



Research article

Unraveling the effect of gender dimensions and wood fuel usage on household food security: evidence from Ghana

Kwame Adjei-Mantey^{a,*}, Paul Adjei Kwakwa^b, Frank Adusah-Poku^{c,d}^a Department of Sustainable Energy and Resources, University of Environment and Sustainable Development, Ghana^b School of Arts and Social Sciences, University of Energy and Natural Resources, Sunyani, Ghana^c Department of Economics, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana^d Environment and Natural Resource Research Initiative (ENRRI-EfD Ghana), Accra, Ghana

ARTICLE INFO

Keywords:

Food security

Exogenous switching

Ghana

de jure FHHs

de facto FHHs

ABSTRACT

Food security discussions have heightened particularly with Sustainable Development Goal (SDG) 2 which focuses on hunger and malnutrition. This study investigates gender dimensions of food security and examines the role of wood fuel on households' food security in Ghana. Data from the most recent round of the Ghana Living Standards Survey (GLSS VII, 2016/2017) were used for this investigation. By employing the Exogenous Switching Treatment Effect Regression to analyze food security, it was found that significant heterogeneities exist among different gender groups. The largest differences exist between male headed households and de jure female headed households. Further, this study finds that among female headed households, there remain substantial differences in food security. Wood fuel usage, household size and residing in the northern part of the country were found to reduce food security among households while education and income increase household food security. These findings are important for enhanced policy targeting to address food insecurity.

1. Introduction

In order to reduce food insecurity, the Sustainable Development Goal (SDG) 2 has targeted among other things that by 2030, there should be a double rate of productivity from the agricultural sector as well as the incomes of women who are into small-scale farming. The reason behind this target is not far-fetched. Food security, to a large extent, is influenced by agricultural productivity. Higher productivity in the agricultural sector ensures there is enough food supply to meet the growing need (Pawlak and Kołodziejczak, 2020). Many farmers in developing countries operate on small scale and often earn low levels of income (Meemken and Bellemare, 2020) which may deprive them of other food needs. Since a large proportion of farmers in developing countries are made up of women, it can be deduced that many of these female farmers earn low incomes and may not be able to meet their food requirement. The extension of this development together with the fact that developing countries have their women denied some productive assets renders households headed by females the poorest of the poor group (Harris-Fry et al., 2020). This eventually would make them more food insecure (Mallick and Rafi, 2010; Kassie et al., 2014). Empirically, Mason et al. (2015), Kassie et al. (2014), and Tibesigwa and Visser (2016) have

shown that households headed by females in Africa are more food insecure compared to those headed by males. It is therefore not surprising that later studies have suggested that empowering women in their economic activities especially agricultural ventures would improve food security among female-headed households (Lutomia et al., 2019; Diiro et al., 2018; Owoo and Boakye-Yiadom, 2015).

There is another school of thought that because women mostly spend greater proportion of their income on food, the female headed households may have better food security status than male headed families (Lutomia et al., 2019). Therefore, recent scholars have indicated the need to also analyze the issue of food insecurity among female headed household along the lines of the two main types of female headed households; de jure female and de facto female headed households (Aryal et al., 2019; Kassie et al., 2014). The former occurs when the woman becomes the head of the household following divorce, death of the husband or separation from the husband while the latter occurs when the woman assumes headship position of the household following the absence of the husband owing to migration or living elsewhere (Klassen et al., 2011; Fuller and Lain, 2020). Women have been identified to be at greater risk from shocks and stress than men (Fuller and Lain 2020). However, de jure female household heads who are more of single income

* Corresponding author.

E-mail address: kadjei-mantey@uesd.edu.gh (K. Adjei-Mantey).

earners and thus financially constrained have a higher tendency to be vulnerable to food insecurity unlike the de facto female household heads who may be financially supported by their husbands who have travelled or migrated (Felker-Kantor and Wood, 2012). Owing to the above, studies such as Aryal et al. (2019) and Kassie et al. (2014) have paid special attention to the gender aspect when it comes to food security by focusing on the male headed households and the type of female headed households. The relatively scarcer empirical studies on the latter aspect (probably it is comparatively newer concept) gives room for more investigation to guide policy formulation.

Another emerging issue in the literature is the role of wood fuel¹ - the direct use of wood (firewood), charcoal and recovered wastes in wood (Kwarteng 2015; Arnold et al., 2003) - in attaining food security. It is argued that the abundance of/or the reliance on wood fuel would be helpful in dealing with the food security issues (Waswa et al., 2020; Mulhollem, 2018). Wood fuel is the commonest cooking source for many households in developing countries, particularly those in the sub-Saharan region of the African continent. It is estimated that globally, over 2 billion people rely on fuel wood for cooking purpose. More than 90% of Africa's population rely on fuel wood (either fire wood or charcoal) (Scheid et al., 2019).

Food and Agricultural Organization (FAO, 2017) has argued that with proper management, fuel wood which is met from 50% of all wood harvested globally has the potential to improve food security for over 2 billion people in the world who are dependent on it for cooking and boiling water. The reason is that the availability of wood fuel for households that rely on it for cooking and other things helps to keep agricultural residues which maintain soil fertility thereby improving food production. This may eventually improve the food security status of households. On the other hand, scarcity of wood fuels may cause households' dependence on agricultural and forest residue to increase. Heavy dependence on agricultural and forest residue may reduce food yield and consequently food security. This is because scarcity of wood fuels sometimes compels households to use agricultural and forest residues which could have been left on farms to decay and improve the fertility of the soil (Mendum and Njenga, 2018). In Ethiopia for instance, owing to scarcity of firewood, Duguma et al. (2014) found that the use of cow dung as a cooking fuel led to a loss of 14.95 kg of nitrogen per year on farm lands. Mekonnen et al. (2017) in an empirical study also reported that burning dung resulted in reduced soil fertility in Ethiopia. Further, when there is no constraint on wood fuels supply, Chikaire et al. (2011) found that, it reduces the time households would use to search for fuel. As a result, much time can be available for productive activities to improve households' food security and vice versa. The authors also established that the scarcity of food fuel compels household to spend on other fuels. This becomes a financial drain which can adversely affect households' food security. In many developing countries, collection of fuel wood has been the responsibility of women and children. From another angle, households that rely heavily on wood fuel may have their children's academics negatively impacted (Petrokofsky et al., 2021). The health of women and children who do the collection may also be impaired through the chain of gathering, transportation, processing and combustion (Parikh, 2011). The process of seeking health care may worsen their financial plight as well as their productivity time and eventual food security (Kussa, 2012; McNamara et al., 2012).

Also, Scheid et al. (2019) have highlighted that fuel wood usage in developing countries is unsustainable and deteriorates the environment which could hamper households' food security. Kebede et al. (2015) in an empirical analysis concluded that "... the process of prolonged use of firewood as source of energy with no replantation and conservation has exacerbated deforestation and deterioration of soil fertility status. Major declines were observed for organic matter which is the principal source of plant

nutrients and helps to sustain soil fertility by mineralization and nutrient retention. This decline in organic matter and other soil quality attributes also affects the status of soil basic nutrients." Despite these conflicting assertions and evidence, there has not been much empirical studies to ascertain the woodfuel-food security nexus among households (Mekonnen et al., 2017; Duguma et al., 2014; Chikaire et al., 2011).

From the above, this paper seeks to further unravel the effect of wood fuel usage and gender dimensions on food security among households. To achieve this, the study focuses on Ghanaian households. Focusing on Ghana presents a good case study for a number of compelling reasons. Between 44.1% and 51.5% of households in Ghana own or operate farm activities (Oxford Business Group, 2020). That notwithstanding, food security in the country has become a challenging issue in recent times. Food yield has been inadequate resulting in the importation of food (Forkuor et al., 2022). It is noted that commercial food import and food aid in Ghana constitute close to 5% of the country's food needs (Ayifli, 2017).

