Dwomoh *et al.*
Agricultural and Food Economics (2023) 11:24
https://doi.org/10.1186/s40100-023-00267-6

Agricultural and Food Economics

RESEARCH Open Access

Modeling inequality in access to agricultural productive resources and socioeconomic determinants of household food security in Ghana: a cross-sectional study

Duah Dwomoh[1*], Kofi Agyabeng[1], Henry Oppong Tuffour[2], Afua Tetteh[3], Anthony Godi[1] and Richmond Aryeetey[3]

*Correspondence:
duahdwomoh@ug.edu.gh

[1] Department of Biostatistics, School of Public Health, College of Health Sciences, University of Ghana, Accra, Ghana
[2] Department of Crop and Soil Sciences, Faculty of Agriculture, College of Agriculture and Natural Resources, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
[3] Department of Population, Family and Reproductive Health, School of Public Health, College of Health Sciences, University of Ghana, Accra, Ghana

Abstract

Women in rural communities remain the most vulnerable population in accessing agricultural productive resources with dire implications for food security, malnutrition, and poverty. Effective agricultural and food-related policies should be based on a better understanding of the complex inter-relationship of how socioeconomic, demographic, gender, women empowerment, and geographical location indicators simultaneously affect access to agricultural productive resources and food security. The study quantified the level of inequality in access to agricultural productive resources and explored the mechanism through which socioeconomic status mediates the effect of geographic location on food security. This is a community-based cross-sectional study using a multi-stage stratified cluster random sampling design to generate a representative sample of the target population who live in coastal and non-coastal communities. The Gini inequality index, generalized structural equation models, multivariable modified Poisson and Negative binomial regression models were used. The inequality in access to agricultural productive resources was marginally higher among women than in men, higher in the coastal areas than in the non-coastal areas, and higher among women with low empowerment in agricultural production decision-making. The empowerment of women in agricultural decision-making was found to increase with age, as older women were more empowered to make decisions in agriculture. Approximately 17% [95% CI 15.6–18.6] of the population were food-secured (coastal = 13.9%, non-coastal communities = 20.7%). Socioeconomic status mediates the effect of living in coastal versus non-coastal rural communities on food security. To improve food security, the government should prioritize interventions geared toward improving women's access to productive agricultural resources. These interventions must consider gender-specific constraints, poverty alleviation schemes, legal framework, sociocultural factors, and decision-making power.

Keywords: Inequality, Agricultural productive resources, Gender gap, Socioeconomic determinants, Women empowerment, Food security, Gini index

Introduction

The 2016 Africa Human Development Report showed that gender inequality costs sub-Saharan Africa approximately 95 USD billion per year (Anderson et al. 2021). The lack of resources and opportunities for women in agriculture in developing countries explains the underperformance of the agricultural sector (FAO 2013). The desire of women to be involved in agriculture, and entrepreneurship remains undoubtedly high. However, almost everywhere they face more severe constraints than men in accessing productive resources, markets, and services (FAO 2017; Singh 2014). This gender gap hinders the likelihood of achieving the Sustainable Development Goal (SDG) 2 of ending all forms of hunger and malnutrition by 2030, lowers productivity and reduces their contributions to the agricultural sector and the achievement of broader economic, and social development goals (Nakai 2018). The impact of changing climate, food economics including the fluctuations in food prices, growing global population inadequate access to agricultural productive resources and environmental stressors will have significant yet uncertain impacts on food security in the next decades.

According to the Ghana Living Standard Survey (GLSS) (GSS 2018), extreme poverty (individuals whose total expenditure falls below GH¢ 792.05 per month) is more prevalent in rural Ghana where women are most vulnerable to poverty and malnutrition compared to urban areas. An estimated 2.2 million persons live in extreme poverty in rural areas. The GLSS report for 2016/2017 indicated that the poverty incidence was approximately 43% among households whose heads are self-employed in the agricultural sector (GSS 2018). Poverty in Ghana is more prevalent in households that own farms compared to non-farm households. The poverty rate among households whose heads are engaged in agriculture was higher than even the unemployed, retired, or inactive (GSS 2018).

Women in rural communities across the globe are constantly confronted with low socioeconomic status, the power to make informed decisions and low self-esteem arising from gender stereotyping (Afzal et al. 2009) and Ghana is no exception. Although the percentage of women involved in agriculture is 41.3%, empirical evidence from the literature shows that women have lower access to agricultural productive resources (credit and extension services, fertilizers, improved seeds, mechanical equipment, and machinery) (FAO 2013). There is evidence that women are more likely than men to be involved in agriculture in part-time, occasional and low-paying jobs and to receive lower wages for the same type of work, even if they have similar experience and qualifications to men (FAO 2013). The hindrance to accessing agricultural productive resources largely emanates from the cultural orientation and practices that identify males as 'heads of households and females as "contributing family workers" in most countries in sub–Saharan Africa (SSA) (GSS 2015).

These practices strengthen the uneven and hierarchical relationships between men and women, especially, in rural areas. Thus, women are limited in power, decision-making opportunities and resources and fulfillment of their rights. These negative tendencies may expose them to low self-esteem and confidence with dire consequences on poverty, high costs for the agricultural sector, food security and economic growth. Improving access to agricultural input services (including improved seedlings and new technologies) through gender empowerment can contribute to poverty reduction, improved food security, and nutrition among women (FAO 2017). The 2011–2013 report from the Food

and Agricultural Organization of the United Nations indicated that closing the gender gap in agriculture would generate increased yields on women's farms, raise the total agricultural output, especially in developing countries, and significantly reduce the number of people suffering from hunger in the world (FAO 2013).

Although some studies (deCampos et al. 2016; Doss et al. 2014; Kabeer 2016) have assessed the inequalities in access to agricultural productive resources in different countries across SSA and concluded that women are generally disadvantaged, there is contradictory evidence in some cases that showed that women had equal access to productive resources such as land, agricultural inputs and even in some cases, higher control of household income than their male counterpart (GSS 2015). This counter-argument raises the need to explore further the impact of geography and the context that enshrines sociocultural norms and their relative effect on women's access to agricultural productive resources. Admittedly, few studies have been conducted in Ghana on this issue, but these studies were limited in scope and geographic boundaries (Ahmed et al. 2016; Nyantakyi-Frimpong 2020; Ragsdale et al. 2018). Almost all the studies that were reviewed assessed gender inequality differentials in the northern part of Ghana due to extreme poverty levels that may be similar to or even lower than poverty levels in coastal and non-coastal rural communities in the Central region of Ghana. Furthermore, to ensure that country-specific agricultural policies tackle the gender aspect more explicitly, we need to collect up-to-date data on the realities faced by rural women and men to inform policy development. As emphasized by the FAO, there is an urgent need to use findings from research to promote policy dialogue among various stakeholders with adequate participation of women (FAO 2017).

Studies sometimes attribute geographic location to food security which is justified due to soil and climate related factors (Hossain and Majumder 2018; Islam et al. 2020), but we current do not know how socioeconomic status mediate that effect. For instance, the geographical effect may not be about living in coastal or non-coastal area but perhaps people who live in coastal communities are poorer compared to non-coastal community and that may contribute to the observed relationship. In other words, intervention must target poverty alleviation in those communities to reduce food insecurity.

Thus, this study sought to quantify the levels of inequality in the access to agricultural productive resources and food security in coastal and non-coastal rural communities, women empowerment, and gender. We further estimated the impact of women's empowerment on access to agricultural productive resources. To better understand the underlying mechanisms of the relationship between geographical location (coastal versus non-coastal) and food security, we explored the mediation effect of socioeconomic status using household wealth as a proxy to measure socioeconomic status.

Materials and methods

Study area

The study was conducted in 10 randomly sampled coastal and non-coastal rural communities in the Central region, a Coastal Savannah agroecological zone in Ghana.

The study was conducted between the 1st of May 2021 and 31st August 2021. The non-coastal communities were Ayeldu, Taabosom, Enyan-main, and Effutuakwa. The coastal

communities included Akokokrom, Ekumfi Nakwa, Ankaful, Ninheni, Ekupoano, and Nanaben.

