

Effects of Climate Shocks and Climate Adaptation through Livelihood Diversification on Gendered Welfare Gaps in Northern Ghana

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Authors' contributions

This work was carried out in collaboration between both authors. Author WA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AK managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Globally, addressing poverty levels and inequality remained one of the topmost priorities and has been accorded the first position in the Sustainable Development Goals (SDGs). Although Ghana as a whole is faring well in poverty reduction over the past decades, poverty levels and inequalities remains high in the northern parts. This study analysed the gendered welfare gap and the effects of climate change and livelihood diversification on the welfare gap. Through multistage sampling, 432 households were selected and interviewed using a questionnaire. A selectivity bias corrected Oaxaca Blinder model was estimated using household per capita consumption expenditure as a measure of households' welfare. The result shows that there is a significant welfare gap of \$45.85 (GH¢211.85), an equivalent of 11.4% between male headed and female headed households. Controlling for selectivity bias revealed that the observed gender welfare gap was underestimated. Livelihood diversification had positive significant effect on the explained component of gender welfare gap. Climate change/variability had positive significant effect on welfare gap through the explained component and a negative significant effect through the unexplained component. Therefore, observed climate change and variability led to an increase in gender welfare gap by

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64.62%, while the unobservable returns from climate factors contributed to a reduction in gender welfare gap by 193.26%. Since addressing unobservable climate factors is limited, there is the need to improve the climate characteristics of women. Although livelihood diversification is a necessary condition, policies such as training and education that would ensure that females also have higher returns from such strategies are sufficient to address gender welfare gaps. To improve the welfare of farmers in the midst of climate change, animal rearing should be promoted among maize crop farmers. Similarly, government's policy of one district one factory should consider improving agro-processing opportunities in the region into commercial activities.

Keywords: Climate change and variability; gender; livelihood diversification; welfare.

1. INTRODUCTION

"We need to face the fact that we will never overcome poverty and hunger without empowering rural women" (IFAD President, Kanayo F. Nwanze on 2017 International Women's day) (www.fao.org/news/story/en/item/473008/icode/).

Poverty and food insecurity reduction continuous to be a global issue. Recent estimates suggests that almost a billion of people live in extreme poverty with the majority of the poor residing in rural areas where agriculture, particularly rain fed crop production remained their primary to sole source of livelihoods (World Bank, 2015 cited in [1]). The vicious cycle of hunger, poverty and low productivity impedes the development of the agricultural sector as well as general economic development. The widespread poverty in most SSA economies have placed them into food insecurity even in periods of favourable production years. Unfortunately, climate change has been observed to affect both income and non-income dimensions of welfare, making the phenomenon more worrying. Poverty intensity is expected to worsen while more households are expected to become poor under the changing climate. It is therefore unsurprising that livelihood security and empowerment are the expected results of adaptation and a cause to future changes in climate vulnerability [2].

The two strategies to respond to climate change or variability are mitigation and adaptation. Although mitigation to climate change is vital, adaptation is becoming more crucial to provide short-term localised gains and to improve recovery from environmental shocks. Adaptation is mostly stimulated by climate variability such as floods and droughts other than climate change [3]. Mostly, these strategies are adopted as anticipatory, reactive or proactive measures. Among others, the primary goal of adaptation is to reduce or spread risks and secure income or

resources [3]. One reason for SSA, including Ghana's high vulnerability to climate change is the low adaptive capacity of the region. Berrangford et al. [3] maintained that there is the need for further scrutiny and learning from current adaptation strategies. As a local context strategy, adaptation remained the most plausible option for farmers and rural dwellers. Adaptation as a strategy allow farmers to harness opportunities and options within their capabilities to reduce the impacts of climate change on their households. Several adaptation strategies are available and adopted by farmers. One class of adaptation strategies is diversification.

Although, diversification is a long-time phenomenon, recent adoption of diversification strategies is tailored to climate change and variability. Depending on the strategy, diversification can be a proactive or reactive adaptation strategy, making it a flexible strategy for households to adopt depending on available opportunities. One of the major advantages of diversification over the other adaptation strategies is its role in reducing household's climate vulnerability and at the same time, improving household's welfare and crop production. Among others, Antwi-agyei [4] estimated that Ghanaian farming households adopts adaptation or coping strategies that are linked to livelihood diversification, hence recommend for policies that would promote diversification. Olsson et al. [5] indicated that although diversification reduces poverty and future welfare deteriorations due to modified weather, it is less available to or harnessed by the resource poor households. Generally, diversification is an economic empowerment tool to improve the economic performance of households or group of people.

While the country have progressively improved in poverty reduction over the past decades, poverty levels in the northern regions still remained higher than other parts of the country. Coupled

with the general poverty levels, inequality in poverty reduction and development remain a major concern to the country's policy makers. One of such inequality sources is the welfare difference between males and females. This inequality is expected to witness some changes due to the worsening climatic conditions of northern Ghana. Since climate change effects are non-gender blind, it is important to estimate the effect of climate change on gender welfare gap in the region. Also, climate change adaptation literature suggest that livelihood diversification is a potential strategy to improve households' welfare amidst climate change. However, the literature failed to examine the effects of livelihood diversification on gender welfare gap among households. This research seeks to address these underlining gaps in the literature and provide policy recommendations on how to improve welfare and reduce gender welfare gaps. Primarily, the objectives of this study are to analyse the gender welfare gap, the sources of welfare inequality and the effects of climate change on one hand and livelihood diversification on other hand on gender welfare gap. Welfare in this chapter is defined as the per capita consumption expenditure of households in US dollar currency (\$). The conversion rate used was the November, 2017 (since the data collection was largely in November) exchange rate of 1\$ to GH¢4.62. The peculiarity of this - study is that it is one of the studies that used a gender decomposition model to examine the welfare inequality in the northern region of Ghana.

