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Smallholder farmers' participation in GASIP and its effect on adoption of climate-smart agriculture practices: Evidence from Ghana's Upper East Region

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Abstract

This study assessed the effect of participation in Ghana Agricultural Sector Investment Programme (GASIP) on the adoption of climate-smart agricultural practices (CSAP). The study collected data using multi-stage sampling for the 2023/2024 cropping season from 410 households in the Upper East Region, Ghana. A probit model was employed to identify the determinants of GASIP participation, and Endogenous Switching Poisson was applied to estimate CSAP adoption with correction for selection bias. Results show that age, education, gender, household size, crop diversification, and access to credit significantly influence CSAP adoption. GASIP participation significantly increased adoption rates, especially adopters of mixed cropping and crop residue retention, while ownership of radios and bicycles enhanced access to information and mobility. The study recommends strengthening agricultural extension services, improving gender-responsive credit schemes, promoting farmer-based organizations, and integrating CSAPs into national agricultural policy to enhance resilience, productivity, and food security. The study recommends to the Ministry of Food and Agriculture (MoFA) which implements government agricultural policies to intensify awareness to promote participation in future programmes, facilitate easy credit access to enable investment in climate-smart agricultural practices by smallholder farmers, and promote crop diversification to mitigate the negative effects of climate change on households in the Upper East Region.

Keywords: *Climate-Smart Agriculture, Smallholder Farmers, Adoption, GASIP, Endogenous Switching Regression, Food Security, Ghana.*

Introduction

In sub-Saharan Africa, smallholder farmers contribute substantially to national food production, rural employment, and economic development (Giller et al., 2021). However, increasing threats from climate variability, land degradation, and declining soil fertility exacerbate food insecurity and poverty in vulnerable farming communities (FAO, 2021; Asfaw et al., 2022). In response to these challenges, Climate-Smart Agriculture (CSA) seeks to sustainably increase agricultural productivity, enhance resilience to climate change, and reduce greenhouse gas emissions (Lipper et al., 2014; Aryal et al., 2021).

Ghana's 80% of agricultural production comes from smallholder farmers (Kamara et al., 2019). They are limited by restricted access to credit, markets, agricultural extension and other support services that lower productivity and increase vulnerability to food insecurity and poverty (Stewart et al., 2015; Teye et al., 2019).

Over several years, programmes like Planting for Food and Jobs (PFJ), Rural Enterprise Programme (REP), and Ghana Commercial Agriculture Project (GCAP) have sought to address production constraints through input supply, credit, and training (Asafo et al., 2016). However, the persistence of these constraints despite earlier interventions highlighted the need for a more integrated and sustainable agricultural support programme. The Ghana Agricultural Sector Investment Programme (GASIP) offered a more holistic and sustainable approach to these persistent challenges. Unlike previous interventions, GASIP delivered an integrated package of financial assistance, inputs, extension, CSAP promotion, market access, and value-chain infrastructure designed to build long-term resilience among smallholder farmers. GASIP placed Climate-Smart Agriculture at the centre, making the link between existing production constraints and the need for sustained climate adaptation much clearer.

The Government of Ghana, through GASIP with IFAD financing, targeted smallholder farmers by improving their access to infrastructure, markets, finance, and institutional services, and integrating the adoption of climate-smart agricultural practices as a core pillar (IFAD, 2020; MoFA, 2021). GASIP was therefore expected to enhance adoption of CSAPs such as crop rotation, agroforestry, mulching, integrated pest management, and improved seed varieties to improve adaptive capacity for smallholder farmers.

Emerging literature recognizes the broader implications of Climate-Smart Agriculture in enhancing productivity, resilience, and climate change adaptation (Akrofi-Atitianti et al., 2018; Anuga et al., 2019). Furthermore, studies (Kassie et al., 2020; Zeweld et al., 2021) have underscored that participation in formal agricultural schemes largely determines the adoption of CSAPs through provision of access to information, extension, input subsidies, and training.

Despite the important role of GASIP in promoting CSAPs, empirical evidence on whether participation in the programme increased CSAP adoption and improved food security among households has remains limited. This gap makes it difficult to assess GASIP effectiveness, particularly within Ghana’s climate mitigation commitments under its Nationally Determined Contributions.

