurity, and poverty.

Women are vulnerable across all the facets of food security: availability, access, utilization, and stability (Botreau & Cohen, 2020). Botreau and Cohen (2020) posited that gender inequalities influence hunger, food security, poverty, and vulnerability to food poverty. More so, vulnerability is dynamic, socially specific, and manifests along social, gender, and poverty (Hertel & Rosch, 2010). Dercon (2002) categorized vulnerability to poverty into three: *forever poor because of prevailing happenings; those with the probability of being poor due to probable incidents; and those most potential to be poor due to shocks or harmful variations damagingly impacting welfare.*

Numerous studies (e.g., Aryal et al., 2018; Bidisha et al., 2021; Broussard, 2019; Gebre et al., 2021; Kassie et al., 2014, 2015; Quisumbing, 2013; Tibesigwa & Visser, 2016) have examined gender gaps or inequalities on household food security and poverty in various settings of the world. Aryal et al. (2018) untangled gender-differentiated food security gaps in Buthan using an exogenous switching treatment regression. They indicated that there is no significant difference between male-headed households (MHHs) and female-headed households (FHHs) in terms of food security. Still, when MHHs are compared with de jure FHHs, the food security is significantly lower among the de jure FHHs. They observed that the food security gap between MHHs and de jure FHHs is due to the household's differences in observable and unobservable characteristics. Furthermore, Aryal et al. (2018) found that the food security gap between de facto and de jure FHHs can be explained by the influence of connections and wider access to off-farm income. In a related study, Broussard (2019) found that women have a higher probability of being food insecure relative to men. He observed that the magnitude of the gender gap in food insecurity varies across regions and varies by severity level of food insecurity. Besides, Gebre et al. (2021) decomposed the gender gaps in household food security in Southern Ethiopia. They observed that

female decision-making households have a lower probability of ensuring food security and a higher probability of being transitionally and chronically food-insecure. Furthermore, they found significant gaps between male and female decision-making households regarding food-secure, transitory food-secure, and chronically food-insecure categories.

Das (2021) recently decomposed household vulnerability to food insecurity in rural India. It was observed that idiosyncratic risk is the largest driver of poverty and covariates shocks; states with poor public distribution system performance are more susceptible. He indicated that a rise in the price of staple food items increases the chances of food insecurity; while there persist gendered differences over time, forward social and religious groups are more vulnerable. Again, it was observed that a higher level of urbanization increases the exposure and sensitivity to shocks, disrupts the supply of food commodities from rural markets, lost income, and increase rural vulnerability to food insecurity. However, the application of the gender indicator to the study of farm household's food poverty, vulnerability to food poverty, and consumption inequalities is scanty in the development discourse of food poverty and food insecurity. Vulnerability to poverty—a forward looking and dynamic measure seems more desirable than the static measure (Bogale, 2012; Das, 2021) of the nexus between gender and poverty and food insecurity that dominates the literature. More so, these studies do not decompose or identify possible sources of vulnerability to food poverty and consumption based on gender. Moving forward, this study attempts to fill this gap by analyzing gender-headed households' disparities in household welfare outcomes. Specifically, this study disentangles the gender-based drivers that impact food poverty, vulnerability, and food consumption.

The study makes the following contributions to the literature. First, for the first time, it provides a gender perspective on food poverty, vulnerability to food poverty, and food consumption inequalities. This will help avoid gender blind deficient approaches to tackling the fragile agri-food systems of the world, especially in sub-Saharan Africa and other developing countries. In Ghana and other developing countries, staple food prices remain volatile, with the recent food price spikes in 2016 and 2017 heavily impacting the purchasing power of the world's poor. With gender disparities in mind, policymakers can design policies to iron out the gender inequalities that impact food poverty, vulnerability, and food consumption (Gebre et al., 2021).

Secondly, this study helps to decompose how gender differentials of household heads impact household dietary diversity. Existing research has established that gender can influence the route through which agricultural decisions impact farm households' diets and nutrition outcomes (Botreau & Cohen, 2020). Women are noted for their 'food first' plan and mostly raise conventional crops purposely for family consumption and have less market value, while men target cash crops. This study contributes to the literature by unraveling the gender-based drivers that influence household dietary diversity among smallholder farm households, an area not explored by previous studies. Thus, the findings of this paper have the potential to aid policymakers in making informed decisions on food security, consumption, and poverty with a gender perspective in mind.

The rest of this article is organized as follows. Section 2 provides the econometric and estimation framework for the study, while Sect. 3 details the data employed and the descriptive statistics of the variables used in the study. Finally, the fourth and fifth sections present the results and discussion, and conclusion, respectively.

## 2 Econometric Framework

### 2.1 Estimation of Food Consumption Inequality and Poverty

According to Haughton and Khandker (2009), the Gini Coefficient is the most extensively used measure of inequality. It is grounded on the Lorenz curve, a cumulative frequency curve that compares the distribution of a variable with the uniform distribution to characterize equality. Researchers can use the Stata software module: *Lorenz* which fully supports variance estimation for complex samples (Jann, 2016). The overall Gini coefficient is employed chiefly in producing estimates of inequality in the distribution of household consumption expenditures over the population (Garner, 1993). Computationally, the coefficient can be expressed in terms of the covariance between total expenditures ( $X$ ) and the cumulative distributions of  $X(F)$ , and the mean of  $X(m)$ . The overall Gini Coefficient can be expressed as:

$$G = \frac{2Cov(X, F)}{m} \quad (1)$$

A lower Gini value indicates lower inequality on the distribution; zero denotes absolute equality.

The poverty estimation of the sample is done using the Foster et al. (1984) indices which can be expressed as:

$$P_\alpha = \frac{1}{N} \sum_{i=1}^q \left[ \frac{z - y_i}{z} \right]^\alpha, \quad (2)$$

where  $N$  is the sum of all households,  $q$  is the sum of all poor households,  $y$  is the household welfare measure (food consumption expenditure per capita),  $z$  is the poverty line, and  $\alpha$  is the parameter of inequality aversion. It follows that if  $\alpha=0$ , the equation assumes a headcount index, which shows the percentage of the sample that lives below the poverty line. When  $\alpha=1$ ,  $P_\alpha$  is the poverty gap index, which measures the average poverty gap in the sample as a proportion of the poverty line, and when  $\alpha=2$ ,  $P_\alpha$  measures the severity of poverty and echoes the extent of inequality among the poor.

### 2.2 Estimating Vulnerability to Food Poverty

The measurement of vulnerability based on cross-sectional data was pioneered by Chaudhuri et al. (2002). This approach has been used in situations where panel data availability is a challenge, especially among developing nations. Chaudhuri (2003) estimated a vulnerability index for households by assuming the following stochastic process generating household consumption:

$$\ln C_h = X_h \gamma + \varepsilon_h, \quad (3)$$

where  $C_h$  is the food consumption expenditure per capita,  $X$  is a set of observable household covariates,  $\gamma$  is a vector of parameters, and  $\varepsilon_h$  is a mean-zero disturbance term that accounts for idiosyncratic shocks. To consider the likelihood of a household with low per capita consumption experiencing immense consumption volatility than a household with

high mean consumption, the variance of the disturbance term is taken as a function of the household characteristics:

$$\sigma_\epsilon^2 = X_h\theta + \varphi. \tag{4}$$

In this study, the estimates of  $\gamma$  and  $\theta$  were obtained by utilizing the three-stage feasible generalized least squares (FGLS). We estimated Eq. (3) by ordinary least squares in the first stage. The estimated residuals from Eq. (3) were used to run the following model:

$$\hat{\epsilon}_{OLS}^2 = X_h\theta + \eta. \tag{5}$$

The estimates obtained from Eq. (5) were transformed as follows:

$$\frac{\hat{\epsilon}_{OLS}^2}{X\hat{\theta}_{OLS}} = \frac{X}{X\hat{\theta}_{OLS}}\theta + \frac{\eta}{X\hat{\theta}_{OLS}}. \tag{6}$$

The OLS estimate of  $\theta$  in Eq. (5) yielded an asymptotically FLGS estimate of  $\theta$ , that is,  $X\hat{\theta}_{FGLS}$  being a consistent estimator of  $\sigma_\epsilon^2$ . Equation (1) was transformed as follows:

$$\frac{\ln C}{\hat{\sigma}_\epsilon} = \frac{X}{\hat{\sigma}_\epsilon}\gamma + \frac{\epsilon}{\hat{\sigma}_\epsilon}, \tag{7}$$

where  $\hat{\sigma}_\epsilon = \sqrt{X\hat{\theta}_{FGLS}}$ . The OLS estimation of Eq. (7) yielded the asymptotically FLGS estimator  $\hat{\gamma}_{FGLS}$ , which in turn enabled us to estimate the expected log consumption and its variance as:

$$\hat{E}(\ln C|X) = X\hat{\gamma}_{FGLS}, \tag{8}$$

$$\hat{V}(\ln C|X) = X\hat{\gamma}_{FGLS}. \tag{9}$$

Assuming that consumption is log-normally distributed, the probability that the household will be poor, that is, the vulnerability index is:

$$v = \Phi \left( \frac{X\hat{\gamma}_{FGLS} - \ln z}{\sqrt{X\hat{\theta}_{FGLS}}} \right) \tag{10}$$

where  $\Phi$  denotes the cumulative density of the standard normal variate. Following Dey (2018), households with a probability greater than or equal to 0.50 can be described as having a high vulnerability to poverty risk.

