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ABSTRACT

This paper attempts to explore crop yield volatility among rural and urban smallholder farmers. The data for the study was sourced from the sixth round of the Ghana Living Standard Survey (GLSS 6). Three separate Ordinary Least Squares (OLS) models were estimated to determine the effect of access to credit, rural farming, and the use of multiple input technology on crop yield. Stochastic Dominance Analysis (SDA) reveals that while rural farmers in the forest and coastal zones experience less volatility in their crop yield, crop yield is highly volatile among rural farmers in the savannah belt. To increase yield among smallholder farmers in Ghana, policy should focus on making credit available to farmers, especially those in the rural areas. Education on the use of technology in farming will help to increase yield and reduce volatility.

Keywords: Small holder farmers; access to credit; technology; Ghana; Crop yield

JEL Codes: Q14, Q16, Q18

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LIST OF ACRONYMS

CDFs	Cumulative Distribution Functions
EAs	Enumeration Areas
GLSS	Ghana Living Standard Survey
GSS	Ghana Statistical Service
ha	Hectare
MoFA	Ministry of Agriculture
NESRA	Network for Socioeconomic Research and Advancement
NGOs	Non-Governmental Organizations
OLS	Ordinary Least Squares
PPS	probability proportional to population size
PSIA	Poverty and Social Impact Analysis
PSUs	Primary Sampling Units
SADA	Savannah Accelerated Development Authority
SDA	Stochastic Dominance Analysis
SSA	Sub-Saharan Africa
SSUs	Secondary Sampling Units

1.0 INTRODUCTION

Agriculture is one of the major sectors of the Ghanaian economy as it employs majority of the populace. As it stands, the agricultural sector employs 54.2 percent of the total population and this translates into 45.8 percent of households (Ghana Statistical Service - GSS, 2013). This means that the contribution of the agricultural sector to the economy of Ghana is overarching. In explaining further, it is evident that majority (73.5%) of these agricultural households are located in rural areas and this confirms the generally accepted fact that majority of agricultural households in Sub-Saharan Africa live in rural areas, where poverty and deprivation are most severe (Diao et al., 2007). These households live in rural areas and have relatively small farm sizes, thus making them smallholder farmers.

According to Chamberlin (2007), Ghanaian agriculture is highly dominated by smallholder farmers (mainly located in rural areas) who produce many commodities. More than 70 percent of farmers in Ghana cultivate about three hectares (ha) of land or even smaller. The small nature of these farms, notwithstanding, they still play a vital role in the economy. A study by Irz et al. (2001) found a significant positive relationship between crop yield and the number of people living in poverty. This implies that increased yield improves livelihoods. The corresponding elasticity coefficient estimated for Africa was higher than that of Asia, which suggests that compared to Asia, Africa could experience a larger reduction in the poverty if it promotes policies that increase crop yields.

In spite of the important role smallholder farmers play in the agricultural sector of the Ghana, these farmers lack access to credit (Chamberlin, 2007; Christen and Anderson, 2013; Peprah and Koomson, 2015) and as a result, are not able to adopt modern (appropriate) technology in their operations. Their problems in accessing credit are also compounded by their farm sizes and locations (Koomson et al., 2016) and they are sometimes compelled to resort to personal savings (Peprah et al., 2015). This is because, security of land tenure and the land size thereof, are major determinants used by financial institutions to advance credit to loan applicants. Unfortunately, for those who would like to use their profits to finance the purchase of needed machines and adoption of new and improved technology, they are highly constrained due to smaller profits realized from their farming operations.

Unlike the usual expectation of many studies coming from this interesting area, there exist no or limited studies on the subject matter. This is the gap that this paper aims at filling and consequently contribute to knowledge. It is presumed that access to credit will enable farmers to embark on more green economy activities such as organic farming instead of traditional application of inorganic fertilizers. With access to credit they will be able to incorporate improved production techniques which will lead to increased efficiency, higher yields, and improved product quality. This in turn means increased household food security and higher household income from more and better quality produce. Especially, in cases where farmers are able to save money through purchasing and using less fertilizer and pesticides, there will be positive environmental knock-on effects.

Owing to the problems confronting smallholder farmers and how these challenges affect their crop yields, this study confirms whether smallholder farmers in rural areas face higher volatility in crop yield compared to their counterparts in the urban areas. It also assesses the effect of access to credit on crop yield, as well as examining the effect of multiple inputs technology use on crop yield. In doing so, this study employs the Stochastic Dominance Analysis to determine whether one can predict crop yield among rural farmers with higher levels of certainty compared to their urban[1] counterparts or vice versa (using outcomes of crop yield volatility). We then proceed to use Ordinary Least Squares (OLS) method to estimate the effect of credit and technology use on crop yield for the pooled model and rural-urban (sub-sampled) models, to cater for heterogeneity among rural and urban farmers.

The rest of the paper is organized as follows: the second section looks at the literature review; section three considers smallholder farming in Ghana**;** the methodology is explained in section four; section five presents the results and discussion and this is followed by conclusions and policy recommendations.

[1] This refers to farm households that have their farms located in the urban areas. Generally, urban farmers compared to rural farmers, are relatively advantaged when it comes to access to credit and usage of technology for farming.

2.0 LITERATURE REVIEW

2.1 Access to credit and crop yield

Over the past ten years or so, Sub-Saharan Africa (SSA) has experienced impressive economic growth averaging about 4.5 per cent with some non-oil-exporting countries reaching an average of more than eight per cent (Chauvin, Mulangu and Porto, 2012). Despite this impressive economic performance, agricultural transformation has been slow and growth rather sluggish. Notably, agricultural productivity is still below yield potentials, agricultural mechanization is weak and declining, and the state of agricultural financing is still nascent. In this context, the worse affected group of farmers is smallholder farmers.