The Upper East Region was chosen for this study because it is one of Ghana’s most climate-vulnerable zones, characterised by erratic rainfall, recurrent droughts and high dependence on rainfed agriculture. The Region also benefitted from the GASIP interventions.

Materials and Methods

Description of Study Area and Sampling Approach

The Upper East Region is situated between longitudes 0° and 1° West and latitudes 10°30' N and 11° N and accounts for 2.7% of Ghana's overall land area (Awuni et al., 2018). Figure 1 illustrates the administrative districts within the Upper East Region. Over 90% of farm holdings are less than 2 hectares (Nuhu *et al.,* 2022) with 80% of the population engaged in agriculture. The soil is primarily derived from granite rock, low in organic content, coarse in texture, and prone to erosion. The climate is characterized by a single rainy season from May/ June to September/ October.

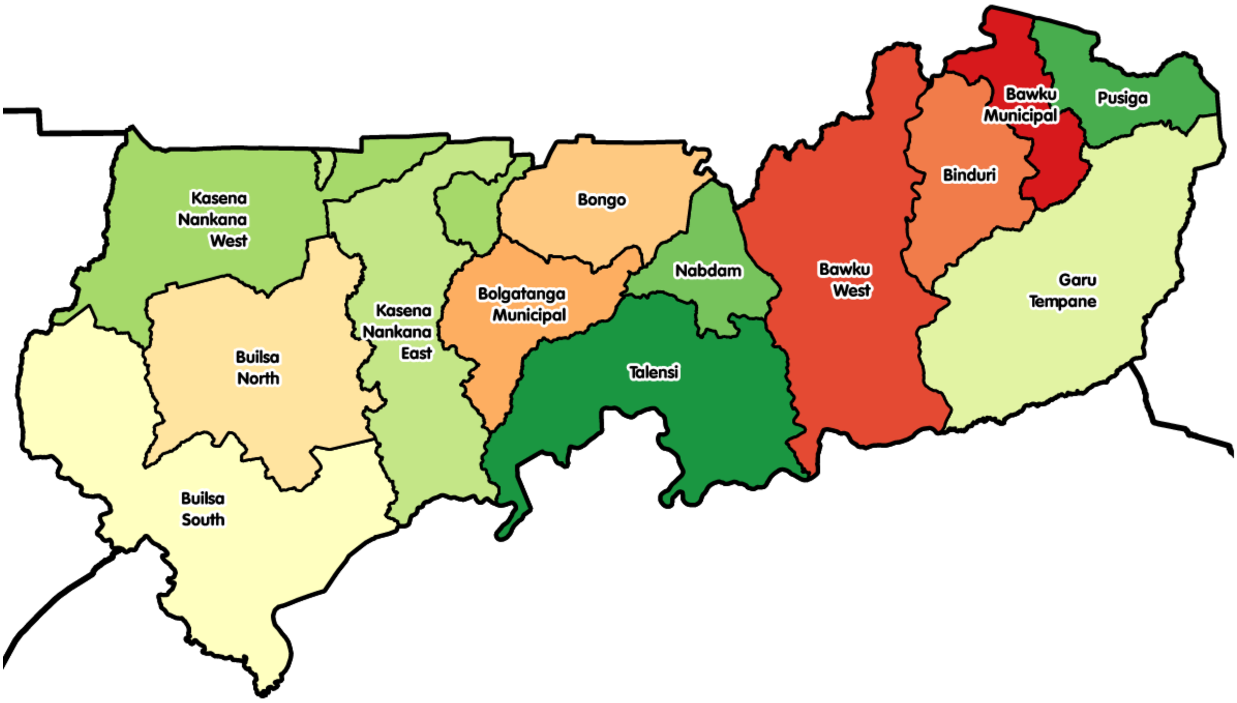

Figure.1 Administrative districts of the Upper East Region

The average yearly precipitation is between 800 and 1,100 mm (Ampadu et al., 2019). According to the 2021 Population and Housing Census, the Upper East Region's population stood at approximately 1,301,221, accounting for 4.22% of Ghana's total population (Ghana Statistical Service, 2022). The region also benefits from a notably youthful labor force: about 55.7% of the population is under 35 years, reflecting a dynamic and potentially productive demographic base (MoFA, 2024).