### 2.3 Oaxaca–Blinder Decomposition

Following Addai et al. (2021) and Gebre et al. (2021), we employ the Oaxaca–Blinder regression approach of mean decomposition to assess the level and factors that influence gender variations in food poverty, vulnerability, and food consumption inequality among smallholders in Ghana. The Oaxaca–Blinder (OB) decomposition procedure explains the extent to which the variance in mean outcome is between two groups (e.g., between Asians and Blacks, and in this study, between male-headed and female-headed farm households) considering group

variations in the characteristics. The aggregate OB decomposition follows the classical linear model:

$$Y_l = X_l' \delta_l + \varepsilon_l, E(\varepsilon_l) = 0, \quad (11)$$

where  $l \in (f, m)$  represented female-headed households ( $f$ ) or male-headed households ( $m$ ),  $X$  is a vector of factors (and a constant term),  $Y$  represents the outcome variables (food consumption expenditure per capita, household dietary diversity score, and vulnerability to poverty), and  $\delta$  is a vector of slope parameters (and the intercept). The gender gap in the outcome variables between female- and male-headed households can be defined as:

$$R = E(Y_m) - E(Y_f) = E(Y_m)' \delta_m - E(Y_f)' \delta_f, E(\varepsilon_l) = 0. \quad (12)$$

Using simple algebraic manipulation, Eq. (2) can be decomposed into a component of the difference because of variations in the levels of the determinants and a part due to variations in the estimates, which is normally referred to as "discrimination," especially if it is connected with some fixed group trait such as race and gender (Fortin et al., 2011). Assuming that there is some unbiased estimate vector  $\delta^*$  by which the variation in the determinants is weighted so that

$$R = (E(X_m) - E(X_f))' \delta^* + (E(X_m)' (\delta_m - \delta^*) + E(X_f)' (\delta^* - \delta_f)). \quad (13)$$

Equation (13) presents a "twofold" decomposition

$$R = Q + U, \quad (14)$$

where  $Q = (E(X_m) - E(X_f))' \delta^*$  represents the parts of the gender outcome gap that form group variations in the determinants (factor effect); and  $U = (E(X_m)' (\delta_m - \delta^*) + E(X_f)' (\delta^* - \delta_f))$  is the residual or structural part of the findings from unequal yields to the determinants (unexplained component: Bidisha et al., 2021; Blinder, 1973; Jann, 2008; Oaxaca, 1973).

The structural component is mainly linked with discrimination and can also consider variations in unobserved factors (Jann, 2008). A decrease in the yields of one group (female-headed), discrimination may lead to a surge in the yields of the other group (male-headed), which explains the struggle toward anti-discriminatory frameworks (Oaxaca & Ransom, 1994). This thought is introduced in the decomposition of the structural component into discrimination in favor of one group (structural advantage),

$$U_m = E(X_m)' \gamma_m, \quad (15a)$$

and discrimination against the alternate group (structural advantage: Aguilar et al., 2015)

$$U_f = E(X_f)' \gamma_f, \quad (15b)$$

where  $\delta_m = \delta^* + \gamma_m$  and  $\delta_f = \delta^* + \gamma_f$  ( $\gamma_m$  and  $\gamma_f$  are group-specific discrimination parameters).

## 2.4 Recentered Influence Function Decomposition

The Recentered Influence Function (RIF) decomposition by Firpo et al. (2009) was employed and estimation was done in Stata software using the *oaxaca\_rif* module

(Rios-Avila, 2020), to examine the differences across the distributions of the outcome. The RIF regression is comparable to the classical linear regions, but the response variable is substituted with the RIF distributional statistics of interest. The RIF is expressed as

$$RIF(y;v) = v(F_y) + IF(y;v), \tag{16}$$

where  $y$  is the dependent variable of interest (hereafter, food consumption expenditure per capita, household dietary diversity score, vulnerability to poverty),  $v(F_y)$  represents the distributional statistics of interest, and  $IF(y;v)$  is the influence function equivalent to an observed outcome  $y$  for the distributional statistic  $v(F_y)$ . The conditional expectations of  $RIF$  are assumed to be a linear function of  $X$

$$E[RIF(y;v)|x] = X_c + \epsilon. \tag{17}$$

The RIF quantiles can be expressed as

$$RIF(y;Q_\tau) = Q_\tau + \frac{\tau + I\{y \leq Q_\tau\}}{f_y Q_\tau}, \tag{18}$$

where  $Q_\tau$  is the population  $\tau$ -quantile of the unconditional distribution of  $y$ ,  $\frac{\tau + I\{y \leq Q_\tau\}}{f_y Q_\tau}$  is the influence function,  $I\{\cdot\}$  is the indicator function, and  $f_y Q_\tau$  is the density of the marginal distribution of  $y$ .

To estimate RIF, the sample quantile,  $\hat{Q}_\tau$ , and the density at that point were computed. The density was obtained using the kernel approach (Fortin et al., 2011). Using the estimates  $\hat{Q}_\tau$  and  $f\hat{Q}_\tau$  and putting them into Eq. (8), we obtained the estimates of RIF for individual observations. Upon an estimation of the RIF, one can execute the Oaxaca–Blinder decomposition using the estimates of RIF as the response variable  $y$ . In the present study, the estimates of RIF were regressed on the same independent variables as in the conventional OB decomposition.

### 3 Study Area, Data, and Descriptive Statistics

In Ghana, extreme poverty is a rural phenomenon, with roughly 2.2 million people living in extreme poverty in the rural parts of the country (GSS, 2018). More specifically, extreme poverty is highest in rural savannah, of which Northern Ghana represents a more significant share. In 2016/2017, the Northern region, Upper East Region, and Upper West represented 67.2% of those living in extreme poverty in Ghana. Compared to the year 2012/2013, in these areas extreme poverty enlarged by 14.5 percentage points. Over the four years (2013–2017), the growing population has overshadowed efforts to reduce extreme poverty, leading to many individuals becoming impoverished, notwithstanding the decrease in poverty prevalence (GSS, 2018).

Taken together, this study utilizes a dataset from a farm household survey undertaken in Northern Ghana from October to December 2018. The sampled farm households were from the Northern, Upper East, and Upper West Regions of Ghana. The sample comprises 900 farm households with 300 from each region. A multistage sampling approach was employed in selecting the households. The initial step involved a purposive sampling of the Northern zone of Ghana. Northern Ghana was chosen on purpose as it represents Ghana’s most rearward region and is labeled as the most poverty-stricken and hunger-prone area in Ghana (GSS, 2018). The zone is also basically dominated by agricultural households with

rice production being the major agricultural production activity. The Upper East, Upper West and Northern regions made for 54.8%, 70.9% and 61.1%, respectively, to poverty prevalence in Ghana (GSS, 2018). WFP (2012) showed that more than 680,000 persons are either severely or moderately food insecure, of which 140,000 were codified as severely food insecure and consuming low-quality food. The next stage involved selecting a district from each region contingent on their scale of rice production. The sampled districts were Savelugu (Northern region), Nadowli Kaleo (Upper West) and Kassena Nankana (Upper East). The subsequent step was a simple random selection of farm households from the different district communities based on rice's size and production levels. The data collected include rice production variables and socio-economic and demographic variables of all farm households through a structured questionnaire. The instrument was pretest to improve validity before a final version was administered to the target population. The survey instrument was administered face-to-face.