Globally, an estimated 500 million agricultural smallholders farm up to two hectares of land, with 2 billion to 2.5 billion people living in these smallholders' households worldwide (Christen and Anderson, 2013; Hazell, 2011). These farms feed a great number of the rural poor. According to the International Finance Corporation (2011), of the three quarters of the world's poor that live in rural areas, 80 percent depend on agriculture as their main source of income and employment. These smallholders also play a key role in increasing food supply, more so than large farms in poor countries, and increasingly supply large conglomerates and corporations with produce for their production processes (Carroll et al., 2012). Despite their socioeconomic importance, smallholder farmers tend to have little or no access to formal credit, which limits their capacity to invest in the technology and inputs they need in order to increase their yields and incomes and reduce hunger and poverty. The situation is not all that different from some Sub-Saharan African countries.

It is well known that the effectiveness of technology adoption has direct impact on yield. Even though yield in turn depends on land characteristics, such as soil quality, water availability and accessibility, and farmer's land tenure system, and other factors such as income levels, wealth and access to credit; these factors have also been identified as key determinants that influence technology adoption (Rosen et al., 2012). For instance, among the factors that contribute to low fertilizer usage is lack of access to credit. Smallholder farmers who recognize the need to adopt the right amount of fertilizer may be constrained by lack of credit facilities, as they cannot afford to purchase the fertilizer from their own means. Thus, lack of access to credit has contributed to low fertilizer application among smallholder farmers in SSA.

Credit is an important element in agricultural production systems. It allows producers to satisfy the financial and resource needs induced by production cycle, which characterizes crucial activities such as land preparation, planting, cultivation, harvesting, storage, and transportation typically done over a period of several months. In the absence of credit markets, farmers would have to maintain cash reserves to facilitate the various activities along the production cycle. The availability of credit allows greater investment in inputs, implements, and infrastructure, which subsequently result in increases in farmers’ yield.

Access to credit does not only influence land use but also has impact on the efficiency and yields of agricultural households (Jorge, 2004). Credit services are useful in overcoming the financial and resource constraints faced by agricultural households in their efforts to manage the risk associated with productivity growth (*risk-coping effects*). Households with access to credit and financial deposits are more inclined to invest in agricultural intensification, which typically offers higher returns.

The majority of smallholder farmers in SSA are credit constrained. It has been argued that the lack of access to credit adversely affects the productivity of farmers. Chisasa and Makina (2013) examined the supply of credit to smallholder farmers in South Africa and concluded that smallholder farmers are indeed credit constrained mainly due to their inability to provide collateral. Wynne and Lynne (2003) confirmed that lack of credit was hampering the development of smallholder farmers in South Africa but did not test the contribution of credit to farm performance. As some authors (e.g. Chisasa and Makina, 2013) have verified that at a macro level, credit makes a positive and significant contribution to the overall agricultural output; by the same token, the lack of it has affected yield among agricultural households, especially rural smallholder farmers.

The effectiveness of credit as an input depends on the economic and financial policies that go with it. If well applied, credit should increase the size of farm operations, introduce innovations in farming, improve marketing efficiency and enhance farmers' consumption (Nwaru, 2004). Unfortunately, the moral hazard problem in the credit market may contaminate the application of credit, thus producing undesired results. This might be one of the major reasons why smallholder farmers are excluded from the credit market thus contributing to the decline in domestic credit to agriculture.

In Ghana for example, domestic credit to the agricultural sector continues to decline. In 2003, the agricultural sector received 5.40 percent of domestic credit and by 2009 the share has reduced to 4.74 percent. The sector saw an increase in 2010 (6.13%), however, since then credit to the sector has dwindled to 4.08 percent in 2013 (Institute of Statistical, Social and Economic Research, 2014). Alongside this, the yield of some major food crops has also not been consistent. Other crops have recorded decreases in yields. This presumes that a possible relationship between access to credit and yield exists, and that with credit being made available smallholder famers' yield could increase.

2.2. Technology and Crop Yield

The main factors that influence the adoption of technology among smallholder farmers in SSA are assets, vulnerability and institutions (Meinzen-Dick, Knox, Place and Swallow 2002). Assets are requisite physical (material) and abstract possessions (e.g. education and finance) that are essential for technology adoption. For farmers to adopt more technology, the new technologies should require little use of assets, so that even the asset constrained smallholder farmers can adopt the technologies easily. Vulnerability factors relate to technologies that impact on the level of exposure of farmers to economic, biophysical, and social risks. In this regards, farmers are generally more attracted to technologies with lower risk. Finally, institutional factors like credit, insurance and information dissemination are those that focus on the extent or degree to which smallholder farmers adopt technology. Other institutional factors relate to mechanisms and facilities that improve farmers' access to productive inputs and product markets (Meinzen-Dick, 2004).

Nkonya et al. (2004) advised that farmers should be trained and advised not only for them to adopt improved yield-raising technologies, such as improved seed varieties but also fertility-restoring and conservation technologies. In implementing programmes that promote the adoption of technologies among smallholder farmers, synergies should be created among government departments, non-governmental organizations (NGOs), researchers, donors and local communities. Effectively doing this will lead to increased agricultural productivity, reduced environmental degradation, and improved soil quality.

In SSA, agricultural technology development is an essential strategy for increasing agricultural productivity, achieving food self-sufficiency and alleviating poverty among smallholder farmers. This strategy is particularly relevant for the smallholders in the sub-region because they are disadvantaged in many ways, which makes them a priority for development efforts. Usually, these farmers live and farm in areas where rainfall is low and erratic, and soils tend to be infertile. In addition, infrastructure such as irrigation and roads, and institutional support factors such as input and product markets, credit and extension services tend to be poorly developed. It is recommended that further research and rural development efforts should focus on the development of infrastructure and institutions in these areas (Muzari et al., 2012).