Primary data was gathered using a semi-structured questionnaire. The study used a multi-stage sampling approach purposive, stratified, and simple random sampling aligned with the framework of the Ghana Agricultural Sector Investment Programme in selecting project beneficiaries, as presented in Table 1. The Upper East Region and three districts (Bolgatanga Municipality, Bongo, and Builsa North) were purposively selected based on their involvement in GASIP interventions. Communities were stratified into beneficiary and non-beneficiary groups, respondents were randomly selected, resulting in a total sample of 400 with equal representation of participants and non-participants

Non-beneficiary communities that shared a boundary with a beneficiary community were excluded to minimize spill-over effect of the project on non-beneficiary communities. The final sampling was random selection of farmers from the communities, following Yamane (1976) formula with 5% margin of error as:

$$S = \frac{N}{1+N(\alpha)^2} \quad (1)$$

where N= farmer population (260188); S= sample size, α= margin of error (5%).

$$S = \frac{260188}{1+260188(0.5)^2} = 399.034 \approx 400 \quad (2)$$

Table 1: Sampling Procedure

	Beneficiaries		Control	
District	**Communities**	**Respondents**	**Communities**	**Respondents**
Bolgatanga	5	70	5	70
Bongo	5	65	5	65
Builsa North	5	65	5	65
Total	15	200	15	200

Poisson Regression with Endogenous Sample Selection

This study employs a **Poisson regression model with endogenous sample selection** to examine smallholder farmers' adoption of Climate-Smart Agricultural Practices (CSAPs) under the Ghana Agricultural Sector Investment Programme (GASIP). The approach is appropriate because CSAP adoption is observed as count **variable**, and farmers' participation in GASIP is **non-random**, potentially leading to selection bias.

The analysis is grounded in the Random Utility Theory (RUT)**,** which assumes that farmers make adoption decisions by comparing the expected utility from adopting CSAPs with non-adoption. A farmer adopts CSAPs if the perceived utility of adoption exceeds that of non-adoption. This utility depends on observable socio-economic, institutional, and farm-level characteristics, as well as unobservable factors such as risk preferences and managerial ability.

The latent utilities associated with adoption and non-adoption are specified as

$$\mathrm{U}_1 = \mathrm{Z}_i' \delta + \beta_i \mathrm{GASIP} + \varepsilon_i{}^{(1)} \quad (3)$$

$$\mathrm{U}_0 = \mathrm{Z}_i' \delta + \beta_i \mathrm{GASIP} + \varepsilon_i{}^{(0)} \quad (4)$$

where Z′ is the vector of explanatory variables, β is the coefficient for GASIP participation and $\varepsilon_i{}^{(1)}$ and $\varepsilon_i{}^{(0)}$ are the error terms for adoption and non-adoption respectively.

Since CSAPs are countable, a count data model is chosen (Terza, 1998; Miranda, 2004). Adoption of CSAPs follows the standard Poisson distribution, assuming an ith farmer from a random sample N = (1..............n) with a vector of independent variables Z_i, an endogenous dummy representing internal causes, and an error term, ε_i.

$$f\left(\frac{\mathrm{CSAPsi}}{\varepsilon_i}\right) = \frac{\exp\{-\exp(\mathrm{Z}_i'\delta + \beta_i\,\mathrm{GASIP} + \varepsilon_i)\}\{\exp(\mathrm{Z}_i'\delta + \beta_i\,\mathrm{GASIP} + \varepsilon_i)\}\mathrm{y}_i}{\mathrm{CSAPsi!}}$$

(5)

δ and β_i are parameters of socio-economic variables (z) and participation in GASIP respectively to be estimated. GASIP participation is influenced by a vector of explanatory variables k_i which may include any or all of the members of Z_i.

