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REGULAR ARTICLE

ASSESSMENT OF AGRICULTURAL CREDIT SOURCES AND ACCESSIBILITY IN NIGERIA

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ABSTRACT

Rural and small holder famers in Nigeria and other developing countries have low capital base and poor access to finance. The inability of these farmers' access to adequate credit has increased the problem of low efficiency in production. Inadequate credit supply is a major problem with which other production factors may exert negative influence on farmers' output and efficiency. In ascertaining the sources and accessibility of credit by crop farmers in Enugu-Ezike in Enugu State, Nigeria, the sources of credit to farmers, the socio-economic characteristics of crop farmers' that have access to credit, access to credit constraints and possible ways of improving farmers' access to credit were investigated. Primary data collected through the administration of questionnaire were analysed using descriptive statistics and probit regression. Results showed that most crop farmers obtained credit mainly for farming and have accessed credit through informal sources, with friends and relatives being the most popular source. Majority of the farmers, who obtained information about credit through phone calls agreed that there were no delays in loan approval. Although, probit regression revealed that the independent variables (gender, age, marital status, education, household size, farm size, membership of cooperatives and farming experience) were not significant in jointly affecting access to credit at all probability levels, however, membership of cooperatives had an individually negative significant relationship with access to credit at the 10% ($p<0.10$) level. Recommendations that will improve access to credit include: increasing farmers' access to information; reducing loan acquisition rigidity; reducing interest rate; having bank account; establishment of community and agricultural banks in the rural areas with simple procedures for securing loans; and the mobilization of farmers into groups to maximize the benefit of collective investment or group savings.

Keywords: agricultural credit, access to credit, crop farmers, Enugu, probit regression
JEL: Q12; Q14; C81

INTRODUCTION

Agricultural credit has shown to be a great contributing factor to agricultural productivity and efficiency (**NNB, 2014**), as such, **Ijioma and Osondu (2015)** posited that agricultural credit insufficiency has been considered a hindrance to the development of rural farmers in Nigeria and the world at large. Credit is defined as the ability to obtain title to, and receive goods for use in the present, although payment would be differed to a future date (**Miler 1977**). **Dixon *et al.*, (2001)** described credit as the use of funds and services without immediate payment. However, agricultural credit is often discussed in monetary terms (**Dixon *et al.*, 2001; DBSA, 2005**). **Aku (1995)** is of the opinion that agricultural credits are loans extended to farmers for production, storage, processing and marketing of farm products. Such credit can be short, medium or long term, depending on its duration. Credit institutions range from well-developed and large sized commercial banks to localized small cooperatives. It can also be formal or informal (**Aku, 1995; CBN, 2004**). Yet, **Badiru (2010)** noted that other authors categorized credit sources into three, by including the semiformal institutions such as non-governmental organisation microfinance institutions (NGO-MFIs) and cooperatives. The formal credit sources serve intermediary function between depositors and borrowers and impose lower rate interests on farmers, which are usually subsidized (**Ijioma and Osondu, 2015**). The formal institutions include commercial, microfinance and rural development banks that offer credit to large and medium scale farmers, considered credit worthy, due to their potential to provide collateral (**Anyanwu, 2004**). The informal credit sources are friends, families, *Esusu*, *Ajo* and merchant traders that tend to be more flexible and operate mainly in a particular market niche (**Ghatak and Guinnane, 1999**). According to **Diagne and Zeller (2001)**, a farmer is said to have access if he is able to or entitled to borrow from a credit source (commercial banks, cooperative societies, money lenders, etc.). However, this study assumed access to credit, which is quite distinct from participation in the credit market, to be, when a farmer applies for credit and obtains at least 70% of the amount applied for.

The decline in agricultural productivity of the

Nigerian economy is considered to be a function of lack of credit facilities that have prevented farmers from adopting new technologies, due mostly as a result of farmers' inability to provide collateral for loans collected from various sources (**Asogwa, Abu and Ochoche, 2014**). Some researchers like **Carter (1989); Feder *et al.* (1990); Carter and Olinto (2003); Petrick (2004); Foltz (2004); Guirkinger and Boucher (2008);** and **Fletschner, Guirkinger and Boucher (2010)** perceive agricultural credit efficiency as the foundation of agricultural productivity, farm investment and profit. Conversely, other researchers, for example, **Kochar (1997)** is of the opinion that agricultural productivity is not dependent on credit. Now, considering this contradiction in the opinion of researchers, it becomes vital to study credit intensively. Explaining the effect of agricultural credit on agricultural output, **Hazarika and Guha-Khasnobis (2008)** reported that agricultural credit can have a secondary spillover effect on non-farm households via input, labour and output linkages. When farmers face a credit constraint, additional credit supply can raise input use, investment and hence output. Where agriculture still remains a risky activity, better agricultural credit facilities can help farmers smoothen out consumption, and therefore, increase the willingness of risk averse farmers to take risks and make agricultural investments. Hence, a better agricultural credit may lead to a higher volume of food output if the increase in credit is used to increase fertilizer, private investment in machines and food crops.

On the course of formulation, implementation and evaluation of policy in agricultural sector; efficiency and availability of irrigation systems, utilization of improved seeds, fertilizer availability and the ease of access to agricultural credit are issues of interest. Amongst these, access to credit is the major focus of policy makers, this is because the ease or availability of credit will facilitate the application of the other factors. Thus, agricultural credit is a key resource in the development of agriculture in developing countries (**Bashir, Mehmood and Hassan, 2010**). Therefore, since credit is vital in the adoption of innovations that would lead to increase in farm productivity and income (**Nwaru, Onyenweaku and Nwosu, 2006**), its acquisition and effective utilization will bring about an increase in farm output and efficiency (**Obwona, 2002**).

In Nigeria, agriculture is the backbone of the economy because without food and basic raw materials industries will be in crisis. Rural farmers in Africa make up more than 75% of the labour force in agriculture and 80% food producers (**Maigida 2001**). These farmers are constrained by issues of poor access to innovation, poor infrastructure, inadequate access to markets, land and environmental degradation, poor extension and research services and finally the inability to consider and improve the financial requirements of these farmers (**Lawal, 2011**). The effect of finance in the development of any sector of the economy cannot be outsourced and agriculture is not an exception. Credit institutions in Nigeria, lack formal credit policy and paucity which can assist farmers to access credit and is one of the reasons for the decline in agricultural contribution to the economy (**Olagunju and Ajiboye, 2010**). Similarly, farmers are also faced with the problem of late loan release or disbursement, non-fulfilment of collateral requirements, diversification of funds by financial institutions for non-agricultural purposes (**Nwaru, Essein and Onuoha, 2011**). The informal or non-institutional sources of agricultural credit cannot be said to be adequate and efficient in terms of providing finance for crop production (**Nwaru, 2004**).

Furthermore, **Magaja and Agai (N.D.); Awotide *et al.* (2015); Linh *et al.* (2019); Okoruwa *et al.* (2020)** insinuated that rural and small holder famers in developing countries (such as Nigeria), have low capital base and poor access to finance. Thus, the inability of these farmers to have access to adequate credit has increased the problem of low efficiency in production. Inadequate credit supply is a major problem with which other production factors exert negative influence on farmers' output and efficiency. For farmers that were opportune to have access to credit, the problem of low efficiency in productions still comes up in situations where there is wide difference between the amount requested and the amount actually paid (**Akinade, 2002**). Considering the benefit of credit or finance in agriculture and other sectors, it is pertinent to study and analyse the sources of credit and the determinants of its accessibility by crop farmers.

Many research works have been carried out on access to agricultural credit (**Diagne and Zeller, 2001; Nwaru, 2004; Muhammad *at al.*, 2013**); some tried to compare the effect of interest rate on access (**Ali *et al*., 2017**); some focused on access by specific farmers (**Bashir, Mehmood and Hassan 2010**); some worked on sources of credit (**Guirkinger, 2008; Ijioma and Osondu, 2015; Mgbakor, Uzendu and Ndubuisi, 2014**); some confined access to small scale farmers (**Badiru, 2010; Asogwa, Abu and Ochoche, 2014**), etc. These and many more works on this aspect stand to show that credit plays a vital role in agriculture. However, little or none has been carried out on crop farmers especially in Enugu Ezike Agricultural Zone of Enugu State, who are predominantly farmers. Thus, this work intends to fill the knowledge gap.

The broad objective of our study was to examine and analyze agricultural credit sources and its accessibility by crop farmers in Enugu-Ezike agricultural zone of Enugu State, Nigeria. The specific objectives include:

i. identifying the socio-economic characteristics of crop farmers;
ii. ascertaining the sources of credit to farmers;
iii. determining the socio-economic determinants of crop farmers' access to credit;
iv. identifying the constraints in the procurement of credit from formal sources; and
v. identifying the possible ways of improving farmers' access to credit.

DATA AND METHODS

The Study Area

This study was conducted in Enugu-Ezike agricultural zone of Enugu State, Nigeria. The zone is made up of three Local Government Areas (LGA), viz: Igbo-Eze North, Igbo-Eze South and Udenu LGAs with an aggregate population of 584,880 people (**NPC 2006**). The Enugu Ezike agricultural zone is situated at about 233 metres above sea level and has predominantly gravely-silt soil that is well drained all year round, mostly reddish in colour and has a high density bearing capacity for intense building construction. It lies within the northern fringes of the tropical rainforest zone and the southern end of the derived savannah vegetation belt, with two distinct alternating wet (rainy) and dry (harmattan) seasons, which lasts for about eight months and four months respectively. Its rainfall ranges from about $0.16CM^3$ in February and $35.7CM^3$ in July, with a mean temperature that ranges from about $15.86^{O}C$ to $30.64^{O}C$ (**Ani, 2015; ESG, 2018**). Farming is the major occupation and source of income in the zone, with crops such as maize, vegetables, yam, cassava, etc. being produced and livestock such as poultry, goat, sheep, pig, etc. being reared. They also engage in other occupations including civil service, trading, hunting, palm wine tapping and so on (**William, 2008**).

Data collection

Primary data were collected for the study by administering semi-structured questionnaires to selected farmers in a two stage random sampling technique. Stage one involved selecting ten (10) communities from each of the 3 LGAs giving a total of 30 communities. In the second stage, two (2) crop farmers were randomly selected from each of the 30 communities, giving a total of 60 respondents for the study.

Data Analysis

Descriptive statistics such as tables, frequencies and percentages were used to present and analyze data to achieve most of the objectives. A 4-points Likert scale type rating, having 'Strongly Agree', 'Agree', 'Disagree', and 'Strongly Disagree' was used to determine the problems or bottlenecks experienced by farmers which tend to hinder their access to credit. Probit regression analysis was done using a multiple linear model. Probit regression analysis was done using a multiple linear model because the dependent variable is a dichotomous variable. This was adopted in line with the study by **Ajagbe (2012)**, who applied the probit regression model to determine the relationship between farmers' access to credit and their socioeconomic characteristics. The model is given below.

The implicit function of the regression model is given as Eq. 1.

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8) \quad (1)$$

While the explicit form is given in the linear equation (Eq.2):

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \varepsilon \quad (2)$$

Where: Y = access to credit (when at least 70% of the amount requested is received), X_1 = age of the crop farmer (years), X_2 = gender of the farmer (male=1 or female=0), X_3 = marital status (married=1, otherwise=0), X_4 = farm size (hectares), X_5 = educational level (No formal education = 0, primary education = 1, secondary education = 2, tertiary education = 3), X_6 = farming experience (years), X_7 = ownership of land (own land=1, otherwise 0), X_8 = membership of cooperatives (member=1, otherwise 0), ε = error term.

RESULTS AND DISCUSSION

Socio-economic characteristics of the crop farmers

The major attributes of individual crop farmers that were considered in the study are summarized in Table 1.

From Table 1, a higher percentage of the respondents fall within the ages of 21-40 years indicating that the farmers in the study area are young farmers. The statistic is important to the government and individual as it shows that even though, there are fears of high rural-urban migration, the population of young people in the rural areas are still high. The participation of young people is also a push factor towards innovation adoption as youths are likely to try out new methods and adopt new technologies than the older people. Majority of the respondents were male. This is most likely due to the fact that women in the study area are culturally not allowed to inherit land and farmers in Nigeria usually engage in labour-intensive agriculture, as corroborated by **Ololade and Olagunju (2013)**. The high percentage of married respondents indicate that most of the farmers are saddled with a higher level of responsibility, as such, there is need to engage in economically productive activities that will provide them the resources needed to carter for their families, in supplying the basic needs of life, such as food, clothing, shelter and so on. Most respondents own farmlands ranging from one to five hectares, this may probably be the reason why most of the respondent's access to credit is through informal sources because they lack adequate collateral to offer for formal loan acquisition. Almost all the respondents have had at least one form of formal education or the other, making it easier for them to adopt innovations and circulate information, as such, learning will have a positive shift as education helps to increase awareness and acceptance of facts. The higher the farming experience, the more likely a farmer is to be trusted by formal credit sources, such as government agencies, commercial banks, etc. However, the result shows that many of the farmers have less than 10 years' experience in farming. This may also be one of the reasons why the crop farmers mostly lacked access to the formal sources of credit. Majority of the respondents owned the lands they farm on, this will bring about a positive impact in access to credit as the land owned can be used for collateral. However, the ability to use the lands as collateral will be dependent on the size of the land owned and the availability of documents indicating ownership. Many farmers do not belong to a cooperative, implying that most of the farmers will be constrained from accessing credit and will lack the benefits enjoyed by members of the cooperative society and as such, will have no option than to access credit from informal sources, rather than formal or semi-formal sources, where they can easily meet credit requirements.

Farmers' access to credit

Table 2 shows the information gathered from the crop farmers about their credits.

Table 1: Descriptive statistics of the socioeconomic characteristics of the respondents

S/N	Socio-economic characteristics		Frequency	Percentage
1.	Age	21-40	39	65
		41-60	15	25
		61 and above	6	10.0
		Total	60	100.0
2.	Gender	Male	43	71.7
		Female	17	28.3
		Total	60	100.0
3.	Marital Status	Married	51	85.0
		Single/divorced/widowed, etc.	9	15.0
		Total	60	100.0
4.	Farm size	Below 1 ha	10	16.7
		1 – 5ha	45	75.0
		Above 5 ha	5	8.3
		Total	60	100.0
5.	Education	No formal education at all	2	3.3
		Primary education	12	20.0
		Secondary education	27	45.0
		Tertiary education	19	31.7
		Total	60	100.0
6.	Farming experience (in years)	Less than 10	41	68.3
		11-30	15	25.0
		Over 30	4	6.7
		Total	60	100.0
7.	Land ownership	Yes	47	78.3
		No	13	21.7
		Total	60	100.0
8.	Cooperative membership	Yes	13	21.7
		No	47	78.3
		Total	60	100.0

Source: Field survey

Table 2: Farmers' access to credit

S/N	Item		Frequency	Percentage
1.	Sources of credit	Formal	24	40.0
		Informal	36	60.0
		Total	60	100.0
2.	Ways of obtaining credit	Bank	11	18.3
		Friends and relatives	34	56.7
		Cooperatives	1	1.7
		Esusu	7	11.7
		Age group	6	10.0
		Church	1	1.7
		Total	60	100.0
3.	Reasons for obtaining credit	Farming	46	76.7
		Education	3	5.0
		Feeding	1	1.7
		Trading	10	16.7
		Total	60	100.0
4.	Delay in receiving credit	Yes	28	46.7
		No	32	53.3
		Total	60	100.0
5.	Information source	Radio and television	10	16.7
		Agric. extension agents	9	15.0
		Telephone calls	41	68.3
		Total	60	100.0

Source: Field survey

The source of credit often chosen by farmers is dependent on the ease of accessibility and other factors. The result above shows that most of the farmers chose the informal sources over the formal sources. This may be probably due to the farmers' low farming experience, small farm size and non-cooperative membership. As seen in Table 2, a good percentage of the farmers source their credit from informal sources, such as friends and relatives, rather than from semi-formal sources like cooperatives and churches or formal sources like banks. Most probably due to the fact that the farmers can easily draw sympathy from these group of people and the conditions required to access such loans are usually not stringent. Thus, reflecting the important role played by friends and relatives in access to credit by crop farmers. Farmers access credit for several reasons, such as farming, trading, education, feeding, etc. Most of the farmers' source for credit for use in farming activities indicating that their interest is in increasing productivity or output, with a view to better their standard of living through agriculture. Although, a good proportion of the farmers agreed that there were delays in receiving the credits, a higher proportion, however revealed that they had no delays in receiving the credits. This is important because of the characteristics or nature of agricultural production in Nigeria, as farmers may decide to access credit for farming, especially at the critical points of the production process. Similarly, the greater the delay in credit approval, the lesser the farmers' access to credit. As the world is going digital, the use of radio and television and extension agents for information transmission is reducing. However, this does not mean that they are no longer useful. From the result obtained, the mostly used information source is the telephone. This means of information dissemination, is relatively cheap and saves time compared to others.

Amount of credit sought and obtained

The data collected in Table 3 reflects the actually amount of credit sought for, in Naira (N) terms, by the crop farmers and the amounts that they actually obtained from their sources.

The average amount of credit a farmer sought for in the study area was N138,083.33K (about US$386.25, at an exchange rate of N357.5/US$), indicating that most of the farmers operate mostly on a subsistence level. This may be partly due to the fact that most times, the credit is often sought after production activities have commenced, perhaps at critical points, as the average amount sought is small and may be needed only for the acquisition of additional inputs in small quantities. An average amount of N110,583.33 (about US$309.32) was received by a farmer who sought an average of N138,083.33 (about US$386.25), thus, giving a difference of N27,500.00 (about US$76.92) or 19.92% of the amount sought. Hence, it is advisable for the farmers to add a 19.92% to the amount of loan they are seeking from friends and relatives, if they really want to get the exact amount they should have sought for. For instance, a farmer who needs N200,000.00 (about US$559.44) should be seeking for about N240,000.00 (about US$671.33), since there is a high probability that (s)he will get 19.92% less than the amount requested as loan from relatives and friends.

Socio-economic factors affecting access to credit

The results of the probit regression done to determine which of the socio-economic characteristic of the crop farmers sampled had effect on farmers' access to credit is presented in Table 4.