2. LITERATURE REVIEW

2.1 Livelihood Diversification and Welfare

Diversification involves providing other alternatives to full-time employment or engaging in multiple economic activity portfolios. Primarily, the aim of diversification is to provide well-meaning and sustainable survival for individuals or households. Therefore, diversification has implications on poverty reducing policies [6]. Lama [7] provided that diversification can be a result of the need to invest surpluses from existing activities or as a way of spreading agricultural risks. While some scholars describe diversification as a transient phenomenon, others hold the view that diversification cannot be so transient but connected with the realisation of livelihood security [8]. There are also debates on the role of diversification as a deliberate strategy (choice) versus diversification as an

involuntary (necessity) response to negative events.

Nonetheless, livelihood diversification provides welfare insurance to households against external shocks. Also, diversification is engaged by households as a capital, income or welfare accumulation purpose. Similarly, distressed households, either due to poverty or vulnerability to environmental shocks, could engage in multiple livelihoods to lift-up themselves from these distresses. Therefore, different diversification strategies may be pursued for different purposes. But the general implication is that any purpose of diversification satisfies the objective of livelihood/welfare improvement; hence the primary objective of livelihood diversification.

Authors such as Osarfo et al. [9] estimated that nonfarm diversification leads to increasing welfare and the smoothening of income or consumption among households in the two upper regions of Ghana. The authors concluded that although non-farm activities cannot be a substitute to farming, the former provides a reliable complement to the latter. Similar findings were shown that non-farm activities leads to higher future food consumption expenditure, hence leading to a reduction in vulnerability to food poverty [10]. Hence, while there is need to enhance non-farm opportunities to households, entry barriers must be mitigated [9,10]. Intuitively, non-farm diversification does not only provide direct effect on welfare through income mobilisation but also, through effects on resource mobilisation for agricultural activities and improve technology adoption. Lama [7] argued that the rural non-farm sector is viewed as solving the twin problem of unemployment and poverty, easing income inequalities and moving rural dwellers from merely subsistence levels. These imply that, diversification ensures the smoothening of income and consumption among households.

At the macro-level, non-farm activities provide the opportunity for structural transformation of the economy from agricultural base to industrial base [7]. The effects of non-farm activity on household welfare is not an isolated finding as it was estimated that crop farming households who diversify into high valued crops are able to escape poverty [11]. Nkegbe and Kuunibe [12] recommended that in order to enhance the welfare of households, livelihood diversification options that are not directly affected by climate

change should be promoted. Aiming at interventions that offer opportunity for diversification would ultimately lead to improved welfare [13].

The mixed effects of different diversification options on wellbeing still remain an issue to be addressed. This was recounted by [14] and also concluded that agricultural diversification options may lead to unique level of effects on wellbeing from diversification into non-agricultural strategies. Therefore, it is unclear whether different diversification strategies would lead to the same welfare outcome. Asfaw et al. [15] argued that although diversification is a welfare increasing strategy, the final effect of diversification on welfare depends on the weight of push and pull factors of diversification since push factors leads to lesser welfare impacts while pull factors leads to more improved welfare.

2.2 Climate Change Impacts on Welfare

The pathways out of poverty are not smooth, and many non-poor (in addition to the poor) households are vulnerable to poverty in events of shocks [1]. Weather-related risks basically affects rural livelihoods and explains the vicious cycle of the poor. Climate change affects both the income and non-income components of welfare and the effects can be direct or indirect. Therefore, climate change exacerbates existing levels of poverty, inequality and wellbeing, hence, climate change is described as a 'threat multiplier' [5 p.802]. In northern Ghana, climate variability has been found to negatively influence household welfare and agriculture income [12] and this impacts are worse in the northern savannah zones [16].

There are increasing evidence suggesting that climate variability and change would worsen the vulnerability of the poor households, thereby worsening incidence, severity and persistence of poverty in the developing countries and hindering global poverty reduction efforts [17]. The impacts of climate change on welfare are particularly pronounced among the poor since their adaptive capacities are less, highly dependent on natural resources and spends large share of their income on food. This explains why the agrarian communities are more vulnerable to climate change. However, the urban and industrial sector also suffers through productivity loss of farmers as food and raw materials become scarce and expensive.

2.3 Gender Welfare Gap (Inequality), Growth and Development

Gender inequality exists globally, although more pronounced in poor countries than rich countries [18]. It is a major concern for most developmental organisations. The paradigm of gender in global discussions has changed over the years with recent connotation as gender and development. Thus, gender issues do not only affect growth but also development. The discussions on this recent paradigm can be summarised under two considerations [19]. Firstly, the negative implications of gender inequality in resource distribution, opportunities on women's welfare and human rights. Secondly, the fact that other developmental goals can be achieved through addressing gender inequality. While some scholars document the existence of gender inequality, others also provided evidence that poverty reduction, agricultural productivity and welfare can be improved through gender equality [19,20].

There are valid concerns on the two-way relationship between gender inequality on economic growth and effects of economic growth or underdevelopment on gender inequality [18,19]. The former relationship is valid due to its implications on changes in per capita output through market participation on one hand and on the other hand, its effects on fertility and capital accumulation that influences long term equilibrium of per capita output [21]. Empirically, [21] estimated in a benchmarked and counterfactual analysis that in a steady state, 50 percent increase in gender gap can lead to 35 percent decrease in per capita output. [22] also reported that over 100 million people could be distant from poverty by providing equal access and control of resources to women.