Comprehensive Food Security and Vulnerability Analysis (CFSVA) survey indicates that about 12% of Ghanaians are food insecure (Asare and Lagba, 2021). This figure shows an increase in the number from 5% reported by MoFA (2015). It however, confirms projections the World Food Programme (WFP) made (WFP, 2009). The country is also battling with underweight and overweight problems alongside vitamin and mineral deficiencies (WFP, 2009). Moreover, 40% of women and 60% of children under 5 in the country are anaemic. It is again argued that child malnutrition leads to about 6.4% loss of Ghana's GDP annually (WFP, 2009). Addressing the above would require sufficient knowledge established through research with regards to what drives households' food security in the country. Hence, empirical studies on food security in Ghana is gaining attention of researchers (Baba and Abdulai, 2021; Akraasi et al., 2020; Seidu et al., 2020; Adom, 2014; Aidoo et al., 2013; Kuwornu et al., 2013; Owusu et al., 2011). Although women are the major group in Ghana's agricultural sector (Kuchar 2020), there is limited knowledge on the dynamics of food security among de jure female household heads and de facto female household heads in Ghana. Previous studies on the country have therefore assumed same covariates for male headed households and female headed households in their analysis ignoring the de jure and de facto female household heads effects (Baba and Abdulai, 2021; Akraasi et al., 2020; Seidu et al., 2020; Aidoo et al., 2013; Adom, 2014; Owusu et al., 2011; Kuwornu et al., 2013).

In addition, the country's energy situation has not been very pleasant. At the national level, although electrification rate is over 80%, supply constraints have led to frequent power outages and load shedding (Kwakwa, 2021). Many households still rely on wood fuel for domestic activities. Karakara and Osabuohien (2020) have revealed about 80% of households in Ghana depend directly on wood fuels for domestic activities. While studies have examined households' energy choice and usage in the country (Kwakwa et al., 2013; Wiafe and Kwakwa, 2013; Mensah and Adu, 2015; Karakara and Osabuohien, 2020; Karakara and Dasmani, 2019) and the effect of energy choice on socio-economic variables (Kwakwa et al., 2021; Adjei-Mantey and Takeuchi, 2021; Weber et al., 2020), there is limited knowledge on the effect of households' wood fuel usage on food security in Ghana. Studies on food security in the country already mentioned have also been silent on the role of wood fuel usage in the promotion of food security. Consequently, this study analyses the role of wood fuels and the de jure female, de facto female headed households and male-headed households in food security in Ghana.

The paper is structured as follows: Section 2 is on review of related literature; section 3 presents methods and data analysis. In section 4, results are presented and discussed; and in section 5, the paper is summarized, conclusions are drawn and recommendations provided.

2. Literature review

Since the 1970s, food security issues have dominated international discourse. While the concept in the 70s was thought of as a matter of

¹ The terms 'fuel wood' and 'wood fuel' have been used interchangeably in this paper.

supply issue more than demand, arguments in 1980s placed much emphasis of demand side to ensure food security. Scholars over the past three decades have given equal weight to both demand and supply factors to ensure food security. The literature on the subject matter has documented numerous reasons why food security is crucial. It improves individuals' welfare by meeting their daily meals (Pérez-Escamilla, 2017). This also promotes healthy living conditions of individuals and higher learning outcomes (Faught et al., 2017). At the national level, once there are healthy citizens as well as better learning outcomes, higher level of economic growth and development is achieved (Manap and Ismail, 2019). There is also an association between food security and political stability (Maxwell, 2012).

The above and other importance of food security make it a matter of national and international concern. That notwithstanding, many remain food insecure in the world. In 2019, FAO estimated 2 billion people in the world experience some form of food insecurity. By 2020, the United Nations Food agencies had documented close to 9% of the people in the world go to bed at night without food. This number translates into 690 million people and it is expected to exceed 840 million by 2030. It is also reported that as at 2019, close to 60 million people more were undernourished compared to 2014². The picture is not the best for the African continent where about 257 million people (25% of population) are experiencing hunger and 237 million people of sub-Saharan African are classified as chronically undernourished more than in any other region.

The quest to improve living conditions in the world has therefore urged world leaders to come up with 17 Sustainable development goals (SDGs). SDGs Goal two (SDG 2) which is on food security seeks to end hunger by 2030. In this light, many discussions have been held and research done to understand helpful ways to realize this goal. The research on food security has increased in recent times especially since the proportion of the world population that is food poor remains significantly high. This scientific exercise has been done at the global level, national level and household level with varied foci. For instance, Kandala et al. (2011) assessed the prevalence of malnutrition among urban and rural households' children. Belachew et al. (2011) focused on adolescents, while Ijarotimi (2013) focused on malnutrition among children. Also, Black et al. (2013) examined under nutrition and overweight of mothers and children. Saaka et al. (2017) focused on nutritional status of pregnant women and Kisi et al. (2018) analyzed the food security situation of pensioners.

A number of studies including Karolina and Kołodziejczak (2020) and Darfour and Rosentrater (2016) have assessed the role of agriculture in food security. The work by Karolina and Kołodziejczak (2020), concluded among other things that food insecurity prevails in agrarian economies with limited or lack of capital and infrastructure. Agidew and Singh (2018) and Abegaz (2017) have assessed the determinants of food insecurity among rural farm households. While Abegaz (2017) found rain and crop shocks, off farm and region of households to influence food security, the former found factors including farmland, poverty, drought and climate change, and land degradation as the forces of food Insecurity. Alpízar et al. (2020) focused their studies on food (in)security on small holder farmers and found that socio-demographic factors such as education and age affect smallholder farmers' food insecurity. Studies like Muhammad and Sidiq (2019) assessed food insecurity determinants among urban and rural households. Tuholske et al. (2018) focused on the measurement and drivers of food security among urban households while Bashir et al. (2012) analyzed what makes rural households food secured. Findings from the above-mentioned and other studies show food (in) security is influenced by socio-economic factors including household education, assets, and dwelling characteristics. Other factors identified are natural shocks or disasters and human conflicts.

Aside investigating the influential factors of food in (security), others like Kisi et al. (2018), Saaka et al. (2017) and Alpízar et al. (2020) have

explored the coping mechanism for food insecurity. These studies revealed savings, working off-farm, selling assets or livestock change of diet and reduction of food intake are some strategies adopted by small holder farmers when faced with food shortages (Alpízar et al., 2020). Other coping strategies are resulting to a different pattern of consumption, eating inexpensive foods, selling household assets (Kisi et al., 2018), eating less, borrowing food, reducing food intake by adult and limiting food size at meal times (Saaka et al., 201).

Household level studies which appear dominant have indicated the need to pay attention to gender dimension (Mallick and Rafi, 2010; Kassie et al., 2014; Harris-Fry et al., 2015; Lutomia et al., 2019). Harris-Fry et al. (2015) in their analysis of determinants of food security status among rural women in Bangladesh reported that age, religion, ownership of asset, literacy, access to media and freedom to access the market reduce food insecurity while larger households increased the risk of food insecurity. Mallick and Rafi (2010) in another study on women in Bangladesh also found that age, education, amount of plain land cultivated and status of the household in the village reduces risk of been food insecure for women while dependency ratio increases their food insecurity. Lutomia et al. (2019) looked at the determinants of gender differences in household food security perception in Kenya. While education, assets and size of relatives reduced female perceptions of household food insecurity, age and dependency ratio were positively associated with female perceptions of household food insecurity.

Aryal et al. (2019) in a gender analysis of food security in Bhutan found de jure female household heads to be less food insecure than male and de facto female heads. Regression analysis pointed that higher education increases food security for de jure female household heads and de facto female household heads and household size increases (decreases) food security for de jure female heads (de facto female household heads). Asset was found to increase food security for both de jure and de facto female household heads. In all, it was found that the effects of education, wealth, and participation in nonfarm activities are higher and significant for de jure female households heads compared with de facto female household heads. Moreover, it was reported that food security gap would have been reduced by 6.6% if the de jure FHHs had possessed the same level of resources as MHHs.