Table 1 presents a description, summary statistics, and test of the difference of the means between male and female-headed household (FHH) characteristics. It is observed that male-headed households (MHHs) had high mean food consumption expenditure per capita and household dietary diversity score than FHHs, and the difference is statistically significant. It illustrates the gender inequalities in food consumption among farm households. In terms of age, male heads of households, on average, are slightly older than female heads. Besides, MHHs have a relatively larger household size than female-headed ones. In terms of years of schooling, female heads have higher years of schooling than their male compatriots.

In terms of farm size, as an endowment factor, male heads have on average larger farm sizes than female heads. This depicts the disparities in resource endowment, an indispensable tool to promote food security and reduce food poverty. On average, female heads travel longer distances to the farm and markets than their male counterparts. This can be a stumbling block in achieving food security among FHHs. Total assets value is a depiction of the resource endowment of people. This reinforces the point that MHHs are more endowed than their female compatriots. On average, MHHs had higher rice yields than female-headed ones. This can partly be attributed to the higher pest infestation experienced during the cropping season for which male heads would more likely deal with, by spraying—which maybe more labor intensive thereby MHHs more likely to control than FHHs. However, other factors could also be at play for this difference in yields. Thus, the next section presents econometric estimation results that explore these gender differences in more detail.

## 4 Results and Discussion

### 4.1 Determinants of Food Consumption Expenditure, Vulnerability to Food Poverty, and Consumption Inequality

Table 2 provides the ordinary least squares estimates of the mean decomposition of the various indicators (food consumption expenditure per capita, household dietary diversity score, and vulnerability to food poverty) being examined. It is observed that being a female household head negatively and significantly influences food consumption expenditure per capita and household dietary diversity score. This result is in line with the findings of Grimaccia and Naccarato (2020). Following Grimaccia and Naccarato



**Table 1** Descriptive statistics

Variable	Description	Pooled	Female HH	Male HH	Diff
Food consumption expenditure per capita	Total food consumption per household member in GHS	8.12 (6.89)	6.62 (6.46)	8.83 (6.98)	-2.210***
HDDS	Household dietary diversity score	6.03 (1.36)	5.20 (1.11)	6.42 (1.30)	-1.222***
Age	Age of household head in years	52.45 (9.82)	52.20 (9.81)	52.57 (9.83)	-0.367
Household size	Number of household members	6.12 (2.02)	5.98 (2.04)	6.19 (2.01)	-0.209
Years of schooling	Years of formal education of the household head	3.02 (4.50)	3.08 (4.47)	2.99 (4.51)	0.089
Farm size	Total rice farm size in hectares	0.64 (0.54)	0.62 (0.55)	0.65 (0.54)	-0.032
Farm distance	Distance from home to the farm in km	3.99 (2.36)	4.02 (2.36)	3.97 (2.36)	0.050
Market distance	Distance from farm to market in km	4.07 (2.05)	4.26 (2.06)	3.98 (2.04)	0.289**
Asset value	Total asset value (GHS) <sup>a</sup>	1130.13 (403.34)	1106.02 (403.40)	1141.47 (403.14)	-35.457
Family labor	Family labor in man-day per ha	173.37 (209.70)	193.12 (245.43)	164.08 (190.10)	29.03*
Rice yield	Rice yield in kg/ha	1419.78 (1160.96)	1412.48 (1153.44)	1423.22 (1165.41)	-10.733
FBO	1 if FBO member, 0 otherwise	0.40 (0.49)	0.48 (0.50)	0.37 (0.48)	0.106**
Land ownership	1 if household head is the landowner, 0 otherwise	0.54 (0.50)	0.52 (0.50)	0.54 (0.50)	-0.020
Chemical fertilizer	1 if household head applies a chemical fertilizer, 0 otherwise	0.59 (0.49)	0.59 (0.49)	0.59 (0.49)	0.002
Improved seeds	1 if household head adopted improved rice variety, 0 otherwise	0.72 (0.45)	0.74 (0.43)	0.71 (0.46)	0.037
Pest	1 if there was a pest outbreak, 0 otherwise	0.46 (0.50)	0.54 (0.50)	0.42 (0.49)	0.126**
Disease	1 if there was disease outbreak, 0 otherwise	0.66 (0.47)	0.64 (0.48)	0.67 (0.47)	-0.028

<sup>a</sup>US Dollars (USD) to Ghanaian Cedis (GHS) exchange rate for December 31, 2018: 1USD: GHS 4.9

**Table 2** Base ordinary least square regression results underlying the mean decomposition

	Log of food consumption per capita			Log of HDDS			Log of vulnerability to poverty		
	Pooled	Female HH	Male HH	Pooled	Female HH	Male HH	Pooled	Female HH	Male HH
Female house- hold head	-0.280*** (0.044)			-0.191*** (0.013)			0.002 (0.003)		
Log of age	-0.073 (0.120)	-0.373* (0.218)	0.018 (0.146)	-0.010 (0.034)	-0.049 (0.064)	-0.001 (0.040)	0.049*** (0.008)	0.053*** (0.010)	0.046*** (0.010)
Log of years of schooling	0.059** (0.021)	0.069* (0.039)	0.046* (0.025)	0.005 (0.006)	0.012 (0.010)	-0.000 (0.007)	-0.049*** (0.001)	-0.049*** (0.002)	-0.049*** (0.001)
Log of farm size	-0.004 (0.099)	-0.098 (0.170)	0.044 (0.122)	0.015 (0.028)	0.010 (0.054)	0.007 (0.033)	-0.023*** (0.006)	-0.043*** (0.012)	-0.014** (0.007)
Log of farm distance	0.084 (0.053)	0.125 (0.094)	0.069 (0.064)	-0.020 (0.014)	-0.013 (0.024)	-0.020 (0.018)	-0.056*** (0.004)	-0.056*** (0.006)	-0.057*** (0.004)
Log of market distance	-0.039 (0.046)	-0.034 (0.086)	-0.030 (0.055)	-0.003 (0.013)	0.012 (0.025)	-0.011 (0.016)	0.050*** (0.003)	0.059*** (0.009)	0.045*** (0.003)
Log of house- hold size	-0.061 (0.054)	-0.241** (0.093)	0.018 (0.066)	-0.030* (0.016)	-0.044 (0.030)	-0.026 (0.019)	0.033*** (0.003)	0.039*** (0.004)	0.032*** (0.004)
Log of asset value	0.127** (0.061)	0.277** (0.107)	0.056 (0.074)	-0.021 (0.017)	-0.024 (0.031)	-0.014 (0.021)	-0.102*** (0.004)	-0.098*** (0.006)	-0.104*** (0.004)
Log of family labor	-0.162*** (0.028)	-0.096* (0.050)	-0.189*** (0.035)	0.004 (0.007)	0.008 (0.013)	0.002 (0.008)	0.137*** (0.003)	0.130*** (0.005)	0.141*** (0.004)
Log of rice yield	-0.031 (0.026)	-0.060 (0.054)	-0.016 (0.030)	-0.005 (0.007)	-0.023* (0.013)	0.005 (0.008)	0.021*** (0.002)	0.021*** (0.003)	0.021*** (0.002)
FBO	0.061 (0.043)	0.070 (0.084)	0.064 (0.049)	0.019 (0.013)	0.006 (0.022)	0.024 (0.015)	-0.021*** (0.003)	-0.021*** (0.005)	-0.021*** (0.003)
Land owner- ship	-0.018 (0.041)	0.052 (0.077)	-0.036 (0.047)	-0.013 (0.011)	0.004 (0.022)	-0.024* (0.014)	0.007** (0.002)	0.007 (0.005)	0.006** (0.003)
Chemical fertilizer	0.198** (0.058)	0.123 (0.106)	0.217** (0.067)	0.002 (0.016)	0.024 (0.029)	-0.011 (0.019)	-0.127*** (0.003)	-0.135*** (0.004)	-0.122*** (0.004)
Improved seeds	0.115** (0.041)	-0.058 (0.080)	0.180*** (0.048)	0.100*** (0.013)	0.062** (0.025)	0.118*** (0.016)	-0.090*** (0.003)	-0.089*** (0.004)	-0.090*** (0.003)