Table 3: Amount sought for vs Amount obtained

S/N	Description	No. of Obs. (N)	Min.	Max.	Mean	Standard Deviation
1.	Amount sought (N)	60	10,000.00	800,000.00	138,083.33	206,521.00
2.	Amount obtained (N)	60	10,000.00	700,000.00	110,583.33	157,275.78

Source: Field survey

Table 4: Socio-economic factors affecting crop farmers' access to credit (Results of the probit regression)

Variable	Coefficient	Standard Error	Z-score	p > |z|	95% Conf. Interval	
GENDER	-.0580001	.5671005	-0.10	0.919	-1.169497	1.053496
AGE	-.0477376	.0301484	-1.58	0.113	-.1068273	.0113522
MARITALST	.2541245	.6642662	0.38	0.702	-1.047813	1.556062
EDUCATION	-.1687247	.1817173	-0.93	0.353	-.5248842	.1874347
HHDSIZE	.120358	.1580503	0.76	0.446	-.189415	.4301309
FARMSIZE	.0035204	.1739192	0.02	0.984	-.337355	.3443958
MEMCOOP	-1.075456	.5754998	-1.87	0.062	-2.203415	.0525026
FARMEXP	.0240439	.0346894	0.69	0.488	-.043946	.0920338
Cons	2.725033	1.188525	2.29	0.022	.3955659	5.0545
Number of Obs.		60				
LR Chi^2 (8)		11.68				
Prob > Chi^2		0.1660				
Log likelihood		-26.755944				
Pseudo R^2		0.1792				

Source: Authors' computation

The socio-economic variables considered as independent variables for this study were gender (GENDER), age (AGE), marital status (MARITALST), education (EDUCATION), household size (HHDSIZE), farm size (FARMSIZE), co-operative membership (MEMCOOP) and farming experience (FARMEXP), while the dependent variable was farmers' access to credit (ACCTOCRE). From the results, we accept the null hypotheses and reject the alternative hypotheses, since the value of prob>Chi^2 (0.1660) is not significant at the 1% ($p<0.01$), 5% ($p<0.05$) or 10% ($p<0.10$) probability levels. As such, it can be deduced that all the variables jointly were not significant in affecting access to credit. Even though all the independent variables were jointly not significant in affecting farmers' access to credit at all probability levels, membership of a cooperative society with a coefficient of -1.075456 and a probability ($p > |z|$) of 0.062 was; however, significant at the 10% ($p<0.10$) probability level. In essence, membership to cooperative societies has an inverse relationship with access to credit. This means that as membership to cooperative societies decreases by one unit, access to credit decreases by 1.075456 and vice versa, *ceteris paribus*. In other words, the more cooperative societies a crop farmer belongs to, the lower the access to credit and the lower the number of cooperatives a farmer belongs to, the higher the access to credit from friends and relatives. This is probably due to the fact that crop farmers who belong to one or more cooperative societies are most likely to access loans from their cooperative and other formal and semi-formal sources, rather than from friends and relatives. The result is similar to findings by **Assogba *et al.* (2017)**, who suggested that belonging to farmers' cooperatives or associations was found to increase the likelihood of access to formal and semi-formal credit by 31%. Conversely, the more a farmer has access to credit from friends and relatives, the less likely it will be, for the farmer to join a cooperative society, as there is probably no reason for a farmer to join a cooperative in order to be able to access credit from formal or semi-formal sources, since friends and relatives could provide the funds required without delays, with just a telephone call.

Constraints to access to credit from formal sources

Results obtained from the field study through the 4-points Likert scale type rating identified some constraints to access to credit from formal sources, as presented in Table 5.

Analysing the data presented in Table 5, lack of collateral can be seen to be a major contributing factor to lack of access to credit by crop farmers. Untimely disbursement of credit has also been seen as a factor constraining crop farmers' access to credit. Since most of the respondents either agreed or strongly agreed, interest rate can therefore be said to be a great contributing factor to crop farmer's access to credit. This is important because, whenever credit is mentioned, the enquiries to be made, normally starts from the interest rates involved. A good proportion of the crop farmers are of the opinion that lack of knowledge of the rules and regulation of banks on credit contribute to farmers' credit inaccessibility, thus, constituting a hinge to farmers' access to credit. Since most of the farmers either strongly agreed or agreed, lack of access to credit information also plays a major role in determining whether or not a farmer can access credit. Similarly, a greater proportion of the farmers opined that the transport cost involved in getting to the area where credit is available can also be a problem to farmers' access to credit. As such, the further away the credit source is from the farmers, the more likely their access is reduced. A high percentage of the farmers were in agreement that the difference between the amount requested and the amount released affects their accessibility to credit, hence, it is a factor of lack of access to credit. Most of the farmers believed that formal institutions issuing credit, are charged with procedures viewed by the farmers as complex. This perception of the farmers, prevents them from accessing credit. The crop farmers in the majority, held the view that farmers' access to formal credit can be reduced by delays in approving and obtaining credit.

Possible ways of improving farmers' access to credit

There are possible ways of improving farmers' access to credit, data collected from the field is presented in Table 6. The Likert type scale rating was used in collecting data on the ways by which farmers access to credit can be improved.

Table 5: Constraints to access to credit from formal sources

S/N	Constraint	Strongly Agree (%)	Agree (%)	Disagree (%)	Strongly Disagree (%)
1.	Lack of collateral	20.00	73.33	6.67	0.00
2.	Untimely disbursement of credit	26.67	60.00	13.33	0.00
3.	Interest rate	48.33	45.00	5.00	1.67
4.	Lack of knowledge of bank rules and regulations	26.67	58.33	10.00	5.00
5.	Lack of access to credit information	50.00	36.67	8.33	5.00
6.	Cost of transportation to the area of credit availability	25.00	46.67	8.33	20.00
7.	Difference between the amount sought and the amount obtained	55.00	30.00	13.33	1.67
8.	Formal institutions issuing credit have procedures that are complex	33.33	45.00	15.00	6.67
9.	Delays in approving and obtaining credit	60.00	20.00	10.00	10.00

Source: Field survey

Table 6: Ways of improving farmers' access to credit

S/N	Ways of improving access to credit	Strongly Agree (%)	Agree (%)	Disagree (%)	Strongly Disagree (%)
1.	Improve information access	15.00	81.67	3.33	0.00
2.	Availability of assets for collateral	26.67	63.33	10.00	0.00
3.	Reduced rigidity	40.00	50.00	10.00	1.70
4.	Interest rate subsidy	35.00	50.00	11.67	3.33

Source: Field survey

The result in Table 6 shows that to improve access to credit, information access should be improved, since almost all the farmers agreed that improved information access improves farmer's access to credit. Similarly, majority of the farmers see the availability of assets to be used as collateral as an important factor to farmer's access to credit. Apart from availability of assets for collateral, most crop farmers believed that reduced rigidity can serve as a means of improving access to credit to farmers. Also, a greater proportion of the farmers were of the opinion that if interest rates were subsidized, it will improve their access to credit.

CONCLUSION

Crop farmers in Enugu-Ezike agricultural zone, through telephone calls obtain credit from informal sources, mostly from friends and relatives for investment in farming activities without delays. With an average amount of N138,083.33 (about US$386.25) sought, the farmers get about N110,583.33 (about US$309.32) or 80% of the credit they seek. None of the socio-economic variables were significant at the 1 and 5% probability levels, with only membership of cooperatives being significant at the 10% probability level. Farmers were constrained to access credit due to factors such as lack of collateral, untimely disbursement of funds, unfavourable interest rates, lack of knowledge of bank rules and regulations, lack of access to credit source, difference between amount sought and obtained, cumbersome procedures of formal credit sources and delays in obtaining credit. However, farmers' access to credit can be improved through improved access to information, availability of collateral, reduced rigidity of credit administration and availability of subsidized credit.

It is obvious that small scale farmers form the bulk of agricultural producers in Nigeria, thus, it is necessary to encourage agricultural development through the provision of credit, enhancing accessibility to credit and educating farmers on how to put the credit obtained to effective use in order to increase their productivity and output, thereby, ensuring food security

This study recommends as follows:

i. The amount allocated to the agricultural sector in the national budget is always very low compared to other sectors. It is from this allocation that the ministry of agriculture carries out its activities, of which credit disbursement is included. An increase in the allocation, will increase credit availability and access, *ceteris paribus*. Therefore, the government should increase its allocation to the agricultural sector, with a view to making more funds available to farmers for increased agricultural production.

ii. Financial institutions such as agricultural and community banks, microfinance banks should be established in the zone.

iii. Farmers usually complain of the procedures involved in credit access. The procedures should be reviewed and simpler ones brought forward. Duration for processing loans should also be minimized.

iv. Government agencies and extension service providers, should mobilize farmers to form formidable groups so that they can derive maximum benefit of collective investment, of group savings and access to inputs.

v. Government should help to reduce the interest rate charged on credit so that farmers can apply for credit from formal sources.

vi. The farmers should try to improve on their education, so that they can have knowledge, skills and attitudes to tackle any problem that may arise in accessing credit.

vii. The level of credit needed by farmers should be considered, by ensuring that the amount of credit released by the financial institutions is equivalent to the amount requested by the farmers.

viii. Policy measures for improving access to credit should be developed based on farmers' preferences and needs. Institutional capacity building for both lenders and borrowers should be an integral part of every credit program that will be provided in order to increase agricultural productivity and the income of farmers.

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REGULAR ARTICLE

DETERMINANTS OF PASTORALISTS' CHOICE OF CAMEL PRODUCTION AND PRODUCTION SYSTEMS IN EASTERN ETHIOPIA

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ABSTRACT

This study aspires to identify determinants of pastoralists' choice of camel production and production systems in Korahay zone of Somali regional state, eastern Ethiopia. A cross sectional survey methods were applied to collect data from 158 sampled households in which 84 households were camel owners obtained through snowball sampling approach and remaining 74 households were non-camel owners obtained by using random sampling technique from three districts of Korahay zone in Somali regional state namely Kebridahar, Shelabo and Shekosh. The results of binary probit regression model revealed that socio-economic determinants including total livestock unit, farm income, non-farm income; herd size and distance from the nearest market were found to positively influence the likelihood of owning camels. Where, other determinants like age of the household head, household size and education level, dependent ratio, and distance from extension service were found to negatively influence the likelihood of owning camels. The overall regression model used indicated significant at 1% significance level (p=0.0013) which imply that all the supposed determinants jointly influenced the decision of pastoralists choice of camel production. In the study areas, majority of camel producer (77.8%) rear camels for income generation, milking production, social and cultural functions. The three main production systems in the study areas were transhumant (71.5%), sedentary system (19.6%), and pastoral nomadic (8.9%), which seems nomadism disappearing in the study areas. Feed shortage (30.4%), drought and water shortage (41.8%), disease prevalence (18.3%), and market problems (9.5%) are the major constraints of camel production in the study area. Majority of pastoralists in Korahay zone of Somali region (77.2%) use extensive camel management system, and they cover long distance of around 12 to 18 km every day for grazing and browsing activities. In general, policy makers and government bodies should take in to consideration these variables determining the choice of camel production, and the current more pressing problems for pastoral communities such as drought and water shortage, lack of veterinary services, market problems, lack of enough capital for investment, and low access to credit services. It is strongly believed that consideration of these problems can enhance the life and livelihood of pastoral communities.

Keywords: Camel, Determinants, Livestock, Pastoralists, Production, Ethiopia
JEL: C01; C13; D13; Q12; Q18

INTRODUCTION

Pastoralism is a culture, mode of production, in Africa especially in the horn whereby pastoralists depend on their livestock (Camel, Sheep and Goats, Cattle), they migrate seasonally due to rainfall and pasture availability. Many scholars defined pastoralism as proud livestock based production system, which is mainly extensive in nature (**Hatfield and Davies, 2006; Mukherji *et al.*, 2017**).

Since the last three decades, pastoralism shows dramatic change in their socio-economic and livelihood systems which were triggered by interruption of wet and dry season grazing patterns, drought and change in land use and all these negative implications affecting livestock population and production **Hartmann and Sugulle (2010).** The changing contexts in which pastoralists operate raise the issue of sustainability of pastoral systems in Africa, particularly in the conflict-prone areas of the Horn of Africa.

In Sub-Saharan African countries, livestock are vital as a source of livelihoods and increasing future global demand for livestock and livestock products indicate greater opportunities for African livestock producers. Livestock production significantly contribute to the pastoralists' economy and is the major source of household wealth and supply end products that include milk, meat and hides and skins and used as transport. However, challenges of camel producers is very complex and complicated with policies and institutions related with the sector, this challenges are not technical (**Too *et al.*, 2015**).

Livestock production makes significant contribution to the pastoral livelihoods, consumption commodity, household income and food security improvement. In the drylands of Ethiopia among other livestock types camel is a great asset recorded as avenue for life and livelihoods improvements. Since, camel is the only large mammal capable of inhabiting the arid lowlands, Somali pastoralists real extensively for their milk, meat, and transportation service and wealth status. Although Ethiopian pastoralists rear large number of camels, the official surveys estimate a total camel population in

Ethiopia is most likely an under-estimate. The unique geographical, economic, social and cultural fabric of this biosphere is less known to the outside world even to many Ethiopians, as pastoralists were marginalized in the past (**Tefera *et al*., 2013**).

In fragile environments, camel contribute significant role for the improvement of pastoralists and agro-pastoralists live, as a drylands animal species it has an incomparable advantage compared with other livestock since it is the only livestock species capable of producing meat and milk when all other animals are limited by dehydration (**Tura *et al* 2010; Simenew *et al*., 2013).** Furthermore, most of its products are nutritious, healthy and have medicinal value. Under Ethiopian context, though the camel is an economically, socially and environmentally important animal, but among the least studied livestock species (**Seifu, 2007; Tefera and Abebe, 2012**). Camel is the most respected and prestigious animal species for pastoralist and agro-pastoralist communities. In economic value, camel fetches the highest price in livestock marketing and its value is equated to 44 heads of shoats **(Badiye *et al*., 2011; and Bediye *et al*., 2018**).

Currently, the estimation of camel population in Ethiopia was 4.5 million (**LMP 2014; Shapiro *et al*., 2015**) in which camel production of the Somali region pastoralists accounts for about 58 percent of the total country's camel population and the rest five pastoralists regions of the country account for 42 percent of the national camel herd. The camel is often regarded as symbolic of Somali people. For Somali pastoralists' camel is one of the basic indication and symbol of love, and status and wealth. Historically, camels were a valuable commodity used by the ruling classes and by the business community (**Kumar, 1994**). Despite Somali pastoralists has continuing emotional linkage with the camel; pastoralists in the region still involved in other animal husbandry like cattle, sheep and goats. Interviewed elders in the study area indicated, young individuals are not interested in keeping camel instead they seek wage labour in villages and urban areas. Camel is among least domestic animals, research on camel is a recent initiative and there are major gaps of knowledge and technology to improve overall productivity and pastoralist livelihood (**Bediye *et al*., 2018**). The scientific research in camel deals with basic science and technology transfer, its approach would make immense contribution to bring effective impacts on pastoralists' livelihood (**Seifu, 2007**). Besides the significances, research effort on camel in Ethiopia has also lagged behind other species and an urgent course of action is needed to benefit pastoralists and agro-pastoralists. The gaps in camel research can be bridged by strengthening and developing different research projects in pastoral setting to use modern production tools and techniques among the pastoralists. The future of camel producing pastoral societies in Somali region is debated by scientists, and pastoralist groups themselves. Therefore, this study is intended to assess the determinants of pastoralists' choice of camel production, and its impacts on pastoralists' livelihoods in the study area.

DATA AND METHODS

Study area

Somali regional state of Ethiopia is the second largest region of the country following Oromia region by having a land cover of 350,000 Kilometer Square. It has a border with Somalia, Djabouti and Kenya countries. Similarly, Somali region bordered with Afar and Oromia regions in West. Somali region has 93 districts and 11 zonal administrates in which Korahay is one of them. Korahay zone had in 2007 a total population of 312,713, of whom 177,919 were men and 134,794 were women (CSA, 2007). The inhabitants of the Korahay are predominantly pastoralists. Korahay zone located at 1004.1 km from Addis Ababa the capital city of Ethiopia. The topography of the study area is predominantly lowland plain. Korahay zone climate characterized as tropical and semi-arid in which temperature ranges from 23 to 36ºC. The area has bimodal rainfall pattern with two main rainy seasons in which the first is 'Gu' that occurs from mid-April to the end of June. The second rainy season known as 'Deyr' occurs from early October to late December.

In the Somali region, camel is a leading animal because of the multipurpose role it has on the provision of milk, meat, social and cultural importance besides unpaid transport service. This national survey (CSA, 2007) indicated that Korahay zone has 115,498 total number of camel and 5 number of camel per square kilometer which makes Korahay zone the second richest zone in camel production following Warder Zone of Somali regional state.

Data collection technique and data sources

Structured questionnaire combined with guided interviews were used to collect information from both camel owners and no-owners from selected three districts in Korahay zone namely Kebridahar, Shilabo and Sheygosh. Both primary and secondary data were collected from their respective sources. Camel owners obtained through snowball sampling approach and non-camel owners obtained by using random sampling technique since mobility, nature of access, under development of the infrastructure in pastoralists' areas make difficult to apply random sampling technique camel owners were selected based on camel possessions and willingness to be part of the survey.

Sampling technique and sample size determination

This study used multi-stage sampling technique to select the target districts and respondents. Districts within Korahay zone are stratified based on the estimated camel population, after stratification district with the highest camel populations are selected for consideration. The households of the selected districts are grouped into two important categories (With and without camels). The snowball-sampling technique was used due to rare and unknown of the households owning camels. To determine the sample size of the study formula developed by **Saxena *et al*., (2010)**, specified in (Eq. 1).

$$n = (z^2 * p * q)/e^2 \quad (1)$$

Where: *n* is the required sample size, *z* is 1.96 at 95% level of confidence, *p* is 0.94 (which is approximately 94% and accommodates the margin of the households without camels in the study area) and *q=1-p*, i.e. 0.5, and *e* = 0.05 (which is the margin of error at 5%). This gave a sample size of 86 households without camels. However, this value was lowered to match up the low sample size that emerged from the snowball sampling of camel herders so as to avoid sample size bias during analysis. Therefore, a total of 158 households are sampled out of which 84 owned camels while the 74 households were owned no camels.