Furthermore, while energy is touted to be crucial for reducing poverty and improving health status of people, empirical studies to assess the role of wood fuels in the food security status in developing households is scanty (Mekonnen et al., 2017; Duguma et al., 2014). The empirical analyses have shown varying outcomes. For instance, review of empirical works by Sola et al. (2016) among other things indicated that fuel wood dependent households that lack access to fuel wood were more food insecure. In Kenya, Waswa et al. (2020) found that the scarcity of wood fuel resulted in changes in cooking habits whereby households opted to cook composite meals as opposed to single meals. Households also reduced their cooking frequencies from the conventional three meals per day to two, or sometimes only one meal per day.

Studies by Mekonnen et al. (2017) found for Ethiopia that fuel wood collection increases food production. Barany et al. (2005) in an exploratory study in Malawi and Mozambique reported that households' food security was improved because of their reliance on fuel wood. Jimoh and Haruna (2007) also found for some communities in Nigeria that about 46% of sellers and customers of fuel wood achieved their food security by relying on fuel wood. In their analysis, Duguma et al. (2014) concluded that reducing fuel wood usage has a higher chance of improving household food security in Ethiopia.

3. Data and methodology

3.1. Data

We used data from the most recent round of the Ghana Living Standards Survey (GLSS VII, 2017). The GLSSs are the most comprehensive household level data collected by the Ghana Statistical Service (GSS) on

² <https://www.actionagainsthunger.org/world-hunger-facts-statistics>.

economic, social and demographic factors. The sampling frame consists of persons living in private households but excludes the population in institutions such as hospitals and schools. The Enumeration Areas (EAs) for the survey are stratified into the 10 regions.³ The GSS used a multi-level stratified random sampling approach. The first level has 1,000 EAs covering a sample of 15,000 households, which was nationally representative, out of which 14,009 responded to the survey.

3.2. Methodology

One theory underpinning this study is the theory of access by Ribot and Peluso (2003), which proposes to differentiate between the right to a resource and the ability to use the resource to one's benefit. Ribot and Peluso (2003) argue that in addition to ownership of rights to a resource, ability to make productive use of the resource is necessary to benefit from same. They argue further that structural and relational mechanisms including knowledge, authority, social relations and identity are crucial in maximizing benefits to be derived from a given resource. In this study we investigate the extent to which household food security is dependent on the gender of the household head as well as on fuel wood usage. The gender of the household head, and the different types that exist in the case of female headed households (FHHs), inherently contain specific identities and authority that can determine their access to food and the food security status of their households. Fuel wood is a resource relied upon by some households for cooking in many developing countries including Ghana. As argued in the literature, reliance on fuel wood as energy source for cooking has implications on household food security (Mendum and Njenga, 2018). Furthermore, we control for other factors that are crucial to the household head's ability to use resources at their disposal to benefit their households with respect to food security. Thus, we estimate the effect of the gender of the head of the household and fuel wood on likelihood of being food secure while controlling for other factors including education, income and location of residence. There is support from the literature (eg. Lutomia et al., 2019; Aryal et al., 2019; Broussard, 2019) on the potential effects of these factors on food security hence controlling for them in this study. Unlike previous studies that pooled data on both male headed households (MHHs) and female headed households (FHHs) together after which they estimated the coefficient for a gender dummy (pooled regression approach), we employ the exogenous switching treatment effect (ESTER) approach. One major limitation of the pooled regression approach is the implicit assumption of homogeneous slope coefficient. In other words, it assumes that both MHHs and FHHs experience the same effect of covariates with respect to food security. This assumption, however, cannot be held to be true without a prior test of homogeneous slope. To address this limitation, an alternative approach is the ESTER which has been noted to be superior due to the fact that it estimates how gender affects food security taking into account the other covariates that affects the household's likelihood of being food secure. This way, the assumption of homogeneous slope held under the pooled regression approach is relaxed. Thus, we first test the homogeneous slope hypothesis using the Chow test with results in Table 1. Following the finding of heterogeneous slope, we proceed to apply the ESTER approach.

Following Kassie et al. (2014) in the implementation of the ESTER approach, two separate equations for MHHs and FHHs are estimated as follows:

$$\begin{cases} y_m = x_m\alpha_m + \varepsilon_m & \text{if } g = 1 \\ y_f = x_f\alpha_f + \varepsilon_f & \text{if } g = 0 \end{cases} \quad (1)$$

³ Since 2019, new regions have been created and the total number of regions in Ghana now stands at 16. The regional analysis for this study is done on the basis of the 10 regions that existed at the time of the survey in 2016/2017.

Table 1. Conditional expectations, heterogeneity and treatment effects.

Household type	MHH	FHH	Treatment effects
Male-Headed	$a) E(y_m g = 1)$	$c) E(y_f g = 1)$	$T_m = (a - c)$
Female-Headed	$d) E(y_m g = 0)$	$b) E(y_f g = 0)$	$T_f = (d - b)$
Heterogeneity effect	$H_m = (a - d)$	$H_f = (c - b)$	

Notes: a) and b) are the observed food security status for each category; c) and d) are the counterfactual outcomes. H_m and H_f are the unobserved heterogeneity effects due to differences in food security by each category. T_m and T_f measures effect of gender on energy choices which are local average treatment effects (LATE).

Where m and f are subscripts for MHHs and FHHs, respectively and g represents the sex of the household head taking the value of 1 for MHHs and 0 otherwise while y represent food security. Food security is computed as a binary variable with 1 being a household that has food security and 0 otherwise. The GLSS VII has a section on food security where respondents were asked eight dichotomous choice questions on feeding experiences in the past 12 months preceding the survey.⁴ The eight questions asked by the GLSS follow a set of questions adopted by the FAO to measure food security. They are therefore deemed appropriate to capture the food security status of households in Ghana. x_m and x_f are vectors of independent variables, α_m and α_f are coefficients to be estimated ε_m and ε_f are random error terms with a mean of zero and have constant variance. We derive a value of food security for each household in the following way: we employed an additive index to aggregate the responses to the eight questions and then classified households into being food secure or otherwise on the basis of their additive index score. Households whose score as a ratio of the total number of questions asked was less than or equal to a mid-point value of 0.5 are deemed to be food secure while households whose score as a ratio of the total number of questions are above the mid-point value were deemed food insecure. This led to a household that answered “no” to at least four out of the eight questions categorized as food secure while households that responded “yes” to more than half of questions being categorized as facing food insecurity. This was done to reflect that if households suffered food insecurity in more than half of the indicative cases, they could be deemed to lean more towards food insecurity than otherwise. Given that “no” and “yes” responses are assigned values of 0 and 1 respectively, food security status is determined by the following:

$$Food\ secure = 1 \text{ if } \frac{\sum_{i=1}^8 Z_i}{8} \leq 0.5; \text{ otherwise } 0$$

This categorization based on the additive index considers households that enjoyed food security in half or more of the metrics to be food secure. Similarly, if the household suffered food insecurity in at least half of the metrics, the household is considered food insecure. This approach is used because no one measure of food security or one question relating to feeding experiences is more important or has a higher value in the determination of food security and therefore cannot be assigned more importance than the other measures. Since the food security status, y_m and y_f , take on binary values, Eq. (1) is estimated by probit regression and marginal effects evaluated at means reported.

We proceed to analyze for the treatment and heterogeneity effects of gender of the head of the household in the likelihood of being food secure. We do this by estimating the counterfactual food security status for FHHs and MHHs. This counterfactual shows what the food security status of MHHs would be had the returns (coefficients) to their covariates been identical to the returns to FHHs and vice versa. Thus, we are able to compare actuals with counterfactuals as far as food security status is

⁴ The 8 questions related to food security have been provided in Appendix A.

concerned. The food security status under the actual conditions are given by Eqs. (2) and (3) as follows:

$$E(y_m|g = 1) = x_m\alpha_m \tag{2}$$

$$E(y_f|g = 0) = x_f\alpha_f \tag{3}$$

Where E is the expectation operator.

The food security status under the counterfactual conditions are given by Eqs. (4) and (5) as follows:

$$E(y_f|g = 1) = x_m\alpha_f \tag{4}$$

$$E(y_m|g = 0) = x_f\alpha_m \tag{5}$$

These are shown in Table 1 where Eqs. (2) and (3) correspond to cells a and b respectively while (4) and (5) correspond to cells c and d respectively. Finally, we estimate the causal effect gender has on food security status by using gender as a treatment variable and combining it with conditional expectations. Table 2 summarizes the processes to obtain both the treatment and heterogeneity effects of the part gender plays in households' food security status.