According to Muzari et al. (2012), the technologies that farmers adopt play significant roles in determining how fast agricultural productivity grows and how that growth affects the poor and the condition of natural resources. The development of agricultural technology for both food and non-food crops, improvement of the rural financial markets, the dissemination of assets and information, development of agricultural research and extension facilities targeted towards smallholder farmers, all work together to increase their agricultural productivity and improve their livelihoods. Overall, the experience and evidence from countries within and around the SSA region indicates that returns to agricultural technology development could be very high and far reaching, not only in the smallholder sector, but in the entire economy as well. However, improved technologies are of little value unless farmers perceive them to be appropriate and subsequently adopt them. It is therefore imperative not only to develop new agricultural technologies, but also promote their adoption by smallholder farmers (Meinzen-Dick, 2004).

As highlight before, prominent among the factors that affect technology adoption are: assets, vulnerability and institutions. Lack of assets, such as land, education or equipment, will limit technology adoption. This necessitates the need for further studies and development efforts to pay more attention to technologies that require fewer assets. Decision makers also need to recognize that technologies that build on assets that the poor farmers already have, are more likely to be adopted (Meinzen-Dick et al., 2002). In order to encourage adoption of new technologies; pro-poor agricultural researchers must look beyond simply boosting productivity. They should emphasize certain variables which reduce the farmers' vulnerability to loss of income, bad health, natural disasters, and other factors. In addition, an understanding of local cultural practices and preferences is important if smallholder farmers are to benefit from agricultural technologies developed through research. All these form a potentially useful area of study for future research (ibid).

In some countries, female-headed households are discriminated against within their local communities and/or by credit institutions. This is because male and female farmers have different access to many aspects including credit and land tenure systems, with female farmers generally having lower access. Besides the challenges faced by women, they are known to contribute a lot in terms of labour and overall production in the smallholding farming sector in SSA. There is clearly a case for improving current credit systems to ensure that a wider spectrum of smallholder farmers are able to access credit, especially female-headed households (Mkandawire et al., 1993).

Other steps that may be taken to encourage the adoption of technologies that increase agricultural productivity and reduce land degradation include reducing the prices of inputs, offering credit, and waiving some of the taxes levied on input trading businesses. The promotion and strengthening of research-extension linkages will also improve technology adoption. Stronger partnerships between agricultural researchers and other agents of change, including local organizations, farmers, community leaders, NGOs, national policy makers, and donors, are also important in stimulating technology adoption for increased agricultural productivity (Muza et al., 1997).

Promotion of various smallholder income sources such as off-farm employment, remittances, and livestock production, can lead to higher total household income to finance the purchase of inputs such as fertilizers, seed, and hired labour. Introducing technologies that require less labour is also likely to lead to their adoption because the smallholder farming sector in the sub-region is beset with chronic shortages of labour during the agricultural season (Muzari et al., 2012).

It is noteworthy to highlight that there are some rational, positive aspects in certain traditional agricultural practices that are done by smallholders in SSA. Modern researchers should therefore seek to investigate the reasons why smallholder farmers do the things they do, and attempt to improve on them. This is a more effective strategy than the prevailing approaches which seek to displace traditional technologies outright on the grounds that they are irrational, unscientific, primitive and backward.

The use of improved technology has the potency of increasing technical efficiency and consequently agricultural production among smallholder farmers. In a study by Maurice et al. (2015) in the Adamawa State in Nigeria, the authors concluded that under existing technology, the use of *agrochemicals, inorganic fertilizers and improved seeds contributed significantly to food crop output. However, these technologies are anti-green economy practices due to their repercussive effects, hence the use of green economy practices such as organic fertilizer application (for example composts) is believed to yield better and sustainable results.*

2.3 Smallholder farming in Ghana

Smallholder, according to Chamberlin (2008), connotes limited land availability and when the connotations are stretched, it is broadened to consider smallholder farmers as those that are "resource-poor" (e.g. those with limited capital including animals, fragmented holdings, limited access to capital). Because resource-poor households are a diverse group of people, Asuming-Brempong et al. (2004), in doing the Ghana's Poverty and Social Impact Analysis (PSIA) argued that different resource and risk conditions better define smallholders than simple measures of landholdings. A smallholder farmer in any part of Ghana is one who farms on less than five hectares (Ekboir et al., 2002). In another descriptive definition, the Ministry of Agriculture (MoFA, 2011), stated that agriculture is predominantly on a smallholder basis in Ghana and that about 90 percent of farm holdings are less than two hectares in size. In Ghana, the break-down of smallholder farmers into groups has largely been done to operate around agro-ecological zones; as pointed out by Asuming-Brempong et al. (2004), this has resulted in these farmers' inability to benefit from government targeted interventions such as provision of high-input and high-output technologies.

Smallholder farmers in general own small-based plots of land on which they grow subsistence crops and one or two cash crops relying almost exclusively on family labour. Some of the main characteristics of the production systems of smallholder farmers are: simple, outdated technologies; low returns; high seasonal labour fluctuations; and women playing a vital role in production. Smallholder farmers differ in individual characteristics, farm size, resource distribution between food and cash crops, livestock and off-farm activities, their use of external inputs and hired labour, the proportion of food crops sold and household expenditure patterns.

3.0 METHODOLOGY

3.1 Data Type and Source

Data for the study was sourced from the Ghana Living Standard Survey (GLSS 6) collected in 2012/2013. The GLSS 6 contains information on smallholder farmers, their input combination and yield. It also contains information on farm levels, household level characteristics and socio-demographic characteristics. The needs of the Savannah Accelerated Development Authority (SADA) areas were adequately catered for in this survey by increasing the number of primary sampling units (PSUs) and households from 580 and 8,700 to 1,200 and 18,000 respectively. This indicates an expansion in coverage of about 107 percent when compared to the previous round of the survey (GLSS 5). The sampling approach adopted for the GLSS 6 was the multi-stage approach, where 1,200 enumeration areas (EAs) were selected to form the primary sampling units (PSUs). The PSUs were allocated into the 10 regions using probability proportional to population size (PPS) and the EAs were further divided into urban and rural localities of residence. The secondary sampling units (SSUs) were generated from a complete list from the selected PSUs. At the second stage, 15 households from each PSU were selected systematically. This yielded a total sample size of 18,000 households nationwide (GSS, 2014).