Labour market discrimination has remained one of the central reason for gender welfare differences. Historically, this discrimination does not only lead to lower income for the vulnerable groups but also leads to higher income for the majority groups [23]. Glass ceiling, occupational differentiation, less working hours of women due to reproductive duties as well as characteristic differences such as education explains bit of this discrimination. However, the impacts of climate change depends on the resilience level of the household [24], hence, more resilient households are less affected by climate change. Nonetheless, CARE [25] argued that gender inequality is the root cause of poverty.

3. MATERIALS AND METHODOLOGY

3.1 Study Location

The study was conducted in the three northern regions (Upper East, Upper West and Northern regions) of Ghana (Fig. 1). Agriculture is the main economic activity, employing 71.9% of the economically active group. The three northern regions has the highest proportion of agricultural households in Ghana. The region is located farther from the pole, which means

that the region is naturally warmer than the southern parts. The implications are long dry season with associated difficulty in food and water access [9]. Similarly, unlike the southern parts where there is bimodal rainfall, the northern regions have a unimodal rainfall, thereby creating a lot of idled agricultural labour periods.

The region is much risky to climate change than other regions of Ghana. Evidence suggests that there are increasing periodic floods, droughts

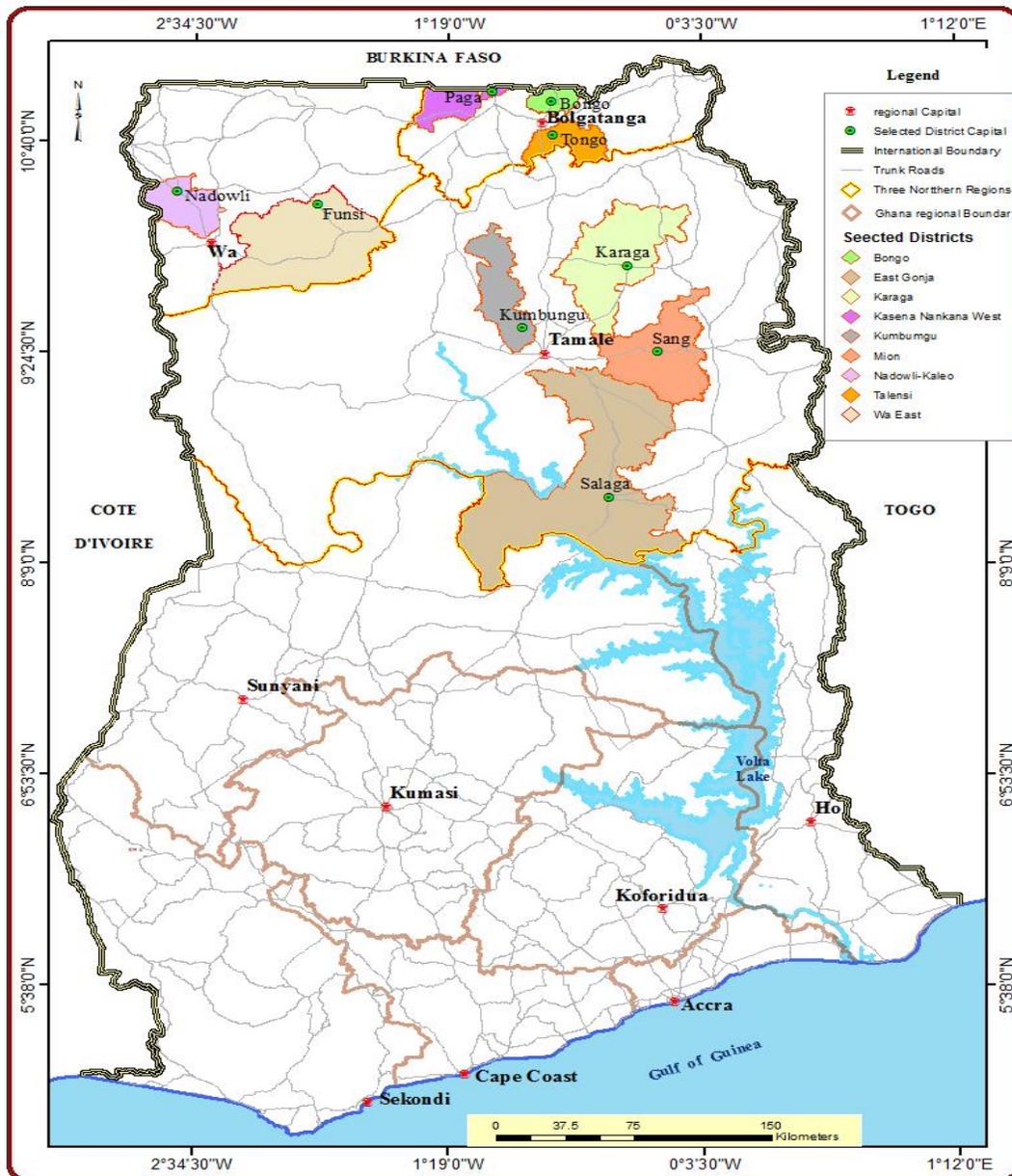


Fig. 1. Map of Ghana showing the study area (the three northern regions)