A list of variables used is provided in Table 2.

4. Results and discussion

4.1. Descriptive statistics

Table 3 presents the descriptive statistics of the data. The results show that 55% of female-headed households are food secure as compared to 57% for male-headed households. The results in Table 4 show that the variation in food security status between MHHs and FHHs is statistically significant at 10% level of significance. MHHs are found to significantly spend more on average than FHHs. In terms of the use of firewood, the share of MHHs that use it is about 50% compared to the proportion of FHHs (43%). With the exception of household heads who have completed junior high/middle school, the results further show significant differences along the other categories of educational attainment of the heads of the households. For instance, the share of MHHs who have completed secondary education and higher are significantly higher compared to FHHs. MHHs have more education than FHHs, on average.

With regards to de jure FHHs and de facto FHHs, the results from Table 3 and Table 4 show several dissimilarities in their socioeconomic and demographic characteristics. For example, the results show that household expenditure and household size are higher and statistically significant for de facto FHHs compared with de jure FHHs. Also, de facto FHHs tend to significantly spend more on average than de jure FHHs. Generally, de facto FHHs, MHHs and FHHs are more food secure compared to de jure FHHs.

4.2. Chow test results

The Chow test is employed to check if the slope coefficients of the gender of the household head is the same across the two gender groups. The results are presented in Table 5. We test the null hypothesis of homogenous slope across the two gender groups against the alternative hypothesis of heterogeneous slope. From the findings, we reject the null hypothesis since the F-test statistic is greater than the F-critical value. We conclude that there exists heterogenous slope for the two gender groups and hence there is a basis to employ the Exogenous Switching Treatment Effect Regression (ESTER) to ascertain the gender dynamics of food security in Ghana.

Table 2. Variable definition.

Variable	Definition
Dependent Variable:	
Food security	1 if household is food secure; otherwise, 0
Independent Variables	
Ln expenditure (Continuous)	Log annual household consumption expenditure; used to proxy the wealth of the household
Education (reference: No education)	0 if a household head has no educational level
Primary	1 if a household head had up to primary education
Junior High/Middle School	1 if head of household had up to junior high or middle school education
Secondary	1 if a household head had up to secondary education
Tertiary	1 if head of household had up to tertiary education
Rural	1 if household is in a rural area; 0 otherwise.
Household size (continuous)	Number of persons in the household
Fuel wood	1 if household uses firewood as primary cooking fuel; 0 otherwise
Regional Variables	
Greater Accra (reference category)	0 if household is located in the Greater Accra region
Western	1 if household is in the Western region
Central	1 if household is in the Central region
Volta	1 if household is in the Volta region
Eastern	1 if household is in the Eastern region
Ashanti	1 if household is in the Ashanti region
Brong Ahafo	1 if household is in the Brong Ahafo region
Northern	1 if household is in the Northern region
Upper East	1 if household is in the Upper East region
Upper West	1 if household is in the Upper West region

Table 3. Characteristics of household types.

Variable Description	FHHs	MHHs	de jure FHHs	de facto FHHs
	Mean	Mean	Mean	Mean
Food security (1 = food secure; 0 otherwise)	0.546	0.565	0.519	0.613
Log of HH expenditure	8.816	8.960	8.751	8.982
No education	0.196	0.199	0.217	0.143
Primary education	0.336	0.297	0.318	0.383
Junior high/middle school	0.287	0.282	0.289	0.282
Secondary education	0.122	0.145	0.124	0.116
Tertiary education	0.059	0.077	0.052	0.077
Rural	0.514	0.596	0.513	0.515
Household size	3.398	4.564	3.190	3.931
Fuel wood	0.434	0.495	0.435	0.433
Greater Accra	0.106	0.097	0.111	0.093
Western	0.121	0.082	0.115	0.137
Central	0.087	0.099	0.090	0.078
Volta	0.120	0.087	0.112	0.141
Eastern	0.111	0.094	0.119	0.091
Ashanti	0.150	0.112	0.143	0.169
Brong Ahafo	0.100	0.092	0.092	0.118
Northern	0.045	0.126	0.047	0.040
Upper East	0.085	0.104	0.093	0.064
Upper West	0.075	0.108	0.077	0.069
Observations	4,366	9,643	3,141	1,225

Table 4. Difference in characteristics among household types.

Description of variables	Difference	Difference	Difference	Difference
	(FHHs & MHHs)	(de jure & MHHs)	(de facto & MHHs)	(de jure & de facto)
Food security (1 = food secure; 0 otherwise)	-0.020*	-0.046***	0.049**	-0.094***
Log of HH expenditure	-0.145***	-0.209***	0.022	-0.231***
No education	-0.003	0.017*	-0.056***	0.074***
Primary education	0.039***	0.021*	0.086***	-0.065***
Junior high/middle school	0.006	0.008	0.000	0.008
Secondary education	-0.023***	-0.021**	-0.029**	0.008
Tertiary education	-0.018***	-0.025***	-0.000	-0.025**
Rural	-0.082***	-0.083***	-0.081***	-0.002
Household size	-1.166***	-1.373***	-0.633***	-0.740***
Fuel wood	-0.060***	-0.060***	-0.061***	0.001
Greater Accra	0.009	0.015*	-0.004	0.018
Western	0.039***	0.033***	0.055***	-0.022*
Central	-0.012*	-0.009	-0.020*	0.012
Volta	0.033***	0.025***	0.054***	-0.029**
Eastern	0.016**	0.024***	-0.004	0.028**
Ashanti	0.038***	0.031***	0.057***	-0.020*
Brong Ahafo	0.008	0.001	0.027**	-0.026**
Northern	-0.081***	-0.079***	-0.086***	0.007
Upper East	-0.019***	-0.010	-0.040***	0.030**
Upper West	-0.033***	-0.031***	-0.039***	0.009

Source: Authors' estimation.

Note: MHHs, FHHs, and HH represent male-headed households, female-headed households, and household, respectively. ***, ** and * denotes 1%, 5%, 10% level of significance respectively.

4.3. ESTER results

This sub-section presents the results from an ESTER of a binary probit model to identify the factors explaining household food security in Ghana. The empirical results are presented for all four groups: MHHs, FHHs, de jure FHHs and de facto FHHs. In the four models in Table 6, the dependent variable is a binary variable for food security status with 1 if a household is food-secure and 0, if otherwise. The results reveal several factors explaining the status of food security of FHHs, MHHs, de jure FHHs and de facto FHHs. It can be observed in Table 6 that there are differences in the marginal effects of the covariates for MHHs and FHHs (comparing (1) and (2)) as well as for de-facto FHHs and de-jure FHHs (comparing (3) and (4)). In other words, covariates that predicts FHHs food security status do not necessarily predict MHHs food security status. Similarly, covariates that predict de-jure FHHs food security status do not necessarily predict de-facto FHHs food security status. This confirms our chow test results that there exist a heterogenous slope for MHHs and FHHs.

4.3.1. Effect of fuel wood

It was found that there is a negative and significant relationship between fuel wood use for cooking and food security status. Specifically, we

Table 5. Chow test result.

Regression Model	Null Hypothesis (H ₀)	F- test statistic	F-critical value	Decision	Conclusion
Food security	Homogenous slope	5.10	F (18, 13842) = 1.36	Reject H ₀	Heterogeneous slope exists

Source: Authors' estimation.

find that all four groups of households that use fuel wood for cooking are less likely to be food secure compared to those that use other cooking fuels. For all four groups, we find that MHHs, FHHs, de facto FHHs and de jure FHHs who use fuel wood are 13.2%, 12.8%, 12.5% and 13.9% respectively, less likely to be food secure. This outcome contradicts the notion that abundance of/or the reliance on wood fuel would be helpful in dealing with the food security issues in developing countries (Waswa et al., 2020; Mulhollem, 2018). The results found is an indication that the food security status of the about 50% of Ghanaians who rely on fuel wood for cooking is at risk. The use of fuel wood involves a lot of time in its collection and as such, prevents the individual from allocating sufficient time to income generating opportunities which is very significant in the household's food security status. Comparatively, most households who use modern cooking fuels tend to be the very educated ones (see: Karimu, 2015; Adusah-Poku and Takeuchi, 2019; Adjei-Mantey et al., 2021) who are knowledgeable on the health effects of using dirty cooking fuels and are likely to be engaged in jobs with a relatively stable income and as such, are more likely to be food secure.