**Table 2** (continued)

	Log of food consumption per capita			Log of HDDS			Log of vulnerability to poverty		
	Pooled	Female HH	Male HH	Pooled	Female HH	Male HH	Pooled	Female HH	Male HH
Pest	0.048 (0.041)	0.064 (0.075)	0.039 (0.049)	0.015 (0.012)	0.051** (0.023)	-0.002 (0.014)	-0.018*** (0.002)	-0.017*** (0.004)	-0.018*** (0.003)
Disease	-0.132** (0.047)	-0.135 (0.088)	-0.135** (0.055)	-0.002 (0.013)	0.002 (0.023)	-0.007 (0.016)	0.100*** (0.002)	0.097*** (0.004)	0.101*** (0.003)
Constant	2.312** (0.680)	2.459* (1.307)	2.277** (0.803)	2.195*** (0.193)	2.259*** (0.352)	2.055*** (0.229)	-0.019 (0.044)	-0.041 (0.092)	-0.011 (0.049)
No. of observations	900	288	612	900	288	612	900	288	612
R-squared	0.2256	0.1392	0.2585	0.2410	0.0666	0.1045	0.9751	0.9729	0.9769

\*\*\*, \*\*, and \* indicate a significance level of 1%, 5%, and 10%. Robust standard errors are in parenthesis

(2020), this could be because female household heads are systemically disadvantaged relative to male household heads regarding ownership of resources and livelihood outcomes such as food consumption. However, these findings contradict Maziya et al. (2017), who indicated that female HHs are more food secure than male HHs in South Africa.

The sign for vulnerability to food poverty is positive even though not significant. As Tsiboe et al. (2017) indicated, pooled regression may seem inappropriate to assess the factors influencing vulnerability to food poverty and consumption inequality based on gender. This is because pooled regression estimates assume that explanatory variables affect both female- and male-headed households. This implies that there is no interaction between the gender variable and other independent variables. In other words, this suggests that it is solely gendered, with an intercept effect or a parallel shift, which constantly remains the same, notwithstanding the values the other explanatory variables may assume in determining the outcome variables. To avoid this econometric trap, in the next section, we decompose the gendered sets of covariates and highlight the roles each variable plays in determining the various outcomes.

The age of the female household heads negatively influences food consumption expenditure per capita. This implies that as female household heads become older, on average, their food consumption expenditure reduces. This corroborates with the results of Huluka and Wondimagegnhu (2019). They posited that aged household heads might not work longer hours per day than their younger compatriots, especially during farming, to improve food production and security. Similarly, as smallholder farmers' age increases their vulnerability to food poverty for the pooled sample as well as for when FHHs and MHHs are examined separately. This is in line with Azeem et al. (2016), who found similar findings among households in Punjab, Pakistan. On the contrary, it contradicts Mba et al. (2021), who indicated that as the age of the head of the household increases, it leads to a reduction in household vulnerability in Nigeria.

Education, expressed in terms of schooling years, positively and significantly improves food consumption expenditure in the pooled sample as well as for FHH and MHH samples. This implies that more educated household heads improve food consumption outcomes for households, which suggests that improving years of schooling can positively reduce food poverty. This corroborates with the results of Gebre et al. (2021), who found similar results in Southern Ethiopia. On the other hand, years of schooling significantly reduce vulnerability to food poverty among all the households (pooled, FHHs, and MHHs). People's exposure to schooling, be it formal or informal, can impact the household's standard of living as it aids in developing skills and becoming more informed. This may lead to an improvement in their marginal productivity in both the farm and non-farm sectors. However, this contradicts the findings of Azeem et al. (2017), who assessed the vulnerability of households in Pakistan.

Farm size negatively and significantly impacts household heads' vulnerability to food poverty. Farm size is an indicator of a household's resource endowment. Resources play a crucial role at improving the food security situation of a household. Large farm size is linked with more wealth and adequate capital that enhances the likelihood of investing in productive resources to increase crop productivity and thus improves food security. This finding is consistent with Zereyesus et al. (2017).

Farm distance to farmstead significantly reduces a household's risk of food poverty. This suggests that the longer the distance from the farmer's homestead to the farm, the less vulnerable the household becomes regarding food poverty. This might be because productive lands for farming are usually located remotely from the smallholder's homestead. Thus,

as Bersisa and Heshmati (2021) put it, reduced farm distance is associated with improved crop productivity and makes households less vulnerable to food poverty.

Market distance positively and significantly influences a household's vulnerability to food poverty. This implies that the longer the distance of the smallholder to the market, the more vulnerable it becomes to food poverty. This serves as a significant setback to households in assessing information and agricultural markets that impact productivity and, hence, increases households' vulnerability to food poverty. This is in line with what was observed by Manda et al. (2020).

The size of female-headed households negatively and significantly reduces their food consumption expenditure per capita. This implies that enlargement in the size of FHHs leads to food insecurity. This is in line with Maziya et al. (2017), who observed the same among smallholders in South Africa. They indicated that enlargement in the household size implies that more people need to be fed. Therefore, it indirectly lowers the income per head, expenditure per head, and per capita food consumption for a fixed income. The increase in the household size also reduces dietary diversity scores among households. This is consistent with the findings of Huluka and Wondimagegnhu (2019). Huluka and Wondimagegnhu (2019) indicated that, this can result from the fact that more children with limited income sources will allocate the already meager resource of the household to an array of competing demands. This entails investment in children's education and health and more mouths to feed concurrently. Such a scenario negatively impacts the per capita income growth of the households, thus, resulting in low dietary diversity. In a similar vein, households become more vulnerable to food poverty with an increase in household size.

The entire asset value of the pooled sample and FHHs positively and significantly improves household food consumption expenditure per capita. This could be because valuable assets can be sold for cash to meet household needs for sustenance. This may help in reducing household food insecurity. In addition, it could serve as household insurance to prepare for periods of food scarcity aside from households having enough food presently. This finding corroborates with what was observed by Gebre et al. (2021). Likewise, valuable assets of smallholder households can be traded off to reduce household vulnerability to food poverty. This is in line with the results of Azeem et al. (2016).

The number of man-days the family spends on a hectare of their cultivated land negatively and significantly influences food consumption per capita. This implies that family labor reduces household food security which could be the case when a large family size with a greater percentage of children contributes virtually nothing to the agricultural labor requirement of the household. Such a scenario will impact crop productivity and hence household food consumption. This finding corroborates with the findings of Kuiper et al. (2020), who underscored the missing link in the current food security projections of the world aside from the price factor, which dominates the discourse. In a similar vein, family labor and many children in the family who do not contribute to the family income increase the household's vulnerability to food poverty. The reason is that this will reduce the family income per capita and subsequently per food consumption, consequently making the household to be more vulnerable to food poverty.

An increase in rice yield within FHHs leads to a reduction in household dietary diversity score. Rice is produced as a pure stand or monocrop, and families have less variety of crop products to choose from in meeting the household dietary requirement. This situation even worsens when farm households are not diversified in terms of agricultural production and income sources. This corroborates with the findings of Grote et al. (2021), who posited that food insecurity in SSA is likely to worsen due to the steady rise in monocropping of crops such as maize. Concurrently, households become vulnerable to food poverty due to

the non-diversification of crop production. This is plausible as non-diversification of crops is associated with increased income variability among smallholders (Mzyece & Ng'ombe, 2020) which could also lead to more food poverty. Any shock in the production of the monocrop is likely going to lead to food poverty, especially if the household does not have other income sources apart from agricultural income.

Membership in farmer-based organizations (FBOs) significantly reduces a household's vulnerability to food poverty. This implied household heads who are members of FBOs are less vulnerable to food poverty. This is probably because farmer organizations or networks constitute a vital resource that household heads can exploit to reduce their risk and improve their household welfare. For example, FBOs provide technical assistance and credit to help smallholders boost crop production and access stable market outlets. Thus, making them less vulnerable to food poverty. This finding is in line with the results of Addai et al. (2021).