Table 1. Definition of variables

Variable	Definition or measurement	A priori sign	VIF
Education	The total number of years of formal education by household head.	+	1.16
Household's education	Total number of household members who completed JHS.	+	1.43
Household size	Total number of adult equivalents in a household sharing and pooling resources.	-	1.49
Dependency	The ratio of the total number of household members under 16 to total number of household older than 15.	-	1.13
Credit access	Dummy: 1 if household head had access to credit in the production season and 0 if otherwise.	+	1.31
Land ownership	Dummy: 1 if household head own land and 0 if otherwise.	+	1.29
Upper East	Dummy: 1 if household head is located in Upper East and 0 if otherwise.	+	1.62
Upper West	Dummy: 1 if household head is located in Upper West and 0 if otherwise.	-	1.54
Flood times	The total number of times a household experienced flood within the past three years.	-	1.56
Drought times	The total number of times a household experienced drought within the past three years.	-	1.32
Windstorm experience	The total number of times a household experienced windstorm within the past three years.	-	1.16
Forest times	The total number of times a household experienced forest fires within the past three years.	-	1.21
Climate perception	Dummy: 1 if household head perceives climate change wrongly and 0 if correctly.	-	1.71
Climate information	Dummy: 1 if household head had no access to climate information and 0 if otherwise.	-	1.46
LVI	The estimated vulnerability of a household without diversification.	-	1.66
On-farm	Dummy: 1 if household head engages in crop diversification and 0 if otherwise.	+	2.93
Animal	Dummy: 1 if household head engages in maize cropping-animal rearing diversification and 0 if otherwise.	+	2.84
Trading	Dummy: 1 if household head engages in maize cropping-trading diversification and 0 if otherwise.	+	1.89
Agro processing	Dummy: 1 if household head engages in maize cropping-agro processing diversification and 0 if otherwise.	+	2.27
Prof/Skilled job	Dummy: 1 if household head engages in maize cropping-prof/skilled diversification and 0 if otherwise.	+	2.34
IMRs	The predicted vector of IMRs of diversification strategies obtained from multivariate probit model (chapter 5)	-/+	
Total VIF			1.94

and wind storms that continue to destroy properties and lives in the region. Nkegbe and Kuunibe [12] noted that despite the effect of climate change on the entire country, the physical and economic vulnerability of the northern part makes households in the area most

impacted by climate change. Poverty levels and inequality have always been higher in the three northern regions (55.17%) than all other regions and the country as a whole (24.2%) [26,27,28].

3.2 Sampling Design and Data Collection

The study used a multi-stage sampling procedure in the selection of the respondents. In the first stage, the three northern regions out of Ghana's ten administrative regions were selected purposively due to their high climate sensitivity and high poverty levels. In the second stage, stratified sampling was used to put all districts in each region into three stratum using regional poverty maps [29]. The stratum includes poor, middle class and rich districts. One district from each stratum were then selected using simple random sampling as in Fig. 1. A total of 27 communities, three from each district, were selected by simple random. In the final stage, stratified sampling was used to put the households into male and female headed households and the final respondents selected using simple random.

From the 2010 population census, 23% of the household heads in the three northern regions were females while the remaining 77% were men. Using proportion allocations in the stratified sampling and given the above information, a total of 324 male and 108 female headed households were selected.

Also, from the 2010 population census, there are about 71.9% farm households in the three northern regions. This was used to estimate the sample using single population proportion approach [30,31] as:

$$n = \frac{z^2 * \hat{p}(1 - \hat{p})}{\varepsilon^2}$$

Where z is the z score, ε is the margin of error, \hat{p} is the population proportion. Given a proportion of approximately 72% of farming households in the three northern regions of Ghana; a 95% confidence level that the estimated sample reflects a true sample if the actual population was known, thus a Z score of 1.96; and a 5% margin of error, the sample was obtained as follows:

$$n = \frac{1.96^2 * 0.72(1 - 0.72)}{0.05^2} = 307$$

Therefore, a minimum of 307 farm households is enough for the study but was adjusted to 432 farm households. From each selected household, primary data was collected in 2017 through questionnaire administration. The questionnaire was designed through a comprehensive process with input from other scholars and policy makers. It was then administered by trained research assistants who are fluent in both English and local dialects.

3.3 Data Analysis of Gender Productivity and Welfare Gaps

One of the economic models used in labour market analysis is Oaxaca-Blinder (OB) decomposition model. The model which was independently proposed by several authors [32,33] has since gained wide applications, particularly in wage gap analysis [34,35,36]. The advantage of the model is that it estimates the inequality or gap, disaggregate the gap to different constituents and the contribution of individual factors to the gap.

Practically, the gendered welfare gap can simply be estimated using mean difference, headcount index or other poverty intensity/severity methods. However, a set of predictor variables differ in the contribution to the wealth among the male and female headed households. Therefore, it is crucial to identify the contributions from factor or resource endowments and gender discrimination. Admittedly, this is one of the unique studies that used the OB model in analyzing gendered welfare. The OB model is illustrated as follows.

Given gender groups as male headed households (M) and female headed households (F), and welfare (W), then the gendered welfare gap (G) can be estimated as:

$$G = E(W_M) - E(W_F)$$

Where $E(\cdot)$ is the expected value of welfare. Under an assumption of linear prediction, a welfare function can be stated as:

$$W_i = X_i\delta + u_i, E(u_i) = 0 \text{ and } i \in (A, B)$$

Where X is a vector of predictors, including a constant, β is a vector parameters including the intercept and u_i is the error term. Basically, the OB model follows four stages. Firstly, the aim of

the OB model is to separate the observation into groups and then estimate the mean outcome difference. Therefore, at the group specific means, G can be given as:

$$G = E(W_M) - E(W_F) = E(X_M)' \beta_M - E(X_F)' \beta_F$$

Secondly, a further decomposition is required to estimate the effect of grouped factors such as livelihood and climate change on G. The

aggregate decomposition is categorised into characteristics effects (I), which measures the contributions by X; the coefficient effect (II) which measures discrimination between the gender groups; and an interaction component (III) which measures the interaction between the first two components [32,33,34,35,36]. This can be given as:

$$G = \{E(X_M) - E(X_F)\} \beta_F + E(X_F)' (\beta_M - \beta_F)$$

The objective of the third stage is to estimate the contribution to G by factors in blocks such as climate change factors and livelihood diversification strategies. In this case, the coefficients on these terms measure the extent to which the blocked factors contribute to G via the characteristics effect and also via the returns effect [34]. Finally, in the fourth stage, the contribution of individual factors to G is estimated. The effect of the individual factors on welfare can also be estimated at the fourth stage. In this study, the welfare function is nonlinear since the researcher suspected the presence of selectivity bias in the inclusion of livelihood diversification. Therefore, this must be corrected in the OB model. This study follows [37] and the subsequent treatment effect model principle of correcting selectivity bias¹ which was also adopted in [38]. Theoretically, This involves estimating the livelihood diversification function (in this study, a multivariate probit model²) and then obtain the predicted values and used to construct an inverse mills ratio (IMR, often described as lambda, λ). The λ is then used as additional variables in the OB model.

The λ is estimated as $\lambda_i = \frac{\phi(-Z_i' \beta)}{1 - \Phi(-Z_i' \beta)}$. Where Φ is the cumulative density function and φ is the standard normal function. Therefore the welfare function becomes:

$$:w_i = X_i \delta + \rho \sigma \lambda = X_i \delta + \theta \lambda$$

Hence the stage two of the OB model was redefined as:

$$\begin{aligned} W_M - W_F &= (\bar{X}_M \hat{\delta}_M + \theta_M \hat{\lambda}_M) - (\bar{X}_F \hat{\delta}_F + \theta_F \hat{\lambda}_F) \\ &= \bar{X}_F (\hat{\delta}_M - \hat{\delta}_F) + (\bar{X}_M - \bar{X}_F) \hat{\delta}_M + (\theta_M \hat{\lambda}_M - \theta_F \hat{\lambda}_F) \end{aligned}$$

Empirically:

$$\begin{aligned} \text{Welfare} &= \delta_0 + \delta_1 \text{Heads' education} + \delta_2 \text{Household's education} + \delta_3 \text{Household size} \\ &+ \delta_4 \text{Dependency} + \delta_5 \text{Credit access} + \delta_6 \text{Land ownership} + \delta_7 \text{Upper East} \\ &+ \delta_8 \text{Upper West} + \delta_9 \text{Flood} + \delta_{10} \text{Drought} + \delta_{11} \text{Windstorm} + \delta_{12} \text{Forest fire} \\ &+ \delta_{13} \text{Climate perception} + \delta_{14} \text{Climate information} + \delta_{15} \text{LVI} + \delta_{16} \text{On - farm} \\ &+ \delta_{17} \text{Animal} + \delta_{18} \text{Trading} + \delta_{19} \text{Agro processing} + \delta_{20} \text{Pr of / Skilled job} + \delta_{21} \text{IMR} \end{aligned}$$

¹ See Maddala, G. S. (1983). *Limited-dependent and qualitative variables in econometrics*. Cambridge University Press, for detailed explanation of correcting selectivity bias.

² Refer to Adzawla W. and Kane A. (2018). *Gender perspectives of the determinants of climate adaptation: The case of livelihood diversification in Northern Ghana*. *Review of Agricultural and Applied Economics*, 2, 113-127. DOI: 10.15414/raae/2018.21.02.113-127 for the detailed analysis and results on the multivariate probit.

4. RESULTS AND DISCUSSION

4.1 Gender Welfare Gap

Table 2 shows the mean welfare level of male and female headed households and the difference between the two households. From the result, the average male headed household spent \$400.76 (equivalent of GH¢1,855.51) per annum while the average female headed household had an average welfare of \$354.91 (equivalent of GH¢1,639.67) per annum. Thus, a pooled welfare of \$389.30 (equivalent of GH¢1,798.56). These average mean values are statistically significant at 1%, suggesting that

they significantly represent the welfare levels of male and female household heads, respectively. The estimated mean welfare values are higher than the lower poverty line (GH¢792.05) and upper poverty line (GH¢1,314.00) of Ghana but lower than the average per capital consumption of the country (GH¢2,926.86) [26].

From the average welfare values, the estimated gender welfare gap is \$45.85 (equivalent of GH¢211.84) per annum. The welfare gap is also significant at 10%, indicating there is a statistically significant difference in the welfare levels between male heads and female heads. Thus, male headed households

Table 2. Gender welfare gap

Gender	Coef.	Std. Err	Z-value	P-value
Male heads	400.76***	15.984	25.07	0.000
Female heads	354.91***	18.115	19.59	0.000
Observed G	45.85*	24.159	1.90	0.058
Adjusted G	79.80**	33.214	2.40	0.016

***, ** and * indicates significant at 1%, 5% and 10%, respectively; Source: Computed from field data, 2017

Table 3. Aggregate decomposition of gender welfare gap

Source of G	Coef.	Std. Err	Z-value	P-value	% of G
Three-way decomposition					
Endowments	83.713***	32.031	2.61	0.009	104.90
Coefficients	13.638	42.041	0.32	0.746	17.09
Interaction	-17.548	34.979	-0.50	0.616	-21.99
Two-way decomposition					
Explained	75.842***	20.850	3.64	0.000	95.03
Unexplained	3.962	30.382	0.13	0.896	4.97