Data collection

The study secured ethical approval from the Ethics Committee for the Humanities, University of Ghana with approval number: ECH 062/20-21.

Women and men aged 18 years and above who have lived in the community for more than 6 months, self-declared to be fit physically and mentally including disabled persons, and consented to the study protocol were included in the study. Exclusion of eligible participants from the study was based on ill health at the time of the survey which limited their ability to complete the survey. A structured questionnaire was developed and uploaded into Open Data Kit (ODK) system. ODK is an open-source Android app that replaces paper forms used in survey-based data gathering. Field data collectors were trained on the content of the questionnaire and how to use the ODK. The trained interviewers conducted face-to-face interviews with the respondents. The field supervisor/interviewers approached the participants selected by the sampling framework in their respective households or any other place that is more convenient and safer for both the participants and interviewers. A Global Positioning System (GPS) device was used to collect information about the location of the households but geocodes in the original data were displaced to 10 km away for security reasons. Any challenges associated with data were identified in real-time and data cleaning occurred simultaneously with the data collection. The COVID-19 pandemic presented challenges for the conduct of the study. Taking cognizance of the movement restrictions and social measures taken by the Ghana government in line with similar actions taken by other governments globally to contain the spread of COVID-19, the following methodological adjustments were taken to ensure that the study was not stalled. The health and safety of all respondents, as well as the accuracy of the survey, were prioritized as follows:

- All field teams were provided and mandated to wear nose masks and always use hand sanitizers during fieldwork.
- All survey respondents were encouraged to wear a nose mask before and during the interview and hand sanitizers were provided during the interview sessions.

Sampling procedure

Sample size estimation

The sample size for the study was based on the modified version of Cochran's formula as follows:

$$n = \text{Strata} \times \text{DEFF} \times \frac{Z^2_{1-\frac{\alpha}{2}} p(1-p)}{[e]^2(1-\text{NR})} \tag{1}$$

where n is the required sample size (number of study participants), $Z_{1-\frac{\alpha}{2}} = 1.96$ is the standard normal variate at type I error $(\alpha) = 5\%$. $p = 50\%$ is the anticipated percentage of females aged 18 years and above who have no access to agricultural productive resources like farmlands and agricultural extension services, and $e = 5\%$ is the margin

error associated with the point estimates. NR = 5% is the individual level non-response rate. This study used a higher design effect (DEFF) of 3 which is slightly higher compared to the Demographic and Health Survey (DHS)-designed effect of 2 to incorporate the effect of modeling the multivariable effect of other factors (GSS 2015). We adjusted for the strata effect in estimating the sample size to generate enough power to estimate the differences in inequality of access to agricultural productive resources between coastal and non-coastal rural communities by multiplying the sample size by 2. Substituting the parameters in Eq. 1, the total number of participants required for the study was 2427. To determine the number of households required to find 2135 older adults, we assumed that 60% of the households would be adults aged 18 years or older with an average household size of 7, which is twice the national estimate since we worked in rural areas (GSS 2015).

The total number of households was estimated as follows:

$$\#\text{Households} = \frac{n}{(1 - r_{\text{h}}) \times H_{\text{size}} \times P_{\text{older}(18+)}} \tag{2}$$

Substituting the parameters $n = 2427$ (number of study participants), $r_{\text{h}} = 10\%$ (the proportion of households that could be missing from the sampled enumeration area-cluster), $H_{\text{size}} = 7$ (the average household size in the rural area), and $P_{\text{older}(18+)} = 60\%$ (the proportion of adults aged 18 years and above). The estimated number of households to be visited by the field interviewers is 642 households across the 10 communities.

Sampling process

A multistage, stratified cluster sampling approach was used. First, we stratified the region into coastal and non-coastal communities, and based on the budget considerations, six coastal and four non-coastal communities were randomly sampled. We obtained the list of enumeration areas for the communities using data from the 2010 Ghana Population and Housing Census obtained from the Ghana Statistical Service. We sampled 21 enumeration areas across all 10 communities and conducted a household listing of all the sampled enumeration areas. In each sampled enumeration area, approximately 30 households were selected using a simple random sampling.

Primary outcome measures

This study has two primary outcome measures, namely access to agricultural productive resources and food security. The primary outcome measure of interest was access to agricultural productive resources geared toward promoting food sustainability, improved nutrition, and poverty reduction. Access was defined as currently using the services, tool or personally owning the tool, properties, etc., that contribute to growth of agriculture and promote food security. The tools and services covered include farmlands, irrigation water, improved seedlings, fertilizer, tractor, weedicides, insecticides, and new technology, improved water sources, improved sanitation, livestock, labor, loan or credit facilities for farming activities, and non-formal financial services. Each access question was measured on a four-point Likert scale as follows: 1 = Not at all; 2 = Low; 3 = Moderate; and 4 = High. Each response was then dichotomized to "0" if the response was "No" or "1" otherwise. The overall access to agricultural productive resources was generated

using total composite scores with higher scores indicating a higher level of access and vice versa. This study adopted the United Nations Committee on World Food Security which defines Food security, as follows: means that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life. We measured food security using the Household Food Insecurity Access Scale (HFIAS) (Coates et al. 2007).

Conceptual framework

The conceptual framework for this study was based on the Food and Nutrition Security Conceptual Framework developed by the United Nations World Food Programme and found in the Emergency Food Security Assessment Handbook (second edition) (WFP 2009). In this study we focused on certain aspect of core determinants of food security as empahasized in the handbook. Our simplified version of the framework (Fig. 1) shows how sociodemographic factors could directly or indirectly influenced food security through the core mediating effect of household wealth and access to productive agricultural resources. Specifically, our study focused on how the interaction among a broad range of agro-ecological conditions/ climate (coastal versus non-coastal), socio-economic (household wealth), gender inequality, women autonomy in decision making and basic services and infrastructure including disparity in access to agricultural productive resources determined the level of food security. Based on this conceptual framework, we further hypothesized that geographic location (coastal or non-coastal) may influence household wealth which have both direct and indirect effect on food security (Fig. 1).

Independent variables

The main independent variables were age, gender, geographical location (coastal or non-coastal), educational level, marital status, household wealth index, and autonomy of decision-making in agriculture. The wealth index was constructed using principal component analysis on the ownership of certain selected assets and then categorized the respondents into five quintiles based on their estimated wealth index scores similar to what is reported in the DHS (GSS 2015). Autonomy of decision-making in agriculture were assessed using an abridged version of the Abbreviated Women's Empowerment in

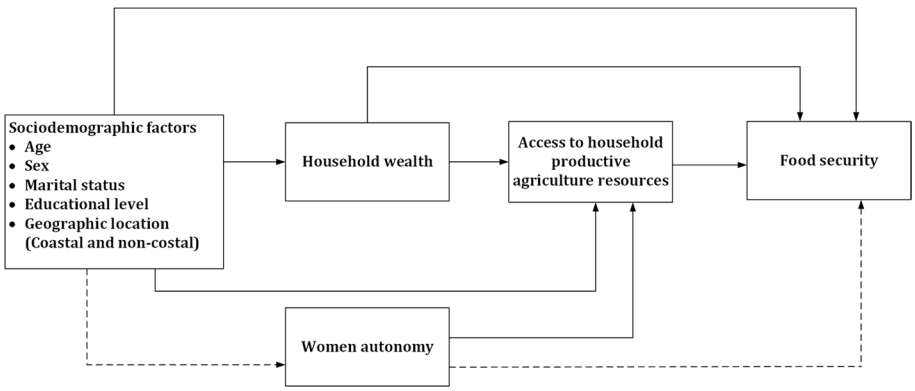

Fig. 1 Conceptual framework for understanding food security. Short dashed line suggests indicator was restricted to only the women sub-group

Agriculture Index (A-WEAI) questionnaire. The A-WEAI is a survey-based tool jointly developed by the International Food Policy Research Institute, the Oxford Poverty and Human Development Initiative, and the U.S. Agency for International Development (USAID) (Alkire et al. 2013). The input in the productive decision was defined as decisions about agricultural production and sole or joint decision-making about food and cash crop farming, livestock, and fisheries. The autonomy in agricultural production involved ownership of, access to, and decision-making power about productive resources such as land, livestock, agricultural equipment and machinery, consumer durables, and credit. The women were asked if they participated in any agricultural production activities in the past 12 months, their level of involvement and input to decisions concerning those activities, the level at which they felt they could make personal decisions if they wanted to, and how much input they had in decisions on the use of income generated from the various activities they were involved in. Questions on the two indicators were assessed on a 4-point scale (1 = no input or input in a few decisions, 2 = input into some decisions, 3 = input into most or all decisions, 4 = no decision made). The degree of "own decision-making" was also assessed on a 4-point scale (1 = not at all, 2 = small extent, 3 = medium extent, 4 = to a high extent). Responses were later dichotomized into 0 "No" for all 1 = "not at all" responses, otherwise 1 "Yes". Input in productive decision autonomy was considered adequate if there was at least one activity in which the individual has some input in the decision/makes decision/feels could make if wanted.