Male-headed households (MHHs) that own cultivated lands are significantly associated with lower household dietary diversity scores. This is primarily the case as landowners' household heads diversify less to improve their food security status and dietary diversity. This is consistent with the findings of Keovilignavong and Suhardiman (2020). They posited that land tenure insecurity pushes farm household heads to explore different approaches and options to guarantee food supply through the farm and non-farm avenues.

Adoption of chemical fertilizer by household heads (from the pooled sample and MHHs) increases the household's food consumption expenditure per capita. A plausible explanation of this is that smallholder chemical fertilizer adoption leads to increased crop productivity and hence increases household food consumption and food security. This is in line with the results of Magrini and Vigani (2016). They observed that the adoption of chemical fertilizer improves food security in multiple dimensions (food expenditure, calorie intake, and diet diversity) and reduces vulnerability to food insecurity.

Improved seed adoption improves food consumption expenditure, dietary diversity and reduces a household's vulnerability to food poverty. This is consistent with Magrini and Vigani (2016) and Biru et al. (2019). Biru et al. (2019) indicated that the adoption of improved seeds improves food consumption expenditure and reduces people's vulnerability, especially when combined with other complementary technologies such as chemical fertilizer, terraces, and pesticides.

Unexpectedly, we find that the occurrence of pests during the production season significantly increases dietary diversity (among FHHs) and reduces the household's vulnerability to food poverty. As a risk aversing mechanism among households, farmers may become more innovative during such periods, may seek alternative strategies such as engaging in off-farm employment to minimize the shock of crop loss due to pest infestation on the farm. Results show that, not only does crop disease occurrence on the farm reduce household food consumption among the pooled households and MHHs, it also increases the household's vulnerability to food poverty. In other words, agricultural shocks such as crop diseases lead to reduced crop output, hence less food for household consumption, let alone having surpluses to sell to improve household income.

## 4.2 Oaxaca–Blinder (OB) Decomposition Estimates

### 4.2.1 Food Consumption Expenditure Per Capita

Table 3 shows the Oaxaca–Blinder (OB) decomposition of the gender differential in welfare outcomes. Columns (2) and (3) of Panel A presents the details of the differentials of

**Table 3** Oaxaca decomposition of the gender differential in welfare outcomes

	Log of food consumption expenditure per capita		Log of HDDS		Log of vulnerability to poverty	
	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust
<i>Panel A: gender differential</i>						
Male-headed households	2.073***	0.026	1.989***	0.007	0.164***	0.009
Female-headed households	1.790***	0.039	1.808***	0.010	0.179***	0.012
Difference	0.282***	0.047	0.181***	0.013	-0.014	0.015
<i>Panel B: aggregate decomposition</i>						
Endowment component of difference	0.002	0.022	-0.010**	0.004	-0.012	0.015
Share of the endowment component of gender outcome differential	1%		-6%		86%	
Unexplained component of difference	0.280***	0.044	0.191***	0.013	-0.002	0.003
Share of the unexplained component of gender outcome differential	99%		105%		14%	
<i>Panel C: detailed decomposition</i>						
Log of age	-0.000 (0.001)	1.542 (1.011)	-0.000 (0.000)	0.192 (0.291)	0.000 (0.001)	-0.030 (0.055)
Log of years of schooling	-0.002 (0.005)	-0.018 (0.036)	-0.000 (0.000)	-0.010 (0.010)	0.002 (0.004)	0.001 (0.003)
Log of farm size	-0.000 (0.002)	0.063 (0.091)	0.000 (0.001)	-0.001 (0.028)	-0.000 (0.000)	0.013 (0.007)**
Log of farm distance	-0.001 (0.004)	-0.068 (0.136)	0.000 (0.001)	-0.009 (0.036)	0.001 (0.002)	-0.002 (0.009)
Log of market distance	0.003 (0.004)	0.004 (0.129)	0.000 (0.001)	-0.030 (0.038)	-0.004 (0.002)**	-0.018 (0.012)
Log of household size	-0.002 (0.003)	0.451 (0.194)**	-0.001 (0.001)	0.032 (0.060)	0.001 (0.001)	-0.012 (0.009)
Log of asset value	0.005 (0.004)	-1.535 (0.884)*	-0.001 (0.001)	0.073 (0.254)	-0.004 (0.003)	-0.045 (0.050)
Log of family labor	0.024 (0.012)*	-0.443 (0.284)	-0.001 (0.001)	-0.032 (0.074)	-0.020 (0.010)**	0.050 (0.028)*
Log of rice yield	-0.001 (0.002)	0.298 (0.407)	-0.001 (0.000)	0.198 (0.101)**	0.000 (0.001)	0.002 (0.022)
FBO	-0.007 (0.005)	-0.003 (0.042)	-0.002 (0.002)	0.008 (0.012)	0.002 (0.001)**	-0.000 (0.002)
Land ownership	-0.000 (0.001)	-0.046 (0.047)	-0.000 (0.001)	-0.015 (0.013)	0.000 (0.000)	-0.001 (0.003)

Table 3 (continued)

	Explained	Structural	Explained	Structural	Explained	Structural
Chemical fertilizer	-0.000 (0.007)	0.056 (0.073)	-0.000 (0.000)	-0.021 (0.020)	0.000 (0.004)	0.008 (0.003) **
Improved seeds	-0.004 (0.003)	0.174 (0.067) **	-0.004 (0.003)	0.041 (0.021) *	0.003 (0.003)	-0.001 (0.004)
Pest	-0.006 (0.005)	-0.012 (0.044)	-0.002 (0.002)	-0.026 (0.013) *	0.002 (0.001) **	-0.001 (0.002)
Disease	-0.003 (0.004)	-0.000 (0.065)	-0.000 (0.000)	-0.006 (0.018)	0.003 (0.003)	0.003 (0.003)

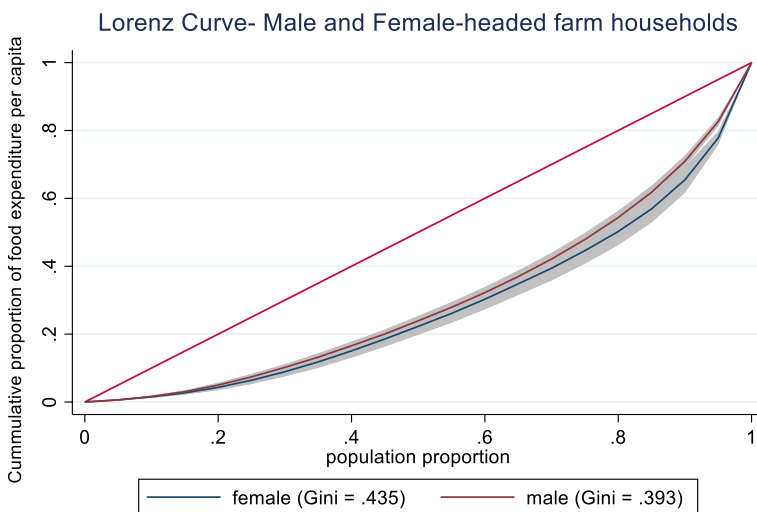
\*\*\*, \*\*, and \* indicate a significance level of 1%, 5%, and 10%. Robust standard errors are in parenthesis



