

Risk Management and Socioeconomic Drivers of Crop Productivity in Ghana

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Article Information:

Received: 06 February 2025, Accepted: 21 February 2025, Published: 25 February 2025

Abstract

This study explores the impact of risk management strategies and socioeconomic factors on crop productivity among smallholder farmers in Ghana. Utilising a cross-sectional survey design, data were gathered from 4,065,095 agricultural households, as reported by the Ghana Census of Agriculture (2018). The sampling frame, derived from the 37,657 Enumeration Areas defined by the Ghana Statistical Service (GSS), provided a systematic approach for identifying the target population. Key variables include crop productivity (measured in kilograms per hectare), socioeconomic factors (education levels, marital status, and gender), agricultural practices (plot size, mixed cropping, and irrigation), and economic and demographic factors (labour costs, hours of work, average market price of crops, and age). The findings reveal that educational attainment at basic and medium levels significantly enhances crop productivity, while higher education levels do not show direct benefits. Mixed cropping and irrigation practices are shown to significantly increase productivity, underscoring their importance in agricultural risk management. Larger plot sizes demonstrate economies of scale, contributing to higher productivity. Sociodemographic factors such as marital status and gender influence productivity, with male and married farmers achieving higher yields. Labour and input costs are critical determinants of productivity, highlighting the financial risks inherent in farming. The study emphasizes the need for integrated policies that incorporate agricultural insurance, education, financial services, and sustainable farming techniques to build a resilient agricultural industry in Ghana. These findings highlight the potential for agricultural insurance and risk management measures to reduce vulnerabilities and improve sustainability.

Keywords: Agricultural Productivity, Smallholder Farmers, Risk Management, Irrigation, Mixed Cropping, Education, Ghana.

Published by:

JEL CODES: Q12 Q16 Q13

1. Introduction

Agriculture is the backbone of Ghana's economy, contributing considerably to employment, food security, and rural community development. However, Ghanaian farmers confront various obstacles endangering agricultural production. The principal categories of risk are pricing risk, coming from volatility in market prices, and production risk, stemming from uncertainty in yield levels owing to shifting environmental and operational circumstances (FAO, 2021). Price volatility has been exacerbated by trade liberalisation, which exposes local markets to global price shifts, while production risks are heightened by the effects of climate change, such as irregular rainfall patterns, droughts, and extreme weather events (Antwi-Agyei et al., 2012; World Bank, 2019). Most of Ghana's agricultural industry is controlled by smallholder farmers, who frequently lack the wherewithal to adequately handle these hazards.

Aside from these hazards, there are also biological threats like pests and diseases (Nyantakyi-Frimpong et al., 2019) that negatively influence productivity. Despite the relevance of these hazards, there is a considerable vacuum in thorough research that examines their cumulative and linked consequences on smallholder farmers. Understanding the nature, intensity, and interdependencies of these risks is critical for establishing targeted, effective mitigation solutions (Abaidoo & Agyapong, 2024). In response, it is vital to understand how farmers in Ghana manage these risks to boost crop output and adapt to evolving agricultural conditions. Yet, successive administrations in Ghana have struggled to adopt solid agricultural policies that address these difficulties thoroughly, leaving many smallholder farmers without enough assistance (Ghana Statistical Service, 2020).

Unchecked agricultural hazards can lead to severe decreases in farmers' income, requiring them to draw from their savings or sell off assets to make ends meet. This not only weakens their long-term resilience but also lowers the value of assets in times of broad crisis, since many families seek to sell at the same time (Ellis, 2000). Such financial volatility adds to rural poverty and affects the standard of living for many farmers, underlining the need for good risk management strategies (Owusu & Rahman, 2011). However, the success of existing solutions utilised by farmers and agricultural organisations in Ghana remains questionable, with minimal research examining their strengths and limitations (Danso-Abbeam et al., 2021).

Agricultural hazards, including production, income, and price risks, continue to make the industry unattractive to young people who might otherwise engage in farming as a sustainable vocation. This reluctance contributes to the ageing farmer population in Ghana, providing further concerns for the sector's future viability. Enhancing the resilience of Ghana's agriculture to these different hazards is vital for guaranteeing food security, stabilising incomes, and supporting larger economic development goals (FAO, 2021).

On the other hand, smallholder farmers, who make up the bulk of the agricultural labour in Ghana, have several challenges such as changes in the climate, fluctuations in the market, and limitations on resources (Dercon et al., 2014; Salifu & Salifu, 2024). Limited access to formal risk management strategies, such as agricultural insurance, makes these vulnerabilities even worse. These products might help reduce the negative consequences of crop failure and income volatility (Maddison, 2007; Moomen et al., 2024).