4.3.2. Effects of control variables

Consumption expenditure is a significant predictor of the likelihood of a household being in the food secure group. We find that the marginal

Table 6. Marginal effects from probit regression. Dependent variable: Pr (Food secure).

VARIABLES	(1)	(2)	(3)	(4)
	MHHs	FHHs	de jure FHHs	de facto FHHs
Ln (expenditure)	0.155*** (0.009)	0.170*** (0.015)	0.150*** (0.017)	0.203*** (0.028)
Education (ref: none)				
Primary	0.049*** (0.016)	0.024 (0.024)	0.028 (0.028)	-0.025 (0.048)
Junior High/Middle	0.074*** (0.017)	0.055** (0.025)	0.062** (0.029)	0.005 (0.050)
Secondary	0.096*** (0.020)	0.136*** (0.031)	0.145*** (0.036)	0.093 (0.061)
Tertiary	0.254*** (0.024)	0.239*** (0.040)	0.217*** (0.050)	0.225*** (0.067)
Household size	-0.018*** (0.002)	-0.040*** (0.005)	-0.033*** (0.005)	-0.062*** (0.009)
Rural	-0.016 (0.015)	-0.005 (0.020)	-0.018 (0.025)	0.022 (0.037)
Fuel wood	-0.132*** (0.015)	-0.128*** (0.021)	-0.125*** (0.025)	-0.139*** (0.038)
Region (ref: GAR)				
Central	-0.349*** (0.026)	-0.288*** (0.035)	-0.301*** (0.040)	-0.269*** (0.067)
Western	-0.210*** (0.026)	-0.234*** (0.038)	-0.249*** (0.043)	-0.209*** (0.077)
Volta	-0.025 (0.026)	-0.030 (0.036)	-0.050 (0.043)	-0.010 (0.066)
Eastern	-0.081*** (0.026)	-0.069* (0.036)	-0.059 (0.041)	-0.115 (0.072)
Ashanti	0.063*** (0.024)	0.039 (0.033)	0.034 (0.038)	0.035 (0.063)
Brong Ahafo	0.064*** (0.024)	0.039 (0.036)	0.004 (0.043)	0.084 (0.065)
Northern	-0.354*** (0.026)	-0.346*** (0.046)	-0.352*** (0.052)	-0.342*** (0.097)
Upper East	-0.290*** (0.027)	-0.337*** (0.041)	-0.394*** (0.046)	-0.167* (0.087)
Upper West	-0.182*** (0.028)	-0.198*** (0.045)	-0.222*** (0.051)	-0.161* (0.089)
Observations	9,544	4,334	3,118	1,216

Standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

effect of consumption expenditure is positive and statistically significant across all the four models in Table 6. We find that a percentage increase in household expenditure increases the likelihood of a household being food secure by 15.5%, 17%, 15% and 20.3% for MHHs, FHHs, de jure FHHs and de facto FHHs, respectively. This is in line with our expectations as expenditure in this study is used as a proxy for wealth. As such, the more wealth a household accumulates, the higher the likelihood that this household is food secure; a finding which aligns with Broussard (2019) and Aryal et al. (2019).

The results also reveal that education positively contributes to a household been food secure. With the exception of de facto FHHs, our results indicate that the higher the educational level of the household head, the higher the likelihood that a household is food secure. For instance, the estimated marginal effects on primary, junior high/middle, secondary and tertiary levels of education increase the likelihood of food security by 4.9%, 7.4%, 9.6% and 25.4 %, respectively for MHHs. In fact, the marginal effect increases with each increasing level of education compared to no formal education for all groups with the exception of de facto FHHs. For de facto FHHs, education is a significant predictor for only those with tertiary educational level. With the exception of the secondary level of education, we find that all other education levels of MHHs have higher positive effects on the status of a households' food security compared with the other groups. The possible explanation is that, most FHHs, de jure FHHs and de facto FHHs are mostly involved in household activities like cooking, cleaning, taking care of children, etc. which limits their chances of adequately accessing productive resources to improve their food security status. These activities prevent them from participating in the labour market to make enough earnings to acquire these productive resources. Another explanation could be the cultural, social and religious perceptions hampering women from acquiring productive resources to improve their food security status. Our results confirm the findings of Lutomia et al. (2019), Mallick and Rafi (2010), Aryal et al. (2019) and Broussard (2019).

The location of the household head, in terms of rural or urban, does not play any significant role in the status of the households' food security. This is consistent for MHHs, FHHs, de facto FHHs and de jure FHHs. According to the World Food Programme in 2009, people that are susceptible to food insecurity are located in both the rural and urban areas (WFP, 2009) and as such, the location of a household's food security status does not significantly depend on the location.

Household size is found to be significantly and inversely related to food security status for all the four groups of households. The results suggest that the larger the household size, the lower the likelihood of a household being food-secure. Larger household size implies a higher household food expenditure which may represent a significant burden on the household budget. In Ghana and in particular in the GLSS VII dataset, household food expenditure takes about 50% of the total household expenditure. As such, larger family sizes push households into the food insecurity group compared to smaller family sizes. This result is in consonance with other results such as those found by Lutomia et al. (2019), Aidoo et al. (2013) and Tiwasing et al. (2018).

This study also controls for regional effects using the Greater Accra Region (GAR) as the reference region. Our results show that with the exception of households in the Ashanti and Brong Ahafo region, households in all the other regions are less likely to be food secure, especially for MHHs. Particularly for the three northern regions (Northern, Upper East and Upper West regions), it is not surprising that their marginal effects are very large. The World Food Programme in 2009 reported that about 59% of the people who are food insecure in Ghana are all located in the three northern regions (WFP, 2009). Also, among the 10 regions in Ghana, seasonal food deficits are the highest in the three northern regions.

5. Gender heterogeneity and treatment effects

The analysis we have done so far fail to consider the heterogenous effects (HE) and treatment effects (TE) of food security of the household

head's gender. The question is: if FHHs were to have similar characteristics as MHHs, would they be more or less food secure than their male counterparts? This question is repeated for de jure FHHs and de facto FHHs. To answer this question, we estimate the average probabilities of food security as well as the heterogeneity and treatment effects for MHHs, FHHs, de jure FHHs and de facto FHHs. Table 7 reports the average probabilities, TE and HE of food security for MHHs and FHHs. Tables 8, 9, and 10 also report the average probabilities, treatment and heterogeneity effects of food security for (MHHs vs. de jure FHHs) (MHHs vs. de facto FHHs), and (de facto FHHs and de jure FHHs).

It is observed that the average probability of food security is similar for MHHs and FHHs. The actual probability of food security is higher for MHHs (58.4%) than FHHs (55.2%), indicating a food security gap of 3.2%. This result suggests that on average MHHs are more food secure compared to their female counterparts confirming earlier results by Kassie et al. (2014). By similar reference, actual probability of food security is higher for de facto FHHs (64.2%) than de jure FHHs (51.8%), indicating a food security gap of 12.4%. This is in consonance with other studies such as Aryal et al. (2019) and Kassie et al. (2014). In general, the results on average probabilities indicate that de jure FHHs have the lowest probability of food security in Ghana. These average probabilities are then compared to counterfactual probabilities of food security to ascertain the treatment effects of gender on household food security. By having a comparable group, it is possible to ascertain the counterfactual probability for one group if their observed characteristics were similar to the observed characteristics of the compared group. This helps in the computation of the treatment and heterogeneity effects.

