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Poisson Count Model to Explain Gender Dynamics of Farmer Adoption of Climate Smart Agricultural Practice

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Abstract

Climate smart agricultural practices are important interventions for addressing effects of climate change in agricultural production. In this paper, a Poisson count regression model is employed to examine multiple factors that drive both men and women farmers' adoption of climate smart agricultural practices. Using a sample of 105 maize farmers, the econometric modelling revealed that men farmers' adoption of climate smart agricultural practices is affected by years of education and climate related shock. Also, men and women farmers' adoption of climate smart agricultural practices is influenced by farm size. Given that women farmers in developing countries are not permitted to own large farms, it is recommended that government considers land reforms that would enable women farmers have more access to large farms to improve their adoption of climate smart agricultural practices.

***Keywords**: Climate change, Gender, Adoption, Maize farmers*

***JEL Classification**: Q15, Q54*

İklim Akıllı Tarım Uygulamalarına Çiftçi Uyumunun Cinsiyet Dinamiklerinin Poisson Sayma Modeli İle Açıklaması

Özet

İklim akıllı tarım uygulamaları, iklim değişikliğinin tarımsal üretim üzerindeki etkilerini ele almak için önemli araçlardandır. Bu çalışmada, hem erkek hem de kadın çiftçilerin iklim akıllı tarım uygulamalarını benimsemesini sağlayan birçok faktörü incelemek için Poisson sayma regresyon modeli kullanılmıştır. 105 mısır çiftçisi örneğini kullanan ekonometrik modelleme, erkek çiftçilerin iklim akıllı tarım uygulamalarını benimsemelerinin eğitim düzeylerinden ve iklim kaynaklı şoktan etkilendiğini ortaya koymaktadır. Ayrıca, akıllı tarım uygulamalarını benimseyen kadın ve erkek çiftçiler çiftlik büyüklüğünden etkilenmektedir. Gelişmekte olan ülkelerdeki kadın çiftçilerin büyük çiftliklere sahip olmalarına izin verilmediği göz önüne alındığında, hükümetin kadın çiftçilerin iklim akıllı tarım uygulamalarını benimsemelerini geliştirmek için büyük çiftliklere daha fazla erişimlerini sağlayacak arazi reformlarını göz önünde bulundurmaları önerilmektedir.

***Anahtar Kelimeler**: İklim değişikliği, Cinsiyet, Benimseme, Mısır çiftçileri*

***JEL Sınıflandırması**: Q15, Q54*

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1. Introduction

Agriculture is one of the major sectors contributing to the economic development of Ghana. The sector contributes about 20% to gross domestic product, employs about 55% of the population and generates 30-40% of foreign exchange earnings (Fosu-Mensah et al., 2012). Despite the enormous contributions of the agricultural sector to Ghana's economic development, it is bedevilled with challenges such as inefficient market systems, low productivity and climate change. Climate change according to the Intergovernmental Panel on Climate Change (IPCC) is a change in state that can be identified by changes in the mean and (or) the variability of its properties and that which persists for an extended period, typically a decade or longer (IPCC, 2014). The effect of climate change on the agricultural sector is widely acknowledged (Lipper et al.. 2014). Studies have shown that climate change will create heat and water stress that will result in yield reductions, decreased livelihood stocks, reduced food accessibility and consumption (Vermeulen et al., 2010).

Given the importance of the agricultural sector and the impact of climate change on the sector (Adger et al., 2003; Deressa et al., 2009a), adaptation to climate change has become a major policy concern to farmers, policy makers and researchers. Over the years, farmers have adopted measures to deal with the effects of climate change including climate smart agricultural practices. Climate smart agricultural practices (CSA) are practices that sustainably increases productivity, resilience, reduce greenhouse gases and enhance achievement of national food security and development goals (Food and Agriculture Organisation [FAO] 2010; Wassie and Pauline, 2018). The CSA practices were introduced by the Food and Agriculture Organisation in 2010.

Since the introduction of CSA practices, several studies have explored farmers' adoption behaviour. For instance, Fosu-Mensah et al. (2012) examined farmers' perception and adaptation to climate change in Ghana and found that farmers believe climate change has negative effects on their production, and have accordingly adopted measures such as crop cultivation, changes in crop species and planting dates, to deal with its negative effect. Also, Deressa et al. (2009a) study on farmers' choice of adaptation to climate change in the Nile Basin of Ethiopia using choice experiment found that farmers adopted agronomic practices such as crop varieties, irrigation and change in planting dates to deal with the effects of climate change. The study further identified level of education, gender, age, access to extension service, credit and wealth of household head as key drivers of farmers' adaptation choice. Other studies on farmers' adaptation to climate change include Below et al. (2012), Bryan et al. (2009), Hassan and Nhemachena (2008), Mertz et al. (2009), Reidsma et al. (2010).