Studies have shown that demographic and socioeconomic factors, such as education and gender significantly influence agricultural outcomes. Farmers with basic education are more likely to adopt innovative practices, including risk management strategies, and enhancing productivity (Barrett, 2008). Additionally, mixed cropping and irrigation systems have been identified as critical techniques for mitigating environmental risks and improving yields (Baffour-Ata et al., 2023). This study aims to explore the interplay between socioeconomic conditions, agricultural techniques, and resource utilisation in shaping productivity among Ghana's smallholder farmers. This research attempts to explore the dynamics of agricultural risk, its influence on crop yield, and the variables determining successful risk reduction.

Addressing these knowledge gaps is critical for informed policymaking and for developing resilient, sustainable agricultural practices that can improve the livelihoods of smallholder farmers and bolster Ghana's food security in the face of future challenges (Antwi-Agyei et al., 2012). This study intends to completely evaluate the complicated link between agricultural risk management techniques and crop yield within Ghana's agricultural industry. Specifically, it studies the dynamics, obstacles, and efficacy of various risk management measures Ghanaian farmers utilise. By doing so, our research gives insights on supporting sustainable agricultural practices that limit risks, increase productivity, and improve farmers' livelihoods. The outcomes of this study are projected to guide policy decisions that promote agricultural resilience, therefore helping Ghana's larger economic development goals (World Bank, 2022).

2. Literature Review

2.1. Theoretical Framework

This research integrates different theoretical approaches to completely explore the dynamics of agricultural risk management, its influence on crop yield, and the adoption of sustainable practices among farmers in Ghana. The theories studied give valuable insights into many parts of the study and correspond with the research aims as follows:

2.1.1. Expected Utility Theory

Expected Utility Theory provides a core framework for understanding farmers' decision-making processes about risk management techniques. Proposed by Von Neumann and Morgenstern (1944), this theory explains how humans make decisions under uncertainty by picking options that maximize their anticipated utility. In the context of this research, it underscores the purpose of examining farmers' selection of risk management measures, guaranteeing they obtain the most advantage. By employing this theory, the study explains the trade-offs farmers evaluate when choosing different risk mitigation options, such as insurance or diversification.

2.1.2. Arrow-Debreu Model

The Arrow-Debreu Model (Arrow & Debreu, 1954) is beneficial for studying the influence of agricultural risk management measures on market outcomes, such as crop prices. This model, anchored on general equilibrium theory, stresses the role of risk allocation and market efficiency in establishing equilibrium prices. Applying this model allows the research to analyze how risk management initiatives, such as futures markets or subsidies, impact price stability, and the larger agricultural market.

2.1.3. Portfolio Theory

Portfolio Theory, created by Markowitz (1952), is used to investigate how agricultural risk management methods affect production. Originating from finance, this theory addresses optimizing risk and return within a portfolio. In agriculture, it is relevant to farmers' decisions to diversify crops, revenue sources, or agricultural practices to minimize risks while optimizing yield. This theory facilitates in measuring the success of such diversification techniques and their effects on total agricultural output.

2.1.4. Adoption Diffusion Theory

Adoption Diffusion Theory, established by Rogers (1962), focuses on the process by which farmers adopt new technology and creative methods. This theory is critical for understanding the factors that impact the adoption of risk management measures, such as climate-resilient crops, enhanced irrigation systems, or financial products like weather-index insurance. By evaluating the distribution of these technologies, the research might identify hurdles to acceptance and recommend measures to boost uptake among smallholder farmers.

2.1.5. Agricultural Risk Management in Developing Economies

Agricultural risk management is vital for limiting the detrimental impacts of environmental, economic, and operational risks on crop yield. Developing nations, where agriculture is predominantly rain-fed, are particularly exposed to climate-related threats (IPCC, 2021). Strategies such as crop insurance, diversification, and access to financial credit have been studied as potential choices for smallholder farmers (Cervantes-Godoy et al., 2013). Crop insurance, for example, offers financial protection against crop loss due to natural catastrophes, although its acceptance remains restricted in many places due to high prices and lack of knowledge (Mahul & Stutley, 2010). In the Ghanaian setting, conventional risk-sharing methods, such as communal support networks, are regularly employed yet may be insufficient to manage large-scale hazards (Abdulai & Huffman, 2020).