*** indicates significance at 1%; Source: Computed from field data, 2017

Table 4. Grouped decomposition of gender welfare gap

Source of G	Coef.	Std. Err	Z-value	P-value	G (%)
Explained component					
Socioeconomic	27.37**	10.57	2.59	0.010	59.70
Location	1.32	5.28	0.25	0.802	2.89
CCV	29.63***	10.16	2.92	0.004	64.62
Diversification	17.52	12.40	1.41	0.158	38.21
IMR	15.30	11.22	1.36	0.173	33.38
Total	91.14***	20.46	4.45	0.000	198.78
Unexplained component					
Socioeconomic	53.45	66.34	0.81	0.420	116.58
Location	8.18	24.52	0.33	0.739	17.83
CCV	-88.61*	50.82	-1.74	0.081	-193.26
Diversification	102.50**	52.34	1.96	0.050	223.55
IMR	-49.25**	23.96	-2.06	0.040	-107.42
Constant	-71.55	101.42	-0.71	0.480	-156.06
Total	-45.29**	20.70	-2.19	0.029	-98.78

***, ** and * indicates significant at 1%, 5% and 10%, respectively; Source: Computed from field data, 2017

Table 5. Determinants of welfare and detailed decomposition of G

Variable	Male heads			Female heads			Contribution to G (%)	
	Coef.	Std. Err	Z-Value	Coef.	Std. Err	Z-Value	Explained (%)	Unexplained (%)
Education	0.009*	0.005	1.74	0.008	0.010	0.84	6.30	-10.56
Household education	-0.056***	0.017	-3.23	-0.035	0.023	-1.50	-1.30	-86.07*
Household size	0.051***	0.009	5.42	0.035*	0.018	1.94	33.88*	250.08**
Dependency	0.027	0.036	0.74	-0.025	0.030	-0.83	-0.64	-12.20
Credit access	-0.010	0.068	-0.14	-0.078	0.112	-0.69	1.81	2.61
Land ownership	-0.003	0.060	-0.05	0.293***	0.094	3.12	19.64*	-27.31
Upper East	-0.137*	0.072	-1.89	-0.287***	0.095	-3.02	2.89	22.21
Upper West	-0.079	0.081	-0.97	-0.055	0.114	-0.48	0.00	-4.38
Flood times	0.017	0.029	0.58	-0.039	0.044	-0.89	11.67	55.10**
Drought times	0.061***	0.019	3.24	0.126***	0.038	3.35	25.09*	-78.88**
Windstorm experience	-0.111*	0.059	-1.87	-0.004	0.087	-0.04	12.42*	-93.97
Forest times	-0.024	0.023	-1.02	-0.033	0.033	-0.99	4.07	14.43
Climate perception	0.102	0.084	1.22	-0.211**	0.102	-2.06	-0.39	-44.45
Climate information	-0.236***	0.063	-3.72	-0.224**	0.099	-2.25	12.94	10.10
LVI	-0.050	0.063	-0.80	-0.141*	0.082	-1.73	-1.20	-55.57*
On-farm	0.055	0.137	0.40	-0.035	0.228	-0.15	7.88	87.28
Animal	0.361***	0.100	3.62	0.345**	0.168	2.05	58.66***	-98.59
Trading	0.093	0.077	1.21	-0.227	0.147	-1.54	1.31	86.76*
Agro processing	0.187**	0.087	2.14	0.099	0.141	0.71	-32.67**	18.36
Prof/Skilled job	0.023	0.091	0.25	-0.444***	0.153	-2.90	3.02	129.71***
IMR-on farm	0.245	0.289	0.85	0.135	0.430	0.31	-1.86	10.77
IMR-Animal	-0.804***	0.275	-2.92	-0.643*	0.374	-1.72	-0.08	15.20
IMR-Trading	0.052	0.265	0.20	0.271	0.362	0.75	-7.80	-36.29
IMR-Agro processing	-0.365	0.275	-1.33	-0.284	0.299	-0.95	51.79**	-15.67
IMR-Prof/Skilled	-0.222	0.311	-0.72	0.998***	0.372	2.69	-8.68	-81.41**
Constant	5.317	0.168	31.70	5.524	0.225	24.54		-156.03
N	324		108					
F	7.62		3.34					
R Squared	38.99%		50.44%					
Adj. R-Squared	33.87%		35.33%					

***, ** and * indicates significant at 1%, 5% and 10%, respectively; Source: Computed from field data, 2017

spend \$45.85 (GH¢211.84) every year more than female headed households. This implies that to address gender welfare inequality, 11.4% ($45.85/400.76 \times 100$) of the welfare of male headed households have to be redistributed between both male and female headed households. However, after controlling for selectivity bias due to livelihood diversification, the gender welfare gap increased to \$79.80 (GH¢368.69). This suggests that under the current diversification differences between male heads and female heads, the observed gender welfare gap was underestimated. Using assets as a measure of welfare in Ghana, [28] found that the gender distribution of welfare is biased in favour of males, with males having a total of 69.8% of total wealth while females had a share of 30.2% of total wealth. Although Ghana is making progress in reducing headcount poverty, inequality continuous to widen [28,39].

4.2 Aggregate Decomposition of Gender Welfare Gap

The aggregate decomposition (stage two of the OB model) is the separation of gender welfare gaps into endowment and discrimination components. This is provided in Table 3. The decomposition was done using two approaches; three-way and two-way decompositions. From the three-way decomposition, the differences in characteristics of male headed and female headed households are found to be the main contributor to G. Thus, the endowment effect contributed 104.9% to the gender welfare gap while the discrimination component contributed 17.09% to G. The interaction between the two showed a reduction of G by 21.99%. The implication is that both the differences in endowment and actual discrimination lead to an increase in welfare difference between male and female headed households. However, the interaction of these two components contributes to a reduction in the gender welfare differences. However, only the endowment effect had a statistically significant effect on G.