From Table 7, MHHs would have had a probability of food security of 50% if their observed characteristics were similar to FHHs. Similarly, FHHs probability of food security would increase from 55.2% to 58.4% if they had similar observed characteristics as their male counterparts. This result suggests that observed male characteristics improves food security status as compared to observed female characteristics. The results also imply that if FHHs are given the similar opportunities as their male counterparts, their average probability of food security would be much higher than currently been observed. From Table 8, our results show that MHHs probability of food security will reduce from 58.4% to 48.2% if they had similar observed characteristics as de jure FHHs. This result indicates that MHHs would be worse off having similar characteristics of de jure FHHs as compared to FHHs. This tends to support the findings from previous studies that de jure FHHs are more vulnerable than other gender groups due to the constant pressure to meet household and family needs which are associated with being a single or widowed household head (Nwaka et al., 2020; Aryal et al., 2019; Kassie et al., 2014). With regards to the relationship between MHHs and de facto FHHs, it is clear from Table 9 that the probability of food security for de facto FHHs decrease from 64.2% to 62.5% if they had similar characteristics as MHHs. Juxtaposing that with the results in Table 10 shows that the probability of food security for de facto FHHs also declines when they are confronted with similar characteristics as de jure FHHs. This reveals the severity of de jure FHHs vulnerability compared to de facto FHHs as they

Table 7. Average probability of being food secure, treatment and heterogeneity effects (MHHs vs. FHHs).

HH type	Food secure		
	MHHs	FHHs	TE
MHHs	0.584	0.500	0.084*** (0.006)
FHHs	0.598	0.552	0.046*** (0.009)
HE	-0.014 (0.009)	-0.052*** (0.007)	

Standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

Table 8. Average probability of being food secure, treatment and heterogeneity effects (MHHs vs. de jure FHHs).

HH type	Food secure		
	MHHs	de jure FHHs	TE
MHHs	0.584	0.482	0.102*** (0.006)
de jure FHHs	0.587	0.518	0.069*** (0.011)
HE	-0.003 (0.010)	-0.036*** (0.007)	

Standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

Table 9. Average probability of being food secure, treatment and heterogeneity effects (MHHs vs. de facto FHHs).

HH type	Food secure		
	MHHs	de facto FHHs	TE
MHHs	0.584	0.546	0.038*** (0.006)
de facto FHHs	0.625	0.642	-0.017 (0.017)
HE	-0.041** (0.016)	-0.096*** (0.010)	

Standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

Table 10. Average probability of being food secure, treatment and heterogeneity effects (de facto FHHs vs. de jure FHHs).

HH type	Food secure		
	de facto FHHs	de jure FHHs	TE
de facto FHHs	0.642	0.544	0.098*** (0.017)
de jure FHHs	0.599	0.518	0.081*** (0.011)
HE	0.043*** (0.012)	0.026 (0.016)	

Standard errors in parentheses.

***p < 0.01, **p < 0.05, *p < 0.1.

are now confronted with additional discrimination compared to de facto FHHs (Aryal et al., 2019).

6. Conclusion

The aim of this paper is to ascertain the factors that explain household food security by determining the effect of fuel wood and whether gender related differences exist in household food security status. Extracting data from the GLSS VII and employing the exogenous switching treatment regression method, our results show that there exist substantial differences between MHHs' and FHHs' food security status. This substantial differences between the two is confirmed even when we consider the counterfactual situation where FHHs are assumed to have similar observed characteristics as their male counterparts. Among MHHs and FHHs, our results also show that the use of fuel wood predicts household food security status in Ghana. In addition, household consumption expenditure, household size and education account for household food security in Ghana. Furthermore, the location of the household played no significant role in the food security status of the household. Our results also reveal that there exist larger substantial differences in MHHs' and de jure FHHs' food security status than in other groups (such as MHHs vs. FHHs, MHHs vs. de facto FHHs and de facto FHHs and de jure FHHs). Thus, the difference in the probability of food security between MHHs and de jure FHHs is largest among all other groups.

In light of these findings, it is recommended for government of Ghana to enhance existing social protection programs by focusing more on the most vulnerable households such as de jure households. In 2017, Ghana introduced a program called Planting for Food and Jobs (PFJ). One of the main aims of PFJ is to ensure food security. Access to land is one of the qualifications for PFJ program participation (Ansah et al., 2020). Since historical and traditional contexts in Ghana show that men tend to possess greater rights to land while women have either limited or no access to land, the PFJ may favor men compared to women. The government needs to take a second look at the participation criteria of the programme to give equal if not more opportunities to women, especially de jure female heads.

Our results show that the use of firewood as the main cooking fuel reduces the likelihood of households becoming food secure in Ghana. The government of Ghana over the past 2 decades has embarked on a number of programmes to encourage households to switch from firewood to Liquefied Petroleum Gas (LPG). Although food security was not part of the goals of these programmes, scaling up of these programmes stands to bring numerous benefits (including food security) beyond the initial aims of the programmes. It also calls for the need for the government to expedite efforts to increase accessibility to electricity in Ghana without neglecting to strategize to keep the prices of both electricity and cleaner cooking equipment affordable. This would offer cleaner and a more time-saving alternative to the use of fuel wood for cooking.

Food security goes beyond physical access to food but also economic access to food. The economic access to food has mostly been ignored with a lot of emphasis being placed on the physical access. This study recommends the need to refocus the discussions on food security on the economic needs of vulnerable groups with the purpose of meeting their food security goals. Education could play a role by enabling people to have access to income generating opportunities which would improve their food security status in the long run.

Declarations

Author contribution statement

Kwame Adjei-Mantey: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.

Paul Adjei Kwakwa; Frank Adusah-Poku: Analyzed and interpreted the data; Wrote the paper.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Data included in article/supp. material/referenced in article.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

APPENDIX

Questions relating to food security.

Number	During the last 12 months:
1	Was there a time when you or others in your household worried about not having enough food to eat because of a lack of money or other resources?
2	Still thinking about the last 12 MONTHS, was there a time when you or others in your household were unable to eat healthy and nutritious food because of a lack of money or other resources?
3	Was there a time when you or others in your household ate only a few kinds of foods because of a lack of money or other resources?
4	Was there a time when you or others in your household had to skip a meal because there was not enough money or other resources to get food?
5	Still thinking about the last 12 MONTHS, was there a time when you or others in your household ate less than you thought you should because of a lack of money or other resources?
6	Was there a time when your household ran out of food because of a lack of money or other resources?
7	Was there a time when you or others in your household were hungry but did not eat because there was not enough money or other resources for food?
8	Was there a time when you or others in your household went without eating for a whole day because of a lack of money or other resources?

Source: GLSS VII.