Method of data analysis

This study used both descriptive statistical analysis and econometric models were applied to analyse the empirical data from this study. The primary data were processed in SPSS 20 and STATA 15. The descriptive statistics was used to describe the main characteristics of sample respondents. t-test and Chi-square tests were applied for testing differences between the camel owner and non-owner households of continuous and dummy variables respectively.

Econometric model specification

Econometric literatures give attention on regression models for dichotomous data, including logistic regression and probit analysis. These models are appropriate when the response takes one of only two possible values representing the presence or absence of an attribute of interest. The determinant of camel production is a binary choice in which we can use either logit or probit model analysis. This study will use probit model for estimating parameters of interest when the dependent variable is not fully observed. The probit model constrains the probability to (0, 1) interval and assumes that the probability that an event will occur is non-linear and that the random error terms follow a normal distribution.

The probability that an individual will choose to own camels depends on an underlying response variable that the expected utility from owning camels is greater than the utility of not. The random utility function (y*) for a herder in Korahay zone facing a decision to rear camels can be specified in Equation 2.

$$Yi = 1 \; if \; y* = i(x_i\beta + \mu) > 0, 0 \; if \; otherwise \quad (2)$$

Where Y is a dummy variable indicating household's ownership of camels (1 = if household owns camels, 0 = otherwise), $\beta = (\beta_0, \beta_1, \beta_2 \dots\dots\dots \beta_k)$ is a vector of unknown parameters, i is the choice of the practice, x_i is a vector of covariates (explanatory variables), that is socio-economic and demographic characteristics of the individual, and μ is the error term.

The empirical model that determines the factors influencing herders' decisions to undertake camel production is specified in Equation 3. A household (i) makes a decision to own camels (*Y*) if the expected utility from camel ownership is positive. Household ownership of camels were associated with socio-economic and production characteristics that can be described as Eq. 3.

$$Y_i = \beta_0 + \beta_{1Ag} + \beta_{2Sex} + \beta_{3HHS} + \beta_{4OFI} + \beta_{5FI} + \beta_{6HS} \dots\dots\dots\dots\dots\dots \beta_{nX} + \mu \quad (3)$$

Where;
Ag Age of the respondent;
Sex Sex of the respondent;
HHS Household size;
EDL Education level of the respondent;
OFI off-farm income;
FI Farm incomer;
HS Herd size;
TLU Livestock holding unit;
DES Distance from extension service;
DMP Distance from market place;
DR Dependent ration.

Marginal Effects defined and calculated to determine how much each of independent variables changes the likelihood of respondents falling in the either category of dependent variables. It implies that how much a unit changes in the independent variable affect the likelihood of camel production, keeping all other variables at their mean values.

RESULTS AND DISCUSSION

Summary of Descriptive and Inferential Statistics

Survey data collected from total of 158 sample households in Korahey zone of Somali regional state, of which 84 households are camel owners and the remaining 74 households are non-camel owner households (Table 1).
The average age of sampled households was 39.44 in which the average age of the respondents from camel owner households was 38.91 years, whereas it is 40.29 years for the non-camel households, the age difference between the two groups was significant at 10% level of significance (t= 0.911). This study contrary to that of **Salamula *et al.*, (2017)** findings, that reported average age of camel owners as 54 whereas that of non-camel owners as 46 years.

Descriptive statistics (Table 1) reveal that in the study area 67.72% of the respondents were males and 32.28% were female. Camel owners were predominantly male (43.67%) than female (17.72%) in the study area. Based on the total sampled households and their respective answer on animal health accessibility in the study area, 65.82% in which 39.87% of them were camel owner households do not have access to animal health service, and 34.18% of sampled households have access to animal health service.

Average family size of sampled households was 7.78 and it indicate that the average family size of the respondents from camel owner households was 7.69, whereas it was 7.93 for the non-camel owner households, the average family size difference between the two groups was in-significant which means that there was no more difference between camel owners and non-owners in their household size.

As indicated in Table 1, the average year of schooling of sampled households was 3.63 and it was indicated that the average year of schooling of the respondents from camel owned households was 3.64 years, whereas it was 3.62 years for the non-camel owned households, the average year of schooling difference between the two groups was found to be in-significant.

Based on study result shown in Table 1, the average total livestock units of sampled households were 111.43 and the average total livestock units of the respondents from camel owned households was 146.48, whereas it was 55.69 for the non-camel owned households, this imply that camel owned households have more total livestock units than non-camel owner in the study area which was highly significant (t= -12.445).

Descriptive statistic study results reveal that the difference between camel owners and non-owners in terms of their average annual income from off-farm and on-farm activities is statistically significant at 1% level of significance (Table 1). The mean income from off-farm activities for camel owner and non-camel owner households was ETB (Ethiopian Birr) 15530.93 (USD 531.966) and ETB 7562.42 (USD 259.028), respectively. The mean income from on-farm activities for camel owner and non-owner households is ETB 21496.39 (USD 736.296) and ETB 10463.92 (USD 358.411) respectively. The t test reveals that there is statistically significant difference in income generation from off-farm and on-farm activities at 1% probability level.

The quantity of milk and income from milk was estimated on the basis of the number of milking animals and the amount of milk that produced from cows, goats, sheep and camels and sold by the households. The descriptive result shows that there was significant difference between the two groups of households in that the mean annual income from milk production by camel owner and non-camel owner households was ETB 21496.39 (USD 736.296) and ETB 7220.574 (USD 247.319), respectively. The t test result reveals that there was statistically significant difference between the two groups at 1% significance level.

The proximity of households to the extension office and market center were analysed and the result showed that the average distances of camel owners and non-camel owners from extension office were 24.07 km and 22.65 km respectively, the difference between the two groups was significant at 10% level of the significance (t= -1.379), while the average distance from nearest market center of the camel owner and non-owner households were 18.05 km and 11.34 km, respectively, this is highly significant at 1% level of the significance with t value of -4.168.

Camel Production and Feeding System

Livestock production especially camel production plays important roles in cultural, economic and social development of Somali pastoral and agro-pastoral communities. Somali pastoralists are among marginalized communities in the country, stricken by recurrent droughts and the camel is usually the sole survivor. Camel herding for Somalis indicated as a basic way of life, insurance against natural disaster, wealth status, prestige, and highly valued cultural heritage. In Korahay zone of Somali regional state three main types of production systems for camel herds were adopted, in which 71.5% were transhumant and pastoralists with their livestock seasonally move from place to place for grazing, 19.6% were sedentary with resettlement and use mixed farming system, and only 8.9% of Korahay zone pastoralists use pastoral nomadic system in which livestock and owner move from place to place without permanent home, but pure nomadism seems to be disappearing in Korahay zone of Somali state (Table 2). To some extent pastoralists shifting to agriculture and original livestock production with resettlement. The transhumant movement of pastoralists resulted into peaceful associations the case of Turkana from the Kenya across the border of the neighbouring Karamoja **(Hartley, 1984).** Originally sedentary pastoralists dependent on agriculture and trade as their main economic activities but due to recent drought they shift to livestock rearing specially camels and small ruminants to compensate their losses in crops due to climate change.

Table 1: Summary statistics

Variables	Camel owned households Mean±StD	Non-camel households Mean±StD	Total households Mean±StD	X2/Ch2
Age (Years)	38.91±10.21	40.29±7.67	39.44± 9.31	0.911*
Household size	7.69±3.02	7.93±2.79	7.78± 2.93	0.307NS
Level of education (year of schooling)	3.64±4.25	3.62±4.13	3.63± 4.19	-0.038 NS
Total livestock unit	146.48±50.43	55.69±33.32	111.43± 62.81	-12.445***
Off-farm income	15530.93±9779.81	7562.42±8465.96	12454.48±10050.88	-5.245***
On-farm income	27408.25± 14395.60	10463.92±9992.61	20866.45±15276.15	-8.049***
Income from milk(Yearly)	21496.39±12887.80	7220.57±8692.04	15984.84± 13380.85	-7.625***
Distance from extension office	24.07±6.72	22.65±5.49	23.52±6.30	-1.379*
Distance from nearest market	18.05±9.78	11.34±9.94	15.46±10.34	-4.168***
Sex				
Male	43.67%	24.05%	67.72%	0.247
Female	17.72%	14.56%	32.28%	
Animal Health Access				
Yes	21.52%	12.66%	34.18%	0.770
No	39.87%	25.95%	65.82%	

Note: * and *** mean significant at the 10% and 1% probability levels, respectively.

Table 2: Herd Management and feeding system in Korahey zone, by districts

Variables	District						Total	
	Kebri Dehar		Shelabo		Shekosh			
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Production system								
Pastoral nomadic	5	9.2	4	7.2	5	10.2	14	8.9
Transhumant	38	70.4	41	73.2	34	70.8	113	71.5
Sedentary	11	20.4	11	19.6	9	18.8	31	19.6
Total	54	100	56	100	48	100	158	100
Feeding system								
Grazing and Browse spp.	47	87	51	91	24	50	122	77.2
Hay	5	9.3	3	5.4	18	37	26	16.5
Crop residues	2	3.7	2	3.6	6	12	10	6.3
Total	54	100	56	100	48	100	158	100

Majority of pastoralists in Korahay zone of Somali region use extensive camel management system. This system is very common among camel breeders who rear small, medium to large camel herds. Pastoralists with their camels cover a long distance of around 12 to 18 km every day for grazing and browsing activities. This in line with the study of **Wosene (1991),** states that Ogaden pastoralists with their camels subjected to travel 14-20 km distance from their village in searching of feed and water. From the total sample 77.2% of pastoralists in Korahay zone use grazing and browsing feeding system, the remaining 16.5% and 6.3% use hay and crop residues feeding system respectively (Table 2). The results of this study in line with that of **Mehari (2017)** and **Mirkena *et al.*, (2018),** reported the major camel feeding systems were grazing and browsing at far distance.

The potential of irrigated pasture and its contribution to camel production substantiates the possibility of supporting intensive system of production in pastoral and agro-pastoral areas **(Knoess, 1979).** According to **Aklilu and Catley (2011),** intensive camel production system is recently observed in the mid altitude areas of Ethiopia which is the indication of the evolving mode of camel production system. In Korahay zone pastoralists use intensive production system to same extent 22.8% (Table 2) by keeping their animals around the town and villages especially in Kebridahar and Shekosh districts. This mode of production was also being experienced in Gode town **(Sora, 2010).**

Purpose for Camel Production

Camels are used as a reserve stock by Somali pastoralists since they are not frequently sold in the pastoral economy. From sampled households, 77.8% of the reason for camel production was for income source, social and cultural functions, and milking purpose (Table 3). This study is in line with the result of **Elmi (1989),** which indicated that Somali pastoralists in Ceeldher District of Somalia produce camel for milking and socio-cultural values. According to **Hartley (1984),** the main motivation for camel ownership in Turkana pastoralists is consistent provision of high quantities of milk by camels even in the dry season when cattle are moved to other locations in search for forage. For surprise, the result of this study shows that on average 6.65% of camel owned households produce camel for meat and wealth status (Saving).

Pastoralists in their nature prefer the status of having large herds to the money and goods that could be obtained by selling surplus animals. Camels are owned by both individuals and considered as communal properties. While camels are always considered as clan property for Somali pastoralists, when a family loses its animals, the individual owner has no absolute right to give or refuses to dispose of his camels, since it considered that camel belongs to all clan members. The results of this study indicate that about 27.8% of camel owner produce camel for social and cultural value in study area.

Major Constraints of Camel Production

Drought and water shortage, and feed shortage are the major constraints of camel production in Korahay zone of Somali region (72.2%) and disease prevalence (18.3%) and market problems (9.5 %) were the next principal constraints of the pastoralists for camel production (Table 4). Comparing the three sampled districts in Korahay zone, the study results reveal that Shekosh district has unique characteristics as compared with others by having high feed shortage problem (45.8%) but there were no market problems. Even though, Afar and Somali pastoralists have the same environmental and socio-economic problems study **by Simenew *et al.*, (2013),** found that disease prevalence as a production constraint in Afar region was 40.9%, which is much higher than the result of this study. Camel herders and owners are increasingly facing feeding problems and water shortage in Gedarif State of Sudan, the amount of coverage of drinking water to the animal population in the state was about 50% **(Ayman, 2011)**.

Disease occurrence, shortage of feed and water are the major concerns for camel producers in Raya-Azabo **(Abdisa *et al.*, 2017).** Interviewed respondents stated that constraints to camel production in Korahay zone of Somali region included among others lack of enough capital for investment, lack of credit services, lack of access to animal health services, and security problems due to pasture based conflict between Somali clans (The case of Shelabo district). Therefore, these problems should get proper attention in addition to the current pressing problems of pastoralists like pasture, animal health services, and water shortages.

Table 3: Purpose of Camel production in Korahey zone of Somali region, by districts

Variables	District						Total	
	Kebri Dehar		Shelabo		Shekosh			
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Income generation	17	31.5	17	30.4	13	27.1	47	29.7
Meat production	2	3.7	3	5.4	5	10.4	10	6.3
Milk production	10	18.5	12	21.4	10	20.8	32	20.3
Sacrifices/rituals	5	9.2	5	8.9	4	8.3	14	8.9
Social and cultural functions	17	31.5	14	25	13	27.1	44	27.8
Wealth accumulation	3	5.6	5	8.9	3	6.3	11	7.0
Total	54	100	56	100	48	100	158	100

Table 4: Major camel production constraints in Korahey zone of Somali region, by districts

Major constraint	District						Total	
	Kebri Dehar		Shelabo		Shekosh			
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Feed shortage	15	27.8	11	19.6	22	45.8	48	30.4
Drought and water shortage	22	40.7	27	48.2	17	35.4	66	41.8
Disease prevalence	11	20.4	9	16.1	9	18.8	29	18.3
Poor access to market	6	11.1	9	16.1	0	0.0	15	9.5
Total	54	100	56	100	48	100	158	100

Socio-economic determinants of camel production

The results of this study revealed that socio-economic determinants namely total livestock unit, on-farm income, off-farm income; herd size and distance from the nearest market were found to positively influence the likelihood of owning camels in the study areas. Where, other determinants namely age of the household head, household size, and education level of the household head, dependent ratio and distance from extension service were found to negatively influence the likelihood of owning camels in the study areas. The overall probit regression model was significant at 1% significance level (P = 0.0013) indicating that all the espoused determinants jointly influenced the decision for camel production. According to **Elmi (1989)**, environmental conditions, family needs, household size, milk requirements and labour availability for herding are the major determinants of camel production for pastoralists in Ceel-dheer, Somalia. Similarly, study by **Martínez García *et al.*, (2015)**, reported that age of the household heads, income sources and herd size were among the factors that influence adoption of animal husbandry technologies among farmers in Central Mexico. The results of these studies are in line with the current study result.

The age of the household head was significantly and negatively related to the probability of owning camels. This finding relates to the estimated mean age values for camel owner and camel non-owner households, where there was a lower average age for camel owners. The marginal effects indicated that if the age of the household increased by one unit, the change in the probability of a household owning camels decreased by 1.8%. This study is in contrary to the study reported by **Salamula *et al.*, (2017)**, states age of the household head was positively and significantly correlated to the ownership of camels. Similarly, studies by **Dossa *et al.*, (2008)** and **Kabubo-Mariara (2008)** showed a connection between age and wealth particularly of livestock in pastoral production systems. The results of this study indicate that the nature of pastoralism came with structural changing and reform, elders resettle in to urban before their retirement age and young people left with livestock with full responsibility of production.

Household size was found to be significantly and negatively related to the probability of camel owning in the study area. Study result revealed that a unit increase in the household size by one person led to a decreased change in the probability of owning camels by very small percent.

Education level of the household head was found to be significantly and negatively related to the probability of camel owning. Study result revealed that a unit increase in the education level of the household head by one year led to a decreased change in the probability of owning camels by 2.7%.

The results revealed that households that had larger livestock herds were more likely to own camels. Pastoralists attached with livestock for their socio-economic and cultural value throughout their life. Increasing the total value of insured livestock and herd size by one unit increases the change in the likelihood of owning camels by 0.052% and 0.73%, respectively. The result of this study is in line with that of **Salamula *et al.*, (2017)**, which states that large livestock holding associated with camel ownership. **Watson and Van Binsbergen (2008)**, **Watson, Kochore and Dabassso (2016), Martínez García *et al.*, (2015)**, results also revealed that large livestock holding is a sign of wealth among pastoralists and wealth often positively associated with new technology adoption which leads to livestock improvement. Camels are desert animals known for its resistant to harsh environment and produce milk during dry seasons and drought years when milk from other livestock species are scarce **(Farah *et al.*, 2004 and Salamula *et al.*, 2017)**.

On-farm and Off-farm income were found to be a positive determinant of ownership of camels. The present results therefore suggest that the more income a household accrues from sale of livestock and their products, and receive extra income from other sectors households are more likely to own camels. A unit increase in the income from sale of farm produce and extra non-farm income would increase the change in the probability of owning camels by a very small extent.

Dependent ratio is ratio of age group those typically not in the labor force (age between 0 to 14 and 65+) and those typically economically active force (age group of 15 to 64). It is used to measure the effect of this ratio on camel ownership in the study area. The study finding revealed that dependent ratio negatively and significantly related with camel ownership. Therefore, a unit increase in the dependent ratio would decrease the change in the probability of owning camels by 1.5%. Similarly, study by **Salamula *et al.*, (2017)** revealed that, large households with presumably more dependents were less likely to own camels. Camels are very expensive to acquire, hence hindering financially constrained households.

Delivery of agricultural extension services and market accessibility for pastoralists were the two major concerns in pastoral development policies. Distance from nearest market and from nearest extension office were found to be positive and negative determinants of camel ownership respectively. The study result reveal that a unit increase in the distance from nearest market and from nearest extension office would increase/decrease the change in the probability of owning camels by 0.027% and 1.43% respectively. Study by **Salamula *et al.*, (2017)**, revealed that the majority of camel herders did not receive extension services as well as veterinary support, mainly due to the distant locations between the government offices and the households which is aggravated by the nomadic nature of the pastoralists.

The numbers in the parentheses are indicates robust standard error (Table 5). The estimated probit regression model in Table 5 suggests that, except distance from extension service, all other socio-economic determinant factors of camel production are found to be significantly positive/negative affecting the likelihood of camel production.