Ghanaian farmers have implemented several risk management measures to meet climatic unpredictability and other difficulties. Diversification, such as producing various crop varieties, is a typical technique to prevent revenue loss from crop failure (Nyantakyi-Frimpong et al., 2019). Additionally, farmers apply indigenous knowledge and local techniques, like crop rotation and mixed cropping, to boost resilience against pests and unexpected rains (Olawuyi et al., 2024). Despite these methods, smallholder farmers in Ghana sometimes encounter difficulties in obtaining formal risk management instruments, such as crop insurance or weather forecasting services (Danso-Abbeam et al., 2021).

2.1.6. Impact of Agricultural Risk Management on Productivity

Effective risk management may play a key role in boosting agricultural output and sustainability. Studies have demonstrated that employing risk management strategies not only decreases susceptibility but also boosts resource usage efficiency and improves yield stability (Vigani & Kathage, 2019). For instance, access to agricultural extension services has been associated to better risk management techniques and greater production among smallholder farmers in sub-Saharan Africa (Feder et al., 2019). In Ghana, however, limited extension services and poor infrastructure restrict the broad adoption of better techniques, creating difficulties to sustainable agriculture and food security (Danso-Abbeam et al., 2018).

While there is a growing body of research on agricultural risk management in sub-Saharan Africa, limited works focus explicitly on Ghana's setting. Existing research frequently focuses on regional or national agricultural data, without a specific study of the methods and outcomes

among Ghanaian farmers (Gyimah et al., 2020). This study tries to address this gap by investigating the specific risk management strategies adopted by Ghanaian farmers and evaluating their influence on crop output. Understanding these processes is crucial for policymakers wanting to design targeted measures that boost agricultural resilience and improve rural lives.

2.1.7. Socioeconomic Drivers of Crop Productivity

Education is a cornerstone of agricultural development, enabling farmers to adopt innovative practices and technologies. Studies have shown that basic and secondary education significantly improves productivity by equipping farmers with the knowledge to manage risks effectively, such as diversifying crops or adopting climate-resilient practices (Barrett, 2008). Conversely, higher education levels often have a limited direct impact on productivity, as they may not focus on practical agricultural skills (Doss, 2018). Moreover, targeted training programs tailored to smallholder farmers can amplify the benefits of formal education. These initiatives can bridge knowledge gaps, particularly in understanding agricultural insurance and modern farming techniques (Maddison, 2007).

Gender disparities in resource access significantly affect productivity in Ghana. Female farmers typically experience lower yields compared to their male counterparts due to limited access to land, inputs, and training opportunities (Doss, 2018). Sociocultural norms often exacerbate these inequalities, restricting women's decision-making power in agricultural households. Addressing these barriers through gender-sensitive policies, such as targeted subsidies and training programs, can enhance productivity and resilience (Carter et al., 2017).

The size of farmland is a key determinant of productivity, with larger plots benefiting from economies of scale. Farmers with larger plots are more likely to access credit and invest in improved inputs, resulting in higher yields (Barrett, 2008). However, smallholder farmers, who often cultivate less than two hectares, face significant challenges in achieving similar productivity levels. Micro-insurance schemes targeting smallholders can mitigate risks and reduce the disparities associated with plot size (Dercon et al., 2014).

The cost of labour and the price of inputs are major elements that impact agricultural productivity, especially for crops that demand a lot of work. Smallholder farmers are often constrained in their capacity to hire enough workers or invest in productivity-enhancing inputs like fertilisers and improved seeds due to rising labour costs, which are driven by rural-urban migration and demographic shifts (Fafchamps & Quisumbing, 2005). Comparably, variable input prices, which are made worse by inflation and disruptions in the global supply chain, boost production costs, making it tough for farmers to retain their yield levels at an acceptable level (Adjimoti & Kwadzo, 2024).

Having access to loans and insurance is vital for eliminating these limits. Farmers who have access to financial services can better handle changes in input costs and invest in labour-saving technology, such as automation and precision farming, which enhances overall efficiency and resilience (Ali et al., 2024). In addition, targeted subsidies, cooperative farming, and digital financial solutions, such as mobile-based lending and insurance platforms, have been proven to enhance resource allocation and boost productivity among smallholder farmers (Acheampong et al., 2024).

2.2. The Empirical Literature Review

The empirical literature on agricultural risk management contains a broad range of research addressing difficulties such as climatic variability, market uncertainty, and adoption of new approaches. This review assesses the merits and limits of these works while emphasising prospects for further study, particularly in the context of Ghana.