Quite distinct from the aforementioned studies are the research that have been conducted in the area of gender and climate change (Andersen et al., 2017; Bryan et al., 2018; Di Falco and Veronesi, 2013; Jost et al., 2016; Külcür et al., 2019; Perez et al., 2015). The fact that women are more vulnerable to climate change effect is well established in the literature (Alston, 2014; Arora-Jonsson, 2011). For instance, Ahmed et al. (2016) using qualitative assessment of climate change adaptation in semi-arid regions of Ghana revealed that alternative groups adopt different adaptation measures which are influenced by climate and non-climate stressors. The specific groups considered under the study were males and females. Codjoe et al. (2012) study on gender and occupational perspectives and adaptation to climate extremes in the Afram plains of Ghana revealed that males and females preferred different climate change adaptation strategies during floods and droughts.

Previous studies have examined some of these differences in perceptions and practices, howbeit with some confusion in the definition of gender. Some studies by gender make use of males and females (Ahmed et al. (2016; Codjoe et al. 2012), while others use men and women (Partey et al. 2009; Murage et al. 2015; Adzawla et al. 2019). There is therefore a confusion in the literature in the use of men and women to represent gender, *vis-à-vis males* and females. This paper follows previous studies that have accurately referred to men and women with reference to gender (Partey et al., 2009; Murage et al., 2015; Adzawla et al., 2019). Gender dynamics, therefore, imply differences in the men and women perceptions of climate change, and adoption of climate smart agricultural practices and its determinants. It suffices to note that males and females refer to sex, which is defined as the biological differences between males and females and not gender that is a social construct and relates to the continuum of complex psychosocial self-perceptions, attitudes, and expectations people have about members of both sexes (Tseng, 2008; Quisumbing, 2014). It is important to note that one cannot be referring to males and females when talking about gender because they are not the same as men and women.

In addition, many studies examining farmers adoption of climate smart agricultural practices in Ghana assume that adoption of the practices is binary and therefore model using probit or logit regression models (Akudugu et al., 2012). The drawback of these approaches is that they ignore simultaneous adoption behaviour of farmers (Mwungu et al., 2018). Failure to incorporate simultaneous adoption implies that the methods also ignore unobserved variation that might influence adoption of multiple technologies (Lin et al., 2005; Mwungu et al., 2018). This study addresses the limitations by using a Poisson count regression model to examine men and women farmers' adoption of climate smart agricultural practices. The Poisson model has the advantage of accounting for the number of climate smart agricultural practices adopted by farmers, which makes the study quite distinct. Specifically, this is the first empirical application of the Poisson model in examining gender dynamics of climate smart agricultural practices adoption in Ghana.

The empirical data for the analyses come from an inter household survey conducted in the Eastern region of Ghana among maize farmers. Maize is considered because it is a major food security crop, mostly consumed by all age groups in Ghana. The crop is cultivated by small-scale resource poor farmers under rain-fed conditions and therefore highly vulnerable to climate change effects. This study is therefore relevant in identifying the gender specific factors that would improve farmers' adoption of climate smart agricultural practices. The results show that men and women farmers are aware of most of the CSA practices. The adoption drivers of the CSA practices, however, vary cross the gender groups. For instance, the Poisson count regression estimation revealed that men farmers' adoption of CSA practices is influenced by years of education and previous experience with climate related shock such as erratic rainfall. However, the women farmers' adoption of CSA practices is mainly influenced by larger farm sizes and higher yields.

The rest of the paper is organised as follows. The next section discusses the literature review followed by the methods employed in the study including a description of the data used in the application. This is followed by a discussion of the results and finally, the paper concludes with policy recommendations.

2. Literature Review

The effects of climate change on agriculture and livelihoods is widely acknowledged in the climate change and development literature (Akudugu et al., 2012; Lipper et al., 2014; Schlenker and Lobell, 2010). For instance, Akudugu et al. (2012) study on implications of climate change on food security and rural livelihood: experiences from Northern Ghana revealed that floods and droughts have become a major issue in the area with consequential effect on food security and livelihoods. Besides the general effect of climate change, it has been established in the literature that women are more vulnerable to climate change effects (Beuchelt and Badstue, 2013). It has therefore become relevant for stakeholders-governments, researchers and farmers to identify the policy options that would help to address the negative consequences of climate change with the aim of promoting sustainable food production (Kamel et al., 2020). Particularly, with about 40-60% of women being engaged in agriculture in Africa and the need to increase their resilience to climate change because of its effect on food security (Doss, 2018, Doss et al., 2015).

To address the problem of climate change, the Food and Agriculture Organisation introduced the concept of CSA practices in 2010. The CSA practices include minimum or zero tillage, compositing that stores carbon in the soil, terracing, contouring and irrigation activities that create water efficiency (Karpouzoglou and Barron, 2014, Wang et al., 2016), weather smart practices that help farmers deal with climate related shocks such as floods, storms, surges and prolonged drought (Akudugu et al., 2012), and finally, knowledge based smart practices or indigenous knowledge systems-traditional knowledge and skills held by farmers outside the formal scientific domain embedded in culture and traditions (Nyong et al., 2007; Codjoe et al., 2014, Tume et al., 2019). The knowledge based smart practices integrate farmers' knowledge on how to implement the other related CSA practices in dealing with climate change effects. Glazebrook (2011) studied women and climate change from Northeast Ghana and found that women farmers have knowledge systems that could contribute to climate change adaptation efforts.