The result in Table 6 shows that to improve access to credit, information access should be improved, since almost all the farmers agreed that improved information access improves farmer's access to credit. Similarly, majority of the farmers see the availability of assets to be used as collateral as an important factor to farmer's access to credit. Apart from availability of assets for collateral, most crop farmers believed that reduced rigidity can serve as a means of improving access to credit to farmers. Also, a greater proportion of the farmers were of the opinion that if interest rates were subsidized, it will improve their access to credit.

Table 5: Determinants of camel production in Korahay zone of Somali region

Determinants	Coefficients	Marginal effects
Age	-0.030948**	-0.0185831
	(0.017215)	
Household size	-0.027609*	-0.007657
	(0.0644718)	
Education level	-0.068180*	-0.0275221
	(0.0431024)	
Total livestock units	0.026477***	0.0073431
	(0.004265)	
on-farm income	0.001362***	0.00001
	(1.4E-05)	
off-farm income	0.002443***	1.5E-05
	(2.1E-05)	
Herd size	0.000816***	0.0052264
	(0.0034484)	
Dependent ratio	-0.0575748*	-0.0159676
	(0.1145846)	
Distance from nearest market	0.010057**	0.0027892
	(0.0317773)	
Distance from extension service	-0.4884291	-0.1436827
	(0.3784758)	
_cons	-1.5851171	
	(0.578723)	
Number of obs.		158
LR chi2(10)		66.25
Prob > chi2		0.0000
Pseudo R2		0.3143
Log likelihood		-72.25686

Note: *, ** and *** mean significant at the 10%, 5%and 1% probability levels, respectively.

CONCLUSION AND POLICY IMPLICATIONS

The study results revealed that young individuals, less household members, high level of education, distance from extension services, and having more dependent household members, were less likely to take on camels in the study areas. The sign of age of household heads came up with interesting result since it contrary with the result of group discussion which indicated that young individuals are not interested in camel rearing instead they seek job in urban areas. But, the model result showed that young individuals were more likely to take on camel than older people. The study results also revealed that large livestock herd sizes, more income generated from livestock sales and products, more income generated from non-agricultural sectors, and having no access to market, were more likely to take on camels in Korahey zone of Somali sate. The descriptive results also revealed that drought, feed and water shortages, disease prevalence, and poor market access, were the major camel production constraints for pastoral communities. For improved camel production in Somali state especially Korahay zone, pastoralists should get training on camel production and management system. Attention should be given to the current pressing pastoralists' problems like feed and water shortage, young individuals should be encouraged in camel production by providing them financial support, and updated veterinary services and information system should be developed. Camel production is an important source of food security and livelihood diversification for pastoralists in Somali state of Ethiopia at present and near future. Therefore, the factors that positively influence camel ownership should be improved whereas special consideration should be given for those negatively influence camel ownership and their treatment.

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REGULAR ARTICLE

THE LONG-RUN ENVIRONMENTAL EFFECT OF AQUACULTURE AND FOOD TRADE IN EGYPT

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ABSTRACT

This research analyses the effects of aquaculture and food trade on the environmental quality in Egypt within the Environmental Kuznets Curve (EKC) Hypothesis. Using an annual time series data from 1971-2014 and employing the fully modified ordinary least squares and the Autoregressive distributed lag techniques, the study finds that the EKC hypothesis holds for carbon dioxide emission and economic growth while there is a U-shape relationship between deforestation and economic growth. Also, livestock production increases carbon dioxide emission and deforestation; urbanization reduces carbon emission and cereal production reduces carbon emission but increases deforestation. Aquaculture has a positive effect on carbon emission but reduces deforestation and food import is seen to reduce carbon emission. These findings were confirmed by results from variance decomposition effect and impulse response analyses. The outcome implies that addressing environmental degradation through these variables cannot be a 'one-size fit all' approach. Instead, the approach must be considered based on the primary environmental cost a particular policy seeks to address. Among others, it is recommended that there is the need for Egyptian government to adopt comparative and/or competitive advantage food trade policies in order to solidify the carbon reducing effect of food import.

Keywords: Aquaculture; Carbon dioxide; Deforestation; Environmental quality; Food trade
JEL: F18; F64; O13; O44; P18; Q22; Q53

INTRODUCTION

Meeting food security has been on the radar of many international organizations such as Food and Agricultural Organization (FAO). This objective was also reflected in the Millennium Development Goals (MDGs) that targeted a reduction of proportion of individuals suffering from hunger in the period between 1990 and 2015 by half. Transiting from the MDGs, the world leaders set out seventeen Sustainable Development Goals (SGDs) of which the second goal is to eliminate hunger by 2030. Achieving this goal is crucial since it is directly or indirectly linked with other goals such as goal one (eliminating poverty) and goal three (good health and wellbeing). Fact is, the role of agriculture in the developmental process of economies cannot be overemphasized. The agricultural sector in many developing countries offers job opportunities to a large proportion of the labour force and it is also a major source of foreign exchange revenue. The expectation therefore is to achieve a vibrant and expanding agricultural sector.

The expansion of the agricultural sector may have implications on countries' effort to meet SDGs six (clean water and sanitation), eleven (sustainable cities and communities), twelve (responsible consumption and production) and thirteen (climate action). Thus, although agricultural development is crucial for achieving the growth and developmental needs of countries, it may have some adverse effects on environmental sustainability. For instance, clearing of forest for agriculture increases carbon dioxide emission and reduces carbon sequestration (**Maraseni and Cockfield, 2011**). According to **FAO (2019)**, forest cover helps to store more than 650 billion tons of carbon dioxide. The reasoning from this is that when the forest covers are removed, emission of carbon dioxide into the atmosphere increases. As a result, **FAO (2014)** has revealed that over the past 50 years, global greenhouse gas (GHG) emissions associated with agriculture, fishery and forestry activities has doubled and it is expected to see another 30% increment in the near future. Between 2001 and 2011, the global carbon dioxide emissions from livestock and crop activities increased by 14% from 4.7 billion tons to more than 5.3 billion tons **(FAO, 2014).**

Literature (**US EPA, 2006; FAO, 2006; and Bellarby *et al.*, 2008**) cited by **Desjardins *et al.* (2015)** also indicate that direct farming activities accounts for 13-15% of global emissions and if combined with land use change, leads to about 18-32% of global emissions. Since environmental degradation, generally, poses great threat to sustainable development, the deforestation effect of agriculture and the associated carbon dioxide emission cannot be overlooked. Efforts must be made to ensure major reductions in the agricultural carbon footprints.

Owing to the importance of the agricultural sector in every economy, one cannot recommend efforts to stall the growth of the sector. Rather, policymakers need to promote environmentally friendly agricultural sector. Accordingly, researchers have recognized the need to estimate the environmental impact associated with the expansion of the agricultural sector as a way of determining whether countries' agricultural practices are environmentally efficient or not in order to inform policymaking. This paper therefore aimed at estimating the environment cost of agricultural indicators using the Egyptian data.

Although there is an increasing empirical studies including **Kwakwa *et al.* (2014), Parajuli *et al.* (2019), Asumadu-Sarkodie and Owusu (2016; 2017)** that have focused on the subject matter there is still the need for further studies to unearth location specific costs and bridge the gaps in these previous studies. Empirically, some past studies examined the effect of aggregate agricultural sector on carbon emission (**Kwakwa *et al.*, 2014; Rafiq *et al.*, 2015**) while others focused on the effect of some agricultural indicators such as crop production and livestock production (**Asumadu-Sarkodie and Owusu, 2017**) and emission effect of agricultural land usage (**Parajuli *et al.*, 2019**). So far, the effect of aquaculture and food trade has not received much empirical attention. Meanwhile**, Robb *et al*. (2017)** have pointed out a high associated energy demand for preparing fish feed and in the transportation of the processed feed. The increasing use of energy may eventually exert pressure on the environment through the depletion of non-renewable energy source and also carbon emission. The need to prepare the feed also requires more forest land is cleared. This should raise concern for all to understand the environmental costs associated with the aquaculture sector. Like aquaculture, scholars have indicated that trade openness negatively affects carbon doxide emission through high energy consumption used for manufacturing, processing and transportation of goods (**Sadorsky, 2011; Kwakwa *et al.*, 2018**). It also affects the environment when there is weak environmental regulation instituted by the government with the aim of attracting foreign direct investment **(Kwakwa and Alhassan, 2018**). Similarly, the effect of food trade on environmental degradation may be witnessed through the processing of agricultural products into finished good and transportation of food to and from the ports. In the light of this, the current study employs econometric tools to investigate the effects of aquaculture and food trade on environmental degradation (carbon dioxide emission and deforestation) in Egypt.

Egypt offers a perfect candidate for the study. The agriculture sector continues to play a major role in the socioeconomic development of the country. Although aquaculture in Egypt can be traced back as far as the 2500 B.C, modern aquaculture began around the mid-1930 and it has intensified since the last two decades. The subsector has, thus, grown to offer significant contributions to the Egyptian economy. For instance, available records show that 65 percent of the country's total fish production is from its aquaculture and it employs close to 70,000 people in the country (**FAO, 2019**). General Authority for Fish Resources Development has revealed that the total aquaculture production in 2009 was valued at about US$ 1,354.65 million (**FAO, 2013**). The production level of fish from aquaculture in Egypt makes it the 9th top fish producing country in the world and the first in Africa (**Soliman and Yacout, 2016**). The nature of aquaculture in the country has seen a shift from traditional family-run business into a modern industry whose effect has been the practice of semi-intensive and intensive fish farming (**FAO 2019).** On trade, food and agricultural products constitute about 40% of the country's imports. Egypt's importation of dairy products amounts to about US$ 1 billion per year and it remains one of the largest importers of wheat, sugar, and oils in the world (**Worldexgroup, 2018).**

The country has its own environmental challenges. Although the country's carbon dioxide emission is comparatively low it has seen an upward trend over the years from 125,393.1kt in 2004 to 206,734.5 kt in 2014 (**WDI, 2019**). Again, the well-known energy challenge that faces Egypt **(Kwakwa, 2017**) has not been resolved yet. When it comes to vegetation loss, Egypt lost 1,300 ha. of its forest cover between 1990 and 2010 **(Mongabay, n.d**). Despite the above facts, empirical investigation of the effect of food trade and aquaculture on the environmental quality in Egypt is rarely available. This paper therefore makes a number of contributions to the literature on environmental degradation. In the first place, this is the first paper to comprehensively examine the environmental degradation effect of human induce activities focusing on carbon dioxide emission and deforestation in a single study. Secondly, the study is the first to econometrically estimate the carbon emission of aquaculture on the environment. Third, the extant studies on the effect of trade on environmental degradation have not yet provided much evidence on food trade specifically. Fourth, the paper contributes to the limited studies that have examined the drivers of environmental degradation in Egypt since with the exception of **Abdou and Atya (2013)** which focused mainly on Egypt, the other works like **Omri (2013), Owoye and Onafowora (2013)** and **Balogh and Jambor (2017)** did a panel study for countries that included Egypt without a detail analysis for the Egyptian economy.

LITERATURE REVIEW

In this section a review of the theoretical and empirical works related to environmental degradation are discussed.

Effect of income on environmental degradation

One of the key theories to explain the human induced environmental effect is the Environment Kuznets Curve (EKC) hypothesis (**Dinda, 2004; Shahbaz and Sinha, 2019**). The theory is used to examine the effect of income on environmental degradation (**Grossman and Krueger, 1995**). According to the EKC hypothesis, an initial increase in economic growth would lead to environmental degradation to a point, beyond where environmental degradation declines. Thus, the relationship between income and environmental degradation exhibits an inverted U-shape. The reasons underpinning this argument is that economic growth has a scale effect (i.e. at the initial stage of development where the use of conventional and inefficient technology in production increases carbon dioxide emissions and degrades the environment); composition effect (i.e. transition of the economy to industrial and then to service sector, encourage investment in sector that degrade less) and technical effects (i.e final stage where higher economic growth reduce environmental degradation through the adoption of environmental friendly policies and use of eco-friendly technology in production) (**Grossman and Krueger, 1995; Panayotou, 1997** and **Stern, 2003**). Empirical studies to verify the EKC hypothesis have yielded conflicting results. Scholars such as **Mahmood *et al.* (2019**), **Shahbaz *et al.* (2012); Tiwari *et al.* (2013); Alam *et al.* (2016); Al-Mulali and Ozturk (2016); Kwakwa and Adu (2016); Aboagye (2017); Shahbaz *et al*. (2018); Sinha and Shahbaz (2018)** found support for the EKC hypothesis. However, studies by **Onafowora and Owoye (2014); Nassani *et al.* (2017); Dogan and Ozturk (2017); Sinha et al. (2017)** and **Balsalobre-Lorente *et al*. (2018)** failed to confirm the EKC hypothesis.

Effect of urbanization on environmental degradation

To avoid omission biased effect in the estimation process of testing for the EKC hypothesis, one variable that researchers include in the model is urbanization. The theoretical literature on urbanization- environmental nexus points to three main theories: ecological modernisation, urban transition and compact city theories (**McGranahan *et al.*, 2001; Poumanyvong and Kaneko, 2010**). According to the ecological modernisation theory, urbanization plays an important role in the economic transformation of the sectoral structure from agricultural to industrial and then to the service sector, which has the potential to reduce the environmental degrading effect of economic growth (**Mol and Spaargaren, 2000**). The theory of urban transition shows the link between wealth and environmental issues in urban cities. On one hand, it argues that, as cities move from low to middle-income stage of development, concentration of people, production and consumption increases industrial pollution. Then as urban cities transit into higher-stage of development, environmental regulations, technological innovation and shift from industrial to service sector reduces pollution. By way of contrast, a higher-stage of development at the urban centers may also increase residents' income and consumption of energy intensive products which may have environmental degrading effects (**McGranahan *et al.*, 2001**). The compact city theory concentrates on the positive effect of increased urbanization. It posits that, compaction of urban cities through the development of existing urban areas rather than in suburbs, promote economies of scale for public infrastructure such as public transportation and electricity production which lowers environmental degradation (**Burton, 2000**). The above theories imply that the effect of urbanization on the quality of the environment is not straightforward and this has reflected in mixed results from empirical studies. For instance, **Poumanyvong and Kaneko (2010)** reported that urbanization increases CO_2 emissions of 99 countries. **Kwakwa and Adu (2016)** recorded a positive effect of urbanization on carbon dioxide emissions in sub-Saharan African countries. In their studies, **Martinez-Zarzoso and Maruotti (2011)** and **Shahbaz *et al*. (2015)** all found an inverted U-shaped relationship between urbanization and CO_2 emissions for a panel of 69 countries and Malaysia respectively. **Hassan, (2016)** and **Adom (2017)** obtained a positive relationship between urbanization and environmental degradation. **Kwakwa *et al*. (2018)** also found that urbanization increases fossil fuel consumption in Ghana, Kenya and South Africa. **De Fries *et al***., (2010) found there is a positive association between urbanization and the rate of deforestation.

Effect of agriculture on environmental degradation

In recent times the effect of agricultural activities on the quality of the environment has attracted much attention. The effect of agricultural growth on the environmental degradation is theoretically ambiguous. Agricultural growth may exert scale and technical effects on the environment. Different reasons have been attributed to the scale effect of agricultural production on the environment. First, conversion of forest to farmlands to meet food and nutritional needs of the ever-growing population may lead to deforestation and that may also lead to higher carbon dioxide emission (**Stern, 2006; Baccini *et al*. 2012**). Second, adoption of fuel-driven agricultural machine and irrigation increase consumption of fossil fuel which emits carbon dioxide (**Arapatsakos and Gemtos, 2008**). Lastly, **Pellerin *et al.* (2013)** argue that increase use of nitrogen-rich fertilizers is reported to increase Greenhouse gas (GHG) emissions. Contrarily, **Valin *et al*. (2013)** and **Panhwar (2004)** posit that adoption of modern and sustainable agricultural practices such as sustainable land intensification, solar tube wells for irrigation and organic farming reduce fuel consumption, increase production and help reduce environmental degradation. Like other researchers, **FAO (2017**) explained that the effect of aquaculture on environmental quality is through the process of preparing and transporting fish feed since these require significant amount of energy. The increasing use of energy may eventually exert pressure on the environment through the depletion of non-renewable energy source and also carbon dioxide emission.

Empirically, **Ismael *et al*. (2018)** use the variance error decompositions to show that fertilizers, crop and livestock production, land under cereal production, water access and agricultural value addition affect the quality of the environment in Pakistan. **Waheed *et al*. (2017**) found that agricultural production increases CO_2 emission whiles forest planting reduces CO_2 emission. Using ARDL method, **Asumadu-Sarkodie and Owusu (2017)** found in the short-run that, increase in copra and green coffee production increases carbon dioxide emissions whiles increase in millet and sorghum production decrease carbon dioxide emissions. In a similar study, **Codjoe and Dzanku (2009)** employed the Dynamic Least Squares technique and found conversion of forestland to crop farm as a contributor to deforestation in Ghana. **Kwakwa *et al.* (2014)** also found agricultural growth increases the long-run carbon emission in Ghana. **Faria de Almeida (2013)** found among other things that cattle rearing, soya bean cultivation increases deforestation in the Amazon region. The empirical findings have indicated a mixed effect of agriculture on environmental quality with little emphasis on the effect from aquaculture.

Effect of trade on environmental degradation

In the economic literature on trade-environment nexus, different channels, of conflicting directions, through which trade openness impacts the environment have been discussed. On one hand, trade openness is argued to have an environmental degrading effect and this is called the pollution-haven hypothesis (**Neumayer, 2004**). The hypothesis argues that, pollution-intensive industries (re)locate their environmental degrading activities from countries with strict regulations (or standards) to economies with weaker environmental regulations (or standards) and poor enforcement, polluting those countries (mostly developing countries). **Sadorsky (2011)** and **Kwakwa *et al*. (2018)** have argued that trade openness increases carbon emission through high energy consumption used for manufacturing and transportation of goods. Contrary to the above, it has been argued that trade increases real income which enables individual to demand for clean environment through strict environmental regulations, production and consumption of clean technology thereby improving the quality of the environment (**Liddle 2001**).