$$\mathrm{GASIP}_i = \begin{Bmatrix} 1 \text{ if } \mathrm{k}_i\alpha + \mathrm{g}_i > 0 \\ 0 \quad \text{if otherwise} \end{Bmatrix} \tag{6}$$

where, α represents the coefficients of the variables that influence participation and g_i is an error term, and it is assumed that ε_i and g_i have joint normal distributions, with mean zero and covariance matrix,

$$\Sigma = \begin{pmatrix} a^2\sigma\pi \\ \sigma\pi 1 \end{pmatrix} \tag{7}$$

The joint restrictive probability density expression of CSAPs_i and GASIP_i, given d_i can be illustrated as:

$$f\left(\mathrm{CSAPs}\ \frac{\mathrm{GASIP}_i}{d_i}\right) = \int_{-\infty}^{\infty} \begin{Bmatrix} \mathrm{GASIP}_i \mathrm{f}\left(\frac{\mathrm{CSAPs}_i}{\mathrm{GASIP}=1, d_i, \varepsilon}\right) \mathrm{prob}\left(\mathrm{GASIP}_i = \frac{1}{d_i, \varepsilon_i}\right) + (1 - \mathrm{GASIP}_i) \\ f\left(\mathrm{CSAPs} \frac{1}{\mathrm{GASIP}=0, d_i, \varepsilon_i}\right) \mathrm{prob}\left(\mathrm{GASIPi} = \frac{1}{d_i, \varepsilon_i}\right) \end{Bmatrix} \mathrm{f}(\varepsilon_i)\mathrm{GASIP}_i\varepsilon_i \tag{8}$$

This integral accounts for the fact that GASIP participation and CSAP adoption are jointly determined, and their unobserved components may be correlated.

The model was estimated in two steps, the first stage estimated the probability of participation in GASIP using probit:

$$\mathrm{GASIP}_i = \mathrm{k}_i\alpha + \mathrm{g}_i$$

$$\mathrm{GASIP}_i = \begin{Bmatrix} 1 \text{ if } \mathrm{k}_i\alpha + \mathrm{g}_i > 0 \\ 0 \quad \text{if otherwise} \end{Bmatrix} \tag{9}$$

where α is the vector of parameters to be estimated.

In the second stage, the number of CSAPs adopted was modeled using the Poisson specification, corrected for endogeneity using a control function approach. The control function λi was introduced to account for the correlation between the unobserved components of GASIP participation and CSAP adoption:

$$Log\langle \mathrm{E}(\mathrm{CSAPs}|\mathrm{GASIP}_i, \mathrm{Zi}, \lambda\mathrm{i})\rangle = \mathrm{Zi}'\delta + \beta\mathrm{GASIPi} + \rho\lambda\mathrm{i} \tag{10}$$

where $\lambda_i = \phi(\mathrm{k}_i'\alpha)/\Phi(\mathrm{k}_i'\alpha)$ is the inverse Mills ratio, capturing the selection bias from GASIP participation and ρ is the coefficient on the control function, capturing the extent of endogeneity. Empirically, the model is specified as:

$$GASIP\ Participation = \beta_0 + \beta_1 Age + \beta_2 Sex + \beta_3 Education + \beta_4 Married + \beta_5 Remittance + \beta_7 HH\ size + \beta_8 Farming\ Experience + \beta_9 Farm\ size + \beta_{10} Land\ ownership + \beta_{11} Access\ to\ inputs + \beta_{12} Access\ to\ market + \beta_{13} Credit + \beta_{14} FBO + \beta_{15} Household\ income + \beta_{15} Non-farm\ income + \beta_{16}\ Farm\ outputs + \beta_{17}\ CSAP + \varepsilon_i$$

Table 2 presents a description of the variables used in the estimation. The Climate-Smart Agricultural Practices include agroforestry, mulching, mixed cropping, mixed farming, crop rotation, improved seed varieties, irrigation management, changing planting time, efficient use of fertilizer, integrated pest management, leaving crop residue, and minimum tillage.

Table 2: Description of Variables

Variable	Description
Age	Number of years of farmer
Sex of farmer	1 = Male, 0 =Female
Educational level	Number of years of formal education
Marital status	1=Married, 0, otherwise,
Remittance received	1=Yes, 0, otherwise
HH size	Number of members in household
HH income	Total income of the household (in GHS)
Farming experience	Number of years in farming
Farm size	Number of hectares of farmland
Farmer land ownership	1=Yes, 0, otherwise
Access to extension service	1=Yes, 0, otherwise
Credit access	1=Yes, 0, otherwise
FBO membership	1=Yes, 0, otherwise
Non-farm income	Amount of income from non-farm activities (in GHS)
GASIP participation	*1= Respondent participated in GASIP, 0, otherwise.*
Farm output	Total output from farm (in kg)

Source: Authors' construction based on survey data set.