3.2 Description of Methods

In order to achieve the objectives of this paper, two main methods are used. First, we test the hypotheses that access to credit and the use of technological equipment affect crop yield among rural and urban smallholder farmers, using an Ordinary Least Squares (OLS) model. Three separate models were estimated. The first is a pooled model for all rural and urban farmers, with rural farming as a dummy. The two other models are subsamples for only rural farmers and urban farmers independently. The Chow/F-statistics are used to determine whether the separate models or pooled model fits the data. The other reason for the separate models for rural and urban farmers is because of the differences in yield for rural and urban areas and also because rural dwellers have been documented as facing more problems in accessing credit. The use of the OLS estimation is deemed appropriate as the asymptotic properties of crop yield suggest a normal distribution having logged it to control for outliers. As shown in figure one, crop yield among rural and urban farmers is normally distributed, thus, symmetrical, hence the use of OLS is fit.

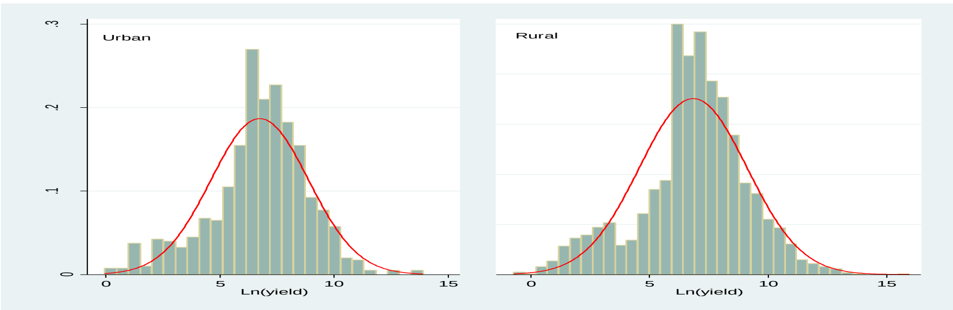

Fig. 1 Distribution of crop yield among rural and urban farmers

Source: Graphed by Authors using the GLSS 6 data

3.3 Empirical models

The following empirical models were estimated using OLS. Model one is the pooled model that regresses the yield per acre on farm-specific, household level and individual level characteristics regardless of location. Model two is specifically for smallholder farms in the rural areas while model three is for smallholder farms in urban areas.

Model 1: pooled model

$$Cropyldpa = \delta_0 + \delta_1 crop_i + \delta_2 credit_i + \delta_3 feqpt_i + \delta_4 landsize_i + \delta_5 hhsize_i + \delta_6 malefms_i + \delta_7 femfms_i + \delta_8 age_i + \delta_9 age^2{}_i + \delta_{10} landown_i + \delta_{11} loc_i + \delta_{12} female_i + \delta_{13} ezone_i + \varepsilon_i$$

Model 2: rural model

$$Cropyldpa_{rural} = \kappa_0 + \kappa_1 crop_i + \kappa_2 credit_i + \kappa_3 feqpt_i + \kappa_4 landsize_i + \kappa_5 hhsize_i + \kappa_6 malefms_i + \kappa_7 femfms_i + \kappa_8 age_i + \kappa_9 age^2{}_i + \kappa_{10} landown_i + \kappa_{11} female_i + \kappa_{12} ezone_i + \eta_i$$

Model 3: Urban model

$$Cropyldpa_{urban} = \lambda_0 + \lambda_1 crop_i + \lambda_2 credit_i + \lambda_3 feqpt_i + \lambda_4 landsize_i + \lambda_5 hhsize_i + \lambda_6 malefms_i + \lambda_7 femfms_i + \lambda_8 age_i + \lambda_9 age^2{}_i + \lambda_{10} landown_i + \lambda_{11} female_i + \lambda_{12} ezone_i + \gamma_i$$

Where:

Cropyldpa — *crop yield per acre*

Crop — *type of crop cultivated*

Credit — *access to credit (1=yes; 0=no)*

Feqpt — *farm equipment (1=yes; 0=no)*

Landsize — *landsize*

Hhsize — *household size*

Malefms — *number of male farmers*

Femfms — *number of female farmers*

Age — *age*

Age^2 — *age square*

Landown — *land ownership*

Loc — *location (0=urban; 1=rural)*

Female — *female headed households*

Eczone — *ecological zones*

3.4 A Priori expectations

The a priori signs are indicated for parameters of the pooled but these also apply to variables in the rural and urban models since the variables are the same in all models

$\delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = \delta_8 > 0$; $\delta_9 = \delta_{12} < 0$ and $\delta_1 = \delta_{10} = \delta_{11} = \delta_{13} = \pm$

3.5 Stochastic Dominance Analysis

The second method which verifies crop yield volatility among rural and urban smallholder farmers is the Stochastic Dominance Analysis (SDA). The SDA is used to refer to a set of relations that may exist between a pair of distributions. Commonly used in the analysis of income distributions and income inequality, SDA has also been applied in many other domains including agricultural economics. In this paper, the SDA is used to determine crop yield variability among smallholder rural and urban farmers in Ghana. To determine whether a relation of stochastic dominance holds between two categories of farmers (rural and urban), the distributions are first characterized by their Cumulative Distribution Functions (CDFs). For a given set of yields, the value of the CDF at yield y is the proportion of yields in the set that are no greater than y. In the context of a random variable Y, the value of the CDF of the distribution of Y at y is the probability that Y should be no greater than y.