Harris (2004) explained that trade openness encourages the transfer of cleaner and eco-friendly technology among trading countries. Although the reverse is also valid, **Robalino and Herrera (2009)** pinpointed that trade liberalization affects deforestation through prices of natural resources. They indicate that a lower price of local natural resource compared to resources in the rest of the world would increase demand for export and hence an increase in the extraction rate; the opposite is true. **Halicioglu (2008)** observed that trade increases carbon dioxide emission for the Turkish economy; **Pié *et al*. (2018)** found among EU countries imports increase carbon dioxide emissions while higher export reduces carbon emissions; **El-Aasar and Hanafy (2018)** found that trade openness has no significant effect on GHG emissions in Egypt; and regarding fossil fuel consumption **Kwakwa *et al.* (2018)** found trade increases fossil fuel consumption for Ghana but reduces for Kenya and South Africa. **Tsurumi and Managi (2014)** found that trade openness increase deforestation for non-OECD countries but decreases it for OECD countries. In addition, **Faria de Almeida (2013)** found that trade openness increases deforestation.

Among studies that have examined the environmental effect of trade openness, the effect of food trade on environmental degradation has been ignored to a large extent. However, the effect of food trade on environmental degradation may be witnessed through the processing of agricultural products into finished goods and transportation of food to and from the ports. In addition, it is seen that studies which analyse the environmental degrading effect of human activities in Egypt is quite limited and these must be addressed.

DATA AND METHODS

Theoretically, within the EKC hypothesis framework, the relationship between economic growth and environmental degradation is expressed as the Eq. 1.

$$ENVD_t = GDP_t * GDP_t^2 * \varepsilon_t \qquad (1)$$

where $ENVD$ is environmental degradation, t represents time, ε is the stochastic error term which captures unobserved factors that influence environmental degradation and * represents the multiplication sign. GDP is income and GDP^2 is income squared to reflect a quadratic relationship.

Empirically, different indicators have been used to represent environmental degradation. Following **Aboagye (2017)** and **Adom *et al*. (2018),** carbon emission and deforestation were used as indicators for environmental degradation. The thinking behind the adoption of these indicators are, conversion of forestland to farmland as well as the excessive felling of trees and burning of forestland may cause deforestation; which in turn increases CO_2 emissions and degrades the environment **(Baccini *et al*., 2012**).

Urbanization is well-known to have significant impact on the environment but its effect is mixed. Rapid rate of urbanization may increase production and consumption which put pressure on resources (**Shahbaz *et al*., 2015; Kwakwa *et al*., 2018)**; or urbanization may promote economies of scale as it reduces the demand for urban infrastructure such as transport system, thus reduction in energy consumption with associated increase in environmental quality (**Elliot and Clement 2014**). As argued in the literature, trade openness is used to capture scale, as well as technique effects (**Erickson *et al*., 2013; Kwakwa *et al*., 2018**). These effects have opposite signs: while the environment deteriorates with growth in trade openness (i.e scale effect), the demand for high environmental quality and the transfer and adoption of cleaner production technology are expected to increase with trade (i.e technique effect). Agriculture is one of the major sectors for Egypt's economy and employs most of the rural population (**ADBG, 2018**). In this light, food trade and aquaculture are included in the model. Following **Ismael *et al*., (2018)** and **Asumadu-Sarkodie and Owusu (2016)**, livestock and cereal production were used as proxy for other agricultural production. This is in part motivated by the argument that agriculture is a victim and emitter of CO_2 and there is the need for policymakers to promote environmentally friendly agricultural sector.

Given these relationships, the study proceeded to expand equation 1 to capture the effects of crop production, livestock production, aquaculture and food trade on environmental degradation (carbon dioxide emission and deforestation) (Eq.2).

$$ENVD_{it} = GDP_t * GDP_t^2 * URB_t * e^{LIVESTOK_t} * ACQ_t * CER_t * FIMP_t * FEXP_t * e^{\varepsilon_t} \qquad (2)$$

Where:
i (=1 and 2) represents the two indicators for environmental degradation: carbon dioxide emission and deforestation. Also, *URB, LIVESTOK, ACQ, CER, FIMP and FEXP* respectively denote urbanization, livestock production, aquaculture, cereal production, food import and food export. *GDP* and GDP_t^2 remains as explained earlier. Assuming a Cobb-Douglas production function with output generated measured as carbon dioxide emissions (CO_2) and deforestation (DEF), the predictors of environmental degradation as inputs, the production function is presented as the Eq. 3.

$$ENVD_{it} = A * GDP_t^{\beta_{1i}} * GDP_t^{2^{\beta_{2i}}} * URB_t^{\gamma i} * e^{LIVESTOK_t^{\delta i}} * ACQ_t^{\vartheta i} * CER_t^{\rho i} * FIMP_t^{\pi i} * FEXP_t^{\varphi i} * e^{\varepsilon_{it}} \quad (3)$$

Where:
A is the technological change. Taking a log transformation of equation (3) expanding equation (3) in terms of the two indicators for environmental degradation, gives Equations (4a) and (4b).

$$LCO_{2t} = a_1 + \beta_{11} LGDP_t + \beta_{21} LGDP_t^2 + \gamma_{11} LURB_t + \delta_{11} LIVESTOK_t + \vartheta_{11} LACQ_t + \rho_{11} LCER_t + \pi_{11} LFIMP_t + \varphi_{11} LFEXP + \varepsilon_{1t} \quad (4a)$$

$$LDEF_t = a_2 + \beta_{12} LGDP_t + \beta_{22} LGDP_t^2 + \gamma_{12} LURB_t + \delta_{12} LIVESTOK_t + \vartheta_{12} LACQ_t + \rho_{12} LCER_t + \pi_{12} LFIMP_t + \varphi_{12} LFEXP + \varepsilon_{2t} \quad (4b)$$

Econometric method
Generally, most time series data are non-stationary at level and as a result are not appropriate for regression estimation since they are likely to generate spurious results. Thus, in order to properly specify a model for estimation of equations (4a) and 4(b), it is important to conduct a unit root test to examine the stationarity situation of the variables. The Augmented Dickey-Fuller (ADF) and the Phillips-Perron(PP) tests developed by Dickey and Fuller (1979) and Phillips and Perron (1988) respectively were used to examine the stationarity property of the variables. The null hypothesis is that there are non-stationary variables (or unit root). To avoid having bias results from the ADF and PP tests in the presence of structural breaks that may be associated with the variables, a further investigation is done to check for the stationarity of the variables using the Zivot and Andrews (ZA) test which is more robust even in the presence of structural breaks.

The next step after the stationarity tests is to examine the existence of long-run relationship among the variables. Engel–Granger residual based test due **Engle-Granger (1987),** the Phillips–Ouliaris residual-based test by **Phillips-Ouliaris (1990)** and the robust Autoregressive distributed lag (ARDL) tests due **Pesaran *et al.* (1996)** and **Pesaran (1997)** were employed to examine if there exists a long-run relationship between the variables. All the tests assume a null hypothesis of no cointegration. After a confirmation of the existence of cointegration among the variables, the ARDL method **by Pesaran *et al*. (1996)** and **Pesaran (1997)** and the Fully Modified Ordinary Least Square (FMOLS) developed by **Phillips and Hansen (1990)** were applied to examine the long-run relationship between the dependents and independent variables for equations (4a) and (4b). While the ARDL estimator is more robust when doing cointegration analysis for small samples like this, the FMOLS is robust to dealing with the problem of endogeneity and serial correlation. Thus, these two estimators were to corroborate each other.

The study also conducted impulse response and variance decomposition analysis (**Amisano and Giannini, 1997; Lütkepohl, 2010**). The impulse response analysis was done to examine how the dependent variables responds to shocks in each independent variable and the duration of the effect of the shock, whiles the variance decomposition analysis was used to examine the pattern of contribution each factor would make due to a shock in the dependent variables (i.e carbon dioxide emission and deforestation) over time.

Data source and descriptions
This study used annual time-series data covering the period 1971–2014 accessed from World Development Indicators (**WDI, 2019).** The choice of this period was based on data availability. Indicators of environmental degradation used were: carbon dioxide (CO_2) measured by carbon dioxide emissions (metric tons per capita); and deforestation measured by land under cereal production in hectares. GDP per capita is used to measured income while urbanization is proxied by total urban population. Furthermore, aquaculture is measured by aquaculture production in metric tons, livestock is denoted by livestock production index and cereal production is measured in metric tons. Food trade is measured as food import and export.

RESULTS AND DISCUSSION

This section provides the empirical findings emanating from the study. It includes hypothesis testing results on stationarity, ARDL and FMOLS results, and results on impulse response function and variance decomposition. Detailed discussion on each of these results are also provided under the section.

Unit root test and cointegration results
The results of the unit root tests are reported in Tables 1 and 2. Table 1 provides results for the ADF and PP tests while Table 2 shows results for the Zivot-Andrews test. The ADF and PP tests indicate that food import is stationary at levels while the remaining are stationary at first difference (Table 1). The Zivot-Andrews test results also confirm that all the variables except the square of GDP, urbanization, aquaculture and food import become stationary after first difference despite the presence of structural break (Table 2) giving us a mixture of I(0) and I(1) variables. The implication is that, the variance and covariance of all the variables remain unchanged over time and hence, appropriate for regression analysis.

Table 1: Unit root test results

	Trend & Intercept		Trend & Intercept	
	PP	ADF	PP	ADF
Series	At levels		At first difference	
LGDP	-2.3491	-0.6804	-5.2309***	-4.2729***
$LGDP^2$	-2.4117	-0.7132	-5.1797***	-4.2386***
LURB	-2.9820	-1.4974	-3.9535**	-2.4348
LIVESTOK	-2.3454	-2.3405	-5.8759***	-5.9044***
LACQ	-2.4332	-2.1293	-4.9645***	-4.9951***
LFIMP	-4.0984**	-3.7012**		
LFEXP	-2.0890	-2.0890	-5.8959***	-7.2431***
LCER	-6.6580	-1.7534	-6.6583***	-6.6584***
LCO_2	-1.5052	-1.7127	-7.7607***	-7.7746***
LDEF	-2.5272	-2.5111	-7.4315***	-7.3774***

Note: ***, ** and * denotes 1%, 5% and 10% level of significance respectively

Table 2: Zivot Andrew unit root test

Series	Levels		First difference	
	Trend	Intercept	Trend	Intercept
LGDP	-5.6150 (1985)	-4.2115 (1980)	-6.4329 (1992)**	-6.8665 (1986)***
$LGDP^2$	-5.4852 (1985)***	-4.4207(1980)		-6.6552 (1986) ***
LURB	-5.2158(1987)	-5.3925(1979)***	-3.6078(1987)***	
LIVESTOK	-2.9686 (2003)	-3.4517 (1985)	-6.4439 (2007)**	-6.8243 (1990) **
LACQ	3.6942 (1994)	-4.6823 (1998) ***	-5.8598 (1995)***	
LFIMP	-5.0308 (1995)***	-5.5879(2005)***		
LFEXP	-3.6130(1981)	-4.6128(1979)	-4.6965 (1998)**	-4.9799(1993)**
LCER	-2.5765 (2003)	-4.4933(1989)	-7.4515(1991)***	-7.7896 (1987)***
LCO_2	-3.0477 (1982)	-2.4386 (1979)	-8.1156(2007)***	-8.1964(1995)***
LDEF	3.0005(1984)	-3.7401(1990)	-7.4638(1991)***	-8.2235(1987)***

Note: ***, ** and * denotes 1%, 5% and 10% level of significance respectively; structural break years in parenthesis

Table 3: Cointegration test results

	ARDL			Engel-Granger		Phillips-Ouliaris	
Model	F-test stat.	I(0)	I(1)	tau-statistic	z-statistic	tau-statistic	z-statistic
CO_2 model	4.2215***	2.79	4.1	-5.8626**	-39.3552**	-6.0060**	-35.1101*
Deforestation model	4.1797***	2.79	4.1	-5.8901**	-39.5051**	-5.9376**	-21.1996

Note: ***, ** and * denotes 1%, 5% and 10% level of significance respectively

In Table 3, the presence of co integration for each of the models is confirmed by the ARDL, Engel-Granger and the Phillips-Ouliaris tests. Thus, cointegration exists between carbon dioxide emission and the selected explanatory variables, and between deforestation and the selected explanatory variables. Therefore, income, livestock production, aquaculture, food import, food export, cereal production and urbanization can be described as the long-run forces of environmental degradation in Egypt.

Long-run effects

Table 4 shows the long-run estimates from ARDL and FMOLS methods. It displays the effects of the independent variables on carbon dioxide emission and deforestation. The result shows that GDP and its square have a significant effect on carbon emission. Also, urbanization, livestock production, aquaculture, food import, food export and cereal production have a significant effect on at least one of carbon emission and deforestation; although the direction of the effects differ for some variables.

Carbon dioxide (CO_2) emission effect

The positive significant effect of GDP shows that an increase in the current GDP levels lead to more carbon dioxide emission by the country. However, the square of GDP reduces the level of carbon emission. This confirms the existence of the EKC hypothesis. Thus, an initial increase in economic growth would lead to deterioration in environmental quality to a point, beyond which economic growth would be accompanied by an improvement in environmental quality. The findings in this study are consistent with the expectation that as GDP increases, the country would be able to invest in more emission reduction technologies that would lower CO_2 emission. Previous empirical studies such as **Kwakwa and Alhassan (2018), Mulali and Ozturk (2016), Aboagye (2017); Shahbaz *et al.* (2018); Sinha and Shahbaz (2018**) confirmed the EKC hypothesis. In the case of Egypt, **Mahmood *et al.* (2019)** found that there is the presence of EKC and that the country is at the second stage of the curve, hence, they concluded that there is a clean economic growth in Egypt. Contrary, **El-Aasar and Hanafy (2018) and Ibrahiem (2016)** observed from

Egypt that there is no evidence of EKC (inverted U-shape) in the short- or long-run.

The level of urbanization has a negative significant effect on carbon dioxide emission. This implies that an increase in the level of urbanization of the country leads to a decline in carbon dioxide emission. This supports the theory of urban transition that explains that as cities transit from middle to high levels of development, environmental regulations, technological innovation and a shift from industrial to service sector leads to a reduction in environmental pollution **(McGranahan *et al*., 2001**). Empirically, **McGee and York (2018)** observed that urbanization have an asymmetric effect on carbon dioxide emission and argued that, in addition to the level of urbanization, the pattern of rural-urban migration are important in explaining carbon emission. Evidently, **Chen *et al.*, (2019)** estimated an inverted u-shape between urbanization and carbon emissions. Similarly, **Ibrahiem (2016)** estimated a negative relationship between population and carbon emission level in Egypt. Contrary to this study, **Aye and Edoja (2017)** and **Zhang *et al.*, (2015)** estimated that irrespective of the duration (long-or short-run), urbanization increases carbon emission.

The effect of livestock production is positive and significant in explaining carbon dioxide emission. Thus, an increase in livestock production in the long-run would lead to a significant increase in carbon emission levels of the country. Although carbon dioxide is not a major greenhouse gas emitted in livestock production, its contribution to global warming remains important in climate discussions. **Moran and Wall (2011)** indicated that livestock production around the world is responsible for 18% greenhouse gas emissions (especially, methane gas). This percentage contribution is high; hence, its footprint can be highly detrimental to global environmental quality. The positive effect on carbon dioxide emission found for Egypt raises a concern for the country. Similarly, aquaculture has a positive significant effect on carbon emission. The implication is that an increase in aquaculture production will lead to an increase in carbon emission in the long-run. In the quest for higher aquaculture production, there is a high tendency of using high carbon emitting equipment and this would increase the carbon levels of the country. This effect is not only observed through forward linkages but also backward linkages where the demand for more aquaculture equipment would force manufacturing companies to increase their production. As explained by **FAO (2017)**, the processes involved in the production and transportation of fish feeds may be environmentally unfriendly.

Food imports have a negative significant effect on carbon dioxide emission. Countries engage in the importation of goods and services to supplement domestic production shortfalls. Therefore, carbon emission levels through production activities would decline as a country tends to import more food demanded by the country granted that emissions from the transportation of these goods is at its minimum. This does not however provide an evidence to support the promotion of importation in the country since this may have a negative effect on the trade balance of the country. Consistently, **Pié *et al*., (2018)** found a negative significant effect of import on carbon emission. Although insignificant, **El-Aasar and Hanafy (2018)** and **Ibrahiem (2016)** found that there is a negative relationship between trade openness and carbon dioxide emissions in Egypt. It is not surprising that **Mahmood *et al*., (2019)** suggested that the Egyptian government should further liberalize its foreign trade since this does not exert a significant effect on the country's environment. Contrary, **Rafindadi (2016**) have found import to increase carbon dioxide emission in his study. The finding shows that an increase in the cereal output leads to a reduction in carbon dioxide emission. The decrease in carbon emissions can be attributed to a long-term shift towards climate friendly production practices. Although insignificant, **Rehman *et al.* (2019)** also estimated a negative effect of total food grain on carbon dioxide emission both in the short and long-run. The finding of this study can be tired with the explanation of **Valin *et al.* (2013)** and **Panhwar (2004)** that the adoption of modern and sustainable agricultural practices such as sustainable land intensification, efficient irrigation schemes and organic farming reduce fuel consumption, increase production and help reduce environmental degradation.

Deforestation effect

The long-run level of deforestation is significantly influenced by GDP and square of GDP, urbanization, livestock production, aquaculture, food export and cereal production. These effects are negative except for GDP squared and cereals. The positive significant effect of urbanization on deforestation in the FMOLS model implies that an increase in the level of urbanization of the country leads to an increase in deforestation. This is due to the high demand for land in urban areas and the high tendency of creating bare lands in the urban areas than in the rural areas. This shows that the growth in the Egyptian urban population over the years from a little over 15 million in 1971 to 25.4 million in 2001 and 36.9 million in 2011 has exerted pressure on the forest resources of the country. The finding corroborates the evidence provided by **De Fries *et al.* (2010)**. It is also found that an increase in livestock production in the long-run would lead to a significant increase in deforestation of the country. The requirement for fodder and land for livestock production could elucidate the positive effect of livestock production on deforestation level in the country. Thus, the high requirement of natural resources in livestock production (**Grossi *et al.*, 2019**) could explain the finding of high deforestation due to livestock production.