Several studies have effectively studied the effects of climatic variability on agricultural output. For instance, Schlenker and Lobell (2010) used climate data to examine how variations in rainfall patterns and temperatures influence crop yields across Sub-Saharan Africa, yielding practical insights into regional vulnerabilities. Research on weather-index insurance, such as that by Carter et al. (2017), has further contributed to understanding the function of financial instruments in lowering farmers' susceptibility to climatic shocks. These studies apply rigorous econometric models to statistically correlate climatic shocks with agricultural results, supporting policymakers in devising targeted responses.

Empirical research employing the Adoption Diffusion Theory (Rogers, 1962) has shed light on variables influencing the acceptance of agricultural innovations, such as drought-resistant seeds and enhanced irrigation systems. For example, Abdulai and Huffman (2005) underlined the relevance of knowledge, market access, and extension services in influencing adoption decisions among African farmers. This line of study highlights the need of capacity-building activities to boost farmers' resilience to hazards.

Studies founded in the Expected Utility Theory have studied farmers' risk preferences and their effect on decision-making. For instance, Ferreira et al. (2022) explored how farmers use resources to reduce risk exposure while increasing benefits. Similarly, the use of Portfolio Theory by Hardaker et al. (2004) revealed how crop diversity decreases risk while boosting revenue stability. These findings underline the importance of diversification methods in mitigating production and market risks.

Much of the existing empirical research focuses on global or regional patterns, with insufficient attention on Ghana. Studies such as Dercon and Christiaensen (2011), while enlightening, sometimes generalise findings throughout Africa, missing distinct socio-economic and environmental constraints faced by Ghanaian farmers. This gap underlines the necessity for specialized research to address context-specific dangers.

Other studies frequently isolate risk factors such as climate, market, or pest-related threats. For instance, Asiedu et al. (2024) evaluated the implications of climatic variability on Ghanaian agriculture but did not account for how these risks combine with market variations or insect outbreaks. This compartmentalised methodology fails to reflect the cascading consequences of interrelated hazards, limiting the comprehensiveness of their conclusions. While measures such as subsidies and insurance programs have been introduced in many developing countries, there is minimal empirical evaluation of their efficacy. Despite increasing government spending on agriculture, smallholder farmers in Ghana have not uniformly enjoyed the advantages. While significant investments have been in agricultural development programs such as the "Planting for Food and Jobs" initiative, challenges remain in reaching all farmers, particularly those in remote areas or with limited access to resources (Prah et al., 2023). Smallholder farmers often face barriers such as inadequate infrastructure, high input costs, and limited access to extension services, which hinder their ability to fully benefit from government interventions. This critique underlines the necessity for policy-oriented assessments to inform more fair actions.

Also, studies on technology adoption tend to concentrate on economic and technological aspects while overlooking socio-cultural and behavioural impacts. For instance, Boakye et al. (2024) emphasised that traditional norms and gender dynamics frequently play a significant role in determining adoption practices, however, these characteristics remain underexplored in most empirical investigations.

3. Methodology

This study explores risk management strategies employed by smallholder farmers in Ghana, focusing on their role in promoting sustainable agricultural productivity. The methodology used for this research is designed to collect data on the adoption of agricultural risk management practices, analyse the factors influencing these decisions, and assess the impact of such strategies on agricultural productivity. A quantitative approach using logistic regression will be applied to estimate the likelihood of adopting risk management strategies, based on various factors such as demographic characteristics, farm size, access to resources, and perceived risks.

3.1. Research Design

The study employs a cross-sectional survey design, gathering data at a single point in time to capture the risk management strategies currently utilized by smallholder farmers across Ghana. This design allows for a comprehensive snapshot of the adoption patterns of agricultural risk management strategies (Creswell, 2014).

The target population for this study consists of smallholder farmers in Ghana from the 2018 Ghana Census of Agriculture, with a total population size of 4,065,095. These households represent a significant portion of the agricultural sector, where risk management practices such as crop insurance, diversification, and government-supported programs are crucial for mitigating risks and sustaining productivity (Ghana Statistical Service, 2018). Each farmer was asked to report on their specific risk management strategies and provide relevant demographic and farm-level data.

The sampling frame for this study was based on the 37,657 Enumeration Areas (EAs) defined by the Ghana Statistical Service (GSS) during the 2010 Population and Housing Census. These EAs are geographically defined areas containing approximately 150 households on average, identifiable on maps. The GCA (Ghana Census of Agriculture) has already adopted these EAs for its agricultural surveys, ensuring that they are suitable for this study (Ghana Statistical Service, 2018). The use of EAs provides a clear and systematic approach to identifying the households that formed part of the study. Given that this is a census study, the analysis focused on the entire population. The data was processed and analysed using Stata 17 software to perform the descriptive and Logistic Regression analyses.