Since the introduction of the climate smart agricultural practices, several studies have examined farmer adoption and the factors that drive farmers' adoption of these practices. For instance, Akudugu et al. (2012) examined the determinants of climate smart agricultural practices among small-holder farmers in Ghana and found that financial availability, access to labour and demand for farm produce drive farmer adoption. Lipper et al. (2014) study on climate smart agriculture for food security revealed that climate change interrupts with food markets, posing population wide risks to food supply. Schlenker and Lobell (2010) study on the negative impacts of climate change on African agriculture showed that diversity in factors including land, credits, markets and technology tend to affect the severity of climate change effect on agriculture.

In another study on determinants of farmer adaptation of climate smart agricultural practices in Tanzania, Mwungu et al. (2018) found that access to credit, wealth, literacy and household food security are important in farmer adoption of these practices. Teklewold et al. (2013) study on adoption of multiple sustainable agricultural practices in rural Ethiopia found the following drivers of farmer adoption including household wealth, social capital and networks, availability of labour and household trust in government support. In a study on the factors affecting adoption of multiple climate smart agricultural practices, Aryal et al. (2018) found that farmer adoption is influenced by access to credit, climate risks, access to extension services in addition to farm related characteristics. Furthermore, Azumah et al. (2016) studied contract farming and the adoption of climate change coping and adaptation strategies in the Northern region of Ghana and found that contract farming enhances adaptation strategies to climate change. Zakaria et al. (2019) also examined factors influencing the adoption of climate smart agricultural technologies among rice farmers in Northern Ghana and found that adoption of CSA is affected by perceived decrease in rainfall, training, and farmers' experience. Other studies have also identified factors of climate smart agricultural practices adoption such as education/literacy (Deressa et al., 2009b), farm size (Acquah, 2011; Deressa et al., 2009a; Saguye, 2011), among others.

Apart from the broad studies on farmers adoption of CSA practices, other researchers have focused on gender differences in climate change perceptions. For instance, Partey et al. (2018) studied gender and climate change risk management with evidence from Ghana and found that men and women had similar perceptions about climate change with majority perceiving changes such as strong winds, higher temperatures, increased frequency of drought and increased rainfall variability. Murage et al. (2015) also examined gender specific perceptions and adoption of the climate smart push-pull technology in Eastern Africa. Using a sample of 900 farmers, the study found that women farmers perceived the climate smart push-pull technology as more effective compared to the men farmers. Therefore, the technology would be more useful to vulnerable women farmers than men farmers. In a related study in Ghana, Owusu et al. (2018) investigated gendered perception and vulnerability to climate change in urban slum communities. The study found that perceptions and knowledge of climate change are differentiated by gender. Similarly, Adzawla et al. (2019) studied gender perspectives of climate change adaptation in two districts in Ghana. Using a sample of 300 farmers, the study found that women farmers are severely impacted by climate change effects compared to men farmers. Also, both men and women farmers have different adaptation strategies to include changing planting dates, row planting and intercropping.

3. Methods

3.1. Study Area

The study was conducted in the Akwapim North district of the Eastern region of Ghana. The Akwapim North district lies between longitude 0^0 00^0 E and 0^0 20^0 E of the Greenwich Meridian and latitude 5^0 51^0 and 6^0 10^0 north of the equator (Ministry of Food and Agriculture [FAO], 2019). It shares boundaries to the northeast with Yilo Krobo, north with New Juabeng municipal, southeast with Akwapim South municipal and west with Suhum Kraboa Coltar district. It covers a land mass of about 480kmsq, representing 2.3% of the total land area in the Eastern region (Owusu et al., 2014). The inhabitants of the district are mainly farmers involved in the production of food and cash crops. Maize is one of the major crops cultivated in the district. Maize cultivation in the district is mainly rain-fed and subsistence-based. Given that maize is a food security crop, it is important to consider farmers adoption of climate smart agricultural (CSA) practices and identify policy options for government to improve adoption of CSA practices to reduce the negative consequences of climate change on maize production.