The positive and negative significance of GDP and GDP squared respectively on deforestation shows that there exists a U-shape relationship between economic growth and deforestation. It was expected that as the economy expands and income of households' increase, there would be high tendency towards the planting of trees, thereby, increasing the forest cover of the country at higher GDP. Although this U-shape relationship is contrary to the expectations of the research, it is plausible that at initial stages of economic growth, there are low technologies available for the fast exploitation of forest products and also, there is high regenerative capacity of forest at initial growth stage of the economy where the forest cover is high. As a developing country, it is expected that as technologies become available, there will be high tendency to exploit forest resources at a faster rate than the regenerative capacity of the forest and this would require significant income investment in afforestation products, which may not be a consideration in poor a country turning its economy into higher development. Admittedly, this result compares favourably with **Galinato and Galinato (2012), Ewers (2006)** and **Couresma *et al.* (2017).** Aquaculture has a negative significant effect on deforestation as well. The implication is that an increase in aquaculture production will lead to a decline in deforestation since through technology, households could possibly shift from large area-base production activities to the small area required for aquaculture.

Cereal production and consumption in Egypt remain significant. It is not surprising therefore that an increase in cereals output leads to an increase in deforestation. This increase in deforestation is because agriculture development in the country is largely due to land area expansion than yield improvement. The negative effect of food export implies that an increase in food export leads to a decline in deforestation. This could be because of the marginal share of food export in the country's total export. Egypt's main exports are gas and non-petroleum products such as gold and insulated wire. These products exert less impact on deforestation. Therefore, an increase in export would increase the income of the country which could be invested into afforestation programs that would reduce the level of deforestation in the country.

Variance decomposition analysis

The variance decomposition of the various independent variables in relation to the two dependent variables are presented in Tables 5 and 6. The objective is to determine the pattern of contributions each factor would make in response to a shock in carbon dioxide emission and deforestation, over time. Thus, the result shows the percentage forecast error variance of each variable. In the first period, presumably the short run, results in Table 5 reveal that the independent variables exhibited weak influence on carbon emission since they do not contribute to the dependent variable. For instance, a change in carbon emission is 100% explained by itself in the first period. This influence decreases sharply as the other variables begin to have a strong influence on the dependent variables. Except for urbanization, all other variables exhibit a weak influence on carbon emission both in the short to the long-run. For instance, urbanization increases its contribution to carbon emission from 9.2% in the second period to about 20% in the fifth period and again declined to about 15% in the tenth period. Aquaculture also increases its influence from 1.79% in the third period, then gets to 5.07% in the 7th period and finally to 8.56% in the 10th period. It is also seen that the share of export is greater than import over the period. Urbanization, export and the square of GDP also exhibit a somehow moderate influence on deforestation. The general observation is that the effects of these variables increase from the short to the medium term, and gradually decline again in the long-run (Table 6).

Table 4: Long-run analysis from FMOLS results

Variable	ARDL		FMOLS	
	Carbon emission	Deforestation	Carbon emission	Deforestation
LGDP	38.8917**	-6.5844**	13.7885***	-1.8150
	(2.2325)	(-2.7585)	(4.4543)	(-0.8184)
$LGDP^2$	-0.8015**	0.1344**	-0.2644***	0.0320
	(-2.1830)	(2.7162)	(-4.1272)	(-0.6972)
LURB	1.8709	-0.0864	-0.9990*	0.7636**
	(1.2112)	(-0.1928)	(-1.9171)	(2.0449)
LIVESTOK	0.0239**	0.0009	0.0069***	0.0028**
	(2.1585)	(0.7300)	(4.0163)	(2.2600)
LACQ	0.2294**	-0.0603***	0.1156***	-0.0748***
	(2.6775)	(-2.9469)	(4.0406)	(-3.6489)
LFIMP	0.1107	0.0199	-0.1311***	-0.0240
	(0.8995)	(0.5826)	(-2.7912)	(-0.7129)
LFEX	0.0133	-0.0297*	-0.0142	-0.0023
	(0.3511)	(-1.7413)	(-0.5218)	(-0.1187)
LCER	-1.1306**	0.3431***	-0.3255***	0.2772***
	(-2.4654)	(4.6585)	(-3.5773)	(4.2515)
CONSTANT	-488.2559**	91.7912***	-157.9826***	23.3037
	(-2.3795)	(3.0451)	(-4.1268)	(0.8494)

Note: ***, ** and * indicates significance at 1%, 5% and 10%, respectively; t-statistics in parenthesis

Table 5: Variance decomposition analysis for carbon emission

Period	S.E.	LCO_2	LGDP	$LGDP^2$	LURB	LIVESTOK	LACQ	LFEX	LFIMP	LCER
1	0.052933	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.071815	63.71174	6.347745	14.06525	9.209495	1.465439	2.565952	1.953314	0.679580	0.001486
3	0.086446	52.83003	5.040300	9.931120	21.92458	2.315675	1.799276	1.386703	0.477394	4.294919
4	0.091973	49.95708	4.830996	8.775351	21.98019	2.726865	1.598149	5.881594	0.423228	3.826551
5	0.096260	49.03182	4.433637	8.129249	20.27430	2.534305	2.638256	8.772629	0.689201	3.496598
6	0.098895	49.53599	4.258544	7.796858	19.21091	2.437249	3.916192	8.763458	0.758079	3.322713
7	0.104177	49.62247	3.882572	9.293473	17.49444	2.264445	5.074107	7.897384	0.979963	3.491144
8	0.107779	49.51887	3.955687	9.281386	16.34618	3.135401	5.710573	7.477122	1.035241	3.539549
9	0.110645	48.71446	3.890156	8.806864	15.59388	3.292798	7.181141	7.575227	1.071548	3.873922
10	0.113525	47.12883	4.196312	8.397662	14.87841	3.298574	8.560290	8.364368	1.018119	4.157440

Table 6: Variance decomposition analysis for deforestation

Period	S.E.	LDEF	LGDP	$LGDP^2$	LURB	LIVESTOK	LACQ	LFEX	LFIMP	LCER
1	0.033739	100.0000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2	0.051648	47.95929	9.812484	18.25626	21.92786	0.284554	0.026831	0.366051	1.343986	0.022683
3	0.059986	36.35791	17.69186	15.81261	18.10755	3.193289	0.359765	6.208422	1.717602	0.551000
4	0.068437	28.88215	27.71748	12.24018	13.93238	6.188406	1.530455	7.446727	1.596358	0.465859
5	0.072111	26.39834	32.52131	11.08934	14.03836	5.623751	1.669562	6.732847	1.490553	0.435937
6	0.077065	23.11460	31.61733	10.76060	14.93872	6.450712	1.740668	8.969488	1.870356	0.537524
7	0.081698	20.90222	31.23707	10.38509	13.29281	7.094331	2.218800	12.27557	1.923759	0.670359
8	0.085916	18.90731	31.12872	10.96331	12.68785	6.744582	2.504569	14.43528	1.823973	0.804400
9	0.087463	18.42211	31.35774	11.97367	12.24390	6.535215	2.744722	14.15555	1.768624	0.798468
10	0.089153	17.81173	30.19553	14.16688	12.21817	6.410303	2.743359	13.96425	1.718213	0.771560

Impulse response analysis

An impulse response analyses was performed to determine how the dependent variables responds to shocks in each independent variable and the duration of the effect of the shock. This is shown in Figures 1 and 2. The results show that carbon dioxide emission and deforestation fluctuate at different periods due to shocks imposed on each explanatory variable. Overall, carbon emission responded negatively to shocks in GDP, GDP squared, urbanization, livestock and import while it responded positively to shocks in aquaculture and exports. For instance, from Figure 1, carbon emission responded to shock in GDP by declining from about 0.05 in the first period to about 0.01 in the tenth period while it responded to shocks in export by declining to about -0.002 in year four and thereafter, increase to about 0.01 in the tenth year. The impulse response running from deforestation to livestock, export, import, cereal production and aquaculture as shown in Figure 2 is stable while that running to the square of GDP is initially positive up to the second year, declines to the fifth year and gradually begins to incline into the future. The implication is that deforestation vary less if there are compulsion in the independent variables over time. This is a laudable finding and suggests that Egypt's forest cover can be maintained for relatively long period even when there are shocks in the observed exogenous factors in the economy. In addition to the provision of sustainable forest products under stable deforestation, there is also a sustainable sink for carbon dioxide, thereby reducing the rate of increase in global warming.

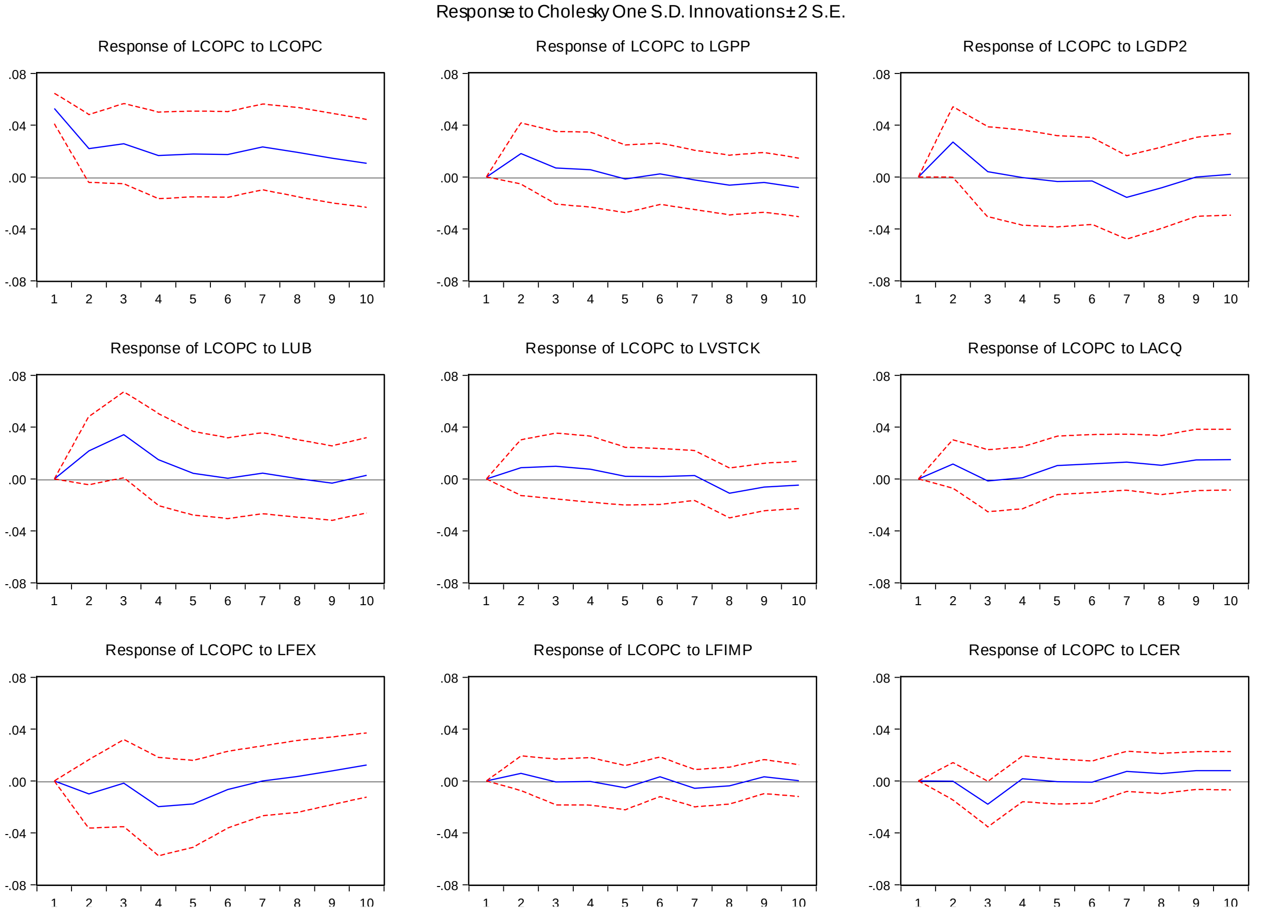

Figure 1: Impulse response function for carbon emission

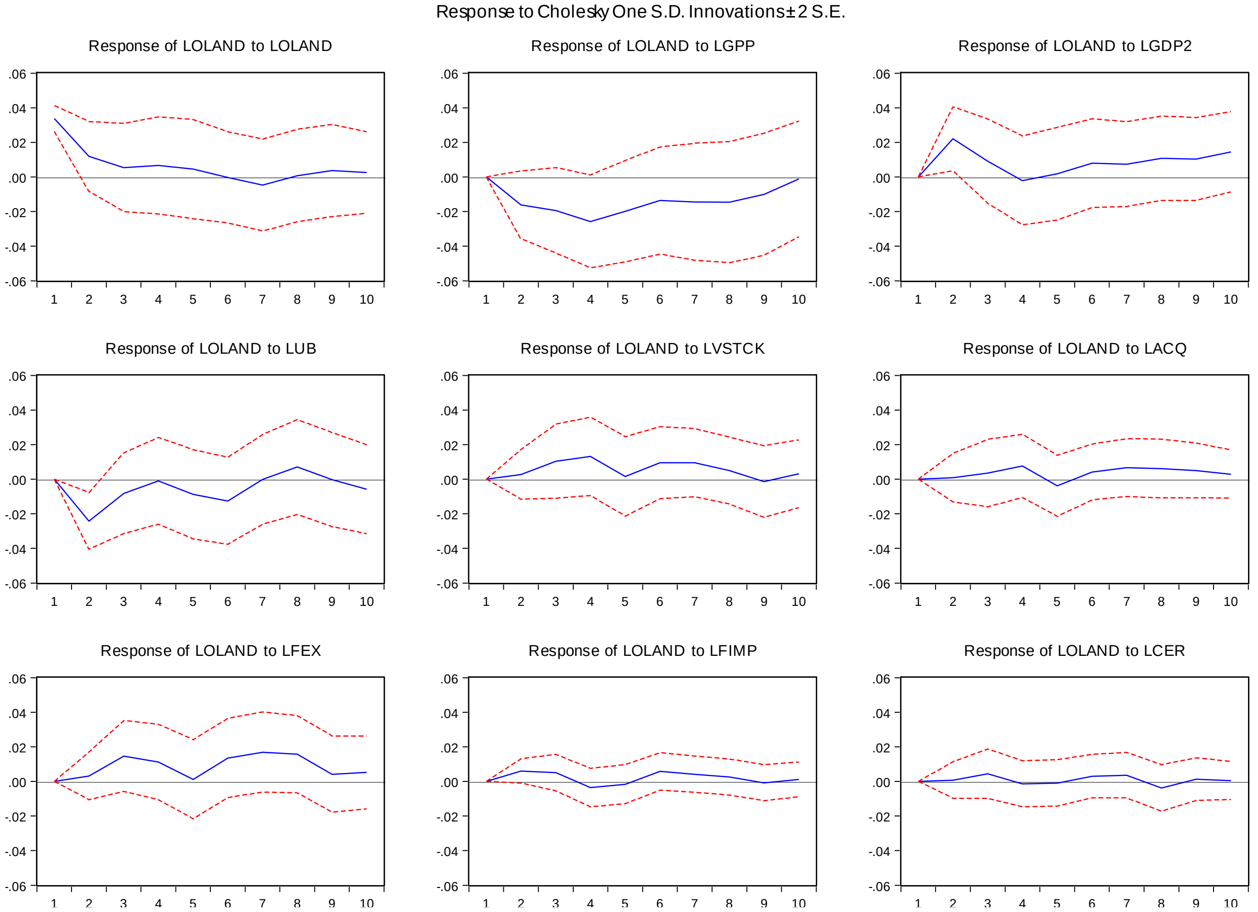

Figure 2: Impulse response function for deforestation

CONCLUSIONS AND POLICY IMPLICATIONS

Projected forecast of climate change and its impacts is driving scholars and policymakers into identifying how environmental quality can be improved and greenhouse gas emissions reduced alongside, an improvement in the economic performance of countries and wellbeing of citizens. This study analysed the long-run relationship between environmental quality and, aquaculture and food trade (after controlling for income, urbanization, livestock production and cereal production) within the Egyptian context. It was evident from this study that economic growth and carbon emission exhibited the EKC hypothesis that suggests that initial economic growth leads to an increase in carbon dioxide emission but further increase in economic growth leads to an improvement in environmental quality through a decline in carbon dioxide emission. In addition, it was found that urbanization, food import and cereal production leads to a reduction in carbon emission while livestock and aquaculture production leads to an increase in carbon emission in the long-run. While cereal production leads to a significant increase in deforestation, an increase in aquaculture production and food export leads to a decline in deforestation. There is also a significant U-shape relationship between economic growth and deforestation, a result that require further analysis. Conclusively, aquaculture had mixed effects on each of the environmental variables; it increases carbon dioxide emission and decreases deforestation. While food export reduces deforestation, food import was found to reduce carbon emission. Therefore, addressing climate change and environmental degradation through these variables cannot be a 'one-size fit all' approach. Instead, the approach must be considered based on the primary environmental cost a particularly policy seeks to address.

These findings have raised a number of policy concerns. For instance, it was evident from the study that effective food trade policies are important to regulate carbon emission in Egypt. To strengthen the effect of food trade on carbon emission and deforestation, there is the need to adopt comparative and/or competitive advantage food trade policies. Livestock and aquaculture production policies should be redesigned to ensure that their production does not foster increased carbon emission as estimated in this study. Cereal production should be promoted since this does not only reduce carbon emission but also, a way of achieving food sufficiency in the country. Nonetheless, sustainable production practices such as climate smart agriculture and intensified land cultivation that require less deforestation is required in promoting cereal production. It is also important to ensure that the intensity of aquaculture activities in Egypt becomes environmentally friendly. Thus, technologies for aquaculture development need a critical assessment to ensure that the benefit accrued to the nation through a reduction in deforestation can also be translated to a reduction in carbon emission. Overall, sustainable low carbon economic development agenda should not be over looked by policymakers in Egypt.

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REGULAR ARTICLE

GIS ANALYSIS OF PHYSICAL ACCESSIBILITY TO FOOD MARKETS IN THARAKA REGION OF KENYA

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ABSTRACT

In semi-arid rural Kenya, most households travel long distances to access food markets. This has negative effects on food consumption and the use of market facilities. Over70 % of farmers in Tharaka Constituency lack access to formal markets often relying on contracted middlemen who buy at farm gate for traders in major urban centres. Studies on intra-variation in accessibility to market services remains scanty, yet market purchases account for most food consumed across urban and rural areas. Distance defines accessibility and performance of market facilities in most areas where food insecurity and malnutrition are common. This study used Geographic Information Systems (GIS) to measure physical accessibility to open air markets within semi-arid Tharaka, a constituency where vulnerability to acute food shortage is comparatively high. Normative, administrative and geospatial datasets were used in the analysis. Results showed that geographic accessibility to local market centres vary spatially across the villages. In terms of market accessibility, 40.4% of the total population live in areas with high inaccessibility risks while 36.1% are found in places with low inaccessibility risks and only 23.5% of the population exists in areas with moderate inaccessibility risks. This means a large proportion of deprived population live in villages within high to very high inaccessibility risk areas. This spatial inequity has implications on household food security and explains the chronic problems of hunger and malnutrition experienced in the area. Therefore, markets within high inaccessibility risk areas should be upgraded and infrastructure thereof improved to enable food mobility across these areas.