Results and Discussion

Determinants of GASIP Participation

The Probit results on the determinants of GASIP participation by smallholder farmers are presented in Table 3. The *chi-square* statistics of 113.27 statistically significant at 10% confirms the independent variables collectively have a strong explanatory power regarding GASIP participation. The marginal effect of 0.379, which is statistically significant at 1% means that households with GASIP awareness were 37.9% more likely to participate in GASIP activities than those without awareness. This finding aligns with Bhanot *et al.* (2022) that awareness drives participation in agricultural programmes. In agricultural extension and rural development programmes, awareness translates into increased engagement because it helps farmers to understand the benefits associated with the programme (Feder *et al.*, 2004).

Table 3: **Probit results of the Determinants of GASIP Participation**

Variable	Coefficient	Marginal effect
Constant	-4.143***	
	(0.828)	
GASIP Awareness	4.215***	0.379***
	(0.423)	(0.026)
Age	0.027**	0.002**
	(0.013)	(0.001)

Sex	-1.267***	-0.114***
	(0.287)	(0.027)
Farm experience	-0.017	-0.001
	(0.012)	(0.001)
Household size	-0.018	-0.002
	(0.041)	(0.004)
Education	0.109**	0.010**
	(0.054)	(0.005)
Farm size	-0.082	-0.007
	(0.053)	(0.005)
Crop Diversification	0.837**	0.075**
	(0.357)	(0.032)
Landownership	1.278***	0.115***
	(0.311)	(0.029)
Access credit	0.601**	0.054**
	(0.261)	(0.024)
Radio	-0.449*	-0.040**
	(0.270)	(0.024)
Bicycle	0.358	0.032
	(0.270)	(0.024)
Mobile Phone	-0.733**	-0.066*
	(0.366)	(0.034)
No. of Observations	410	
Chi-square	113.270***	

Standard errors in parentheses. ***, **, *, indicate statistically significant at 1%, 5% and 10% respectively.

The marginal effect of 0.002 at 5% significance level indicates an additional year in age increases the likelihood of participation by 0.2%. This is consistent with Asfaw *et al* (2017) that older farmers have accumulated farm experience and are better able to evaluate the potential benefits of new programmes (Asfaw and Simane, *et al*., 2017). However, the small magnitude of this effect also suggests that age, while statistically significant, is not the primary driver of participation. The negative and highly significant (at 1%) marginal effect for sex (-0.114) indicated that the likelihood of male farmers taking part in GASIP was lower than female farmers. Males were 11.4% less likely to participate in GASIP activities than females. The objective of GASIP was to target smallholder resource-poor rural farmers particularly women and the youth.

The positive and statistically significant (at 5%) marginal effect (0.010) for education indicated that higher educational attainment increased the probability of GASIP participation. An extra year of education increased the likelihood of involvement in GASIP activities by 1%. The adoption of new agricultural technologies and practices depends heavily on education because it gives farmers the ability to implement programme components effectively (Ragasa and Lambrecht *et al*., 2018). Educated farmers are better positioned to access information and resources, which enhance their participation in programmes like GASIP. The marginal effect of 0.075 (statistically significant at 5%) suggested that the households that diversified crop production had a 7.5% likelihood of participating in GASIP activities as opposed to their counterparts who did not diversify crop production. Crop diversification has been associated with better resilience against environmental and market risk, and thus diversified farms are more likely to cooperate with projects that offer additional support and inputs (Kassie and Wale, 2022). Thus, diversified farming systems are more adaptable and open to innovation (Van et al., 2014). The marginal impact of 0.115 (significant at 5%) indicated that land ownership increased the likelihood of GASIP participation by 11.5%. Ownership of land is a prerequisite for participation in agricultural programmes because it provides the security to invest in the long term (Holden and Ghebru, 2016). Access to credit also marginally affected participation with 0.054 at 5% level of statistical significance. It, therefore, means that households with access to credit were 5.4% more likely to engage in GASIP activities than their counterparts without access to credit. This finding emphasizes the contribution of financial inclusion in enabling farmers to buy inputs and technologies spread by agricultural programmes in order to enhance productivity (Karlan and Osei, 2014). Hence, access to credit lowers liquidity constraints, enabling farmers to take advantage of the opportunities provided by GASIP. The negative sign under radio ownership contradicts a priori expectation because access to information via radio allows for more participation in programmes such as Ghana Agricultural Sector Investment Program (GASIP). The marginal effect of -0.040 (statistically significant at 10%) suggests that households with access to radio sets were 4.0% less likelihood to participate in GASIP than those without access. Several explanations can account for this unexpected result. First, the nature of the information disseminated through radio could play a crucial role. This is likely to be the case if radio content prioritizes non-agricultural topics Recent studies show that radio ownership alone does not guarantee exposure to actionable agricultural information, particularly when programmes are not tailored to local farming needs or aligned with ongoing interventions (Bailey et al., 2023; Kassie et al., 2021.