3.2. Survey Instrument

The purpose of the study was to compare climate change perception, awareness and adoption of climate smart agricultural practices on gender basis. The individual inter-household level data employed in the study were generated using household survey. The household survey was adapted from the Climate Change Agriculture and Food Security (CCAFS) survey (Mwungu et al., 2018). The survey instrument consisted of three sections. Section one contained information on the socio-economic characteristics of respondents (age, gender, average income, years of education, among others). The second section was composed of questions on farmers' perception of climate change and experience with climate related shocks

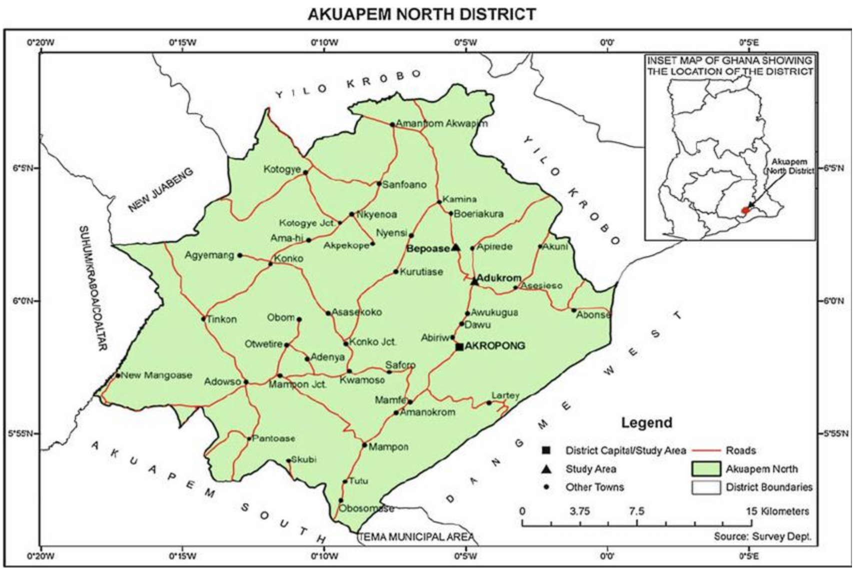

Figure 1. Map of Study Area.

Source: Owusu et al. (2014)

(droughts, erratic rainfall and floods). Here, climate change was defined as perceived changes in the average temperature and average rainfall over the last 10 years. The last section, section three comprised questions on farmers' awareness and adoption of climate smart agricultural practices.

3.3. Sampling and Survey Method

The respondents for the study were randomly selected from the Akwapim North district taking into consideration the gender dynamics (differences) of the study. Gender balance was achieved by interviewing men and women maize farmers who were heads of their households. A total of 105 respondents were interviewed comprising 51 men and 54 women.

3.4. Econometric Modelling

Econometric analyses were conducted to determine the best predictors of men and women farmers' adoption of climate smart agricultural practices. Generally, farmer adoption decision is modelled as a binary variable, which takes the value of 1 for adopters and 0, for non-adopters using probit or logit estimation techniques. However, adoption of farmers in developing countries often happen sequentially and to address this scenario, count regressions are proposed, where adoption equals 0,1,2…n, where *n*, represents the largest number of technologies adopted (Jara-Rojas et al., 2012). In this paper, a Poisson regression model, a member of the family of count regressions is used to examine farmer adoption of CSA practices.

Given that the utility a farmer derives from the adoption of CSA practices depends on W, a vector of farm specific factors, and K, a vector of fixed regional effects, the utility (U) to farmer i as a result of adopting a number of j climate smart agricultural practices can be represented as:

$$U_{ji} = \gamma_j(W_i, K_i) + \varepsilon_{ji} \quad j = 0,1,2 \dots, n \qquad (1)$$

where j is an integer that represents the number of climate smart practices adopted by the ith farmer, γ is a vector of conformable parameters to be estimated, and ε_{ji} is the error term. The ith farmer adopts ($j = 1$ or higher) when $U_{ji} > U_{0i}$. Given a dependent variable, Y_i the number of practices adopted by farmer i can be expressed as:

$$prob(Y_i = j) = \frac{e^{-\lambda_i}\lambda^{j_i}}{j!}, \text{ j=0,1,2…m; i=1,2…n} \qquad (2)$$

where j shows the number of practices adopted by farmer i, λ_i is both the conditional mean and the variance of the Poisson distribution, and m is the maximum number of climate smart agricultural practices adopted. The equality of the mean and the variance distinguishes the Poisson model from other count regression models. The expected number of practices adopted, and the variance are given as:

$$E|Y_i| = Var(Y_i) = \lambda_i = e^{\beta'(W,K)} \qquad (i = 1,2, \dots n) \qquad (3)$$

where $E|Y_i|$ is the expected value of the dependent variable for the ith farm, β is a vector of unknown parameters, n is the number of farms, W and K are as defined earlier. The Poisson regression model requires that the mean and variance are equal. If the variance is higher than the mean, we have a case of overdispersion. On the other hand, if the variance is lower than the mean, we have under dispersion. In both cases of overdispersion and under dispersion, the Poisson model becomes inappropriate, under which case a negative binomial regression model becomes appropriate (Kim et al., 2005). A diagnostic test conducted revealed that the Poisson model is suitable in this application because we neither had an issue of overdispersion or under dispersion.