Keywords: Geographic accessibility; open air markets; food security; GIS
JEL: R52, R58, H41

INTRODUCTION

Population growth and inability of people to produce their own food has increased demand for food worldwide. As a result, more people are now buying food supplies from local markets which are spatially disperse and temporal especially in developing countries. Therefore, availability and accessibility to market facilities is important in averting food insecurity and addressing problems of malnutrition in developing countries. Although well-functioning market systems promotes food trade and ensures consistent supply, poor geographic access to food retail markets remains a big challenge. In Sub Saharan Africa alone, close to 60% of the households own less than one hectare of farmland comprising a large proportion of all small scale farmers in the world (**Eyzaguirre *et al.*, 2006**). Most of these farmers produce traditional food crops which are sold in the informal and village markets thus fetching low incomes to farmers. Although there is a consensus on market participation as an important pathway for enhancing food security and general improvement in the livelihood of small scale farmers, the participation rate of smallholder farmers in marketization is low and often hindered by high transaction costs due to small surplus production (**Torero, 2011**). The greatest challenge facing development of small scale farming is availability of markets and issues to do with market accessibility.

In Kenya, market access and efficient distribution of food from areas with excess production to those in need is limited by poor road infrastructure **(RSA, 2015**). This translates to many households being cut off from available food supplies while consumers end up paying up for high food prices in local markets. Notably, in the rural and remote semi-arid areas, farmers face constraints of physical accessibility to market facilities due to long distances they have to trek to nearest village markets. As a result, most of them miss out the opportunities to commercialise their produce and increase a share of market sales or still diversify their market products (**Asfaw *et al.*, 2010**). This influences farmers' as well as households' decision to use markets and also the quantity of produce to sell or buy (**Omiti *et al.*, 2009; Makhura, 2001**). Physical accessibility is an important factor in the use of markets more so in rural areas where long distances to markets impact on the ability to access markets for food needs, purchase of merchandise and livestock sales for financial resources. One of the objectives of Kenya's food and nutrition security policy 2011 is to increase the quantity and quality of food available, accessible and affordable to all at all times (**GOK, 2011**). Approaches identified by the policy to realise this are those geared towards increasing production, maintenance of strategic food reserves and reduction of post-harvest losses without underscoring the significant role markets can play in promoting food availability and access within local areas.

An important question on which strategies can be adopted for farming to support small scale households with adequate income and food rations is of essence in the wake of increased poverty and uneconomical subdivisions of small scale lands. The fact that in rural areas most people are net buyers of food makes the situation more complicated as echoed in studies done locally (**Waithaka *et al.*, 2006; Jayne *et al.*, 2016**). Generally, these studies have shown how small scale mixed livestock and crop farmers face challenges in satisfying income and meeting food needs.

Although improving local food distribution systems and physical accessibility to markets can address challenges of food availability, it has not received much attention in policy and research. This clearly calls for shift of focus from increase production strategies of addressing food insecurity in the country to those of enhancing marketization and distribution of local produce. Improving physical accessibility to markets promotes linkage between consumers and producers opening up more opportunities for commercialisation and consumption of local produce. In the country, poor physical accessibility limits efficient food distribution and market access leading to high food prices for consumers and low food supplies in local markets by farmers. Given this scenario, present study seeks to model physical accessibility to open food markets using geographic information systems and analyse how inaccessibility impacts on household food security. Geographic information systems has been applied in measurement for physical accessibility of retail sites, health care planning, transport as well as emergency services (**Bhatti, 2005; Noor *et al.*, 2006; Smoyer *et al.*, 2004**). However, a review of literature on GIS based measures of access shows that its application has been extensively in the health sector. There is limited work on the use of GIS outside the domain of health care as large part of existing literature is on use of GIS to examine spatial patterns of disease spread and partly in environmental studies for correlation analysis.

This research is a first attempt to show how spatial accessibility to food retail markets can be measured using GIS to assist understand local area food needs and for planning of food and nutrition security interventions for deprived population. This is important in realising sustainable development goals number 2, 3 and 12 at both local and national levels.

Rationale of the Study

This paper seeks to analyse the problem of geographic accessibility to rural village food markets by households. Village food markets are centers in rural areas where local farmers sell their food crops and livestock. These markets operate periodically at certain days of the week. Measuring physical accessibility is important in understanding service utility of markets because number of people using any given facility will normally decrease as the distance from that facility increase. Due to under developed transport networks in most rural areas, mobility is challenging especially moving of farm produce to the open air markets.

In the rural areas, majority of people access food through open air markets and as such physical accessibility defines food security especially for the resource poor households who depend on markets for food. In modelling physical accessibility, administrative, normative and geospatial data was acquired and used (Table 1).

Table 1: Data used in modelling physical accessibility

Type of data	Data sets name	Indicator measured
Geospatial	Open air markets	Location position of markets
Administrative	Villages, sub locations	Market service range area
Socio-economic	Population	Number of Deprived persons
Normative	Road classes and associated speed limits	Travel time to nearest market

Location position of open air markets was captured to show spatial distribution of market facilities and to aid in computing distances across market facilities. Villages and sub location geometry data was applied to define catchment areas for markets since they comprise source regions of households using these markets. Population data was needed to understand socio-economic characteristics of market dependent households who represented deprived persons in need of food. In measuring mobility, important road network data was the road class and associated speed limits to be used to compute travel time from villages to the markets.

DATA AND METHODS

Study Area

Tharaka constituency is one of the three constituencies within Tharaka Nithi County. It lies between sub-humid highlands to the west and the arid and semi-arid plains to the south and east (Figure 1). The constituency has a total population of 130,098 persons and 27493 households spread across five wards. These wards include; Nkondi, Mukothima, Marimanti, Gatunga and Chiakariga. Population distribution across the study area vary spatially with Chiakariga ward having a population of 34,679; Marimanti ward with 32,609, Gatunga ward with 21,421 while Nkondi has 15,574 and finally Mukothima ward has approximately 28,555 persons (**KNBS, 2009**). Agriculture is the main livelihood of the Tharaka sub tribe with at least 92% of the households engaged in agricultural activities (**ISS, 2016**). Communities living in this area practice mixed farming and the dominant staple crops grown are maize, bulrush millet, sorghum and legumes (**Smucker and Binsey, 2008**). The area comprises of low, hilly, stony and sandy lowlands with major economic activities being crop farming and livestock keeping. Based on food security vulnerability analysis, the region is classified into marginal mixed farming (MMF), rain-fed cropping (RFC) zone and the mixed farming (MF) zone (**WFP, 2006**).

Open air markets

Market centres are important food hubs in the study area as most households sell and even buy from these open air retail village markets. Each of the open air market was visited to understand food marketing systems where the type of food sold, physical infrastructure and functional services performed were examined. Geographic location was mapped by collecting coordinates of the markets using Trimble GPS receiver. To increase positional accuracy, three readings for latitude and longitude were taken and the average reading used to give the final location for that particular market. Field survey revealed that markets in the study area vary in market functional services from those dealing with food bulking services, to livestock auctioning as well as to food assembly and livestock auctioning (Table 1).

Figure 1: Physiographic map of Tharaka constituency showing 5th level Administrative Units

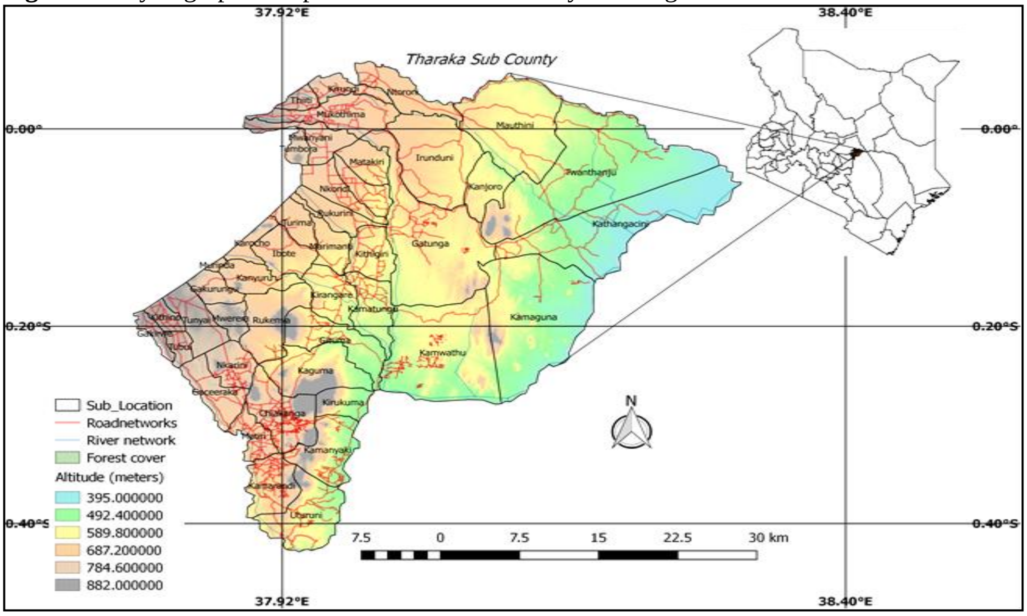

Table 1: Location and functions of village open air market centres

Market Name	Function and Service of the Market	Latitude (DD)	Longitude (DD)
Mukothima	Food Assembly market	0.013272	37.945258
Miomponi	Food Assembly market	-0.000625	37.904954
Nkondi	Food Assembly market	-0.045627	37.957797
Gaciongo	Food Assembly market	-0.029883	38.019463
Kathangacini	Livestock market	-0.094119	38.151877
Gatunga	Food and Livestock market	-0.997253	38.010969
Marimanti	Food and Livestock market	-0.157041	37.977835
Kibung'a	Food Assembly market	-0.076775	37.919951
Tunyai	Food and Livestock market	-0.175883	37.836882
Nkarini	Food Assembly market	-0.243508	37.877654
Chiakariga	Food and Livestock market	-0.277302	37.923869
Shauri	Livestock market	0.012805	38.073438
Karocho	Food Assembly market	-0.131622	37.885863
Matiri	Food Assembly market	-0.319019	37.901902

Population distribution

Population data which was projected to 2018 based on 2009 Kenya population and housing census data was sourced from Tharaka Nithi county office of the Central Bureau of Statistics (**KNBS, 2009**). Sub location was chosen because it forms the lowest and fifth administrative level in Kenya. Currently, census data is aggregated to this level and therefore population data at sub location level forms highest spatial resolution demographic data available for public access. According to the projected 2018 population data, Tharaka constituency has a total population of 147583 inhabitants spatially spread across 48 sub locations.

Administrative units

Paper map showing Tharaka North and South sub counties was acquired from Tharaka Constituency Office. It was scanned and then digitized in CATALINX digitizing software. All the 48 Sub location boundaries were digitized and corrected for errors through running of polygon closure algorithm to ensure there were no slivers or gaps in resultant polygons. The layer was then exported to QGIS open source GIS software where the map was re-projected into the common spatial reference system adopted all geospatial datasets used in this study (Figure 2).

Road networks

Road network vector format data was derived as paper map data supplied by County Kenya Rural Roads Authority (KeRRA) for Tharaka-Nithi based at Chuka town. The sourced data was not adequate for analysis after comparison with Google Earth imagery since it only covered lower level road classes P and N. It was therefore updated using Open Street Map data accessed using OSM plugin in QGIS. Additionally, road data from the WRS (2019) was also used to supplement county roads data. Both county roads and WRI roads shape files datasets were integrated to derive the final road distribution network data (Figure 3).

Digital Elevation Model

Elevation in the area range from the lowest of 395m to the highest of 882m above sea level (Figure 4). Slope was considered an important parameter affecting travel time to and from markets by households. Area slope was derived from the digital elevation model using slope function in QGIS geo processing tool box and expressed in per cent. The region's slope ranged from 0.6% (Flat surfaces) to 26 % (steep surfaces). The digital elevation model used was downloaded from NASA Shuttle Terrain Radar Mission in 30m to match grid resolution of other datasets.

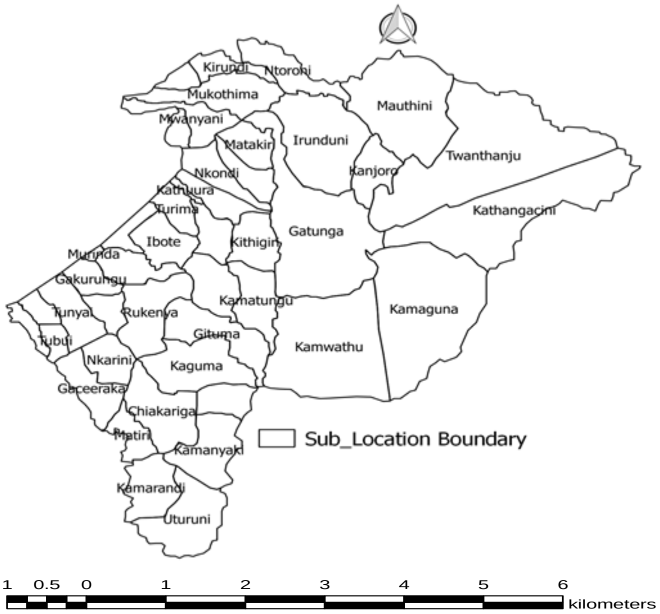

Figure 2: Fifth level administrative units map showing sub location boundaries

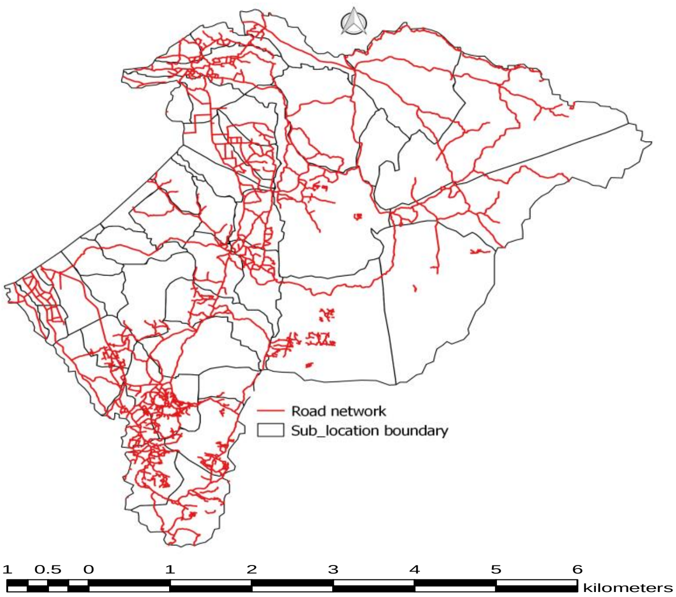

Figure 3: Spatial distribution of roads across the study area

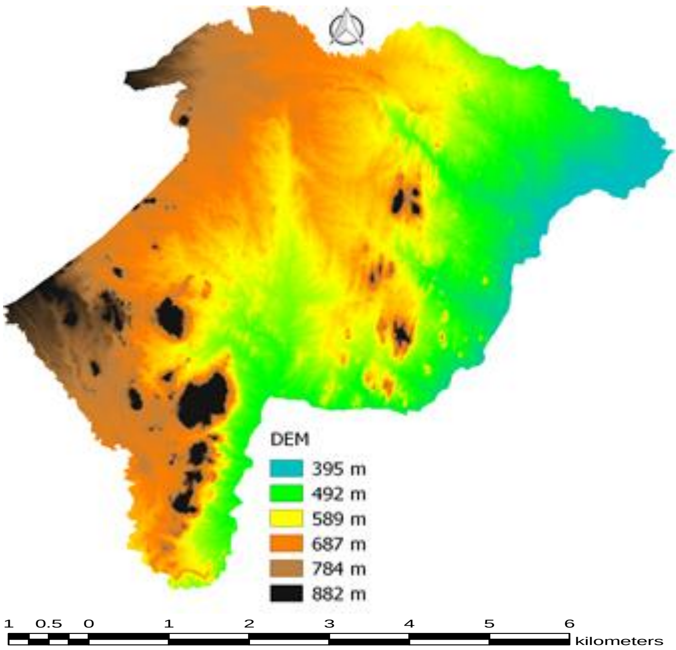

Figure 4: Altitudinal height of the study area in meters

Data Processing Methods

Creation of sub-location Population Database

The fifth level administrative units were digitized as polygons and the polygon's centroid calculated to represent a point-polygon feature. Projected population for 2018 for each fifth level administrative unit was then assigned to each centroid. Therefore, a population geo database for all the 48 sub locations was created through linking the administrative units' polygon to sub location population. Resultant database contained relevant data to facilitate GIS analysis and visualisation.

Road Network Classification

Road distribution map data was cleaned to remove duplicate and short road segments. It was then reclassified based on the Kenya Roads Act, 2015 as primary, secondary and tertiary roads. According to the Act, primary roads are those which connect countries through international boundaries. Secondary roads on the other hand link counties, major towns as well as primary roads. Tertiary roads are those roads that connect small markets and also feed into secondary roads. Tharaka has secondary and tertiary road categories.

Development of Travelling Scenarios

To understand mobility across markets and villages by households, various transportation modes were considered. Basic transportation modes identified during field survey were walking, cycling and use of vehicles. Identified transportation modes were used in modelling different travelling scenarios. Land use/cover map for the study area was created from recent acquired Landsat 8OLI/TIRS images using semi-automatic classification plugin in QGIS Version 3.8. Four classes of bare land, built up area, thick vegetation and crop land were developed. Speed limits adopted for each land cover were based on recommendations by **Nelson (2000); Ray and Ebener (2008)**. Recommended speed limit assumes travelling surface is always a zero degree slope flat surface. To address this limitation, speed limit correction based on digital elevation model was done to cater for slope variations in the study area. Walking speed was corrected based on Tobler's formula (**Tobler, 1993**) (Eq.1)

$$W = 6\, exp\, \{-3.5 * abs\, (S + 0.05)\} \quad (1)$$

Where:

W is corrected walking velocity in kilometres per hour and S is slope in degrees. Tobler's formula was chosen because it increases or decreases the effective walking speed based on the steepness of surface slope. Corrected walking speed based on slope intensity is as shown in Table 2.