Additionally, households that possess radio sets may be engaged in diverse income-generating activities, leading them to rely less on agricultural programs like GASIP. Furthermore, radio ownership might also provide access to diverse viewpoints and if households receive competing narratives that highlight the risks or inefficiencies of participating in government programmes, it could deter them from enrolling in GASIP.

Similarly, mobile phone ownership had a marginal effect of -0.066 which was statistically significant at 5%. This indicated that mobile phone owners were 6.6% less likely to participate in GASIP. This finding could reflect the socio-economic status of mobile phone owners, who could have different livelihood priorities other than agriculture that GASIP was about. Recent evidence indicates that while mobile phone penetration is high among smallholder farmers, usage is often skewed toward social media communication, mobile money, and non-agricultural enterprises rather than participation in agricultural extension or development programmes (Aker & Ksoll, 2022; Zanello et al., 2022). Consequently, mobile phone ownership does not necessarily translate into higher programme participation and may instead reflect livelihood diversification away from agriculture.

3.2 Effect of GASIP Participation on Adoption of Climate-Smart Agricultural Practices (CSAPs)

The Exogenous Switch Poisson accounts for selection bias by distinguishing between endogenous and exogenous factors affecting GASIP participation and the adoption of CSAPs. The models were statistically significant, with robust Wald chi-square values, confirming the relevance of the included variables as presented in Table 4. The coefficient for age was positive and statistically significant at 5%, indicating an additional year in age led to an increase in the expected count of adopting CSAPs. Older farmers likely adopted CSAPs to ensure long-term sustainability and reduce vulnerability to climate change (Asfaw et al., 2016). However, Mishra et al. (2017) argued that younger farmers might adopt innovative practices due to their openness to new technologies.

Table 4: Results of the Endogenous –Switch Poisson Regression

	Endogenous –Switch Poisson Regression		Exogenous –Switch Poisson Regression	
Variable	CSAP	Participation in GASIP	CSAP	Participation in GASIP
Constant	1.352***	-4.038***	1.343***	-4.211***
	(0.153)	(0.993)	(0.152)	(0.993)
Age	0.006**	0.023	0.006**	0.026*
	(0.003)	(0.016)	(0.003)	(0.015)
Sex	0.232***	-1.408***	0.215***	-1.359***
	(0.054)	(0.322)	(0.052)	(0.321)
Farm experience	-0.002	-0.020	-0.002	-0.019
	(0.002)	(0.013)	(0.002)	(0.013)
Education	0.017**	-0.029	0.017**	-0.022
	(0.007)	(0.041)	(0.007)	(0.041)
Household size	-0.041***	0.123**	-0.040***	0.110*
	(0.010)	(0.059)	(0.010)	(0.059)
Crop Diversification	0.283***	0.684*	0.293***	0.709*
	(0.068)	(0.374)	(0.067)	(0.377)
Land ownership	-0.068	1.337***	-0.052	1.299***
	(0.062)	(0.330)	(0.060)	(0.326)
Access to credit	0.077	0.652**	0.089	0.612*
	(0.059)	(0.323)	(0.057)	(0.318)
Ownership of radio	0.089*	-0.410	0.092*	-0.421
	(0.049)	(0.277)	(0.048)	(0.282)
Ownership of bicycle	0.157***	0.344	0.161***	0.354
	(0.051)	(0.280)	(0.051)	(0.282)
Ownership of mobile	-0.075	-0.787*	-0.076	-0.777*
	(0.074)	(0.454)	(0.074)	(0.453)
GASIP participation	0.171**		0.115**	
	(0.079)		(0.055)	
GASIP awareness		4.209***		4.210***
		(0.491)		(0.492)
Lnsigma		-1.206***		-1.213***
		(0.103)		(0.103)
Rho		-0.354		
		(0.372)		
No of Observations	410		410	
Wald $chi^2(12)$	106.43***		107.33***	
Log likelihood =	-1194.3367		-1196.847	

Standard errors in parentheses. ***, **, *, indicate statistically significant at 1%, 5% and

10% respectively.