We consider two distributions of farmers, rural (A) and urban (*B)*, characterized respectively by CDFs F_A and F_B. According to Davidson and Duclos (2013), the distribution *B* dominates distribution *A* stochastically at first order if, for any argument *y*, $F_A(y) \geq F_B(y)$. If *y* is measured as crop yield, then the volatility or disparity means that the proportion of farmers in distribution *A* with yields no greater than *y* is no smaller than the proportion of such farmers in *B*. Thus, there exits at least as high a proportion of low yield farmers in *A* as in *B*, if low yield means a yield smaller than *y*. If *B* dominates *A* at first order, then whatever maximum yield we choose as efficient, there is always more low yield in *A* than in *B*, which is why A is defined as a dominated distribution.

4.0 RESULTS AND DISCUSSION

4.1 Descriptive Statistics

The descriptive statistics are presented in Table 1. In general, the average yield per acre for all crops for all farmers is about 4173.025 kg per acre, when disaggregated, the averages are 4452.468 kg and 3006.637 kg per acre for rural and urban farmers respectively. These values have very high standard deviation indicating the presence of outliers. Fig 2 shows that such high yield is driven by yield among farmers who cultivate industrial crops (crops grown to produce goods to be used in the production sector, rather than food for consumption such as cocoa, coffee and cotton production, etc.). The average cereal yield per acre among urban and rural farmers are 2986.12kg and 2664.7 kg respectively. Farmers in rural areas experience lower yield in vegetable production than any other type of crops.

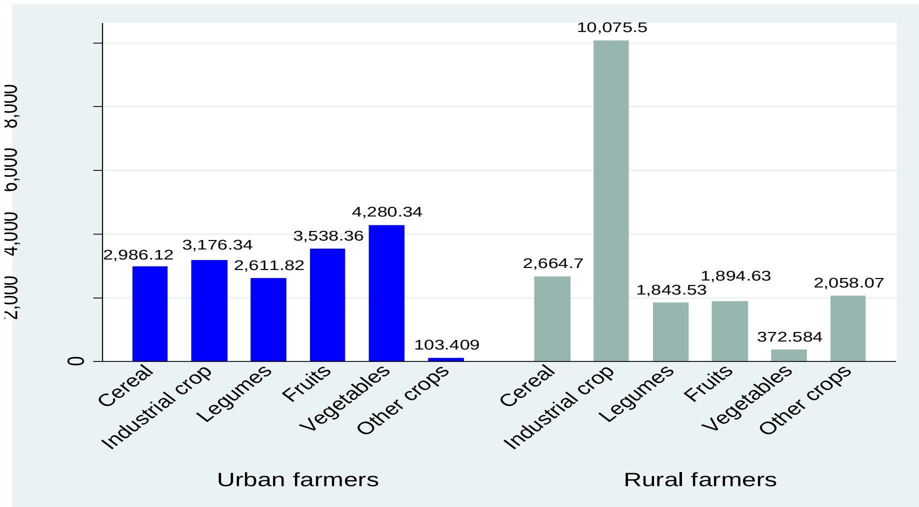

Fig. 2: Distribution of crop yield per acre among rural and urban farmers

Source: Graphed by Authors using the GLSS 6 data

About 11.3 percent of rural farmers accessed credit as compared to 14.6 percent of urban farmers. This suggests that relatively more farmers in the urban areas access credit compared to those in the rural areas. This is possibly due to the fact that many financial institutions are normally located in the urban settings as noted by Amoah-Mensah et al. (2013). More than 50 percent of farmers in the rural areas adopted at least one input technology on their farms while less than 50 percent of farmers in the urban areas adopted multiple input technology.

The findings revealed that about 81 percent of smallholder farm lands in Ghana are personally owned either through purchase or distributed by families, and in other cases, used by a farmer for free, though owned by another person. The descriptive statistics suggest that the average number of people within a farm household is about four, while the average number of male and female labourers employed on a farm is about two each.

Table 1: Descriptive Statistics

	Variable Description/Definition	Pooled		Rural		Urban	
		Mean	SD	Mean	SD	Mean	SD
Crop yield	Crop yield per acre; continuous variable	4173.025	56354	4452.468	61794.89	3006.637	22201.55
<u>Dummies for crop type harvested</u>							
Cereals	Cereals or not (1=yes/0=no)	0.655	0.476	0.642	0.480	0.708	0.455

Industrial	Industrial or not (1=yes/0=no)	0.216	0.411	0.222	0.416	0.188	0.391
Legumes	Legumes or not (1=yes; 0=no)	0.091	0.287	0.097	0.296	0.062	0.242
Fruits	Fruits or not (1=yes/0=no)	0.023	0.152	0.022	0.146	0.031	.0172
Vegetables	Vegetables or not (1=yes/0=no)	0.001	0.038	0.002	0.039	0.001	0.033
Other crops	Other crops (1=yes/0=no)	0.014	0.118	0.015	0.122	0.010	0.099
Credit	Dummy variable for whether the household has accessed credit or not (1=yes/0=no)	0.119	.0324	0.113	0.316	0.146	0.353
Farm equipment use	Dummy variable for whether the household uses equipment for farming or not (1=yes/0=no)	0.526	0.499	0.533	0.499	0.489	0.499
Land	Total land size cultivates in acres	0.552	0.471	0.544	0.472	0.586	0.461
Household size	Total household members	4.904	2.701	4.946	2.746	4.728	2.498
Male farmers	Number of males engaged on farm	1.739	2.177	1.751	2.260	1.688	1.782
Female farmers	Number of females engaged on farm	1.694	2.531	1.727	2.518	1.553	2.581
Age	Age of the household head	44.410	14.145	44.251	14.352	45.081	13.223
Age square	The square of the age of the individual	2172.319	1367.201	2164.10	1388.63	2206	1273.071
<u>Land ownership</u>							