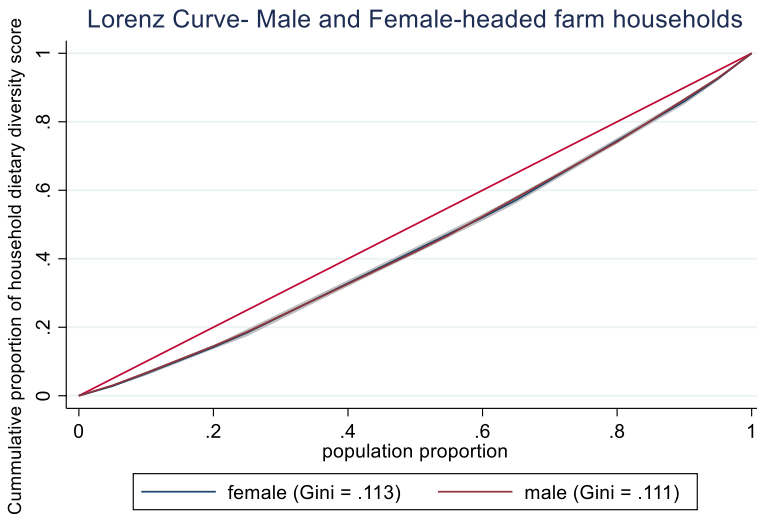
household food consumption expenditure per capita. The observed mean gender gap in food consumption expenditure per capita is about 28.2%, and this is statistically significant and in favor of MHHs. In Fig. 1, the Lorenz curves show the inequality in household food consumption to understand the pattern of male and female households. Panel B of Table 3 also presents the aggregate decomposition of the gender gap. It is observed that the explained part of the difference is insignificant, whereas that of the structural part is statistically significant. The MHHs have an endowment advantage of 0.2% and a structural advantage of 28%. It is important to highlight that the unexplained component accounted for a larger percentage (99%) of the differences in household food consumption expenditure per capita. For panel C of Table 2, columns (2) and (3) provide the different covariates contributing to households' food consumption expenditure. Since the endowment part is positive, any negative estimate reduces the gender differences in favor of FHHs, whereas any positive estimate increases the endowment in favor of male HH. Family labor, household size, and adoption of improved seed had a positive and significant impact on the gender difference. This implies these factors widen the gender gap in favor of MHHs for food consumption expenditure per capita. In addition, total asset value negatively influenced the unexplained component of the gender difference in food consumption expenditure. The implication is that asset value minimizes the gender differential in favor of FHHs.

#### 4.2.2 Household Dietary Diversity Score

Columns (4) and (5) of Table 3 present the decomposition of a household's dietary diversity scores. From Panel A, the raw gender gap is 18.1%. Also, to further understand the dietary diversity in MHHs and FHHs, the respective Lorenz curves portrayed the household dietary diversity score inequality in Fig. 2. In Panel B, MHH endowment advantage is -1%, and the male HH structural advantage is 19.1% (the raw mean gap minus the endowment advantage). The structural part of the household dietary diversity part accounted for 106% of the dietary diversity score. However, it is counterintuitive that FHHs have an



**Fig. 1** Lorenz Curve- Male and Female-headed farm households (food consumption expenditure per capita)



**Fig. 2** Lorenz Curve- Male and Female-headed farm households (household dietary diversity score)

endowment advantage of 1%. Panel C provides the contribution of the various covariates to the household dietary diversity score gender gap.

Moreover, as the structural part is positive, any positive and significant estimate increases the gender differential in favor of MHHs and negative otherwise. Rice yield and improved seed widen the gender differential between MHHs and FHHs, affecting dietary diversity scores in favor of MHHs. Pest had a negative and significant impact on the unexplained part of the gender gap in dietary diversity. This suggests that pest reduces the gender differential in favor of FHHs that may be more likely seek to alternative avenues to curb the pest risks as explained before.

#### 4.2.3 Vulnerability to Food Poverty

Columns (6) and (7) present the decomposition of a household's vulnerability to food poverty. Panel A provides details of the gender differences. It is observed that the raw gender gap is 1.4% (in favor of FHHs) and is insignificant. Panel B presents the aggregate decomposition of the gender difference. It is observed that both the endowment ( $-1.2\%$ ) and unexplained ( $-0.2\%$ ) components of the differential are not significant (in favor of FHHs). The explained and structural shares 86% and 14%, demonstrate the gender household vulnerability to food poverty differential. Panel C of Table 3, columns (6) and (7) provide the different covariates contributing to the household vulnerability to food poverty. All the contributory components are negative, a positive coefficient reduced the gender difference in favor of MHHs, and a negative one widens the gender differential. The negative effect of market distance and family labor on endowment implies increasing the gender differentials in favor of FHHs.

Furthermore, farmer-based organizations (FBOs) and pest occurrence positively influenced endowment, thus reducing the gender gap in favor of MHHs. On the unexplained part, as the effect is negative, a positive estimate reduces the gender differential in favor of MHHs, and any negative estimate widens the gender gap. Farm size, family labor, and

chemical fertilizer positively and significantly influenced the unexplained component, thus reducing the gender differential in favor of MHHs.

## 5 Recentered Influence Function (RIF) of the difference at the average of the distributions

### 5.1 Food Consumption Expenditure Per Capita

Table 4 provides the gender differential estimates and complete RIF decomposition of the average and individual percentiles of the food consumption expenditure per capita. The gender gap in food consumption expenditure for the mean and median is estimated significantly at 28.3% and 30.3%, respectively. On the other hand, the 25th and 75th percentiles estimates are 33.8% and 34.7%, respectively, and are both significant. Again, the endowment effects are all insignificant and increase across the food consumption expenditure per capita distribution. However, all the structural effects are significant and exhibit a zig-zag pattern across food consumption expenditure per capita distribution.

Panel C gives the detailed RIF decomposition estimates for the mean, 25th, 50th, and 75th percentiles. It is observed that all the coefficients are insignificant in the explained effects along with the entire distribution. This minimizes the gender differential in food consumption expenditure in favor of FHHs. On the 25th percentile of the distribution, the age of household head and household size contribute positively and significantly to the unexplained effect of the gender difference of food consumption expenditure. Farm distance also negatively impacts the 25th percentile of the distribution to the structural effect. On the 75th percentile, family labor negatively contributes to the unexplained effect of the gender difference in food consumption expenditure.

### 5.2 Household Dietary Diversity Score

Table 5 shows the mean from the decomposition and the estimates of the detailed RIF decomposition for the 25th, 50th, and 75th percentiles for household dietary diversity scores. The gender gap is estimated at 18% and 17%, respectively, for the mean and median of the distribution and significant. Besides, the 25th and 75th percentiles coefficients are 15.5% and 16.1%, respectively. All these differences are in favor of MHHs. On the other hand, the endowment component of the differential favors FHHs and are all significant except the 75th percentile point on the dietary diversity distribution. The portion of the explained part of the gender differential upsurges and remains constant along with the distribution. Contrarily, the structural part of the effect on the gender gap is positive and significant for all the estimates. Besides, it exhibits a zig-zag pattern of trend along with the dietary diversity distribution.

Panel C of Table 5 presents a detailed decomposition of covariates that influence the explained and structural part of the gender gap. It can be observed that all the covariate coefficients of the endowment component of the gender differential distribution are insignificant. On the 25th and 50th percentiles, years of schooling, market distance, and pests negatively influence the structural effect on dietary diversity scores. This minimizes the gender differences in dietary diversity scores in favor of FHHs. In addition, improved seed positively influences the structural part and widens the gender difference for dietary diversity in favor of MHHs. With the 75th percentile, improved seed and rice yield positively

**Table 4** Detailed RIF decomposition of gender differential at selected points of the food consumption expenditure per capita distribution

	25th			50th			75th		
	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE	
<i>Panel A: gender differential</i>									
Male-headed households	2.073***	0.027	1.733***	0.035	2.112***	0.027	2.478***	0.038	
Female-headed households	1.790***	0.040	1.395***	0.067	1.809***	0.036	2.131***	0.045	
Difference	0.283***	0.048	0.338***	0.076	0.303***	0.046	0.347***	0.059	
<i>Panel B: aggregate decomposition</i>									
Endowment component of difference. Share of the endowment component of gender outcome differential	-0.009	0.024	0.008	0.045	0.021	0.024	-0.022	0.027	
Unexplained component of difference. Share of the unexplained component of gender outcome differential	0.292***	0.045	0.331***	0.073	0.282***	0.045	0.370***	0.058	
<i>Panel C: detailed decomposition</i>									
	Explained			Structural					
	Mean	25th	50th	75th	Mean	25th	50th	75th	
Log of age	-0.002 (0.005)	-0.005 (0.011)	-0.001 (0.002)	0.002 (0.005)	1.544 (1.036)	3.089* (1.577)	0.440 (0.963)	-0.064 (1.281)	
Log of years of schooling	-0.003 (0.005)	0.000 (0.002)	-0.002 (0.005)	-0.004 (0.009)	-0.018 (0.037)	-0.001 (0.054)	-0.025 (0.033)	-0.022 (0.044)	
Log of farm size	-0.002 (0.004)	-0.002 (0.007)	-0.002 (0.004)	-0.001 (0.005)	0.065 (0.096)	0.136 (0.151)	0.026 (0.094)	-0.058 (0.136)	
Log of farm distance	-0.002 (0.005)	-0.004 (0.012)	0.000 (0.001)	-0.000 (0.002)	-0.067 (0.138)	-0.345* (0.201)	0.056 (0.135)	-0.020 (0.180)	
Log of market distance	0.003 (0.007)	-0.010 (0.012)	-0.004 (0.006)	-0.005 (0.008)	0.004 (0.127)	-0.056 (0.194)	-0.100 (0.123)	-0.227 (0.157)	
Log of household size	-0.009 (0.007)	-0.014 (0.010)	-0.003 (0.004)	-0.004 (0.005)	0.458** (0.201)	0.787** (0.321)	0.265 (0.209)	0.321 (0.261)	
Log of asset value	0.010 (0.008)	0.015 (0.013)	0.006 (0.006)	0.006 (0.006)	-1.540* (0.908)	-1.807 (1.435)	-1.079 (0.865)	-1.515 (1.117)	
Log of family labor	0.014 (0.010)	0.014 (0.012)	0.012 (0.009)	0.008 (0.010)	-0.434 (0.284)	-0.114 (0.373)	-0.287 (0.254)	-1.144** (0.348)	