References

- Abegaz, K.H., 2017. Determinants of food security: evidence from Ethiopian Rural Household Survey (ERHS) using pooled cross-sectional study. *Agric. Food Secur.* 6 (1), 70.
- Adjei-Mantey, K., Takeuchi, K., 2021. The effect of in utero exposure to household air pollution on child health: evidence from Ghana. *Health Policy OPEN* 2, 100029.
- Adjei-Mantey, K., Takeuchi, K., Quartey, P., 2021. Impact of LPG promotion program in Ghana: the role of distance to refill. *Energy Pol.* 158, 112578.
- Adom, P.K., 2014. Determinants of food availability and access in Ghana: what can we learn beyond the regression results? *Stud. Agric. Econ.* 116 (3), 153–164.
- Adusah-Poku, F., Takeuchi, K., 2019. Household energy expenditure in Ghana: a double-hurdle model approach. *World Dev.* 117, 266–277.
- Agidew, A.M.A., Singh, K.N., 2018. Determinants of food insecurity in the rural farm households in South Wollo Zone of Ethiopia: the case of the Teleyayen sub-watershed. *Agric. Food Econ.* 6 (1), 10.
- Aidoo, R., Mensah, J.O., Tuffour, T., 2013. Determinants of household food security in the Sekyere-Afram plains district of Ghana. *Eur. Sci. J.* 9 (21).
- Akrasi, R.O., Eddico, P.N., Adarkwah, R., 2020. Income diversification strategies and household food security among rice farmers: pointers to note in the North Tongu District of Ghana. *J. Food Sec.* 8 (3), 77–88.
- Alpizar, F., Saborío-Rodríguez, M., Martínez-Rodríguez, M.R., Viguera, B., Vignola, R., Capitán, T., Harvey, C.A., 2020. Determinants of food insecurity among smallholder farmer households in Central America: recurrent versus extreme weather-driven events. *Reg. Environ. Change* 20 (1), 1–16.
- Ansah, I.G., Lambongang, M., Donkoh, S.A., 2020. Ghana's planting for food and jobs programme: a look at the role of capability in farmers' participation. *J. Hum. Dev. Capabilities* 21 (2), 161–182.
- Arnold, M., Köhlin, G., Persson, R., Shepherd, G., 2003. *Fuelwood Revisited: What Has Changed in the Last Decade?* Center for International Forestry Research. Occasional Paper No. 39. https://www.cifor.org/publications/pdf_files/OccPapers/OP-39.pdf.
- Aryal, J.P., Mottaleb, K.A., Rahut, D.B., 2019. Untangling gender differentiated food security gaps in Bhutan: an application of exogenous switching treatment regression. *Rev. Dev. Econ.* 23 (2), 782–802.
- Asare, K., Lagba, C., 2021. Ghana: 2020 food security, vulnerability analysis - 3.6m people lack food. They Don't Have 'Chow' At Right Time. <https://allafrica.com/stories/202112150550.html>.
- Ayifli, R.W.A., 2017. Food security challenges in Ghana. In: Presented at the 2nd International Conference on Food Security and Sustainability June 26-27, 2017 San Diego, USA. <https://www.longdom.org/conference-abstracts-files/2157-7110-C1-06-2-016.pdf>.
- Baba, A.R., Abdulai, A.M., 2021. Determinants of crop diversification and its effects on household food security in northern Ghana. *Arthaniti: J. Econ. Theor. Pract.* 20 (2), 227–245.
- Barany, M., Holding-Anyonge, C., Kayambazinthu, D., Siteo, A., 2005. Firewood, food and medicine: interactions between forests, vulnerability and rural responses to HIV/AIDS. In: Proceedings from the IFPRI Conference: HIV/AIDS and Food and Nutrition Security, pp. 14–16.
- Bashir, M.K., Schilizzi, S., Pandit, R., 2012. The Determinants of Rural Household Food Security: the Case of Landless Households of the Punjab. Working Paper, Pakistan, p. 1208.
- Belachew, T., Hadley, C., Lindstrom, D., Gebremariam, A., Lachat, C., Kolsteren, P., 2011. Food insecurity, school absenteeism and educational attainment of adolescents in Jimma Zone Southwest Ethiopia: a longitudinal study. *Nutr. J.* 10 (1), 29.
- Black, R.E., Victora, C.G., Walker, S.P., Bhutta, Z.A., Christian, P., De Onis, M., Maternal and Child Nutrition Study Group, 2013. Maternal and child undernutrition and overweight in low-income and middle-income countries. *Lancet* 382 (9890), 427–451.
- Broussard, N.H., 2019. What explains gender differences in food insecurity? *Food Pol.* 83, 180–194.
- Chikaire, J., Nwakwasi, R.N., Osuagwu, C.O., Oparaojiaku, J., 2011. Renewable energy resources for women empowerment in Nigeria. *Researcher* 3 (10), 348–357.
- Darfour, B., Rosentrater, K.A., 2016. Agriculture and food security in Ghana. In: 2016 ASABE Annual International Meeting. American Society of Agricultural and Biological Engineers, p. 1.
- Diirro, G.M., Seymour, G., Kassie, M., Muricho, G., Muriithi, B.W., 2018. Women's empowerment in agriculture and agricultural productivity: evidence from rural maize farmer households in western Kenya. *PLoS One* 13 (5), e0197995.
- Duguma, A., Minang, P., Freeman, O., Hager, H., 2014. System wide impacts of fuel usage patterns in the Ethiopian highlands: potentials for breaking the negative reinforcing feedback cycles. *Energy for Sust. Dev.* 20, 77–85.
- Faught, E.L., Williams, P.L., Willows, N.D., Asbridge, M., Veugelers, P.J., 2017. The association between food insecurity and academic achievement in Canadian school-aged children. *Publ. Health Nutr.* 20 (15), 2778–2785.
- Felker-Kantor, E., Wood, C.H., 2012. Female-headed households and food insecurity in Brazil. *Food Secur.* 4 (4), 607–617.
- Forkuor, G., Amponsah, W., Oteng-Darko, P., Osei, G., 2022. Safeguarding food security through large-scale adoption of agricultural production technologies: the case of greenhouse farming in Ghana. *Cleaner Eng. Technol.* 6, 100384.
- Fuller, R., Lain, J., 2020. Are female-headed households less resilient? Evidence from Oxfam's impact evaluations. *Clim. Dev.* 12 (5), 420–435.
- Harris-Fry, H., Azad, K., Kuddus, A., Shaha, S., Nahar, B., Hossen, M., Younes, L., Costello, A., Pottrell, E., 2015. Socio-economic determinants of household food security and women's dietary diversity in rural Bangladesh: a cross-sectional study. *J. Health Popul. Nutr.* 33, 2.
- Harris-Fry, H., Nur, H., Shankar, B., Zanello, G., Srinivasan, C., Kadiyala, S., 2020. The impact of gender equity in agriculture on nutritional status, diets, and household food security: a mixed-methods systematic review. *BMJ Global Health* 5 (3), e002173.
- Ijarotimi, O.S., 2013. Determinants of childhood malnutrition and consequences in developing countries. *Current Nut. Rep.* 2 (3), 129–133.
- Jimoh, S.O., Haruna, E.A., 2007. Contributions of Non-timber forest Products to Household Food Security and Income Around Onigambari forest reserve. Oyo State, Nigeria.
- Karakara, A.A., Dasmani, I., 2019. An econometric analysis of domestic fuel consumption in Ghana: implications for poverty reduction. *Cogent Soc. Sci.* 5 (1), 1697499.
- Karakara, A.A., Osabuohien, E.S., 2020. Clean versus dirty energy: empirical evidence from fuel adoption and usage by households in Ghana. *African J. Sci. Technol. Innov. Dev.* 1–11.
- Karimu, A., 2015. Cooking fuel preferences among Ghanaian households: an empirical analysis. *Energy for Sustainable Development* 27, 10–17.
- Karolina, P., Kolodziejczak, M., 2020. The role of agriculture in ensuring food security in developing countries: considerations in the context of the problem of sustainable food production. *Sustainability* 12 (13), 5488.
- Kandala, N.B., Madungu, T.P., Emina, J.B., Nzita, K.P., Cappuccio, F.P., 2011. Malnutrition among children under the age of five in the Democratic Republic of Congo (DRC): does geographic location matter? *BMC Publ. Health* 11 (1), 261.
- Kassie, M., Ndiritu, S.W., Stage, J., 2014. What determines gender inequality in household food security in Kenya? Application of exogenous switching treatment regression. *World Dev.* 56, 153–171.
- Kebede, A., Chimdi, A., Nair, A.S., 2015. Effect of firewood energy consumption of households on status of soil fertility in debris watershed, ambo district, oromia regional state, Ethiopia. *Sci. Technol. Arts Res. J.* 4 (1), 154–159.
- Kisi, M.A., Tamiru, D., Teshome, M.S., Tamiru, M., Feyissa, G.T., 2018. Household food insecurity and coping strategies among pensioners in Jimma Town, South West Ethiopia. *BMC Publ. Health* 18 (1), 1373.
- Klasen, S., Lechtenfeld, T., Povel, F., 2011. *What About the Women? Female Headship, Poverty and Vulnerability in Thailand and Vietnam*, OECD Discussion Papers, p. 76. <https://www.oecd.org/dev/pgd/46982877.pdf>.
- Kuchar, M., 2020. Ghanaian Women and Agriculture. The Organization for World Peace. <https://theowp.org/reports/ghanian-women-and-agriculture/>.