4. Empirical Results and Discussion

4.1. Adoption Levels and Socio-economic Characteristics of Respondents

Table 1 presents the adoption levels and socio-economic variables of the respondents. From the table, about 28% of men farmers (14) had adopted between 4 or 5 CSA practices, 17.6% had adopted 7 practices, and 1.9% had adopted 9 practices. Only 4, representing 7.8% of the sampled men farmers had not adopted any of the CSA practices. Also, none of the sampled men adaptors had adopted less than one practice. Similarly, for the women farmers, about 22% had adopted 5 practices and there was no woman non-adopter in the sample. However, unlike the men, about 5 women, representing 9.3% had adopted only 1 practice (Table 1). The composition of the CSA practices adoption between the men and women farmers also justify the application of the Poisson regression model.

The results also show that the age of the respondents ranges from 23 to 89 years with a minimum of 44 years, indicating a youthful sample. In terms of years of education, the average years of education is 7 years, indicating a minimum of primary education. The average household size is 5 and the average farm size is 2 acres, showing that these farmers are producing on a small scale. The farm size is also slightly larger for the men farmers compared to the women farmers. The small farm sizes of the women farmers could be resulting from the gender inequalities in land ownership and access (Yaro, 2009). Culturally, in Ghana, women cannot inherit lands when there are men members in the family. Such a cultural barrier in land ownership affects women access to land for agricultural purposes. It is therefore not surprising that women have smaller farm sizes as recorded in this study. The men farmers are also more productive compared to the women farmers (Table 1). The productive nature of men farmers compared to the women farmers has also been reported in previous studies (Sneryers and Vandeplas, 2015). Men farmers are more productive probably because they are able to spend more time on farm work compared to women farmers that also engage in domestic activities, which limit their access to productive resources such as extension and advisory services and participation in income generating activities (Diiro et al., 2018; Wekwete, 2014).

Table 1. Adoption Levels of CSA Practices and Other Socio-economic Variables

	Men		Women	
Variables	Category	Freq.	Category	Freq.
Non adoption	0	4	0	-
CSA practices counts	1	-	1	5
"	2	4	2	5
"	3	4	3	7
"	4	14	4	6
"	5	14	5	11
"	6	3	6	2
"	7	9	7	4
"	8	5	8	1
"	9	1	9	-
"	10	3	10	1
"	11	2	11	-
Independent	Mean	SD	Mean	SD
Age	43.9	11.4	43.0	9.9
Years of education	8.3	6.2	6.0	5.1
Farm size	2.6	1.5	1.9	0.9
Household size	5.6	2.9	4.5	1.8
Average farm income	1187.1	1296.5	681.0	390.7
Labour cost	309.6	359.3	179.6	103.2
Flood shock	0.3	0.5	0.4	0.5
Drought shock	0.9	0.2	0.9	0.3
Erratic rainfall shock	0.7	0.4	0.8	0.4
Yield	180.7	99.4	129.5	53.0
N	51		54	

SD=Standard deviation; Freq=Frequency, N=Number of observations

4.2. Men and Women Farmers' Perception of Climate Change

In furtherance to examining differences in men and women attitudes towards climate change, their perceptions of climate change specific changes over the last ten years were sought and the responses are presented in Table 2 and Table 3. The results in Table 2 represent perceived temperature specific climate changes. The findings show that a greater percentage of women farmers observed more hot days (70.37%), as compared to the men farmers (54.90%). The results further show that greater percentage of men farmers (49.02%) observed more cold days than women farmers (29.63%). With exception of the significant difference in the perception of more cold days (Wilcoxon rank-sum test, p-value<0.04), the men and women farmers' perception of more hot days and more frequent heatwaves are similar because the difference between them is not significant. This finding is consistent with McKinley et al. (2016) study on gender differences in climate change perception and adaptation strategies that found that both men and women farmers observed similar changes in temperature. The gender difference in the perception of men and women farmers to temperature specific changes could be resulting from the biological makeup of the men and women (Vierck et al., 2008). By nature, women are more sensitive to cold weather compared to men, which could be affecting their perception of temperature changes. Partey et al., (2018) findings on similar perception of men and women farmers in Ghana confirms the outcome of this study.

Table 2. Perceived Temperature Specific Changes

	Men (% Yes)	Women (% Yes)	Percent point	Sig.
More hot days	54.90	70.37	-15.47	0.10
More cold days	49.02	29.63	19.39	0.04
More frequent heatwaves	36.00	51.85	-15.85	0.13

Note: Sig.=Significance.