**Table 4** (continued)

	Explained					Structural						
	Mean	25th	50th	75th	Mean	25th	50th	75th	Mean	25th	50th	75th
Log of rice yield	-0.001 (0.005)	0.000 (0.001)	-0.001 (0.003)	-0.002 (0.009)	0.298 (0.418)	0.189 (0.627)	0.482 (0.372)	0.796 (0.507)	0.298 (0.418)	0.189 (0.627)	0.482 (0.372)	0.796 (0.507)
FBO	-0.007 (0.009)	-0.013 (0.015)	0.006 (0.008)	-0.012 (0.011)	-0.002 (0.036)	-0.018 (0.054)	0.024 (0.035)	-0.066 (0.044)	-0.002 (0.036)	-0.018 (0.054)	0.024 (0.035)	-0.066 (0.044)
Land ownership	0.001 (0.002)	-0.002 (0.004)	0.001 (0.002)	0.001 (0.003)	-0.047 (0.049)	0.065 (0.075)	-0.034 (0.047)	-0.099 (0.061)	-0.047 (0.049)	0.065 (0.075)	-0.034 (0.047)	-0.099 (0.061)
Chemical fertilizer	-0.000 (0.004)	-0.001 (0.009)	-0.000 (0.006)	-0.000 (0.006)	0.056 (0.074)	0.019 (0.110)	-0.038 (0.069)	0.014 (0.091)	0.056 (0.074)	0.019 (0.110)	-0.038 (0.069)	0.014 (0.091)
Improved seeds	0.002 (0.004)	0.022 (0.019)	0.014 (0.012)	-0.001 (0.004)	0.168** (0.066)	0.306*** (0.111)	0.351*** (0.068)	0.334*** (0.093)	0.168** (0.066)	0.306*** (0.111)	0.351*** (0.068)	0.334*** (0.093)
Pest	-0.008 (0.010)	0.003 (0.015)	-0.001 (0.009)	-0.002 (0.011)	-0.010 (0.037)	0.037 (0.058)	0.034 (0.037)	0.043 (0.046)	-0.010 (0.037)	0.037 (0.058)	0.034 (0.037)	0.043 (0.046)
Disease	-0.003 (0.005)	0.005 (0.007)	-0.003 (0.004)	-0.007 (0.009)	-0.000 (0.068)	-0.183* (0.106)	0.025 (0.063)	0.049 (0.083)	-0.000 (0.068)	-0.183* (0.106)	0.025 (0.063)	0.049 (0.083)

\*\*\*, \*\*, and \* indicate a significance level of 1%, 5%, and 10%. Robust standard errors are in parenthesis

**Table 5** Detailed RIF decomposition of gender differential at selected points of the household dietary diversity score distribution

	25th			50th			75th		
	Mean	Coef.	Robust SE	Mean	Coef.	Robust SE	Mean	Coef.	Robust SE
<i>Panel A: gender differential</i>									
Male-headed households	1.989***	0.007	0.004	1.950***	0.004	0.004	2.010***	0.004	0.006
Female-headed households	1.808***	0.011	0.005	1.795***	0.005	0.005	1.840***	0.005	0.008
Difference	0.180***	0.013	0.006	0.155***	0.006	0.006	0.170***	0.006	0.010
<i>Panel B: aggregate decomposition</i>									
Endowment component of difference	-0.015**	0.006	0.002	-0.005**	0.002	0.002	-0.005**	0.002	0.004
Share of the endowment component of gender outcome differential	-8%			-3%			-3%		
Unexplained component of difference	0.195***	0.014	0.007	0.160***	0.007	0.007	0.175***	0.007	0.010
Share of the unexplained component of gender outcome differential	108%			103%			103%		
<i>Panel C: Detailed decomposition</i>									
Log of age	-0.000 (0.001)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.192 (0.298)	0.038 (0.134)	0.038 (0.134)	0.038 (0.134)	-0.064 (0.221)
Log of years of schooling	-0.000 (0.001)	-0.000 (0.001)	-0.000 (0.001)	-0.000 (0.000)	-0.010 (0.010)	-0.008* (0.005)	-0.008* (0.005)	-0.008* (0.005)	-0.003 (0.007)
Log of farm size	0.000 (0.001)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.001)	-0.001 (0.029)	-0.002 (0.012)	-0.002 (0.012)	-0.002 (0.012)	0.010 (0.021)
Log of farm distance	0.000 (0.001)	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.008 (0.036)	0.003 (0.019)	0.003 (0.019)	0.003 (0.019)	-0.016 (0.029)
Log of market distance	-0.001 (0.002)	-0.001 (0.001)	-0.001 (0.000)	-0.001 (0.001)	-0.029 (0.037)	-0.029* (0.018)	-0.029* (0.018)	-0.029* (0.018)	-0.006 (0.026)
<i>Explained</i>									
Mean									
		25th	50th	75th	Mean	25th	50th	75th	
<i>Structural</i>									

Table 5 (continued)

	Explained					Structural				
	Mean	25th	50th	75th	Mean	25th	50th	75th		
Log of household size	-0.002 (0.002)	-0.001 (0.001)	-0.001 (0.000)	-0.001 (0.000)	0.032 (0.063)	0.016 (0.029)	0.016 (0.029)	0.049 (0.046)		
Log of asset value	-0.001 (0.001)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	0.073 (0.261)	-0.020 (0.118)	-0.020 (0.118)	0.016 (0.189)		
Log of family labor	-0.001 (0.002)	0.000 (0.000)	0.000 (0.001)	0.000 (0.001)	-0.031 (0.073)	-0.012 (0.033)	-0.012 (0.033)	0.057 (0.054)		
Log of rice yield	-0.000 (0.002)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.001)	0.199** (0.103)	0.058 (0.052)	0.058 (0.052)	0.200** (0.079)		
FBO	-0.001 (0.002)	-0.001 (0.001)	-0.001 (0.001)	0.000 (0.002)	0.007 (0.010)	0.002 (0.005)	0.002 (0.005)	0.004 (0.008)		
Land ownership	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.001)	-0.015 (0.014)	-0.006 (0.007)	-0.006 (0.007)	-0.021** (0.010)		
Chemical fertilizer	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.001 (0.001)	-0.021 (0.021)	-0.002 (0.010)	-0.002 (0.010)	-0.021 (0.014)		
Improved seeds	-0.002 (0.002)	-0.000 (0.000)	-0.000 (0.000)	-0.002 (0.001)	0.039* (0.021)	0.040*** (0.010)	0.040*** (0.010)	0.036*** (0.014)		
Pest	-0.006* (0.003)	-0.002 (0.001)	-0.001 (0.001)	-0.002 (0.002)	-0.021* (0.011)	-0.010* (0.005)	-0.010* (0.005)	-0.004 (0.008)		
Disease	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.001)	-0.006 (0.018)	-0.002 (0.009)	-0.002 (0.009)	-0.003 (0.013)		

\*\*\*, \*\*, and \* indicate a significance level of 1%, 5%, and 10%. Robust standard errors are in parenthesis

influences the unexplained component, increasing the gender differential in favor of MHHs. Besides, landowners have a negative effect on the unexplained part of the gender differential on dietary diversity in favor of FHHs.