3.2. Variables and Measurements

The table below displays the dependent and independent variables and their associated measurement scales.

Table 1: Variables and Measurements

Variable Type	Variable Name	Measurement
Dependent Variable	Crop Productivity	Output of crops per unit area (kg per hectare) (Continuous)

Independent Variable	Education Levels	No Education, JSS/JHS, Middle, Secondary, Voc/Tech/Comm, Post-Secondary, Tertiary (Categorical)
	Marital Status	Married, Single, Others (Categorical)
	Gender	1 = Male, 0 = Female (Dummy)
	Plot Size	Measured in hectares (Continuous)
	Mixed Cropping	1 = Yes, 0 = No (Dummy)
	Irrigation	1 = Yes, 0 = No (Dummy)
	Labour Costs & Other Costs	Measured in Ghana Cedis (Continuous)
	Hours of Work	Total hours allocated to farming weekly (Continuous)
	Price	Average market price of crops (GHS per kg) (Continuous)
	Age	Measured in years (Continuous)

3.3. Analytical Framework

The analysis employs a multiple linear regression model to estimate the contribution of independent variables to crop productivity. The general model is expressed as:

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki} + \varepsilon_i$$

Where:

Y_i : Crop productivity for household i .

$X_{1i}, X_{2i}, X_{3i}, \dots, X_{ki}$: Independent variables.

β_0 : Intercept term

$\beta_1, \beta_2, \beta_3, \dots, \beta_k$: Coefficients for the independent variables.

ε_i : Error term for household i , capturing unobserved factors.

Model Assumptions

- Linearity: The relationship between predictors and the dependent variable is linear.
- Homoscedasticity: The variance of residuals is constant across levels of predictors.
- Independence: Observations are independent of each other.
- Normality: Residuals are normally distributed.

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Model Evaluation

1. **Statistical Significance:** Individual coefficients were tested using t-tests, with a significance level of $p < 0.05$
2. **Goodness of Fit:** Adjusted R^2 was used to evaluate the proportion of variance in crop productivity explained by the model.

4. Results And Discussions

4.1. Statistic Descriptive

This section analyses data collected for the study on the impact of agriculture risk management on crop productivity among members of agriculture households and persons engaged in agriculture activities in Ghana. The study identified 4,864,276 households, with 2,585,531 being agricultural households. Of these, 3,037,381 persons aged 15 or older are involved in agriculture, with 65.8% being males and 76.6% in rural areas. Most agricultural holders are male, with 87.1% having either basic education (44.0%) or no formal education (43.1%). The marital status of agriculture households is predominantly male, with nearly three-quarters of the population being married. Over half of agricultural household members aged 16 or older are married, with 33.4 percent having never been married. The proportion of married household members in rural areas is higher than in urban areas, and the proportion of males who have never been married is higher than females. The age range of respondents is 18-29 years, with a significant proportion of respondents aged 30-39 years. Education levels are generally low in most sub-Saharan African countries, with farmers often having low levels of education. The study highlights the importance of having the right education levels to boost agriculture productivity, which is currently at its lowest levels in the country.

Ghana's agricultural activity is primarily focused on arable and tree crops, with 77.7% of households cultivating these crops and 39.3% engaged in livestock activities. Females are more likely to cultivate arable crops than males, with a higher proportion of females (80.6%) than males (76.2%). This pattern is observed in both urban and rural areas. The most common land tenure arrangement for crop and forest tree production is ownership through freehold (52.2%) or inheritance (23.5%), with institutions having a higher percentage (75.3%). However, most holders do not have any documentation covering land tenure arrangements. Over half of land parcels used for crop and forest tree production are small, with a higher proportion (71.4%) belonging to females. Most arable crops are produced on land parcels less than 2 acres, while forest trees are larger. Most holders use agricultural equipment that they do not own, with knapsack sprayers being the most commonly owned. Males generally own and use agricultural equipment more than females, with male holders using tractor, knapsack, and mist blower more than females.