The coefficient for sex was positive and significant at 1%. Thus, male farmers were more likely to adopt CSAPs. Doss and Knopp (2020) explained that males have more access than females to resources such as land and credit. However, Ragasa and Aberman (2019) suggested some women might adopt sustainable practices to ensure household food security.

The coefficient for education was positive and significant at 5%, implying an additional year of education increased the expected count of CSAP adoption. This suggests education equips farmers with the knowledge and skills to implement CSAPs effectively to mitigate the adverse effects of climate change. This finding is consistent with previous studies (Ragasa and Lambrecht, 2018; Asfaw and Neka, 2017) that education promoted the adoption of new and sustainable agricultural practices. The coefficient for household size was negative and statistically significant at 1%. This implies a one-member increase in household size decreases the expected count of adopting CSAPs. This is especially for households with higher dependents (children or elderly) relying on fewer working members. This can limit labour availability for investment in new agricultural practices. The higher consumption needs of larger households could also limit the resources available for investing in new agricultural practices (Paul et al., 2022). Additionally, households with many dependents might prioritize short-term food security over long-term CSAPs' sustainability practices that require up-front costs or changes from traditional farming practices. However, Kassie et al. (2015) found that larger households might have more practices due to greater household labour availability.

The crop diversification coefficient was positive and significant at 1%. Crop diversification increased the expected number of CSAPs adopted. Diversified farming systems are more resilient to climate shocks and can reduce risks associated with single-crop specialization (Kassie et al., 2015). This finding corroborates Di Falco et al. (2011) and Mngomezulu et al. (2023) that resilience makes diversified farmers adopt other practices that enhance their adaptability to changing climatic conditions.

Ownership of radio sets was also significant at 10% and positively influenced the adoption of CSAPs. Radio sets are one of the major sources of information for rural farmers, as they expose them to information on weather forecasts, market prices, and new agricultural technologies (Aker et al., 2011). Farmers who own radio sets will have more exposure to agricultural information through radio programmes that can facilitate the adoption of CSAPs. This finding corroborates Khan et al., (2020) and Bailey et al. (2023) that radio broadcasts in rural communities were key in the dissemination of climate-smart agricultural technologies, leading to higher adoption. Similarly, Sulemana et al. (2022) and Chapoto et al. (2022) point out that radio programs dedicated to agricultural topics have been effective in increasing farmers' awareness and knowledge of new practices, particularly where the coverage of extension services is limited. Nonetheless, Kassie et al. (2021) points out that despite the usefulness of radios in spreading information, their effectiveness could be weakened by the quality and relevance of broadcast content and the ability of farmers to contextualize the information to the local situations. The coefficient for bicycle ownership was positive and significant at 1%.

Thus, ownership of a bicycle increased the estimated number of CSAPs adopted. Bicycles facilitated farmers to attend training sessions, go to input markets, and meet extension officers, thus adoption of CSAPs was facilitated. Manda et al. (2016) clarified that improved mobility significantly enhanced farmers' accessibility to agricultural extension services, markets and adoption of improved agricultural technologies and practices. Moreover, Ali (2021) found that mobility enabled better market integration and access to prompt agricultural information. This illustrates the importance of mobility in rural agricultural development, where physical accessibility can be a significant barrier to technology adoption and programme participation. The GASIP participation estimate was also large and positive, at 5%, indicating that GASIP participation increased the estimated number of CSAPs adopted. Thus, there was a positive effect of GASIP on CSAP adoption because of the resources and training provided through the programme. Abebe (2021) confirmed that participation in agricultural extension programs increased the adoption of improved agricultural technologies Similarly, Nkegbe (2022) emphasized that participation in farmer support programmes increased adoption rates of climate-smart practices, underscoring the role of interventions such as GASIP in promoting sustainable agriculture.