Table 3 presents perceived rain-fall specific climate changes based on gender differences. The results show that both men and women farmers noticed a change in climate. On the average, majority of the women farmers (94%) affirmed that they have observed decreasing rainfall in the last ten years. This is followed by late onset of rains (74.07%). Similarly, majority of the men farmers observed decreasing rainfall (86.27%) and late onset of rains (94.44%). Nevertheless, there was no significant difference in their perceptions about specific changes in rainfall specific climate changes (Table 3). This finding is also consistent with McKinley et al. (2016) study that found both men and women farmers reporting differences in rainfall patterns, particularly, decreasing rains, but could not establish a significant difference in their perceptions. However, it is contrary to the findings of Partey et al. (2018) that found that men and women farmers observed an increasing rainfall pattern compared to the findings of this study of a decreasing rainfall. The difference in the perception of rainfall by respondents in Partey et al. (2018) study and this study is the fact that the present study was conducted in the Eastern region of Ghana, a forest zone with much rainfall, compared to their study that was

Table 3. Perceived Rainfall Related Changes

	Men (% Yes)	Women (% Yes)	Percent point	Sig.
Increasing rainfall	19.61	9.26	10.35	0.13
Decreasing rainfall	86.27	94.44	-8.17	0.15
More erratic rains	54.90	42.59	12.31	0.21
Early rains	25.49	16.67	8.82	0.27
Late rains	70.00	74.07	-4.07	0.64
Longer periods of drought	9.80	12.96	-3.16	0.61
More frequent flood	64.71	57.41	7.3	0.44
Less frequent flood	2.00	1.85	0.15	0.96

Note: Sig.=Significance.

conducted in the Upper West region of Ghana, a savannah zone. It may therefore suffice to suggest that prevailing climatic conditions of a study could affect the perception of the respondents and therefore the findings.

4.3. Men and Women farmers' awareness of climate smart agricultural practices

Table 4 presents the inter-household analysis regarding the awareness of climate smart agricultural practices. The outcomes of the survey show that men and women maize farmers were aware of climate smart agricultural practices. Specifically, both the men and women farmers were aware of the use of improved high yielding varieties as a climate smart agricultural practice compared to the other practices.

Table 4. Awareness of Climate Smart Agricultural Practices

	Men (% Yes)	Women (% Yes)	Percent point	Sig.
Agro forestry	76.47	59.26	17.21	0.06
Terraces, bunds	23.53	11.32	12.21	0.10
Use of stress tolerant varieties	88.24	85.19	3.05	0.65
Water harvesting	82.35	88.89	-6.54	0.34
Use of irrigation	84.31	64.81	19.5	0.02
No tillage/minimum tillage	27.45	7.41	20.04	0.00
Leaving crop residue	86.00	86.79	-0.79	0.90
Composting	42.00	20.37	21.63	0.01
More efficient use of fertilizer	86.27	70.37	15.9	0.04
Use of improved high yielding varieties	94.12	92.59	1.53	0.75
Cover cropping	68.63	35.85	32.78	0.00
The integrated pest management	39.22	7.41	31.81	0.00

Note: Sig.=Significance.

The men farmers were more aware of the use of improved high yielding varieties as a CSA practice (94.12%) compared to the women farmers (92.59%). However, the difference in the level of awareness of high yielding varieties as a CSA practice is not significant (Table 4).

Also, it can be deduced from the table that a significant difference exist among the men farmers and the women farmers concerning the awareness of CSA practices such as the use of irrigation (p-value < 0.02), no tillage or minimum tillage (Wilcoxon rank-sum test, p-value < 0.00), composting (p-value < 0.01), more efficient use of fertilizer (Wilcoxon rank-sum test, p-value < 0.04), cover cropping (p-value < 0.00) and integrated pest management (Wilcoxon rank-sum test, p-value < 0.00). The finding of difference in the perception of men and women farmers on the integrated pest management technique confirms the study finding of Murage et al. (2015) that found similar differences in the perception of men and women farmers.

4.4. Men and Women Farmers' Adoption of Climate Smart Agricultural Practices

Table 5 presents the CSA practices adopted by both men and women farmers. Generally, both men and women farmers adopted CSA practices to deal with the harsh weather conditions. There is a slight similarity between the men and women farmers concerning the adoption of improved high yielding varieties as a CSA practice, though there was no significant difference between men and women farmers (Table 5).

Table 5. Adoption of Climate Smart Agricultural Practices

	Men (% Yes)	Women (% Yes)	Percent point	Sig.
Agro forestry	37.25	27.78	9.47	0.30
Terraces, bunds	9.80	3.70	6.1	0.21
Use of stress tolerant varieties	70.59	59.26	11.33	0.23
Water harvesting	50.98	61.11	-10.13	0.30
Use of irrigation	39.22	42.59	-3.37	0.73
No tillage/minimum tillage	21.57	3.70	17.87	0.01
Leaving crop residue	78.43	62.96	15.47	0.08
Composting	21.57	7.41	14.16	0.04
More efficient use of fertilizer	78.43	57.41	21.02	0.02
Use of improved high yielding varieties	84.31	81.48	2.83	0.70
Cover cropping	35.29	14.81	20.48	0.01
Integrated pest management	27.45	5.56	21.89	0.00

Note: Sig.=Significance.