Table 2: Correlation Analysis

	Prod	Edu	Plot	Marital	Sex	log_LC	log_OC	log_Age	Log_pric e	Hrs wk	C_syste m	I_farms
Prod	1.000											
Edu	-0.117	1.000										
Plot	0.115	0.128	1.000									
Marital	-0.017	0.103	-0.100	1.000								
Sex	-0.047	0.021	-0.210	0.440	1.000							
log_LC	0.199	-0.039	0.352	-0.064	-0.124	1.000						
log_OC	0.134	0.012	0.343	-0.081	-0.155	0.447	1.000					
log_Age	0.035	0.151	-0.001	0.381	0.102	0.007	-0.011	1.000				
Log_pric e	-0.423	0.057	0.138	-0.038	-0.064	0.055	0.097	-0.014	1.000			
Hrs wk	-0.004	0.120	0.172	-0.090	-0.195	0.079	0.110	-0.070	0.061	1.000		
C_syste m	0.077	-0.132	-0.014	0.071	0.091	0.058	-0.031	0.069	-0.134	-0.110	1.000	
I_farms	0.102	-0.092	-0.170	0.071	0.098	-0.084	-0.274	0.043	-0.145	-0.067	0.176	1.000

4.2. Regression Analysis

The model's R^2 value of 0.268 suggests a decent fit, as it explains a portion of the variance in crop productivity by the predicting variables. A low R-square of at least 0.1 (or 10 percent) is acceptable because some or most of the predictors or explanatory variables are statistically significant. If this condition is not met, the low R-square model cannot be accepted (Ozili, 2023; Saliya, 2023). This demonstrates the complex and diverse nature of agricultural production, in which numerous factors, such as socioeconomic traits, farming techniques, and environmental conditions, interact to influence outcomes. The modest R^2 result indicates that, while the model captures many of the important drivers of productivity, there may be other unobserved factors impacting crop production that were not included in the research.

Table 3: Regression Analysis

A number of obs.	4,065,092					
F(25,4065066)	59586.580					
Prob (F)	> 0.000					
R-squared	0.268					
Adj R-squared	0.268					
Productivity	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
<i>Education level</i>						
Primary	0.034	0.034	1.000	0.317	-0.032	0.100
JSS/JHS	0.135	0.034	4.000	< 0.001	0.069	0.202
Middle	0.116	0.034	3.440	0.001	0.050	0.182
SSS/SHS	0.029	0.034	0.860	0.388	-0.037	0.096
Secondary	0.111	0.034	3.250	0.001	0.044	0.178
Voc/Tech/Comm	0.081	0.034	2.350	0.019	0.013	0.148
Post-secondary-Non	0.022	0.035	0.630	0.526	-0.046	0.091
Tertiary						
Tertiary	0.002	0.034	0.050	0.963	-0.065	0.068
No education	-0.224	0.034	-6.640	< 0.001	-0.290	-0.158
<i>Plot_size(in acres)</i>						
2-<5	0.091	0.002	61.710	< 0.001	0.088	0.093
5-<10	0.531	0.003	214.380	< 0.001	0.526	0.536
10+	0.765	0.004	208.660	< 0.001	0.757	0.772
<i>Marital status</i>						
Informal/consensual union	0.084	0.004	19.920	< 0.001	0.076	0.093
Married	-0.708	0.003	-23.030	< 0.001	-0.077	-0.065
Separated	0.029	0.005	6.330	< 0.001	0.020	0.037
Divorced	0.068	0.005	14.520	< 0.001	0.059	0.078
Widowed	-0.062	0.004	-15.470	< 0.001	-0.070	-0.054
<i>Sex</i>						
Female	-0.105	0.002	-60.040	< 0.001	-0.109	-0.102
log_LabourCost	0.206	0.001	275.320	< 0.001	0.205	0.208
log_Other Cost	0.136	0.001	189.480	< 0.001	0.134	0.137
log_Age	0.227	0.003	85.650	< 0.001	0.221	0.232
Log_price	-0.460	0.000	-	< 0.001	-0.461	-0.459
			1010.810			

Hrs worked(per week)	0.000	0.000	6.710	< 0.001	0.000	0.000
<i>Cropping system</i>						
Mixed cropping	-0.054	0.001	-40.060	< 0.001	-0.057	-0.052
<i>Irrigated Farms</i>						
No	0.298	0.002	193.470	< 0.001	0.295	0.301
cons	2.254	0.036	63.460	< 0.001	2.184	2.323

The study's results provide important insights into the factors that influence crop productivity among Ghana's smallholder farmers. The findings emphasise the role of diverse demographic, socioeconomic, and agricultural practices in determining agricultural outcomes.

Education has a substantial impact on agricultural output, especially among those with JSS/JHS, Middle, Secondary, and No Education ($p < 0.001$). This shows that lower educational levels, particularly basic and middle school education, have an important role in increasing agricultural output. These findings are consistent with earlier research that has highlighted the role of education in enhancing agricultural knowledge and practices, resulting in greater production (Maddison, 2007). Higher education levels, such as postsecondary, non-tertiary, and tertiary, had no significant influence on agricultural productivity (t-values of 0.63 and 0.05, respectively, and p-values of 0.53 and 0.96). These findings imply that, while higher education may provide advantages in terms of off-farm work or other income alternatives, it has little direct impact on crop output in smallholder farming situations. This indicates that investing in basic and secondary agricultural education might enhance smallholder farmers' production. Considering the distinct demands and obstacles farmers encounter is essential for successfully customising educational programs.