Personal ownership	Dummy variable for whether farm land is personally owned or not (1=yes/0=no)	0.808	0.394	0.807	0.394	0.809	0.392
Rented	Dummy variable for whether farm land is rented or not (1=yes/0=no)	0.062	0.241	0.059	0.236	0.073	0.261
Shared cropping	Dummy variable for whether farm land is shared cropping or not (1=yes/0=no)	0.130	0.337	0.133	0.340	0.117	0.322
Rural	Dummy variable rural farming (1=yes/0=no)	0.809	0.393	-	-	-	-
Female	Dummy variable for female headed household (1=yes/0=no)	0.245	0.429	0.241	0.427	0.260	0.439
Ecological zone							
Coastal	Coastal or not (1=yes/ 0=no)	0.082	0.272	0.089	0.284	0.053	0.205
Forest	Forest or not (1=yes/0=no)	0.553	0.497	0.548	0.498	0.574	0.495
Savannah	Savannah or not (1=yes/0=no)	0.365	0.481	0.363	0.481	0.373	0.483

Source: Computed from GLSS 6

4.2 Regression analysis of crop yield among smallholder farmers in Ghana

The analysis and discussion are done for three models: pooled, urban and rural. For access to credit and technology, all models are analysed and discussed to ascertain the relative effect of these variables in these locations and to also inform policy directions. With regard to the rest of the variables, the model of focus is the pooled model that covers all smallholder farmers in Ghana, regardless of whether they are located in urban or rural areas. The chow test shows an F-statistic, which is significant at 1% level and this leads to the rejection of the null hypothesis that the coefficients in the urban and rural models are equal. This implies that the differences in beta coefficients in both models stem from differences in locational characteristics of smallholder farmers in rural and urban areas of the country. Thus, running the sub-sampled models gives preferable estimates compared to the pooled model. The set of explanatory variables included in the models explain about 17% of the variability of crop yield among rural and urban farmers respectively. These R-squares (although relatively small) are good enough for a cross-sectional analysis of this nature (Wooldridge, 2010). In addition, the Chi-square statistics in the two models indicate that the regression lines are good fit at 1% significance level.

The regression analysis results (Table 2) revealed that, in general, access to credit has a significant effect on the productivity of smallholder farmers. The pooled model showed that smallholder farmers that have access to credit obtain yields per acre that are 35.5 percent more than their counterparts that do not have access to credit at a significance level of one percent, holding all other variables constant. This significant effect is driven by increased yield among rural farmers as a result of accessing credit. Rural farmers stand a chance of increasing their produce by about 38.5% if they access credit. On the contrary, access to credit has no significant effect on yield among farmers in the urban areas. It suggests a relatively high opportunity cost for use of credit on farm activities among urban farmers. In the urban areas, farming is normally not the primary occupation among households, hence farmers will always have to sacrifice a significant part of their returns to invest in accessing credit for use in their farming activities. For the rural folks, farming is seen as a primary economic activity as about 80.9% of farmers used in this study are in a rural setting. This finding does not only support similar studies conducted in developing economies (e.g. Nwaru, 2004; Chisasa and Makina, 2013), but also demonstrates the significant role credit plays in improving the yields of rural smallholder farmers. This also rehashes the several calls that have been made to, increasingly, make credit available to rural farmers to aid them in increasing their productivity in terms of the yield per acre.

Technology adoption also significantly affects crop yield of the smallholder farmers. From the pooled model, smallholder farmers that adopted technology experienced yields per acre that are 65.7 percent more than farmers who did not adopt any farming technology, at a one percent significance level, holding all other variables constant. Among urban smallholder farmers, farmers who adopted technology had about 70.30 percent extra yield compared to farmers who did. In the rural areas, farmers who adopted technological equipment had yields that were 61.90 percent more than their counterparts who did not adopt technology in their farming operations. To this end, it can be inferred that adopting technology and the mix of it is very beneficial in increasing yield. This warrants the call on smallholder farmers to embrace the use of technology. They also need to be given more credit to enhance their ability to acquire the technology necessary for increasing yields. The technological effect is much felt among urban farmers than among rural farmers. Nkonya et al. (2004) advises that when implementing programmes that promote the adoption of technologies among smallholder farmers, there is need to create synergies among government departments, NGOs, researchers, donors and local communities. This will not only lead to increased agricultural productivity among smallholder farmers, but will also facilitate the reduction in environmental degradation and the improvement of soil quality.

The analysis controlled for own labour and hired labour input in the cultivation process. With respect to own labour, household size which was used as proxy, showed a positive impact on yield. In general, inclusion of an additional person to the size of smallholder farmers' households leads to an increase in crop yield per acre by 2.50 percent, at a five percent significance level, holding all other variables constant. Thus, households with many adult members have higher yields compared to those with fewer adult members. Such positive effect is not realized among farmers in the urban settings as this variable does not significantly affect crop yield per acre. Consistent with the general findings, rural farmers who have larger household size are better off in terms crop yield. This variable is statistically significant at one percent level. The reason for the differences in this effect between urban and rural areas is that in the urban areas, farm labour comes from outside the home while farm labour in the rural areas mainly comes from within the household. This is why an additional person to the household increases farm productivity in the rural areas but has no effect on the productivity of the urban smallholder farms.

In terms of hired labour, it was proxied with number of female and male workers engaged on the farm. For this gender dynamics of farm labour, we observed that while male labourers were much productive in the urban areas, such significant effect was not the case in rural areas. Instead, increased number of female labourers leads to increased productivity among rural farmers. This finding is in line with other studies in the literature which indicate that, relative to men, women with little training in good farm management practices make marginal productivity very high (Applefield and Jun, 2014). An increase in the number of females engaged in the smallholder farm by an additional person increases farm yield per acre by 6.3 percent at a one percent significance level, holding all other variables constant. This supports the fact that in Ghana women dominate rural farming. In terms of decision making, we noticed that female decision makers harvested lower yield. Thus, female smallholder farmers experienced about 48.30% lower yield compared to their male counterparts, all else being equal.