### 5.2.1 Vulnerability to Food Poverty

The detailed RIF decomposition of the average and the 25th, 50th, and 75th percentile of the vulnerability to food poverty distribution is shown in Table 6. The gender gap in households' vulnerability to food poverty is estimated at  $-1.5\%$  and insignificant at the mean. The coefficients for the 25th and 50th percentiles are  $-3.8\%$  and  $-0.4\%$  and not significant—all in favor of female FHHs. However, the gender gap estimated at the 75th percentile is  $1.7\%$  and is insignificant in favor of MHHs. Panel C of Table 6 presents the detailed covariates decomposition of the endowment and structural effects on the gender gap. On the 25th percentile of the explained part and market distance and family labor, it is observed that family labor negatively increases the gender gap on vulnerability to food poverty in favor of FHHs.

Contrarily, pests minimize the gender differential in favor of MHHs. With the median endowment point on the distribution, family labor increases the gender difference in favor of FHHs. But we notice that pests reduce the gender differential of vulnerability to food poverty in favor of MHHs. On the 75th percentile of the endowment effect, family labor increases the gender differential in favor of FHHs. On the 25th percentile of the unexplained component of the gender differential on vulnerability to poverty, years of schooling increase the difference in favor of FHHs. On the same distribution point, family labor minimizes the gender differential in favor of MHHs. Farm size and chemical fertilizer contribute negatively to the distribution's median to the structural effect in favor of female-headed households for vulnerability to food poverty gender gap. With the 75th percentile, farm size and family labor increase the gender gap in households' vulnerability to food in favor of the female-headed households.

## 6 Conclusion and Policy Implications

We examined gender-based differences in household welfare outcomes (food poverty, vulnerability, and food consumption inequality) of smallholder farmers in Ghana using household survey data collected from Northern Ghana. Two approaches, an Oaxaca–Blinder mean and Recentered Inference Function (RIF) decomposition, were adopted in each household welfare variable to unearth the sources of gender differentials and to identify a set of covariates influencing those differences. We also highlighted the potential avenues and benefits of reducing the gender gaps of these welfare outcomes amongst smallholder farmers.

The Oaxaca–Blinder mean decomposition indicates significant gaps in food consumption expenditure per capita (28.2%) and household dietary diversity scores (18.1%) between male-headed households (MHHs) and female headed households (FHHs). However, we did not find any significant gendered household difference in vulnerability to food poverty, even though negative in favor of FHHs. This underscores the systemic female household vulnerability to food poverty in Ghana and SSA in general. The mean decomposition results were confirmed with the RIF decomposition estimates. The



**Table 6** Detailed RIF decomposition of gender differential at selected points of the vulnerability to poverty distribution

	Mean		25th		50th		75th	
	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE	Coef.	Robust SE
<i>Panel A: gender differential</i>								
Male-headed households	0.165***	0.009	0.040**	0.015	0.196***	0.011	0.334***	0.010
Female-headed households	0.179***	0.012	0.078***	0.017	0.201***	0.015	0.333***	0.014
Difference	-0.015	0.015	-0.038	0.023	-0.004	0.019	0.002	0.017
<i>Panel B: aggregate decomposition</i>								
Endowment component of difference	-0.012	0.015	-0.013	0.018	-0.003	0.015	-0.006	0.014
Share of the endowment component of gender outcome differential	80%		37%		75%		-300%	
Unexplained component of difference	-0.003	0.003	-0.024	0.016	-0.001	0.012	0.007	0.012
Share of the unexplained component of gender outcome differential	20%		63%		25%		400%	

Table 6 (continued)

Explained	Structural							
	Mean	25 <sup>th</sup>	50 <sup>th</sup>	75 <sup>th</sup>	75 <sup>th</sup>			
<i>Panel C: detailed decomposition</i>								
Log of age	0.000 (0.001)	0.001 (0.001)	0.000 (0.000)	-0.000 (0.001)	-0.030 (0.056)	-0.223 (0.352)	-0.005 (0.254)	0.267 (0.266)
Log of years of schooling	0.002 (0.004)	0.002 (0.003)	0.001 (0.003)	0.000 (0.001)	0.001 (0.003)	-0.031** (0.012)	0.008 (0.008)	0.004 (0.009)
Log of farm size	-0.001 (0.001)	-0.004 (0.004)	-0.000 (0.001)	0.003 (0.003)	0.013** (0.006)	0.040 (0.038)	-0.042* (0.024)	-0.047* (0.024)
Log of farm distance	0.001 (0.002)	0.000 (0.001)	0.000 (0.001)	0.001 (0.002)	-0.002 (0.009)	0.015 (0.048)	-0.012 (0.035)	-0.017 (0.034)
Log of market distance	-0.004** (0.002)	-0.006* (0.004)	-0.002 (0.002)	0.000 (0.002)	-0.017 (0.012)	0.003 (0.043)	0.033 (0.033)	0.008 (0.033)
Log of household size	0.001 (0.001)	0.003 (0.002)	0.002 (0.002)	0.000 (0.001)	-0.013 (0.010)	-0.020 (0.071)	-0.043 (0.055)	0.000 (0.056)
Log of asset value	-0.003 (0.003)	-0.005 (0.004)	-0.004 (0.004)	-0.003 (0.002)	-0.045 (0.052)	-0.013 (0.299)	-0.115 (0.229)	0.016 (0.247)
Log of family labor	-0.019** (0.009)	-0.019** (0.010)	-0.015** (0.007)	-0.016** (0.008)	0.049* (0.028)	0.164* (0.086)	-0.056 (0.064)	-0.156** (0.073)
Log of rice yield	0.000 (0.002)	0.000 (0.001)	-0.000 (0.000)	0.000 (0.001)	0.002 (0.023)	-0.079 (0.131)	0.071 (0.099)	0.063 (0.104)
FBO	0.002** (0.001)	0.004 (0.003)	0.002 (0.002)	0.004 (0.003)	-0.000 (0.002)	0.016 (0.012)	-0.001 (0.009)	-0.000 (0.009)
Land ownership	0.000 (0.000)	-0.000 (0.001)	0.001 (0.001)	0.000 (0.000)	-0.001 (0.003)	0.012 (0.016)	-0.002 (0.013)	0.009 (0.012)
Chemical fertilizer	0.000 (0.005)	0.000 (0.004)	0.000 (0.005)	0.000 (0.007)	0.008** (0.003)	0.015 (0.022)	-0.037** (0.018)	0.002 (0.018)
Improved seeds	0.003 (0.003)	0.002 (0.002)	0.003 (0.002)	0.004 (0.003)	-0.001 (0.004)	-0.031 (0.022)	-0.007 (0.018)	0.005 (0.020)
Pest	0.002** (0.001)	0.009** (0.004)	0.005* (0.003)	-0.002 (0.002)	-0.001 (0.002)	0.006 (0.012)	0.015 (0.009)	0.001 (0.010)
Disease	0.003 (0.003)	0.002 (0.002)	0.003 (0.004)	0.002 (0.003)	0.003 (0.003)	0.074 (0.023)	-0.015 (0.016)	-0.020 (0.016)

\*\*\*, \*\*, and \* indicate a significance level of 1%, 5%, and 10%. Robust standard errors are in parenthesis

detailed RIF decomposition of the household dietary diversity scores and the gender gap estimated for the mean is significant.

These results have relevant policy implications. The significant differences in welfare outcomes imply that the relevant stakeholders (e.g., local and international agencies) should address food systems' structural deficiencies and inequalities with gender in mind. The results also highlighted the covariates that influence food consumption per capita and dietary diversity, especially among female-headed households. Aged female household heads have low food consumption expenditure. This implies that stakeholders such as governments should institute potential retirement insurance packages for smallholders in the prime age of their agricultural careers. This could help them to overcome the food consumption difficulties as they age. Improvement in yield with diversified crop production could also improve the dietary diversity of female household heads. Governments and NGOs should support female households with productive agricultural resources to help them boost their agricultural productivity.

Finally, further research needs to be done using panel data to control for unobserved specific heterogeneity and observe whether male and female household food consumption expenditure per capita, household dietary diversity, and vulnerability to food poverty persist over time. Such analyses will help to understand how male and female HH-specific factors influence the differentials in food consumption expenditure per capita, household dietary diversity, and vulnerability to food poverty over time.

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