From the two-way decomposition also, the explained component that measures the contribution of differences in observable characteristics contributed positively (95.03%) to welfare gap between male and female heads. Also, the unexplained component that measures the contribution by unobservable characteristics (a measure of discrimination) had a positive insignificant effect on G; contributing 4.97% to G. The results imply that in order to address welfare

or poverty inequalities in the northern regions of Ghana, more efforts should be directed in improving the resource difference between male and female headed households. These resources include the socioeconomic endowment such as education and credit access, livelihood diversification as well as improve the resilience of female headed households to climate change and variability. In the subsequent sections, the contribution of the resource groups and the individual characteristics to G are provided. These further decompositions are based on the two-way decomposition approach.

4.3 Grouped Decomposition of Gender Welfare Gap

Table 4 shows the decomposition of G under the grouped variables (stage three of the OB model) in Table 2. The factors were grouped into socioeconomic, location, climate change and variability, and livelihood diversification sources. From the result, the socioeconomic and climate change/variability factors had significant influence on the explained component of G while climate change/variability and livelihood diversification significantly contributed to the unexplained component of G.

Socioeconomic factors had a positive effect on G through both explained and unexplained components. This means that the differences in resource endowment such as education as well as the returns from these characteristics worsen G. Thus, in addition to the observed differences, the returns associated with these characteristics favour the male heads more than the female heads. In terms of percentage, socioeconomic factors contributed 59.70% and 116.58% to the observed and unobservable portions of gender welfare gap, respectively. However, the effect of socioeconomic factors on gender welfare gap is significant only through the observed difference. These contributions are reasonably high and call for improving the socioeconomic status of the female heads. Also, efforts that would ensure that women realize higher returns from an improvement in their socioeconomic statuses are needed to address gender welfare inequalities.

Livelihood diversification had positive effect on explained and unexplained components of G. However, the effect is significant only through the unexplained component. This means that the unobservable returns from livelihood diversification leads to an increase in gender welfare gap by as high as 223.55%. Thus, male

heads have higher returns from livelihood diversification than female heads. The inclusion of the IMR was to correct for selectivity bias in estimating the gender welfare gap. This was also significant at the unexplained component, consistent with the estimates of livelihood diversification. Empirically, [40] concluded from their study that diversification does not necessarily lead to higher welfare, but the ability of the households to attract high return sectors into their livelihood portfolio is what brings about the improvement in welfare. Also, [41] concluded that livelihood diversification in Ghana is transient and this have a significant welfare cost on the households.

From Table 4, climate change/variability had positive significant effect on G through the explained component and a negative significant effect through the unexplained component. Thus, while the gender differences in the resilience to drought, flood, forest fires and windstorm, access to climate information and climate perception increased G by 64.62%, the unobservable returns associated with these factors contributed to a reduction in gender welfare gap by 193.26%. Since addressing unobservable climate factors is a limited action, there is the need to improve the climate characteristics of women. Generally, [28] hinted that climate change pose a threat to poverty reduction in northern Ghana. Also, [42] estimated that higher climate variability is associated with lower per capita consumption in Ghana.

4.4 Factors Influencing Households' Welfare and Gender Welfare Gap

Table 5 shows the effect of each factor on the welfare of male and female household heads. It also show the percentage contribution of each factor to both explained and unexplained components of G.

Empirically, one of the observed field of research is the estimation of the effects of socioeconomic factors on households' welfare. This is justifiable considering the role of these factors in shaping households' resource mobilization, production and consumption decisions. From Table 5, the socioeconomic factors that significantly influenced the welfare of households are education of the household head, number of household members with a minimum of primary education, household size and land ownership.

Education of the household head had a positive effect on the welfare of both male and female

heads. On the other hand, household members' education had negative effect on the welfare except that it was significant for only male heads. The positive effect of education means that higher levels of education leads to improved welfare. In most occupational descriptions, particularly the formal occupations, the educational level of a person determines the qualification for higher position and higher wage. However, in the informal sector such as farming, higher education improves the efficiency of the farmers, obtain higher yields and also search for information on higher produce prices. Estimates from [26] shows that households headed by uneducated persons contributed 72.4% of Ghana's poverty incidence. The estimated negative effect of household members' education was unexpected. However, the survey revealed that most of the highly educated household members always want to assume some level of independence which would reduce resource contribution to the entire household. While household head's education had positive and insignificant contribution to G, the household members' education contributed negatively to the G and significant through the unexplained component. [41] estimated that having educational level above basic level have a positive effect on both consumption expenditure and composite welfare index. Similarly, studies such as [43,44,45,46] estimated an increasing welfare benefit from education.

Household size had a positive effect on households' welfare. Thus, an increase in the number of people (adult equivalent) in a household leads to an increase in the welfare of the households. This is contrary to the apriori expectations of the research. The result also shows that, household size contributed positively and significantly to G through both explained and unexplained components. Thus, the observed difference in household size and the associated returns from household size leads to a widening G. [47] also estimated a positive significant effect of household size on asset growth in Mozambique. Contrary, [45] used Ghana Living Standard Survey panel data and found that adult equivalent household size had a negative effect on household's welfare. Also, [46] found a convex relationship between household size and welfare while [43] found a negative effect of household size on welfare.

Land ownership had a positive significant effect on the welfare of female heads but insignificant effect on the welfare of male heads. This was expected since land ownership or access is an

important resource in farming communities. Land access and ownership by women is low and a major source of gender discrimination in the area. Consistently also, the differences in land ownership significantly contributed 19.64% of the total G. Empirically, [44] estimated a positive effect of land ownership on welfare. But contrary to this study, [48] found that ownership of land does not necessary improve women's welfare, instead, ensuring tenure security, access to complementary inputs and market are crucial to accrue the benefits of land ownership by women.