Regarding age and productivity, a non-linear relationship was found among rural farmers. While farmers are very productive below age 45, their productive capacity diminishes beyond age 45. Surprisingly, no significant effect was found among urban farmers. Among the rural folks, farmers below age 45 have about 29% extra yield more than those beyond 45 years. The implication is that farming should not be left at the mercy of the aged as is witnessed in most developing countries today.

Smallholder farmers that cultivated cereals, legumes, fruits, and other crops all experienced crop yield per acre that were 86.80 percent, 79, 42.30 and 90.40 percent respectively lower than what were experienced by farmers cultivating industrial crops. Cereals and legumes were significant at one percent while fruits and other crops were significant at five percent.

Smallholder farmers who farm on their own lands as well as those who practise shared-cropping realized lower yield per acre compared to farmers who cultivate on rented plots. Output of farmers that owned farm land was 24.3 percent and that of farmers that share-cropped was 26.1 percent lower than that of those who rented plots. The reason for these differences could result from land-renting farmers' obligation to work and pay for rent and still reap some profit from their enterprise.

Using coastal zone as a reference category, ecological dummies turn out to significantly influence crop yield among farmers in both urban and rural settings. Among the rural farmers, those in the forest and savannah belts had higher yields than those in the coastal belt.

Table 2: Determinants of crop yield among small holder farmers in Ghana

Log(crop yield per acre)	Pooled	Rural	Urban
Explanatory variables	Coefficients	Coefficients	Coefficients
Dummies for crop type harvested (Base= Industrial crop)			
Cereals	-0.868(0.083)***	-0.858(0.093)***	-0.844(0.180)***
Legumes	-0.790(0.150)***	-0.817(0.167)***	-0.243(0.340)
Fruits	-0.423(0.212)**	-0.331(0.233)	-0.699(0.479)
Vegetables	-0.740(0.980)	-1.712(920)*	0.831(0.232)***
Other crops	-0.904(0.357)**	-0.682(0.38)*	-2.543(0.628)***

Credit	0.355(0.102)***	0.385(0.119)***	0.155(0.186)
Farm equipment use	0.657(0.068)***	0.619(0.076)***	0.703(0.147)***
Land size	-1.626(0.072)***	-1.702(0.079)***	-1.274(0.161)***
Household size	0.025(0.012)**	0.037(0.014)***	-0.020(0.029)
Male farmers	0.019(0.016)	0.013(0.017)	0.098(0.046)**
Female farmers	0.057(0.012)***	0.063(0.013)***	0.021(0.023)
Age	0.029(0.013)**	0.027(0.015)*	0.038(0.032)
Age square	0.0003(0.0001)**	0.0002(0.0001)**	-0.0005(0.0003)
Land ownership (Base= Rented)			
Personal ownership	-0.243(0.123)**	-0.247(0.140)*	-0.197(0.251)
Shared cropping	-0.261(0.146)*	-0.272(0.164)*	-0.252(0.316)
Rural	-0.009(0.0818)	-	-
Female	-0.483(0.084)***	-0.466(0.096)***	-0.454(0.171)***
Ecological zone (Base =Coastal)			
Forest	0.274(0.154)*	0.315(0.165)*	0.510(0.443)
Savannah	0.577(0.159)***	0.463(0.172)***	1.347(0.425)***
Constant	6.739(0.425)***	6.729(0.421)***	-8.886(1.081)***
N	4002	3234	768
Prob > chi2	40.51***	36.88***	30.59***
R^2	0.156	0.165	0.165
Chow test (F=2.186)	0.0021		

Robust standard errors are in parentheses. *, **, *** significant at 10%, 5% and 1%, respectively.
Source: Authors' own computation using the GLSS6

4.3 Stochastic Dominance Analysis of crop yield volatility

In order to analyse crop yield volatility among the smallholder farmers, we controlled for the three main ecological zones in Ghana. This is because, the volatility of farmers' yield also depends on the climatic conditions within which the farmer cultivates. According to Wood (2013), variation in precipitation and temperature are controlled by the movement and interaction of continental and maritime winds. The evergreen rain forest, deciduous rain forest, transition and coastal savannah zones make up the southern half of the country. These agro-ecological zones have a bimodal equatorial rainfall pattern, allowing for minor and major growing seasons within the year. The Guinea and Sudan Savannah make up the northern half of Ghana. These agro-ecological zones have a unimodal tropical monsoon, allowing for only one growing season (major season). The single growing season in the north is bound by the harmattan period, which begins in December and ends in March. Generally, annual precipitation in Ghana ranges from 600mm to 2800 mm (ibid). Annual precipitation generally decreases from the hot and humid southwest coast, north, to the relatively hot and dry savannah (average of 1000 mm) whereas the lowest annual precipitation typically occurs within the warm southeast coastal savannah zone (600 to 1200 mm) (Oppong-Anane, 2001). Relative humidity also tends to decrease from south to north, creating a general increase in evapotranspiration potential in the north.

The three main ecological zones considered in this paper are the forest, coastal and the savannah. In the forest zone, the analysis shows that rural farmers first order stochastically dominate urban farmers. Thus, one can predict yield with higher degrees of certainty (i.e., lower cumulative probability levels) for rural farmers compared to the urban farmers within the same climate zone. The analysis for farmers in the coastal zone mimics similar trend as those in forest zone. Farmers who cultivate in the rural coastal areas are certain of higher crop yield compared to their fellow farmers in the urban savannah (Fig 3). Thus, in spite of the favourable weather conditions enjoyed by farmers in the forest and coastal zones of the country, urban farmers in these areas seem not to benefit much from this as their crop yields tend to be relatively lower.