The household wealth index was used as a proxy to measure socioeconomic status defined as a composite measure of a household's cumulative living standard. The wealth index was calculated using principal component analysis of household's ownership of selected assets, such as televisions and bicycles; materials used for housing construction; and types of water access and sanitation facilities.

Empirical model

$x \in \Re^n$ be a vector of independent variables (household wealth, geographic location, gender, etc.) that could influence both access to agricultural productive resources and food security, then the Poisson/Negative binomial regression model take the form $\log\left(E\left(Y_{ij}|X\right)\right) = \beta_0 + \beta' X$ where Y_{ij} is the outcome measure for individual i in community j with cluster robust standard errors to address the problems of overdispersion in fitting a model with a binary outcome using Poisson or negative binomial. The multivariable binary logistic regression model follows the form: $\log\left(\frac{P(Y_{ij}=1|X)}{1-P(Y_{ij}=1|X)}\right) = \beta_0 + \beta' X$.

For the mediation analysis using structural equation modeling, we specified the model as follows.

The Poisson regression model that connects the exposure (geographic location) and the mediating variable (socioeconomic status) to food security controlling for additional confounding variables is given by:

$$\log\left(E(Y|X*, M*, Z)\right) = \beta_0 + \beta_1 X* + \beta_2 M* + \beta * Z$$

$X*$ = geographic location, $M*$ = Mediating variable: socioeconomic status (household wealth) and Z represents other confounding factors such mothers' education, age of the respondent etc.

The Poisson regression model that assessed how the exposure influenced the mediator controlling for possible confounding covariates is as follows:

$$\log\left(E(M|X*,Z)\right) = \alpha_0 + \alpha_1 X * + \beta * Z$$

The direct effect $= \beta_1$, indirect effect $= \alpha_1\beta_2$ and the total effect $= \beta_1 + \alpha_1\beta_2$

Statistical analysis

Descriptive prevalence estimates and the corresponding 95% confidence intervals (CIs) were estimated using the binomial exact—Clop-per-Pearson method. Chi-square test of independence was used to determine the correlation between the background characteristics, access to agricultural productive resources, and how they vary with the gender of the participants and geographical location (coastal versus non-coastal). The Z-test for comparing the difference in proportion was used to determine whether there was a statistically significant difference between each indicator of access, gender, and geographical location. A multivariable modified Poisson, Negative Binomial, and binary logistic regression models that generated adjusted prevalence ratios (aPRs) and odds ratio (aORs)s were used to quantify the effect of gender, socioeconomic status, geographical location, and women empowerment in agricultural decision-making on access to agricultural productive resources and food security. This study is cross-sectional study and usually studies report odds ratio from the logistic regression model. However, our study rather focused on a more preferred prevalence ratio which were generated using Modified Poisson/negative binomial regression model (i.e., models with robust standard errors) which is the best estimate for cross-sectional studies (Barros and Hirakata 2003). For the purposes of conducting sensitivity analysis, we also included the odds ratio from the logistic regression model. Usually for rare outcomes (prevalence < 15%) both the prevalence and odds ratio looks very similar. Reporting the prevalence ratios from both Poisson and Negative Binomial was to address the issues of over dispersion.

The mediation analysis based on the structural equation model was used to determine how socioeconomic status (proxy for household wealth) mediates the relationship between geographical location and food security.

We used the "INEQDECO" Stata module (Jenkins 2021) to calculate the Gini Inequality Index with decomposition and stratification by subgroups (sex, location, women empowerment in agriculture). Bootstrapped standard errors with 1000 replications for the estimates of the Gini indices were generated. The Gini Index ranges between 0 and 1, and inequality in access to agricultural productive resources increased with an increasing index. A value of "0" meant there was a completely equal distribution of access to agricultural productive resources, whereas a value of "1" referred to the extreme situation of one group of people having complete access to agricultural productive resources, and all the rest to have no access at all. Although the estimates were self-weighted because the sample size was quite close to the population size in the rural communities, for all the statistical models, the analyses adjusted for the complex survey design features (clustering, and stratification) to obtain a more robust standard error. A mediation analysis was conducted using generalized structural equation models to better understand how socioeconomic status mediates the effect of geographical location on the prevalence of food insecurity. *P* values less than 0.05 were considered statistically significant.

All the data management and statistical analyses were conducted using Stata SE version 17 (StataCorp, College Station, Texas, USA).

Results

Characteristics of the study participants

The survey was conducted in the Central region of Ghana and involved 2447 participants with 623 males and 1824 females in four coastal ($n=1318$) and six non-coastal ($n=1129$) communities with an average age of 40.5 years (youngest = 19 years, oldest = 97 years). Most of the women were from poorer households compared to the men. Almost all respondents had access to an improved drinking water supply. However, less than half of them had access to improved toilet facilities (43.5%). The study was dominated by people of the Akan ethnicity (98.8%) and Christian faith (95.1%). More than half of the respondents were as of the time of the survey married (57.0%) with a few divorcees (5.3%). While a little more than half (52.0%) of the respondents had primary education, about one-third (37.2%) had received no formal education. Less than three percent (3.0%) of the respondents (2.1%) had received tertiary education. The completion rates of higher education and literacy were higher among men than women. The body mass index was predominantly normal (56.6%) with few respondents being underweight (4.1%). Approximately half of the respondents had enrolled and registered on the National Health Insurance Scheme (NHIS) with evidence from their NHIS cards. Close to three-fourths (74.9%) of the respondents had full-time employment. The detailed distribution of the characteristics of the study participants and how they varied by gender based on the Chi-square test of independence and their corresponding p-values are summarized in Table 1.

Determinants of women's autonomy in agricultural decision making

Table 2 shows factors associated with women's autonomy in agricultural decision-making. The two core determinants of women's autonomy in agricultural decision-making were the geographical location and the age of the woman. The prevalence of a woman being autonomous in agricultural decision-making if she lives in a non-coastal area increased by 10% compared to women who lived in coastal areas [adjusted prevalence ratio, aPR = 1.10, 95% CI 1.04–1.16, $p<0.05$]. Women's autonomy in agricultural decision-making increased with age as older women were found to be more autonomous to make decisions in agricultural activities. Among older women aged 50 years or more, the prevalence of being autonomous in agricultural decision-making increased by approximately 33% compared to those aged 18–24 years [aPR = 1.33, 95% CI 1.15–1.55, $p<0.05$]. Household wealth, however, did not have a statistically significant association with women's autonomy in agricultural decision-making.