Although the relationship between both Upper East or Upper West regions and welfare are negative, the estimates are only significant for the Upper East region. This means that households located in the Upper East region have lower welfare than those located in Northern region. Consistently, the study of [49] found that the average welfare of households in Northern region are higher than those in Upper East and Upper West regions. This is however contrary to the 2012/13 national estimates which shows that among the three northern regions, Upper East region have a higher average welfare (GH¢1,861.14) and poverty level (44.4%) than the Northern region's average welfare of GH¢1,763.60 and poverty level of 50.4%, and Upper West region's average welfare of GH¢1,390.67 and poverty level of 70.7% (26). The location variables had no significant contribution on G. Empirically, [41] used selected districts from the Eastern region (south of Ghana) and Upper East region (north of Ghana) and found that there is welfare discrimination against rural households in Upper East region. Therefore, the author argued that, there is the need for more emphasis on location specific poverty reduction policies.

From the result, the climate variables that had significant effect on households' welfare include drought, windstorm, climate perception, climate information access and LVI. Although flood had no significant effect on the welfare of both males and females, it significantly contributed 55.10% to G through the unexplained component. Drought had a positive significant effect on the welfare of both male and female headed households. Although this is contrary to the researchers' expectations, it can be explained that households that experienced frequent droughts might have spent more, especially on non-food commodities in order to maintain the living conditions of the households. While the observed difference in drought experienced significantly contributed positively (25.09%) to G,

the unobservable effects significantly contributed negatively (-78.88%) to G. [47] found a negative effect of drought on asset growth. Contrary to this finding, [43] estimated that, households that experienced drought within five years had lower welfare outcomes such as consumption expenditure.

Expectedly, windstorm had a negative effect on the welfare of both males and female headed households but significant for only the latter. This means that female headed households that experienced frequent windstorm over the past three years had lower welfare than those that experienced few or no windstorm. Windstorm contributed to a reduction in welfare gap through both explained (-12.42%) and unexplained (-93.97%) components but the reduction is significant only in the explained component. This is consistent with the findings of [24].

Climate perception had a positive effect on male headed household's welfare while a negative effect on female headed household's welfare. The negative effect means that households who perceived climate change appropriately have a higher welfare than those who predicted climate change wrongly. Climate perception however had no significant contribution to the gender welfare gap among the households.

LVI had a negative significant effect on the welfare of female headed households. This means that the higher the LVI, the lower the welfare. This can be explained by the fact that the severely vulnerable households do not have enough resources to improve their consumption expenditure. This also indicate that there is an inverse relationship between LVI and welfare, therefore, if LVI is not strategically addressed, it can lead to total welfare loss. However, LVI contributes to a reduction in gender welfare gap, and this is significant through the unobservable component.

The livelihood strategies that had significant effect on the welfare of households are animal, agro processing and profession/skilled employment. Although trading had no significant effect on the welfare of households, it contributed significantly, 86.76%, to G.

Animal rearing in addition to crop production had a positive significant effect on the welfare of both male and female headed households. This means that households who engaged in this diversification strategy have higher welfare than their counterparts who did not engage in crop-

animal diversification. Animal rearing is one of the recommended strategies to adapt to climate change. In terms of gender welfare gap, animal diversification significantly contributed 58.66% of the gender welfare gap. Consistently, [43] estimated that livestock holding leads to an improvement in household's income.

From the result, agro-processing had positive effect on the welfare of both male and female headed households, however, this is significant for only the male headed households. This implies that engaging in agro-processing tends to increase the welfare of such households. This justified the need to improve agro-processing in the country and this will also help reduce post-harvest loses. Relatedly, the study of [47] revealed that nonfarm employment is important to offset the effects of droughts on asset wealth.

Professional and skilled employments were found to increase welfare for male headed households but decrease welfare for female headed households. In terms of contribution to G, observed differences in engaging in professional and skilled employment led to an increase in the welfare gap, although insignificant. Nonetheless, the unobserved characteristics of professional and skilled employment led to a positive and significant effect on G. This is consistent with the findings of [40,45,46] who estimated that households who diversify into salaried jobs have higher welfare.

5. CONCLUSIONS AND RECOMMENDATIONS

This study analysed gender welfare inequality among farming households in the northern regions of Ghana. It specifically examined the sources of gender welfare gap, the effect of climate change/variability and climate adaptation through livelihood diversification on gender welfare gaps, and the determinants of welfare among farming households. The correction of selectivity bias in the OB model was justified. It is concluded that there is a significant difference of 11.4% in the welfare between male and female headed households. This study also conclude that climate change does not only lead to welfare reduction but also, leads to increased welfare inequality. While the effect of livelihood diversification on households' welfare was established, it is concluded that the unobservable returns from livelihood diversification are male favoured, thereby, leading to a worsening gender welfare gap. Generally, the factors that influenced the welfare of households include

education of the household head, education by household members, household size, land ownership, Upper East location, drought, windstorm, climate perception, climate information, LVI, crop-animal diversification, crop-agro processing and crop-professional/skilled employment. In addition to most of these variables, flood and trading also had a significant contribution on the estimated gender welfare gap.

There is therefore the need to improve the socioeconomic status of female headed households. This can be achieved by improving access to credit by the households. Promotional efforts on girl child education must be stepped-up to avert educational gaps and its impact in the future. Although livelihood diversification is a necessary condition to improving households' welfare, policies that would ensure that females also have higher returns from such strategies are sufficient to address gender welfare gaps. For instance, training and education of females on livelihood diversification portfolios is crucial to improve their abilities to obtain higher returns from such ventures. To improve the welfare of farmers in the midst of climate change, animal rearing should be promoted among maize crop farmers. Specifically, integrated farming systems are recommended. Similarly, government's policy of one district one factory should keenly consider agro-processing opportunities in the region and develop them into more commercial activities.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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