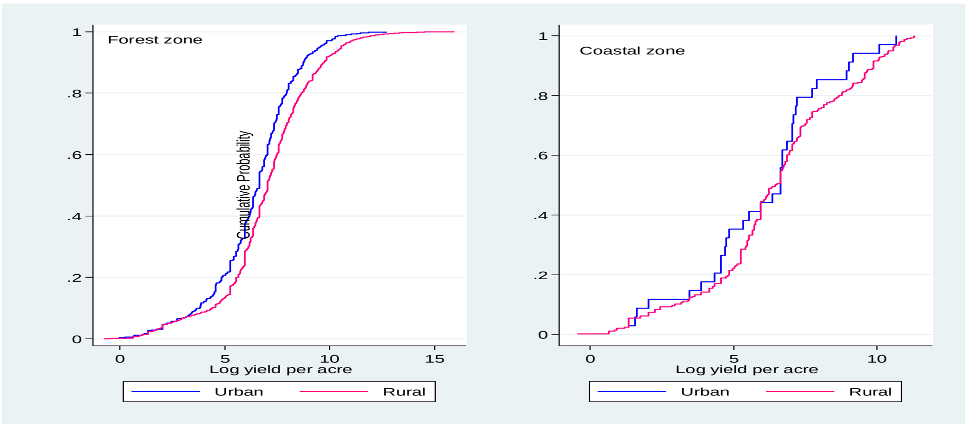

Fig. 3: SDA of Crop Yield Volatility-Forest and Coastal Zones

Source: Graphed by Authors using the GLSS 6 data

Contrary to the certainty of predicting yield among farmers in rural forest and coastal zones of Ghana, urban farmers in the savannah zone seem to perform better than rural farmers. Urban farmers stochastically dominate rural farmers in terms of crop yield. While urban farmers are certain of higher yield, their rural counterparts are not because the later have higher cumulative probability levels in crop yield. This is an indication that although the savannah zone of the country has low rainfall and other unfavourable weather conditions, urban farmers within the zone seem to employ adaptive measures to reduce the negative impacts of such weather conditions on their crop yield (Fig 3 and Fig 4).

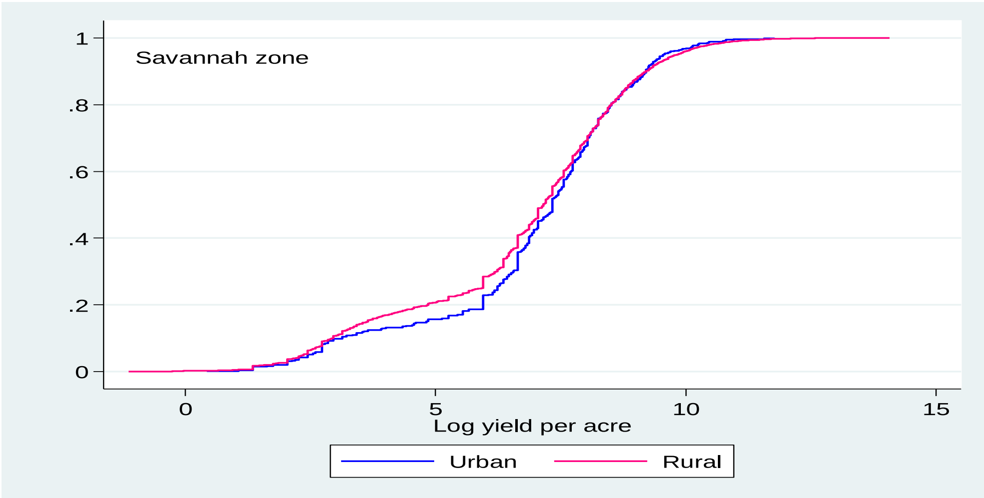

Fig. 4: SDA of Crop Yield Volatility among Smallholder Farmers-Savannah Zone

Source: Graphed by Authors using the GLSS 6 data

5.0 CONCLUSIONS AND POLICY RECOMMENDATIONS

The study sought to explore yield volatility among rural and urban smallholder farmers and also find out how access to credit and technological usage affect crop yields among smallholder farmers in Ghana. The OLS technique and the stochastic dominance analysis were employed on the sixth round of the GLSS 6 data.

The findings showed that in the forest and coastal zones, rural farmers' first order stochastically dominate urban farmers, while in the savannah zone, it is vice versa. This implies that rural farmers in the forest and coastal areas are more certain of higher crop yields compared to their urban counterparts, while in the savannah zone, urban farmers seem to be more certain and perform better than rural farmers. In terms of access to credit, the findings showed that, across the country, smallholder farmers that have access to credit obtain yields per acre, about 35.5%, more than their counterparts that do not have access to credit. This effect is significantly experienced by rural farmers, where they stand a chance of increasing their produce by about 38.5% if they have access to credit. On the contrary, access to credit did not have any significant effect on yield among farmers in the urban areas.

Smallholder farmers that adopted farming technology experienced 65.7% yields per acre, more than farmers who did not adopt any farming technology. This technology-adoption effect was more pronounced in the urban areas than in the rural areas (the effect was 8.4% more in the urban than rural areas). Based on these findings, we are proposing policies that increasingly make credit available to smallholder farmers, especially those in rural areas, so that they can increase their crop yields significantly. Such policies should ensure that cost of credit is reduced to promote access among rural farmers. The availability of credit will help smallholder farmers to acquire the needed technology that will increase their productivity. There is also the need for education on the use of technology among smallholder farmers in both rural and urban farmers.

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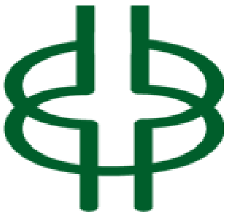

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