Access to agricultural productive resources by gender and geographic location

Table 3 shows the level of access to agricultural productive resources by gender and geographic location based on the Z-test for comparing the difference in proportion. Only 21.9% [95% CI 18.7, 25.3] of the respondents (men and women) had high access to agricultural productive resources with men having higher access (24.3%, 95% CI [17.3, 31.3]) compared to women (21.2%; 95% CI [17.6, 24.8]) resulting in

Table 1 Characteristics of study participant

	Total *N* = 2447 ***n* (%)**	**Male *N* = 623** ***n* (%)**	**Female *N* = 1824** ***n* (%)**	***P* value**
Location				< 0.001
Coastal	1318 (53.9)	288 (46.2)	1030 (56.5)	
Non-coastal	1129 (46.1)	335 (53.8)	794 (43.5)	
Household wealth				< 0.001
Poorest	492 (20.1)	72 (11.6)	420 (23.0)	
Poor	488 (19.9)	111 (17.8)	377 (20.7)	
Middle class	490 (20.0)	120 (19.3)	370 (20.3)	
Rich	488 (19.9)	154 (24.7)	334 (18.3)	
Richest	489 (20.0)	166 (26.6)	323 (17.7)	
The main source of drinking water for household				0.690
Unimproved	107 (4.4)	29 (4.7)	78 (4.3)	
Improved	2340 (95.6)	594 (95.3)	1746 (95.7)	
Toilet facility household usually uses				< 0.001
Unimproved	1329 (54.3)	298 (47.8)	1031 (56.5)	
Improved	1118 (45.7)	325 (52.2)	793 (43.5)	
Ethnicity				0.016
Non-Akan	29 (1.2)	13 (2.1)	16 (0.9)	
Akan	2418 (98.8)	610 (97.9)	1808 (99.1)	
Religion				< 0.001
Christian	2327 (95.1)	569 (91.3)	1758 (96.4)	
Non-Christian	120 (4.9)	54 (8.7)	66 (3.6)	
Marital status				< 0.001
Married/cohabiting	1395 (57.0)	356 (57.1)	1039 (57.0)	
Widowed/divorced/separated	693 (28.3)	119 (19.1)	574 (31.5)	
Single	359 (14.7)	148 (23.8)	211 (11.6)	
The current age of respondents in years				
Mean [minimum–maximum]	40.5 [18–97]	41.3 [18–80]	40.2 [18–97]	0.081
Age categorized (years)				
18–25	328 (13.4)	79 (12.7)	249 (13.7)	0.240
25–29	350 (14.3)	89 (14.3)	261 (14.3)	
30–39	613 (25.1)	138 (22.2)	475 (26.0)	
40–49	475 (19.4)	130 (20.9)	345 (18.9)	
≥ 50	681 (27.8)	187 (30.0)	494 (27.1)	
Level of education				< 0.001
None	910 (37.2)	137 (22.0)	773 (42.4)	
Primary	1272 (52.0)	355 (57.0)	917 (50.3)	
Secondary/tertiary	265 (10.8)	131 (21.0)	134 (7.3)	
Respondent can read and write a sentence in English				< 0.001
No	1811 (74.0)	363 (58.3)	1448 (79.4)	
Yes	636 (26.0)	260 (41.7)	376 (20.6)	
Body mass index (kg/m^2)				< 0.001
Underweight	101 (4.1)	21 (3.4)	80 (4.4)	
Normal	1386 (56.6)	454 (72.9)	932 (51.1)	
Overweight	668 (27.3)	130 (20.9)	538 (29.5)	
Obese	292 (11.9)	18 (2.9)	274 (15.0)	
Self-rating of health today				< 0.001
Good	2034 (83.1)	547 (87.8)	1487 (81.5)	
Moderate	337 (13.8)	66 (10.6)	271 (14.9)	

Table 1 (continued)

	Total $N=2447$ *n* (%)	Male $N=623$ *n* (%)	Female $N=1824$ *n* (%)	*P* value
Poor	76 (3.1)	10 (1.6)	66 (3.6)	
Valid NHIS card				< 0.001
No	1219 (49.8)	405 (65.0)	814 (44.6)	
Yes	1228 (50.2)	218 (35.0)	1010 (55.4)	
Employment status				0.003
Unemployed	352 (14.4)	67 (10.8)	285 (15.6)	
Employed	2095 (85.6)	556 (89.2)	1539 (84.4)	
Completed level of education				< 0.001
No	786 (51.2)	206 (42.5)	580 (55.2)	
Yes	750 (48.8)	279 (57.5)	471 (44.8)	
Stability of current employment				0.260
Regular	1499 (71.6)	408 (73.4)	1091 (70.9)	
Irregular	596 (28.4)	148 (26.6)	448 (29.1)	
Agricultural autonomy in decision making				
Inadequate	–	–	143 (15.0)	
Adequate	–	–	809 (85.0)	

NHIS—National Health Insurance Scheme, *n*—Frequency, %—column percentage

p value: 0.05

a difference of approximately 3 percentage points (pp). Access to farmland was estimated as 65.8% (95% CI [62.0, 69.5]) among the respondents with men having a higher access of 75.0% (95% CI [67.9, 82.1]) compared to women 63.1% (95% CI [58.9, 67.4]). Access to fertilizers decreased by about 22.1% (95% CI [− 29.3, − 14.9]) in the coastal communities compared to the non-coastal communities.

Overall, access to agricultural productive services decreased by 7.0% (95% CI [− 13.4, − 0.6]) in the coastal communities compared to the non-coastal communities. Access to farming land, irrigation water, agricultural extension services, and improved planting materials (seeds and seedlings) decreased significantly in the coastal communities compared to the non-coastal communities.

Relationship between gender empowerment, socioeconomic status, geographic location, and access to agricultural productive resources

Access to the various agricultural productive resources increased by approximately 21.0% among women living in the non-coastal communities compared to those living in the coastal communities [adjusted prevalence ratio**,** aPR = 1.21, 95% CI 1.04–1.42, $p < 0.005$] as presented in Table 4. Again, access to agricultural productive resources increased by approximately 46% among women who were adequately empowered to make decisions in agricultural productive services compared to women who were not adequate empowerment ([aPR = 1.46, 95% CI 1.18–1.82]). Although, increased level of household wealth increased access to productive agricultural resources, the effect was not statistically significant.

Table 2 Determinants of women's autonomy in agricultural decision-making

	Sensitivity analysis	
	Adjusted binary logistic regression model	**Adjusted Poisson regression model**
	aOR [95% CI]	**aPR [95% CI]**
Location		
Coastal	1	1
Non-coastal	2.27 [1.39–3.7]**	1.10 [1.04–1.16]**
Age in years		
18–24	1	1
25–29	1.41 [0.77–2.56]	1.12 [0.94–1.34]
30–39	2.31 [1.31–4.08]**	1.25 [1.08–1.45]**
40–49	3.16 [1.61–6.19]**	1.3 [1.12–1.51]**
50 or more	4.77 [2.36–9.67]***	1.33 [1.15–1.55]***
Marital status		
Married/cohabiting	1	1
Single	0.61 [0.33–1.13]	0.91 [0.78–1.06]
Divorced/separated/widowed	2.94 [1.52–5.69]**	1.08 [1.03–1.13]**
Educational level		
None	1	1
Primary	1.09 [0.72–1.67]	1 [0.95–1.06]
Secondary/tertiary	0.69 [0.28–1.71]	0.95 [0.81–1.13]
Household wealth		
Poorest	1	1
Poor	1.05 [0.61–1.81]	1.01 [0.92–1.12]
Middle class	1.46 [0.78–2.73]	1.06 [0.96–1.16]
Rich	0.96 [0.52–1.79]	1.01 [0.92–1.12]
Richest	1.84 [0.9–3.79]	1.09 [0.99–1.21]

p value notation: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

Measuring inequality in access to agricultural productive resources

The comparisons of inequalities in the access to agricultural productive resources in the context of gender, women's decision-making, and geographical location, using the Gini Inequality Index are presented in Table 5. Inequality in access was higher among women (0.366) than men (0.337). Women with inadequate agricultural decision-making had the highest degree of inequality in access to agricultural productive resources (0.368) compared to those with adequate decision-making power (0.268). Men who live in coastal communities had the highest degree of inequality (0.470).

Prevalence of food security by socioeconomic status, gender and geographic location

Table 6 shows the prevalence of food security among the study participants. Overall, only 17.0% of the study participants were food secure as at the time of the survey. The overall prevalence of food security among males 20.7 [17.6–24.1] while food security prevalence was 15.8 [14.1–17.5] among females. In the costal areas, the prevalence of food security was 13.9 [12.1–15.9] while in the non-coastal areas the prevalence was 20.7 [18.4–23.2]. Details of food security distribution are found in Table 6.