The variables Mixed Cropping and Irrigation are both highly significant ($p = 0.000$), indicating that both practices have a considerable beneficial impact on crop productivity. Mixed cropping aids in risk diversification, which is critical in the face of volatile weather and market prices (Danso-Abbeam et al., 2021). Irrigation, which allows farmers to access water during dry spells, also boosts productivity by mitigating the negative effects of seasonal rainfall variability. These findings complement the research, which suggests that implementing water management and varied farming methods may greatly increase production in rain-fed agricultural systems (Zhang et al., 2015). The integration of mixed cropping and irrigation methods may significantly enhance agricultural yield since they collaboratively tackle many issues encountered by farmers. By integrating these measures, farmers may optimise their yields and mitigate risks related to weather variability and market unpredictability.

The plot size variable is likewise highly significant ($p = 0.000$), showing that greater farm sizes lead to better productivity. This conclusion is consistent with research demonstrating economies of scale in agriculture, in which larger farms can invest in better technology, techniques, and resources, resulting in higher yields (Barrett, 2008). However, it is important to highlight that greater farm sizes may be connected with better access to finance and resources, which can boost productivity even more. Moreover, bigger farms may profit from reduced production costs by distributing expenditures over a greater output. This may also enhance the elevated output seen in farms with larger plot sizes. Moreover, bigger farms may possess greater bargaining power in pricing negotiations with suppliers or consumers, resulting in possibly increased earnings. This competitive edge enables companies to endure market volatility more successfully than smaller enterprises.

Marital status was shown to be extremely important ($p = 0.000$), indicating that married farmers produce more. This might be because marital stability is frequently associated with family stability, allowing for better coordination of agricultural operations and resource allocation (Badstue, 2021). Similarly, sex was extremely significant ($p = 0.000$), with male farmers being more productive than females. This might represent gender differences in access to resources, technology, and decision-making authority in agricultural operations (Doss, 2018). These results underscore the relevance of incorporating social issues in agricultural productivity improvements. Addressing gender inequities and fostering fair access to resources might assist increase overall agricultural production and sustainability. Furthermore, policymakers and non-governmental organisations must develop measures that empower female farmers and guarantee women have equal chances in the agricultural industry. By fostering gender equality, not only may production rise, but it can also lead to more sustainable and inclusive farming methods.

The labour cost, other costs, and hours of work variables all had a substantial impact on crop yield ($p = 0.000$). These findings show that investing in labour, both financially and time-wise, is crucial to increasing productivity. Efficient labour resource management and cost control (such as inputs, machinery, and transportation) are critical for optimising outputs (Fafchamps and Quisumbing, 2005). The findings also highlight the necessity of knowing how smallholder farmers divide their time and labour resources among various agricultural chores. Understanding the distribution of labour resources may assist in identifying areas for improvement and raise overall efficiency in crop production. Additionally, applying techniques to simplify labour costs and hours spent might lead to improved yields and eventually enhance the lives of smallholder farmers.

While age and price were shown to be very significant ($p = 0.000$), their contributions to productivity may differ depending on other factors such as experience and market circumstances. Older farmers may benefit from years of agricultural knowledge and expertise, increasing efficiency, yet price swings might influence farmer incentives and profits. The relevance of these elements reinforces the importance of market stability and the role of experience in increasing productivity. Overall, policymakers and stakeholders need to evaluate the interaction of these elements to establish a favourable climate for sustained agricultural output. Additionally, additional studies might dive deeper into how various combinations of age, price, experience, and market circumstances affect productivity in the agricultural industry.

The findings of the study can be directly related to the role of agricultural insurance and risk management in enhancing crop productivity and mitigating vulnerabilities faced by smallholder farmers. The significant impact of lower educational levels (JSS/JHS, Middle, Secondary, and No Education) on crop productivity highlights the need for targeted education and awareness campaigns. Farmers with basic education may better understand the benefits of agricultural insurance products and adopt risk management practices effectively. Conversely, the insignificance of higher education suggests that insurance programs should focus on simplifying policy terms and procedures to accommodate farmers with limited educational backgrounds. This aligns with earlier studies that have shown educational campaigns significantly improve farmers' understanding of agricultural insurance and risk management practices, leading to greater adoption (Maddison, 2007; Dercon et al., 2014).