The LnSigma value of −1.206 was highly significant at the 1% level. LnSigma represents the natural logarithm of the dispersion parameter in the endogenous switching Poisson regression. A negative value indicates low variability in the adoption of Climate-Smart Agricultural Practices (CSAPs) among farmers, suggesting relatively consistent adoption behaviour influenced by similar observable factors. This consistency is statistically robust and implies that the model is well specified.

The rho (ρ) value of −0.354 was not statistically significant. The rho measures the correlation between the unobserved factors influencing farmers' participation in GASIP (selection equation) and those affecting the intensity of CSAP adoption (outcome equation). The negative sign of rho suggests that unobserved characteristics that increase the likelihood of programme participation tend, on average, to be associated with slightly lower CSAP adoption intensity, and vice versa. However, the lack of statistical significance indicates that this relationship is weak and indistinguishable from zero, implying that unobserved selection effects do not systematically bias the estimated impact of participation on CSAP adoption. This result suggests that observed household and farm-level characteristics included in the model adequately capture the key drivers of adoption behaviour.

4.0 Conclusion and Recommendations

This study analyzed the determinants of farmer participation in the Ghana Agricultural Sector Investment Programme (GASIP) and its effect on the adoption of Climate-Smart Agricultural Practices (CSAPs). The study relied on data collected using multi-stage sampling for the 2023/2024 cropping season from 410 households in the Upper East Region. Probit was applied to estimate the determinants of GASIP participation and endogenous switching Poisson to model the effect of GASIP participation on adoption of CSAPs.

The Probit results revealed that awareness of GASIP, age, education, diversification of crops, land ownership, and access to credit had significant and positive impacts on participation in GASIP. Conversely, male-headed family, owners of radio sets, and mobile phone users were not likely to participate in GASIP. Also, education, crop diversification, male-headed households, radio ownership, and bicycle ownership had positive impacts on adoption of CSAPs, while household size had adverse effect.

Taken together, these findings indicate that participation in GASIP was shaped by farmers' human capital, asset ownership, and access to institutional support. The results further suggest that GASIP participation is positively associated with higher adoption intensity of CSAPs after accounting for both observable and unobservable differences between participants and non-participants. Rather than acting as a stand-alone driver, GASIP enhanced CSAP adoption by easing key constraints—such as limited awareness, inadequate skills, and financial barriers—that enabled farmers to adopt climate-smart technologies.

The findings of this study align with the strategies of the National Agricultural Investment Plan (NAIP) which seeks to modernize the sector through its flagship 'Planting for Food and Jobs' programme. The strategies under NAIP include the provision of structured government investment and promoting private investments to modernise the agri-food system to engender growth, create employment opportunities, raise farm incomes, and improve food and nutrition security of Ghanaian households.

Based on the above findings, this study concludes that GASIP contributed to increased uptake of Climate-Smart Agricultural Practices by creating an enabling environment that supports learning, access to resources, and risk management among smallholder farmers, thereby reinforcing sustainable agricultural productivity and climate resilience in the study area.

Government agricultural policies are enforced by the Ministry of Food and Agriculture (MoFA), and based on this research, the following recommendations are proposed:

MoFA should scale up targeted and community-based sensitization campaigns that draw on lessons from GASIP implementation, with emphasis on direct farmer engagement through extension services, farmer-based organizations, and demonstration activities to improve programme awareness and enrolment.

MoFA should collaborate with rural financial institutions to design and extend flexible credit facilities that are explicitly linked to investments in climate-smart agricultural practices, thereby reducing financial barriers to adoption among smallholder farmers.

MoFA should maintain crop diversification as a core component of climate-smart programmes by supporting diversified input packages, extension advice, and market linkages that help buffer households against climate-related production risks.

Agricultural extension service delivery under future programmes should be differentiated to reflect household characteristics, particularly household size and asset constraints, by promoting labour-saving and context-appropriate CSAP options for resource-constrained farmers.

Finally, MoFA should strengthen information dissemination and extension logistics by leveraging local radio platforms for CSAP education while improving field mobility of extension agents to ensure effective follow-up and sustained adoption.

Conflict of Interest

None to declare.

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