Table 3 Access to agricultural productive resources by gender and geographic location

Agricultural productive resources	Total	Gender		Diff = M − W	Location		Diff = C − NC
		Men (M)	Women (W)		Coastal (C)	Non-coastal (NC)	
	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]
Access to farming land	65.8 [62, 69.5]	75.0 [67.9, 82.1]	63.1 [58.9, 67.4]	11.9 [3.6, 20.1]**	37.5 [31.7, 43.3]	86 [82.5, 89.5]	− 48.5 [− 55.3, − 41.7]***
Access to irrigation water	16.4 [13.6, 19.5]	23.6 [16.7, 30.5]	14.3 [11.2, 17.3]	9.4 [1.8, 16.9]**	12.1 [8.2, 16.1]	19.4 [15.4, 23.4]	− 7.3 [− 12.9, − 1.7]*
Access to agricultural extension services	21.9 [18.7, 25.3]	26.4 [19.2, 33.6]	20.6 [17, 24.1]	5.8 [− 2.2, 13.9]	18.9 [14.2, 23.7]	24 [19.6, 28.3]	− 5.0 [− 11.5, 1.4]
Access to improved seedlings	35.7 [32, 39.6]	38.9 [30.9, 46.9]	34.8 [30.6, 39]	4.1 [− 4.9, 13.1]	29.9 [24.4, 35.4]	39.9 [34.9, 44.9]	− 10.0 [− 17.4, − 2.5]*
Access to fertilizer	36.4 [32.6, 40.3]	42.4 [34.3, 50.4]	34.6 [30.4, 38.8]	7.7 [− 1.4, 16.8]	23.5 [18.4, 28.6]	45.6 [40.5, 50.6]	− 22.1 [− 29.3, − 14.9]***
Access to tractor	10.7 [8.4, 13.4]	16.7 [10.6, 22.8]	9 [6.4, 11.5]	7.7 [1.1, 14.3]**	8.7 [5.3, 12.1]	12.1 [8.8, 15.5]	− 3.4 [− 8.2, 1.3]
Access to weedicides	43.1 [39.3, 47.1]	45.8 [37.7, 54]	42.4 [38, 46.7]	3.5 [− 5.8, 12.7]	25.0 [19.8, 30.2]	56.1 [51, 61.1]	− 31.1 [− 38.3, − 23.8]***
Access to insecticides	40.5 [36.6, 44.4]	43.1 [35, 51.1]	39.7 [35.4, 44]	3.3 [− 5.8, 12.5]	24.2 [19.1, 29.4]	52 [46.9, 57.1]	− 27.8 [− 35, − 20.5]***
Access to new technology	5.5 [3.9, 7.6]	9 [4.3, 13.7]	4.5 [2.7, 6.3]	4.5 [− 0.5, 9.6]*	1.9 [0.2, 3.5]	8.1 [5.3, 10.9]	− 6.2 [− 9.4, − 3]**
Access to an improved water source	85.7 [82.7, 88.3]	84 [78, 90]	86.2 [83.1, 89.2]	− 2.1 [− 8.8, 4.6]	86.0 [81.8, 90.2]	85.4 [81.9, 89]	0.5 [− 5, 6.1]
Access to improved sanitation	88.2 [85.4, 90.6]	85.4 [79.7, 91.2]	89 [86.2, 91.8]	− 3.6 [− 10, 2.8]	89.4 [85.7, 93.1]	87.3 [83.9, 90.7]	2.1 [− 3, 7.1]
Access to livestock	40.5 [36.6, 44.4]	36.8 [28.9, 44.7]	41.5 [37.2, 45.9]	− 4.7 [− 13.7, 4.3]	40.2 [34.2, 46.1]	40.7 [35.7, 45.7]	− 0.5 [− 8.3, 7.2]
Access to labor	51.5 [47.5, 55.4]	59 [51, 67.1]	49.3 [44.9, 53.7]	9.7 [0.6, 18.9]*	31.4 [25.8, 37]	65.8 [60.9, 70.6]	− 34.3 [− 41.7, − 26.9]***
Access to credit facilities for farming activities	20.6 [17.5, 24]	20.8 [14.2, 27.5]	20.6 [17, 24.1]	0.3 [− 7.3, 7.8]	23.1 [18, 28.2]	18.9 [14.9, 22.8]	4.2 [− 2.2, 10.7]
Access to non-formal financial services	23.5 [20.2, 27]	24.3 [17.3, 31.3]	23.2 [19.5, 27]	1.1 [− 6.9, 9]	25.4 [20.1, 30.6]	22.1 [17.9, 26.3]	3.3 [− 3.5, 10]
High access	21.9 [18.7, 25.3]	24.3 [− 17.3, 31.3]	21.2 [17.6, 24.8]	3.1 [− 4.8, 11.0]	17.8 [13.2, 22.4]	24.8 [20.4, 29.2]	− 7.0 [− 13.4, − 0.6]**

p value notation: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$, Access was considered to be high if the individual had a total score of ≥ 10/15. Access to agricultural productive resources is defined as the percentage of people who are able to access the different agricultural productive resources

Table 4 Factors influencing access to agricultural productive resources

	Total		Men		Women	
	Adjusted Poisson regression model	**Adjusted negative binomial regression model**	**Adjusted Poisson regression model**	**Adjusted negative binomial regression model**	**Adjusted Poisson regression model**	**Adjusted negative binomial regression model**
	aPR [95% CI]	**aPR [95% CI]**	**aPR [95% CI]**	**aPR [95% CI]**	**aPR [95% CI]**	**aPR [95% CI]**
Location						
Coastal	1	1	1	1	1	1
Non-coastal	1.25 [1.08–1.44]*	1.25 [1.08–1.45]*	1.23 [0.91–1.66]	1.28 [0.94–1.74]	1.21 [1.03–1.42]*	1.21 [1.04–1.42]*
Age in years						
18–24	1	1	1	1	1	1
25–29	1.22 [0.91–1.63]	1.22 [0.91–1.63]	0.68 [0.4–1.17]	0.61 [0.34–1.09]	1.04 [0.76–1.42]	1.04 [0.77––1.41]
30–39	1.20 [0.92–1.56]	1.2 [0.92–1.57]	0.65 [0.37–1.15]	0.62 [0.34–1.14]	1.03 [0.75–1.41]	1.05 [0.77–1.43]
40–49	1.37 [1.05–1.77]*	1.36 [1.04–1.77]*	0.83 [0.5–1.38]	0.77 [0.43–1.36]	1.10 [0.8–1.51]	1.12 [0.82–1.53]
≥ 50	1.62 [1.24–2.11]***	1.64 [1.25–2.15]***	0.88 [0.52–1.47]	0.84 [0.46–1.51]	1.31 [0.95–1.82]	1.35 [0.98–1.85]
Marital status						
Single	0.79 [0.62–1.01]	0.79 [0.61–1.03]	0.5 [0.34–0.75]*	0.43 [0.28–0.67]***	0.97 [0.74–1.28]	1 [0.76–1.32]
Married/cohabiting	1	1	1	1	1	1
Divorced/separated/widowed	0.91 [0.81–1.03]	0.92 [0.81–1.05]	1.02 [0.8–1.29]	1 [0.77–1.29]	0.91 [0.8–1.03]	0.91 [0.8–1.04]
Educational level						
None	1	1	1	1	1	1
Primary	1.23 [1.1–1.38]***	1.23 [1.1–1.39]*	1.2 [0.88–1.65]	1.22 [0.89–1.66]	1.19 [1.06–1.33]*	1.19 [1.06–1.34]*
Secondary/tertiary	1.38 [1.12–1.69]*	1.4 [1.12–1.74]*	1.76 [1.25–2.48]*	1.87 [1.31–2.65]*	1.18 [0.91–1.53]	1.17 [0.9–1.51]
Wealth quintile						
Poorest	1	1	1	1	1	1
Poor	1.12 [0.89–1.42]	1.11 [0.88–1.4]	0.86 [0.47–1.56]	0.86 [0.48–1.55]	1.19 [0.93–1.53]	1.19 [0.93–1.51]
Middle class	1.14 [0.9–1.46]	1.15 [0.9–1.47]	1.06 [0.6–1.88]	1.07 [0.61–1.87]	1.25 [0.97–1.63]	1.26 [0.98–1.62]
Rich	1.06 [0.83–1.35]	1.05 [0.83–1.34]	0.95 [0.56–1.62]	0.91 [0.54–1.56]	1.16 [0.89–1.51]	1.17 [0.90–1.51]
Richest	1.16 [0.9–1.49]	1.17 [0.91–1.5]	1.07 [0.63–1.81]	1.04 [0.62–1.76]	1.23 [0.92–1.63]	1.23 [0.93–1.63]
Sex						
Male	1	1	–	–	–	–
Female	1.04 [0.92–1.16]	1.04 [0.92–1.18]	–	–	–	–
Women empowerment						
Inadequate	–	–	–	–	1	1
Adequate	–	–	–	–	1.47 [1.17–1.84]*	1.46 [1.18–1.82]*