The probability values indicate that a substantial difference exist amongst the men and women on the adoption of CSA practices such as no tillage or minimum tillage, composting, more efficient use of fertilizer, cover cropping and integrated pest management. The use of improved high yielding varieties and use of stress tolerant varieties are consistent with Deressa et al. (2009a) study that also established that improved high yielding varieties and use of stress tolerant varieties are unique techniques for addressing the negative effects of climate change, especially among farmers in developing countries.

4.5. Determinants of the Adoption of Climate Smart Agricultural Practices

The Poisson count regression model estimates for the determinants of climate smart agricultural practices are presented in Table 6 with the corresponding marginal effects reported in Table 7. The model estimates are presented based on gender differences-that is whether the respondents are men or women. The results for the men respondents are presented in the second and third columns of Table 6, while those of the women respondents are presented in the fourth and fifth columns of Table 6. Prior to estimating the final model, in this case the Poisson model, a goodness of fit test was conducted in Stata 14. The estimated test results based on the Bayesian Information criteria (BIC) revealed that the Poisson model (253-men and 257-men) is appropriate for the sampled data compared to the Negative Binomial counterpart[2] (256-men and 261-men). Also, the Pearson goodness of fit test based on GOF Stata command revealed that the Poisson model (30.36, p>chisq 0.88-men and 35.26, p>chisq 0.82-women) is more suitable for our analysis compared to the Negative Binomial model.

From the estimated results (Table 6), three variables have significant impact on the adoption of CSA practices by men: years of education, farm size and erratic rainfall shock. The positive and significant coefficient on the years of education variable in predicting adoption of CSA practices imply that men adoption of CSA practices is directly related to the years of education, suggesting that men maize farmers with higher years of education adopt more CSA practices compared to men maize farmers that have lower years of education. It is likely that men farmers with higher years of education are involved in active search for information and might have the exposure about profitability and proceed to adopt the CSA practices (Conley and Udry, 2010; Krishnan and Patman, 2013). This finding that education affect men farmers' adoption of CSA practices is consistent with Deressa et al. (2009a) study that found education as important for farmers' adaptation to CSA practices. The implication of this finding is that government investment in extension activities for farmers would prove beneficial to increase farm productivity.

Table 6. Estimates of the Poisson Count Regression Model

Variables	Men		Women	
	Coef.	Robust SE	Coef.	Robust SE
Age	-0.010	0.006	0.007	0.007
Years of education	0.034***	0.007	0.008	0.015
Farm size	0.088**	0.039	0.347***	0.116
Household size	0.000	0.015	-0.066*	0.040
Average farm income	0.000	0.000	0.000	0.000
Labour cost	0.000	0.000	-0.001	0.001
Flood shock	0.095	0.110	-0.005	0.127
Drought shock	-0.227	0.151	-0.100	0.237
Erratic rainfall shock	0.340***	0.119	0.078	0.150
Yield	0.001	0.001	0.002*	0.001
Constant	1.274	0.239	0.741	0.464
LL	-106.86		-108.72	

Note: SE=standard errors, LL=Log likelihood

The results also show that men farmers with large farm sizes are likely to adopt more CSA practices compared to men farmers with smaller farm sizes, suggesting that resource availability is very vital for farmer adoption of CSA practices. Similarly, women farmers' adoption of CSA practices is positively and significantly affected by farm size, suggesting that women with larger farm sizes are more likely to adopt more CSA practices. This finding has implications for the culture

[2] Detailed results are available upon request from the author.

governing acquisition of lands in developing countries. In countries such as Ghana, women are not culturally allowed to own lands, which could affect their access to land and therefore adoption of CSA practices. Generally, the finding that farm sizes predict adoption of CSA practices confirm Saguye (2011) and Aryal et al. (2018) study outcomes that farm size is important in CSA adoption. They are, however, contrary to Uddin et al. (2014) and Acquah (2011) study outcomes that established a negative relationship between farm size and adaption to climate change effect. The influence of farm size on adoption of CSA practices imply that government should invest in land tenure systems and promote corporate farming systems to increase farm size in developing countries such as Ghana given that generally, farm sizes are small.

In addition, men farmers with experiences with erratic rainfall patterns have high probability of adopting more CSA practices. However, for the women farmers, erratic rainfall variable is not significant suggesting that the factor may not account for women adoption of CSA practices. For the women farmers, larger household sizes reduce the adoption of more CSA practices. Also, the likelihood of obtaining higher yields from the production process increases their adoption of more CSA practices. However, these variables are not significant in the men farmers' adoption model, implying that the factors may not necessarily affect their adoption of CSA practices.

Considering the marginal effects (Table 7), age is inversely related to men farmers' adoption of CSA practices. This implies that younger farmers are more likely to adopt more CSA practices compared to older men farmers. This finding confirms Deressa et al. (2009a) study outcome that age is relevant in farmers' adoption of CSA practices. The average marginal effects also show that a percentage increase in erratic rainfall experience improves men farmers' adoption of CSA practices by about 185%. Similarly, a percentage increase in farm size increases CSA practices by about 48%.