The significant influence of mixed cropping and irrigation on productivity underscores the importance of integrating these practices into agricultural risk management strategies. Mixed

cropping inherently diversifies risks by spreading reliance across multiple crops, thereby reducing the impact of crop failure on overall income (Danso-Abbeam et al., 2021). Similarly, irrigation mitigates water-related risks, a critical concern in rain-fed agriculture. Agricultural insurance products can be designed to encourage and support these practices, offering lower premiums for farmers employing mixed cropping or irrigation systems. Index-based insurance schemes, particularly those linked to water availability or crop yield thresholds, can be tailored to protect farmers against climate-related risks.

The positive relationship between plot size and productivity suggests economies of scale, where larger plots allow for better resource utilisation and access to credit and insurance products. Farmers with larger plots are more likely to afford insurance premiums and adopt risk management practices due to better financial stability and access to formal credit markets (Barrett, 2008; McKinsey & Company, 2024). Smallholder farmers with smaller plot sizes, however, are often the most vulnerable to risks but the least insured. Micro-insurance schemes targeting these farmers can address this disparity, providing affordable coverage for those unable to access traditional insurance products.

The significant influence of marital status and gender on productivity suggests that these demographic factors also play a role in risk management behaviour (Sapbamrer et al., 2024). Married farmers may have greater financial stability and labour resources, enabling better adoption of insurance and other risk management tools (Phiri, 2015). On the other hand, the lower productivity among female farmers highlights gender disparities in resource access, which can also affect their ability to participate in insurance programs (Doss, 2018).

The strong relationship between labour costs, other costs, and hours worked with productivity underscores the financial burden faced by farmers. These costs, along with unpredictable price fluctuations, highlight the financial risks inherent in farming. Agricultural insurance can offset these risks by protecting farmers against income shocks resulting from crop failure, rising input costs, or falling market prices (Fafchamps and Quisumbing, 2005). Income-stabilising insurance policies can ensure farmers' ability to meet labour and input costs even during adverse conditions. Also, bundling insurance with credit products can provide the liquidity needed to sustain labour-intensive farming operations.

5. Conclusion

This research emphasises the importance of socioeconomic conditions, agricultural techniques, and resource utilisation in impacting crop yield among Ghana's smallholder farmers. Key findings suggest the following:

1. Educational attainment, particularly at the basic and medium levels, improves agricultural output, but higher education levels have little direct benefit.
2. Mixed cropping and irrigation systems greatly increase production, highlighting their importance as risk-mitigation measures.
3. Plot size illustrates economies of scale since larger farms produce more products.
4. Sociodemographic characteristics, such as marriage status and gender, are important predictors, with male and married farmers having greater production levels.
5. Labour expenses, input prices, and hours worked all contribute considerably to higher yields, highlighting the significance of effective resource allocation.

6. The modest R^2 value highlights the importance of unobserved variables including climate shocks and technological adoption on productivity, in addition to important determinants.
7. These findings highlight the importance of socioeconomic, demographic, and agricultural practices in determining production outcomes. They also illustrate the potential for agricultural insurance and risk management measures to reduce vulnerabilities and improve sustainability.
8. Specialised insurance products and policies can help smallholder farmers overcome vulnerabilities and achieve long-term agricultural growth by addressing education, crop systems, plot size, demographic considerations, labour costs, and market risks. Building a resilient agricultural industry in Ghana requires integrated policies that incorporate insurance, education, financial services, and sustainable farming techniques.

Policymakers should implement targeted teaching initiatives to help smallholder farmers understand agricultural insurance and risk management methods. This can be accomplished by streamlining insurance policies to accommodate farmers with low formal education.

Insurers can incentivize farmers using mixed crops and irrigation systems, such as subsidies or premium reductions. As a result, more people will have access to inexpensive irrigation infrastructure, especially in water-stressed areas. Insurers are consequently urged to design policies that incentivize sustainable practices such as irrigation and mixed cropping, thus strengthening resilience and increasing production (Zhang et al., 2015).

Insurers could provide subsidized micro-insurance products specifically for farmers with smaller plots to ensure fair access to risk mitigation instruments (Carter et al., 2017).

Insurers can create gender-sensitive policies, such as tailored subsidies or training programs, to alleviate resource imbalances encountered by female farmers. They can also improve support networks for smallholder farmers, particularly those from disadvantaged demographic groups, to provide fair access to resources and services.

Further research should look into the effects of climate resilience, technological adoption, and pest control techniques on production.

Future research can look at the long-term consequences of insurance uptake on farmer behaviour and production trends.

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