aPR—adjusted prevalence ratio, – not applicable

p value notation: ****p* < 0.001; ***p* < 0.01; *p < 0.05

Table 5 Measuring inequality in access to agricultural productive resources

Indicators	Category	Gini inequality index
Overall		0.361
Gender	Men	0.337
	Women	0.366
Location	Coastal	0.319
	Non-coastal	0.286
Women empowerment in agricultural decision making	Inadequate	0.341
	Adequate	0.317
Interaction between sex and location	Women who live in coastal communities	0.363
	Women who live in non-coastal communities	0.396
	Men who live in coastal communities	0.470
	Men who live in non-coastal communities	0.297
Interaction between women's agricultural decision-making and location	Women who are not adequately empowered in agricultural decision making	0.368
	Women who are adequately empowered in agricultural decision making	0.268

The Gini Index is a measure between zero (perfect equality) and one (maximum inequality) which in our case summarizes the degree of inequality in access to agricultural productive resources in the coastal and non-coastal communities in the Central region of Ghana for 2021. A Gini index of zero indicates that everyone in the community has the same access, so there is perfect equality across the population. A Gini index of one lies on the other extreme and indicates that only one individual from the whole population has all the access, everyone else has no access. Numbers closer to zero indicate less inequality, and the closer the Gini index is to one, the more unequal income is within the population considered

Determinants of food security

Table 7 shows the factors associated with food security. Educational level, wealth and geographical location were identified to have significant effect on food security. The prevalence of food security among the richest households was approximately 3 times as high as the prevalence of food security among the poorest households (aPR = 2.72, [95% CI [1.71–3.52], $p < 0.001$). The prevalence of food security among those with secondary and tertiary level of education was approximately 3 times as high as the prevalence of food security among those with no education (aPR = 2.72, [95% CI 1.97–3.76], $p < 0.001$). Although access to agricultural productive resources increased the prevalence of food security by approximately 7%, the effect was not statistically significant (aPR = 1.07, [95% CI 0.88–1.30], $p = 0.053$).

Our mediation model shows a significant effect of household socioeconomic status on the relationship between geographical location (coastal versus non-coastal) and food security (indirect effect = 13.3, [95% CI 11.50–15.05], $p < 0.001$).

Discussion

This study quantified and compared the level of inequality of access to agricultural productive resources and food security in rural coastal and non-coastal communities. The study further estimated the effect of gender-related constraints, geographical location, women empowerment, socioeconomic determinants, agricultural decision-making on access to agricultural productive resources and food security. Households that were food-secured remain low in coastal and non-coastal areas. Although most women were empowered in agricultural decision-making, our findings showed that

Table 6 Prevalence of food security by socioeconomic status, gender and geographic location

	Overall	Sex		Geographic location	
		Males	Females	Costal	Non-costal
	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]	% [95% CI]
Overall	17.0 [15.6–18.6]	20.7 [17.6–24.1]	15.8 [14.1–17.5]	13.9 [12.1–15.9]	20.7 [18.4–23.2]
Age	*				**
< 25	20.4 [16.2–25.2]	29.1 [19.4–40.4]	17.7 [13.1–23]	13.4 [8.8–19.1]	29.8 [22.4–38.1]
25–29	19.7 [15.7–24.3]	23.6 [15.2–33.8]	18.4 [13.9–23.6]	16.1 [11.4–21.6]	25.8 [18.5–34.1]
30–39	17.8 [14.8–21]	22.5 [15.8–30.3]	16.4 [13.2–20.1]	15.6 [11.9–19.9]	20.4 [15.9–25.6]
40–49	16.8 [13.6–20.5]	16.2 [10.3–23.6]	17.1 [13.3–21.5]	12.2 [8.4–16.9]	22.2 [16.9–28.2]
≥ 50	13.5 [11–16.3]	17.6 [12.5–23.9]	11.9 [9.2–15.1]	12.3 [8.9–16.4]	14.6 [11.1–18.7]
Marital status	**	**			**
Single	22.8 [18.6–27.5]	30.4 [23.1–38.5]	17.5 [12.7–23.4]	18.8 [13–25.9]	25.9 [20–32.4]
Married/cohabiting	17.2 [15.3–19.3]	18.3 [14.4–22.7]	16.8 [14.6–19.3]	13.6 [11.3–16.1]	22.7 [19.3–26.5]
Divorced/separated/widowed	13.7 [11.2–16.5]	16 [9.9–23.8]	13.2 [10.6–16.3]	12.4 [9–16.5]	14.9 [11.4–18.9]
Educational level	***	***	***	***	***
None	9.8 [7.9–11.9]	8.8 [4.6–14.8]	10 [7.9–12.3]	10.3 [8–13]	8.7 [5.8–12.5]
Primary	17.4 [15.3–19.6]	18.6 [14.7–23]	16.9 [14.5–19.5]	15.4 [12.7–18.4]	19.4 [16.4–22.7]
Secondary/tertiary	40.4 [34.4–46.6]	38.9 [30.5–47.8]	41.8 [33.3–50.6]	33.9 [22.3–47]	42.4 [35.5–49.5]
Wealth quartile	***	***	***	***	***
Poorest	9.8 [7.3–12.7]	6.9 [2.3–15.5]	10.2 [7.5–13.5]	9.9 [7.3–13]	7.4 [0.9–24.3]
Poor	9.2 [6.8–12.1]	16.2 [9.9–24.4]	7.2 [4.8–10.2]	10.1 [7.2–13.6]	6.7 [2.9–12.7]
Middle	13.7 [10.8–17]	15.8 [9.8–23.6]	13 [9.7–16.8]	16.1 [11.9–21.1]	10.8 [7–15.6]
Rich	15.8 [12.7–19.3]	15.6 [10.2–22.3]	15.9 [12.1–20.2]	16.8 [11.1–23.9]	15.4 [11.7–19.6]
Richest	36.8 [32.5–41.3]	38 [30.5–45.8]	36.2 [31–41.7]	44 [32.5–55.9]	35.5 [30.9–40.3]
Sex	**			*	
Male	20.7 [17.6–24.1]	_	_	17.7 [13.5–22.6]	23.3 [18.9–28.2]
Female	15.8 [14.1–17.5]	_	_	12.8 [10.8–15]	19.6 [16.9–22.6]
Study area	***		***		
Coastal	13.9 [12.1–15.9]	17.7 [13.5–22.6]	12.8 [10.8–15]	_	_
Non-coastal	20.7 [18.4–23.2]	23.3 [18.9–28.2]	19.6 [16.9–22.6]	_	_
Autonomy in decision making					
Inadequate	_	_	11.9 [7.1–18.4]		
Adequate	_	_	16.7 [14.2–19.4]		

aPR—adjusted prevalence ratio, *CI*—confidence interval

p value notation: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

women, compared to men had lower access to resources for agricultural activities; higher inequality was found in coastal communities compared to non-coastal communities. Except for access to loans or credit facilities for farming activities that were marginally higher among women compared to men in the rural communities, access to all other productive resources (farmland, irrigation water, extension services, etc.) was lower among the women compared to men. These findings are similar to what has previously been reported in the vast array of literature on gender-related food and nutrition inequality issues in Ghana, SSA, and beyond (Agarwal 2018; Asitik and Abu 2020; Larson et al. 2019; Lutomia et al. 2019; Ogato et al. 2009). There are empirical evidence that shows that women in SSA usually cultivate smaller land, have less access to inputs, advisory and extension services, display a lower rate of modern