Table 7. Marginal Effects of the Poisson Count Regression Model

Variables	Men		Women	
	ME	Delta method SE	ME	Delta method SE
Age	-0.052*	0.031	0.031	0.028
Years of education	0.187***	0.039	0.034	0.063
Farm size	0.479**	0.201	1.437***	0.481
Household size	0.001	0.080	-0.273	0.167
Average farm income	0.000	0.000	-0.001	0.001
Labour cost	-0.001	0.001	-0.004	0.003
Flood shock	0.515	0.586	-0.022	0.526
Drought shock	-1.234	0.836	-0.416	0.983
Erratic rainfall shock	1.849***	0.646	0.324	0.619
Yield	0.004	0.003	0.009**	0.005

Note: ME=Marginal effects; SE=standard errors

In the case of the women farmers, a percentage increase in farm size increases CSA adoption by about trice the value of the men farmers, suggesting that women with larger farm sizes have greater probability of adopting more CSA practices compared to men farmers in the sample. The findings of this study corroborate previous study outcomes (Saguye, 2011, Deressa et al., 2009a, Aryal et al., 2018).

4. Conclusion

This study investigated the factors that determine the probability of farmers' adoption of climate smart agricultural practices with specific emphasis on the gender dynamics. Gender dynamics implies the differences in the perception of men and women farmers on climate change and adoption of climate smart agricultural practices. Generally, there could be a broad perception of climate change but that would not give a holistic picture of the differences in perceptions and adoption of the climate smart agricultural practices. Gender is very important in climate change studies because of the susceptibility of women to climate change impacts (Alston, 2013). It has been widely acknowledged that the effects of climate change and variability are not gender neutral but has far reaching effects. Studies have examined some of these differences in perceptions and practices, howbeit with some confusion in the definition of gender. Some studies by gender make use of males and females (Ahmed et al., 2016; Codjoe et al., 2012), while others use men and women (Partey et al., 2009; Murage et al., 2015; Adzawla et al., 2019). This study therefore refers to men and women, when referring to gender.

Gender in agriculture is very important because women contribute about 43% to the agricultural labour force in developing countries (Quisumbing, 2014). Women in developing countries' agriculture have limited access to productive resources and opportunities in terms of inputs, land, labour, technology, education, extension and financial services. In agricultural production, men are often involved in the production, while women are involved in harvesting, processing and marketing. In recent years, however, women have been involved in the production as well as performing their primary operations-harvesting, processing and marketing. In Ghana for instance, about 37% of women are involved in cultivating crops such as maize (Doss, 2002). Regarding climate change adaptation practices, Wrigley-Asante et al., (2017) found that many men farmers cultivate drought resistant crop varieties, adopt improved seed varieties, soil fertility conservation practices, soil and water conservation practices, while women farmers practice traditional and mixed cropping systems. Also men are interested in an on-farm adaptation strategies compared to women who are interested in off-farm adaptation strategies (Assan et al., 2018). In Ghana, Adzawla et al. (2019) found that about 78% of men-headed households have very high adaptation levels, compared to 51.1% women-headed households. Specifically, about 96% of men had adopted row planting as a climate change adaptation strategy as compared to 88% women. The climate smart agricultural practices are measures adopted to address climate change effects through adaptation.

This paper provides a good understanding of the barriers to adoption of climate smart agricultural practices in Ghana with the aim of providing guidelines in designing and formulating agricultural policies. It is important to provide a gender-responsive climate change adaptation strategies to encourage and support women in promoting food production in developing countries including Ghana. Using Poisson count regression model, the results revealed that men farmers' adoption of climate smart agricultural practices is driven by farm size, educational status, age and experience of climate shock. For the women farmers, adoption is driven by larger farm sizes and the likelihood of obtaining higher yields from the production. The results imply that the likelihood of men and women farmers to adopt climate smart agricultural practices is influenced by availability of cultivable land for large scale production.

The findings of the study have policy implications. Firstly, factors that have significant effect on climate smart agricultural practices adoption should be considered in the design of extension activities for farmers. For instance, the findings show that large farm sizes have positive effect on the adoption of climate smart agricultural practices. Therefore, Government should reconsider the cultural laws that ban women from having access to land for agricultural practices. Also, government should devise strategies such as corporate farming systems to increase farm sizes of farmers for agricultural production in Ghana. This suggestion is stemming from the fact that farm sizes in developing countries like Ghana are low, and on top of that, women are disadvantaged in having access to large farm sizes (Doss, 2002). In addition, Government should invest in extension services to ensure that farmers engaged in climate smart agricultural practices are well educated to understand the practices involved and undertake them effectively. Proper application of the climate smart agricultural practices would also increase the yield of farmers, which will in turn improve upon their adoption of the practices as is in the case of the women farmers.

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