- Kussa, M.U., 2012. Farmer's Health and Agricultural Productivity in Rural Ethiopia. Master's thesis. Norwegian University of Life Sciences, Ås.
- Kuwornu, J.K.M., Demi, S.M., Amegashie, P.K., 2013. Analysis of food security status of farming households in the forest belt of the Central Region of Ghana. *Russ. J. Agric. Soc. Econ. Sci.* 13 (1).
- Kwakwa, P.A., 2021. The carbon dioxide emissions effect of income growth, electricity consumption and electricity power crisis. *Manag. Environ. Qual. Int. J.* 32 (3), 470–487.
- Kwakwa, P.A., Adusah-Poku, F., Adjei-Mantey, K., 2021. Towards sustainable environment: does electricity crisis matter for the effect of industrialisation and urbanisation on carbon dioxide emissions?. In: *Responsible Management in Emerging Markets*. Palgrave Macmillan, Cham, pp. 297–323.
- Kwakwa, P.A., Wiafe, E.D., Alhassan, H., 2013. Households' energy choice in Ghana. *J. Empir. Econ. I* (3), 96–103.
- Kwarteng, E., 2015. Fuelwood value chain analysis literature ReviewReport. The USAID/Ghana sustainable fisheries management project (SFMP). In: Graduate School of Oceanography, University of Rhode Island and SNV Netherlands Development Organization. GH2014_SCI010_SNV. Coastal Resources Center, Narragansett, RI, p. 36.
- Lutomia, C.K., Obare, G.A., Kariuki, I.M., Muricho, G.S., 2019. Determinants of gender differences in household food security perceptions in the Western and Eastern regions of Kenya. *Cogent Food & Agric.* 5 (1), 1694755.
- Mallick, D., Rafi, M., 2010. Are female-headed households more food insecure? Evidence from Bangladesh. *World Dev.* 38 (4), 593–605.
- Manap, N.M.A., Ismail, N.W., 2019. Food security and economic growth. *International Journal of Modern Trends in Social Sciences* 2 (8), 108–118.
- Mason, R., Ndlovu, P., Parkins, J.R., Luckert, M.K., 2015. Determinants of food security in Tanzania: gendered dimensions of household headship and control of resources. *Agric. Hum. Val.* 32 (3), 539–549.
- Maxwell, D., 2012. Food security and its implications for political stability: a humanitarian perspective. In: *FAO High Level Expert Forum on Addressing Food Insecurity in Protracted Crises*. FAO, Rome).
- McNamara, P.E., Ulimwengu, J.M., Leonard, K.L., 2012. In: *Do Health Investments Improve Agricultural Productivity? Lessons from Agricultural Household and Health Research*. Shenggen Fan and Rajul Pandya-Lorch, p. 113.
- Meemken, E.M., Bellemare, M.F., 2020. Smallholder farmers and contract farming in developing countries. *Proc. Natl. Acad. Sci. USA* 117 (1), 259–264.
- Mekonnen, D., Bryan, E., Alemn, T., Ringler, C., 2017. Food versus fuel: examining tradeoffs in the allocation of biomass energy sources to domestic and productive uses in Ethiopia. *Agric. Econ.* 48, 425–435.
- Mendum, R., Njenga, M., 2018. Integrating wood fuels into agriculture and food security agendas and research in sub-Saharan Africa. *Facets* 3, 1–11.
- Mensah, J.T., Adu, G., 2015. An empirical analysis of household energy choice in Ghana. *Renew. Sustain. Energy Rev.* 51, 1402–1411.
- MoFA, 2015. Ministry of Food and Agriculture: Northern Region Agricultural Development Unit, July 2015.
- Muhammad, N.A., Siddique, S.F.B.A., 2019. Research article determinants of food security among households in Nigeria. *Pakistan J. Nutr.* 18, 1042–1052.
- Mulhollem, J., 2018. Wood Fuels Key to Easing Food Insecurity Situation in Sub-saharan. Africa <https://news.psu.edu/story/507274/2018/02/26/research/wood-fuels-key-easing-food-insecurity-situation-sub-saharan-africa> Accessed 17th February, 2021.
- Nwaka, I.D., Uma, K.E., Ike, G.N., 2020. Determinants of household fuel choices among Nigerian family heads: are there gender-differentiated impacts? *Environ. Sci. Pollut. Control Ser.* 27 (34), 42656–42669.
- Owoo, N.S., Boakye-Yiadom, L., 2015. The gender dimension of the effects of land tenure security on agricultural productivity: some evidence from two districts in Kenya. *J. Int. Dev.* 27 (7), 917–928.
- Owusu, V., Abdulai, A., Abdul-Rahman, S., 2011. Non-farm work and food security among farm households in Northern Ghana. *Food Pol.* 36 (2), 108–118.
- Oxford Business Group, 2020. *The Report, Ghana*. <https://oxfordbusinessgroup.com/ghana-2020>.
- Pawlak, K., Kolodziejczak, M., 2020. The role of agriculture in ensuring food security in developing countries: considerations in the context of the problem of sustainable food production. *Sustainability* 12 (13), 5488.
- Parikh, J., 2011. Hardships and health impacts on women due to traditional cooking fuels: a case study of Himachal Pradesh, India. *Energy Pol.* 39 (12), 7587–7594.
- Pérez-Escamilla, R., 2017. Food security and the 2015–2030 sustainable development goals: from human to planetary health: perspectives and opinions. *Current Dev. Nut.* 1 (7), e000513.
- Petrokofsky, G., Harvey, W.J., Petrokofsky, L., Ochieng, C.A., 2021. The importance of time-saving as a factor in transitioning from woodfuel to modern cooking energy services: a systematic map. *Forests* 12 (9), 1149.
- Ribot, J.C., Peluso, N.L., 2003. A theory of access. *Rural Sociol.* 68 (2), 153–181.
- Saaka, M., Oladele, J., Larbi, A., Hoeschle-Zeledon, I., 2017. Household food insecurity, coping strategies, and nutritional status of pregnant women in rural areas of Northern Ghana. *Food Sci. Nutr.* 5 (6), 1154–1162.
- Scheid, A., Hafner, J.M., Hoffmann, H., Kächele, H., Uckert, G., Sieber, S., Rybak, C., 2019. Adapting to fuelwood scarcity: the farmers' perspective. *Front. Sustain. Food Syst.* 3, 28.
- Seidu, A.A., Ahinkorah, B.O., Agbablo, E., 2020. Food insecurity among in-school adolescents in Ghana: what are the determinants? *J. Hunger Environ. Nutr.* 1–13.
- Sola, P., Ochieng, C., Yila, J., Iiyama, M., 2016. Links between energy access and food security in sub Saharan Africa: an exploratory review. *Food Secur.* 8 (3), 635–642.
- Tibesigwa, B., Visser, M., 2016. Assessing gender inequality in food security among small-holder farm households in urban and rural South Africa. *World Dev.* 88, 33–49.
- Tiwasing, P., Dawson, P., Garrod, G., 2018. Food security of rice-farming households in Thailand: a logit analysis. *J. Develop. Area.* 52 (1), 85–98.
- Tuholske, C., Andam, K.S., Blekking, J., Evans, T., Caylor, K., 2018. Measures and Determinants of Urban Food Security: Evidence from Accra, Ghana, 50. *Intl Food Policy Res Inst.*
- Waswa, F., Mcharo, M., Mworio, M., 2020. Declining wood fuel and implications for household cooking and diets in tigania sub-county Kenya. *Scientific African*, e00417.
- Weber, E., Adu-Bonsaffoh, K., Vermeulen, R., Klipstein-Grobusch, K., Grobbee, D.E., Browne, J.L., Downward, G.S., 2020. Household fuel use and adverse pregnancy outcomes in a Ghanaian cohort study. *Reprod. Health* 17 (1), 1–8.
- WFP, 2009. *Comprehensive food security and vulnerability analysis, 2008-2009*. Executive Brief on Ghana 168. April 2009.
- Wiafe, E.D., Kwakwa, P.A., 2013. Fuel-wood usage assessment among rural households in Ghana. *Spanish J. Rural Dev.* 4 (1), 41–48.