Table 7 Determinants of food security

	Unadjusted Poisson regression model	Adjusted Poisson regression model
	uPR [95% CI]	**aPR [95% CI]**
Age		
< 25	1	1
25–29	0.97 [0.71–1.30]	0.81 [0.59–1.11]
30–39	0.87 [0.66–1.14]	0.81 [0.60–1.08]
40–49	0.82 [0.62–1.10]	0.81 [0.58–1.12]
≥ 50	0.66 [0.50–0.88]**	0.75 [0.53–1.07]
Marital status		
Married/cohabiting	1	1
Single	0.75 [0.60–0.94]*	0.85 [0.65–1.12]
Divorced/separated/widowed	0.60 [0.46–0.78]***	1.06 [0.82–1.36]
Educational level		
None	1	1
Primary	1.78 [1.41–2.24]***	1.62 [1.24–2.11]***
Secondary/tertiary	4.13 [3.23–5.28]***	2.72 [1.97–3.76]***
Wealth quartile		
Poorest	1	1
Poor	0.95 [0.64–1.39]	0.80 [0.54–1.20]
Middle	1.40 [0.99–1.99]	1.00 [0.69–1.47]
Rich	1.62 [1.15–2.27]**	1.19 [0.81–1.74]
Richest	3.77 [2.82–5.06]***	2.45 [1.71–3.52]***
Sex		
Male	1	1
Female	0.76 [0.63–0.92]**	1.04 [0.85–1.28]
Geographical location		
Coastal	1	1
Non-coastal	1.49 [1.25–1.78]***	0.71 [0.57–0.90]**
Access to productive resources and agricultural services		
Low access	1	1
High access	1.17 [0.96–1.42]	1.07 [0.88–1.30]
Mediation analysis		
Indirect effect	13.3 [95% CI 11.50–15.05]***	

aPR adjusted prevalence ratio, *CI* confidence interval

p value notation: ***$p < 0.001$; **$p < 0.01$; *$p < 0.05$

inputs application than their male counterparts, and suffer from discriminatory land laws (Adamon and Adeleke 2016).

The gender gap has implications for economic growth, food security, poverty, unemployment, crime rate, and malnutrition that are critical to achieving the SDG on ending poverty in all its forms; SDG 2 of ending all forms of hunger and malnutrition; and SDG 5 which targets gender equality by 2030, particularly in countries where a significant share of the population depends on the agricultural sector. However, our findings contradict the results from a study in South East Asia where women were more empowered than men to make informed decisions on agricultural productive resources (Akter et al. 2017). Several factors may have contributed to the observed inequality in access to agricultural productive resources. First, although women generally are workers and

entrepreneurs, women who are involved in agriculture as their main source of livelihood do not have adequate resources and opportunities and are unfairly constrained to make the most productive use of their time compared to men (Ankrah et al. 2020; Larson et al. 2019). Second, the contribution of women to the agricultural sector is often unrecognized; they are perceived to be unqualified to venture into agricultural production, and usually unpaid, they have limited rights to acquisition and ownership of land; and insufficient access to critical services, information, and technologies (Justice et al. 2022). Moreover, the traditional division of labor and sociocultural and political factors often relegates women to manual, time-consuming operations with high degrees of labor (Justice et al. 2022). Ensuring equality in access to agricultural productive resources evenly between men and women in agriculture may unravel the productivity potential of women in as much as many gender productivity studies have stressed that female managers might be as efficient as males when they had equal access to agricultural productive resources (Kilic et al. 2013). Access to agricultural productive resources was lower in rural coastal communities compared to the non-coastal communities and this could be explained by two major contextual factors. First, is the inherent preference of women who live in coastal communities to naturally prefer economic activities that are tailored toward fish marketing than food-based agricultural production. Second, the climatic and non-climatic factors that hinder the effective and more efficient use of agricultural land in coastal communities may contribute significantly to the differential access to productive resources and the sustainability of agriculture in coastal rural communities. Some studies have shown that coastal farming is more susceptible to climate change and other non-climatic factors (temperature, rainfall, sea-level change, tropical cyclones, salinity, coastal floods, gender issues, and migration) compared to inland farming (Awal 2014; Pachauri et al. 2014). Since these challenges are naturally occurring events in coastal communities, it is difficult and complex to propose a single strategy to mitigate their impact. We propose more adaptive methods including seasonal forecasts and modern technologies such as climate-smart agriculture to cope with climate shocks and minimize greenhouse gas emissions while sustaining crop yield in coastal areas. This climate-smart agriculture includes altering cropping patterns and planting dates, cultivating stress-tolerant crop varieties, cultivating vegetables in floating beds, composting manure and crop residues, urea deep placement, water harvesting, and use, efficient harvesting and reducing post-harvest loss, diversifying the production system, crop rotation, minimum tillage and efficient water management (Hasan et al. 2018). Most studies have established a significant positive correlation between women's empowerment and access to agricultural resources (Ampaire et al. 2020; Ankrah et al. 2020; Ogato et al. 2009; Quisumbing et al. 2021). The current study confirmed these findings, as women's empowerment correlated with access to agricultural productive resources. This highlights the need to intensify education on alternative sources of income for women living along the coastal belt of the country with the emphasis on a more sustainable, efficient, and effective agricultural production. This is specifically so when our mediation analysis showed that household socioeconomic status mediates the relationship between place of residence and household food security.

Policy implication

Governments, donors, and development agencies have shifted their attention to developing more robust gender-sensitive interventions aimed at closing the gender gap in agriculture to increase agricultural productivity, reduce poverty and hunger and promote socio-economic growth (FAO 2013). We, therefore emphasize that more needs to be done to achieve the SDG on ending poverty in all its forms; SDG 2 of ending all forms of hunger and malnutrition; and SDG 5, which targets gender equality by 2030. For the past three decades, the Government of Ghana has invested in various social interventions aimed at reducing issues related to gender inequality. This includes setting up the Ministry of Gender and Social Protection with the primary responsibility of policy formulation, coordination and monitoring, and evaluation of gender, children, and social protection issues within the context of the national development agenda. The overarching goal was to achieve gender equality, equity, and the empowerment of women and girls, promoting the survival and development of children, and thus ensuring their rights. However, a merger between legislation and implementation is lacking, which requires strengthening the connection between gender and rural development, but these policies are usually relegated to separate chapters on women rather than treated as an integral part of policy and programming (FAO 2013). Accordingly, the Gender and Agricultural Development Strategy (GADS) has identified, among many other constraints, the inadequate integration of gender into agricultural policies and programs, and accessibility to productive resources, especially land and agricultural inputs, such as fertilizer and credit as largely gender insensitive. There is the need to adopt climate-smart agriculture and enhance the participation of rural women in agriculture-related policy-planning processes and promote policy dialogue among various stakeholders with adequate participation of women.

Limitation

Although standard statistical methods have been applied in addressing the study objectives, the results of this study should be interpreted with caution. This was a cross-sectional study and causality may not be directly inferred.

Conclusion

The study estimated the level of gender-location based inequality and explored the complex interrelationships between gender, women empowerment, geographic location, and women's access to agricultural productive resources in rural coastal and non-coastal communities in the Central region of Ghana. We highlight the need for government to implement gender-sensitive policies, programs, and interventions with the involvement of key stakeholders aimed at increasing accessibility to agricultural productive resources and mitigating the effect of inherent gender bias based on the complex sociocultural context and taking cognizance of the effect of geographic-specific barriers (coastal and non-coastal effect). There should be strong political will and social dialogue to focus all stakeholders on encouraging growth in rural agriculture in the coastal and non-coastal rural communities to improve food security. This could be achieved through the implementation of poverty alleviation schemes by Government and all relevant stakeholders with special focus on rural communities.

Acknowledgments
This study was made possible by the willingness of study participants (males and females) and the support of opinion leaders in the coastal and non-coastal rural communities in the Central region of Ghana. We acknowledge the valuable contributions of Prof. Grace Marquis and Dr. Nii Addy of McGill University, Canada for reviewing the draft manuscript. We are grateful to Ms. Anita E. Asamoah for providing guidance and overseeing the field data collection.

Author contributions
DD conceptualized and designed the study, conducted the analysis and interpretation of data, and provided the initial draft of the manuscript. KA, AG conducted analysis and interpretation of data. AT and KA, AG, and HOT trained field interviewers and provided support for data collection. DD, AG, RA, HOT, and AT provided critical revision for important intellectual content. All authors approved the final version to be published.

Funding
This work was supported by the Canadian Queen Elizabeth II Diamond Jubilee Scholarships (QES) is managed through a unique partnership of Universities Canada, the Rideau Hall Foundation (RHF), and Community Foundations of Canada (CFC), and Canadian universities. The QES-AS is made possible with financial support from IDRC and SSHRC.

Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declaration

Competing interests
The authors declare that they have no competing interests.

Received: 21 November 2022 Revised: 29 June 2023 Accepted: 14 July 2023
Published online: 20 July 2023

References

Adamon M, Adeleke S (2016) Gender equality in agriculture: what are really the benefits for sub-Saharan Africa? Retrieved from Chief Economist Complex: https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/AEB_Vol_7_Issue_3_Gender_equality_in_agriculture.pdf
Afzal A, Ali T, Ahmad M, Zafar MI, Niazi SK, Riaz F (2009) Identification of factors hampering women empowerment in agricultural decision making and extension work in district Okara, Punjab, Pakistan. Pak J Agric Sci 46(1):64–68
Agarwal B (2018) Gender equality, food security and the sustainable development goals. Curr Opin Environ Sustain 34:26–32
Ahmed A, Lawson ET, Mensah A, Gordon C, Padgham J (2016) Adaptation to climate change or non-climatic stressors in semi-arid regions? Evidence of gender differentiation in three agrarian districts of Ghana. Environ Dev 20:45–58
Akter S, Rutsaert P, Luis J, Htwe NM, San SS, Raharjo B, Pustika A (2017) Women's empowerment and gender equity in agriculture: a different perspective from Southeast Asia. Food Policy 69:270–279
Alkire S, Meinzen-Dick R, Peterman A, Quisumbing A, Seymour G, Vaz A (2013) The women's empowerment in agriculture index. World Dev 52:71–91
Ampaire EL, Acosta M, Huyer S, Kigonya R, Muchunguzi P, Muna R, Jassogne L (2020) Gender in climate change, agriculture, and natural resource policies: insights from East Africa. Clim Change 158(1):43–60
Anderson CL, Reynolds TW, Biscaye P, Patwardhan V, Schmidt C (2021) Economic benefits of empowering women in agriculture: assumptions and evidence. J Dev Stud 57(2):193–208
Ankrah DA, Freeman CY, Afful A (2020) Gendered access to productive resources–evidence from small holder farmers in Awutu Senya West District of Ghana. Sci Afr 10:e00604
Asitik AJ, Abu BM (2020) Women empowerment in agriculture and food security in Savannah Accelerated Development Authority zone of Ghana. Afr J Econ Manag Stud 11:253–270
Awal MA (2014) Water logging in southwestern coastal region of Bangladesh: local adaptation and policy options. Sci Postprint 1(1):e00038
Barros AJ, Hirakata VN (2003) Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. BMC Med Res Methodol 3(1):1–13
Coates J, Swindale A, Bilinsky P (2007) Household Food Insecurity Access Scale (HFIAS) for measurement of food access: indicator guide: version 3
deCampos AP, Covarrubias KA, Patron AP (2016) How does the choice of the gender indicator affect the analysis of gender differences in agricultural productivity? Evidence from Uganda. World Dev 77:17–33
Doss C, Summerfield G, Tsikata D (2014). Land, gender, and food security. In: vol 20. Taylor & Francis, pp 1–23
FAO (2013) The state of food and agriculture. https://www.fao.org/3/i2050e/i2050e.pdf
FAO (2017) Rural women: striving for gender-transformative impacts [SN Forum Team in collaboration with Clare Bishop, Regina Laub and Ilaria Sisto (ESP)]. https://www.fao.org/3/i8222e/i8222e.pdf
GSS (2015) Ghana demographic and health survey 2014. https://dhsprogram.com/pubs/pdf/FR307/FR307.pdf
GSS (2018) Ghana living standards survey round 7 (GLSS 7): poverty trends in Ghana 2005–2017. In: Ghana Statistical Service Accra
Hasan MK, Desiere S, D'Haese M, Kumar L (2018) Impact of climate-smart agriculture adoption on the food security of coastal farmers in Bangladesh. Food Secur 10(4):1073–1088

Hossain M, Majumder A (2018) Impact of climate change on agricultural production and food security: a review on coastal regions of Bangladesh. Int J Agric Res Innov Technol (IJARIT) 8(2355-2020–1646):62–69
Islam MA, Warwick N, Koech R, Amin MN, de Bruyn LL (2020) The importance of farmers' perceptions of salinity and adaptation strategies for ensuring food security: evidence from the coastal rice growing areas of Bangladesh. Sci Total Environ 727:138674
Jenkins S (2021) INEQDEC0: stata module to calculate inequality indices with decomposition by subgroup
Justice S, Flores Rojas M, Basnyat M (2022) Empowering women farmers—a mechanization catalogue for practitioners. https://www.fao.org/publications/card/en/c/CB8681EN/
Kabeer N (2016) Gender equality, economic growth, and women's agency: the "endless variety" and "monotonous similarity" of patriarchal constraints. Fem Econ 22(1):295–321
Kilic T, Palacios L, Goldstein M (2013) Caught in a productivity trap: a distributional perspective on gender differences in Malawian agriculture. Policy Research Working Paper
Larson JB, Castellanos P, Jensen L (2019) Gender, household food security, and dietary diversity in western Honduras. Glob Food Secur 20:170–179
Lutomia CK, Obare GA, Kariuki IM, Muricho GS (2019) Determinants of gender differences in household food security perceptions in the Western and Eastern regions of Kenya. Cogent Food Agric 5(1):1694755
Nakai J (2018) Food and agriculture organization of the United Nations and the sustainable development goals. Sustain Dev 22:1–450
Nyantakyi-Frimpong H (2020) What lies beneath: climate change, land expropriation, and zaï agroecological innovations by smallholder farmers in Northern Ghana. Land Use Policy 92:1044
Ogato G, Boon E, Subramani J (2009) Improving access to productive resources and agricultural services through gender empowerment: a case study of three rural communities in Ambo District, Ethiopia. J Hum Ecol 27(2):85–100
Pachauri RK, Allen MR, Barros VR, Broome J, Cramer W, Christ R, Dasgupta P (2014) Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change: Ipcc
Quisumbing A, Heckert J, Faas S, Ramani G, Raghunathan K, Malapit H (2021) Women's empowerment and gender equality in agricultural value chains: evidence from four countries in Asia and Africa. Food Secur 13(5):1101–1124
Ragsdale K, Read-Wahidi MR, Wei T, Martey E, Goldsmith P (2018) Using the WEAI+ to explore gender equity and agricultural empowerment: baseline evidence among men and women smallholder farmers in Ghana's Northern Region. J Rural Stud 64:123–134
Singh J (2014) Role of women in agricultural sector. Indian J Polit Sci 411–420
WFP (2009) Emergency food security assessment handbook [Electronic] (2nd edn). https://documents.wfp.org/stellent/groups/public/documents/manual_guide_proced/wfp203246.pdf?_ga=2.170480288.1853431953.1684134862-1722683823.1684134861

Publisher's Note