Table2. Walking speed corrected based on slope intensity

Land Cover	Walking speed (Km/hr)
Bare land	2.2
Crop land	1.6
Built up area	3.1
Thick Vegetation	1.0

As for road based velocity, slope correction was not done given the flat nature of landscape in the study area. In most cases it is the acceleration which propels the speed of movement; therefore, slope does not influence the overall speed of motorized transportation (motorcycles and vehicles). Speed limits used were those adopted from **Ouko *et al.* (2019)** (Table 3). These speed limits were applied because they represent optimal velocities allowable in event of encountered barriers to movement.

Table3. Optimal speed limits for motorised transportation

Road Category	Motorcycle(Km/hr)	Vehicle(Km/hr)
Primary	28	60
Secondary	24	50
Tertiary	10	30

Note: Based on **Ouko *et al.*, 2019**

Data Analysis Techniques

All datasets were projected to local datum of arc1960 and UTM zone 37 South for purposes of ensuring they were in the same spatial reference properties.

Distance Analysis

Distance to the nearest market was computed for all the open air markets using Distance to the Nearest Hub tool in QGIS. This tool was used to calculate linear distances covered by the people to the markets moving on foot where there are no roads (Figure 5). Each centroid was assigned the number of villages in each sub location. Calculated distance in kilometres was then classified into a six-point equal interval distance scale starting from the nearest to the farthest as; 0.5 - 2.4 km, 2.4 - 4.2 km, 4.2 - 6.1 km, 6.1- 8.0 km, 8.0 - 9.8 km and 9.8 - 11.7 km.

Travel Time Estimation

Travel Time was calculated based on a formula by **Kayode and Efosa (2014)**. Average and maximum travel time was computed for walking, motorcycle and vehicular mobility (Table 5). In computing travel time by pedestrians, distances derived through estimation of linear trajectories to the closest road and slope corrected walking velocity were used. Travel time for motorised movement was calculated for secondary and tertiary roads as they were suitable for motorised transport. To get travel duration for vehicles and motor cycles, length of the closest road to each market centre was divided by the optimal speed of 50 km/hr adopted for all roads used by vehicles. On the other hand, for motor cycles average speed of 24km/hr was applied assuming barriers encountered by motorcycle users to the markets were the same across all the sub locations.

Developing a Composed Index of Critical Accessibility (CICA)

Important factors used in analysing accessibility were the; population, number of villages, travel time used to reach the nearest road and finally distance covered. The factor values were combined together to compose an index of critical accessibility. The index comprised of total Z score values for all indicators used. Z values are used because they explain how many standard deviations the individual scores are from mean **(Hinton, 1999).** Composed Index of Critical Accessibility was calculated in SIGEpi, the special program for health analysis by Pan Africa Health Organisation **(Martinez *et al.*, 2001).** The CICA index was composed as Eq.2, Eq. 3.

$$CICA_j = \sum Zn_i = 1 \quad (2)$$

Where; CICA = composed Index of Critical Accessibility, i = indicators, j =villages in each sub locations, *Z* =*Z* score

Table.5: Travel time computed for major modes of transport used by households

Mobility	Mean_Travel Time	Maximum_Travel Time	Average Speed
Walking	18.7 Minutes	4hours.39 Minutes	5 Km/hr
Motor cycle	3.9 Minutes	54.9 Minutes	24Km/hr
Vehicle	1.8 Minutes	26.4 Minutes	50Km/hr

$$Z = (X - \bar{x}) / SD \quad (3)$$

Where:

SD =Standard deviation, *X* =Indicator value for villages, $\bar{x}$ = Mean

CICA was generated for each sub location which contains aggregated population at village level for all households. In order to identify population exposed to the risk of inaccessibility, computed CICA was then classified and arranged into categories showing Very High risk, High risk, Medium risk, Low risk and Very Low risks of accessibility problems.

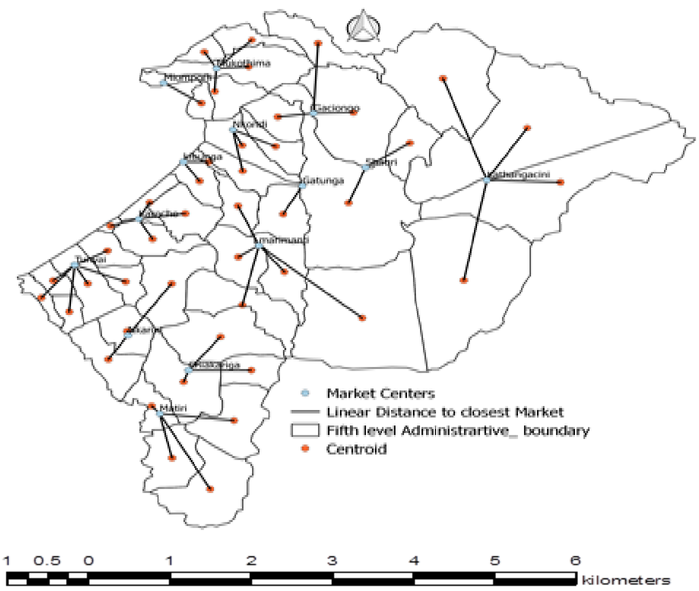

Figure 5: Straight-line Distance segments between each sub-location and its closest market centre.

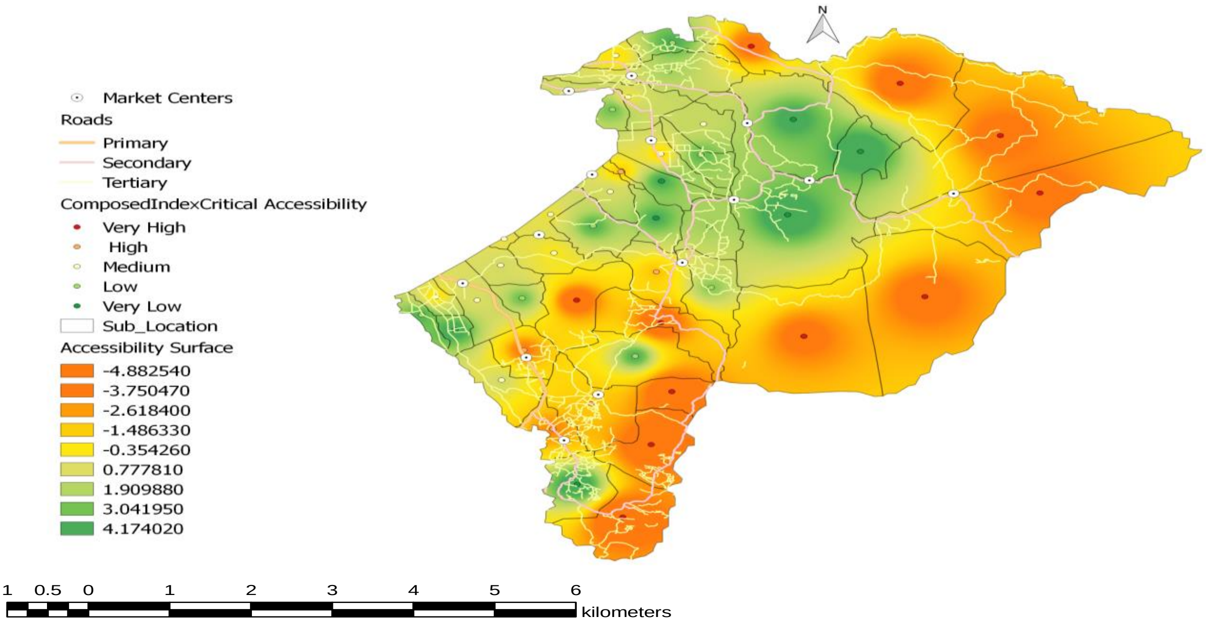

Figure 6: Village to market accessibility surface for households based on Composed Index of Critical Accessibility

Creation of Accessibility Surface

In order to spatially delineate and visualise areas of critical accessibility, boundary of possible accessibility surface was created. This was done through spatial interpolation of the composed index of critical accessibility Z values using Inverse Distance Weight (IDW). Inverse Distance Weight approach was used because it works on the premises that each input point has a local influence that diminishes as distance increases away from that point. From the generated market-village accessibility surface, areas with low accessibility to markets are shown in orange colour while those with high accessibility to markets are shown in green colour (Figure 6).

RESULTS AND DISCUSSION

Population with access based on distances

Population with access to each market facility at each of the 6-point equal interval distance scale is shown in Table 6. Straight line distance analysis revealed that 27,415 persons lived within half a kilometre to two and half kilometres from a market centre. 54,443people were found within a distance rang of two and half and four kilometres. Within four kilometres and six kilometres distance from a market, a total of 35,562 people were found living in this range. Only 19,761 people lived within six kilometres and eight kilometres distance. Minimal population of 1,780 persons lived between eight kilometres and ten kilometres from any given market centre. The population which lived over ten kilometres from any market was estimated at 11,049 persons.

Using six kilometres from a village centroid to the nearest market centre as maximum distance households were willing to travel to any market centre 80% of the population in semi-arid Tharaka live within a distance of 6km to the nearest market centre. The mean distance of access to markets in the region was computed as 2.3 kilometres. In general, overall spatial concentration and distribution of population reached peak at 2.4 kilometres and 4.2 kilometres respectively.

Table.6: Population with access to each market for a 6-point distance scale

Point	Distance range (Km)	Persons with Access
1	0.5 – 2.4	27,415
2	2.4 – 4.2	54,443
3	4.2 – 6.1	35,562
4	6.1 – 8.0	19,761
5	8.0 – 9.8	1,780
6	9.8 – 11.7	11,049

Source: own calculation

Spatial distribution of village markets accessibility risks

From the analysis, about 39.1% of the population live in areas with high accessibility risks while 22.7% are in medium risk zones and 38.2% of the population are found in low risk areas (Table 7).

Table.7: Spatial distribution of physical accessibility risks from villages to food market centres

Composed Index of Critical Accessibility	Total_ Population	Number of Villages	Average_ Distance to nearest road (Km)	Travel_ Time (Minutes)
Very High	33,595	255	4.43	14.75
High	25,351	113	3.77	12.55
Medium	34,325	159	2.77	9.22
Low	31,888	181	1.01	3.32
Very Low	20,755	175	0.88	0.43

Source: own calculation

This means 33,595 people live in villages with the highest risk of inaccessibility conditions, 25,351 persons in high risk places, 34,325 persons in moderate risk zones and 31,888 people in areas with low risk of poor accessibility. Villages with lowest risks of accessibility problems cover 20,755 persons geographically spread across the study area. A total of 368 villages across the five wards were found in sub locations with very high to high risks of accessibility. For instance, 255 villages had very high risks while 113 villages had high risks of accessibility respectively. About 159 villages were found in areas with moderate accessibility risks while 356 villages exist in low to very low accessibility risk areas.

Similarly, people within very high accessibility risk travel on average 4.4km to the nearest road using about 15minutes. Those in high accessibility risk areas cover about 3.8km to reach a road from the village spending 13 minutes. In medium risk zones, people travel about 2.8km to the nearest road within 9 minutes while those in low risk areas cover about one kilometre within 3 minutes. People living in very low accessibility areas travel about 900 meters to a road spending less 0.4 minutes.

Areas of critical accessibility mapped

Households identified to have low accessibility to markets are those found in the sub locations of Kathangacini, Mauthini, Twanthanju, Kamaguna, Kamwathu, Kirukuma, Kamanyaki, Uturini, Gituma, Rukenya, Nkarini, Matiri and Ntoroni respectively. These areas are not well served with roads and exist on the border with counties of Kitui to the East and South East and Meru County to the North and North East. Additionally, household within Gatunga, Kanjoro, Irunduni, Marimanti, Rukurini, Ibote, Tubui, Gakirwe, Kaguma, Kamarandi, Tumbora, Kirundi, Mukothima, Kithigiri, Kamatungu and Mwerera sub locations fall in areas with high accessibility. These areas are well served by many feeder roads and the only major secondary trunk road connecting Embu, Kitui and Meru Counties with Tharaka Nithi county passes through these areas.

CONCLUSIONS

In an attempt to analyse challenges of physical accessibility to markets by locals in Tharaka constituency, two extremes were considered with location of people on one hand and market availability on the other. Populated places aggregated at sub location level were geocoded by a centroid through assigning population data to that geometry. Location coordinates of open air markets was collected in the field using a GPS receiver while road network and associated data was acquired from relevant authorities. Travel time and distances were considered important indicators of physical accessibility in this case study.

When distance was analysed across the study area, 59% of the population lived within 2.5 kilometres to 6 kilometres from nearest market with 18% within less than 2.5 kilometres and about 23% of the total population living over 6 kilometres from the closest market centre. As per travel time computed for both motorised and non-motorised mobility, folks walking to the nearest road from their homesteads would use on average 18.7minutes if walking at a speed of 5km/hr. Those using motor cycles would use only 3.9 minutes riding at a mean speed of 24km/hr while those opting for vehicular movement would use 1.8minutes driving at an average speed of 50km/hr. On the basis of accessibility, 52,643 people living in 356 geographically dispersed villages are found in areas with low accessibility, while 34,325 people within 159 villages live in areas with moderate ease of accessibility. A total of 58,946 people spread across 368 villages live in areas with high accessibility. These are opened up regions with improved roads and more transportation alternatives to reach market centres.

This study has succeeded in showing approaches that can be used to establish conditions of physical accessibility to village food markets for populated rural areas. Additionally, markets within areas having higher risks of inaccessibility were identified as Kathangacini, Chiakariga, Matiri and Nkarini market centres. These market facilities should be considered by the county government of Tharaka Nithi for upgrading in order to address local food needs. Furthermore, identified areas of very high to high inaccessibility risks represent "food deserts" which can be targeted by county government for relief food distribution and construction of village feeder roads to link households to market centres.

There is need to lower food prices and market usage fees across all markets in an effort to promote increased supply and consumption of locally produced foods. It is important to have sections within open air markets where local farmers can sell their produce and get a chance to interact with consumers. Similarly, public health and sanitation of food markets through provision of clean tap water, waste bins and toilets should be a priority for authorities to ensure markets hygiene and food safety is realised. Further research should be done to investigate patronage behaviour of market users as well as spatial availability of market services in the country if the food availability and access pillar of Kenya's Food and Nutrition Security Policy is to be strengthened.

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REGULAR ARTICLE

EFFECT OF AGRICULTURAL AND NON-AGRICULTURAL EXPORTS ON ECONOMIC GROWTH IN IVORY COAST

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ABSTRACT

The objective of this paper is to assess, empirically, the effects of agricultural and non-agricultural exports on economic growth in Ivory Coast. The data used are those of the World Bank (World Development Indicators) and the Central Bank of West African States and cover the period from 1985 to 2015. The analysis of the data required the use of the AutoRegressive Distributed Lag (ARDL). It emerges from the study that the agricultural exports have positive and significant effects on the Gross Domestic Product. However, this rate appears to be increasingly weak in long term. On the other hand, the non-agricultural exports have a positive but not significant effect on economic growth in short term. Nevertheless, in the long run, they improve the country's economic performance. Moreover, the Gross Fixed Capital Formation stimulates the economic wealth generation. Finally, the trade openness negatively affects the economic development. Therefore, the Ivorian government, while giving priority to improving the competitiveness of export products, must apply a diversification policy in order to reduce the risks of deterioration in the terms of trade.

Keywords: Exports; Economic growth; Ivory Coast
JEL: C01; O47; Q00

INTRODUCTION

Ivory Coast, an exporter of primary products, is heavily dependent on agriculture in the formation of its wealth. Indeed, agriculture contributes to 22.3% of GDP and accounts for 47% of the country's overall exports (62% excluding oil). It employs 46% of the country's working population and is an important source of income for two thirds of the Ivorian population according to **Banque Mondiale (2016)**.

However, dependence on world prices of agricultural raw materials plunged the country into a deep crisis from 1980 to 1993. This crisis was characterized by a sharp drop in economic growth, a significant drop in per capita income, worsening internal and external imbalances (deterioration of the balance of payments, growing public deficits) according to **AISA (2015).** This underperformance of the agricultural sector, which makes a significant contribution to national GDP, can be explained by the low level of agricultural productivity, the slump in production, the low purchase prices of agricultural products and an inequitable distribution of the rebates generated by the various sectors. In addition to these causes, there are significant post-harvest losses, the low level of conservation and processing of agricultural products, the general ageing of orchards, insufficient use of quality inputs and the poor mastery of modern cultivation techniques. Moreover, the cost of inputs remains high and research results are not always accessible and sufficiently valued. Similarly, agricultural actors are insufficiently supervised and have limited access to credit and to regional and international markets **(Kouakou, 2017).** Finally, the agricultural sector suffers from the isolation of many production areas. In addition, the industrial processing of agricultural production remains insufficient to drive strong economic growth, substantially improve added value and absorb local production **(AISA, 2015).**

To cope with this situation, Ivory Coast has been engaged since 1994 in a process of diversification of its economy under the aegis of the Bretton Woods institutions, including the IMF and the World Bank. Today, export production accounts for nearly 40% of export earnings and supports the country's agro-industrial development. These exports are also dominated by agricultural products (about 60%) and non-agricultural products (about 40%) according to **Zamble (2015).**

However, despite these achievements and according to **AISA (2015),** diversification has not yet had a significant effect. Competition and international legislation constitute a hindrance to the development of other sectors of the economy. Moreover, world economies are marked by vulnerability to the dynamics of external trade. In this context, it is necessary to assess the contribution of agricultural and non-agricultural exports to Ivory Coast's economic growth. Specifically, it is necessary to estimate the causal link between agricultural and non-agricultural exports and economic growth in Ivory Coast.

DATA AND METHODS

Theoretical and conceptual frameworks

Several studies have been carried out by economists to show the relationship between economic growth and exports.

Michaely (1977) tested the hypothesis that rapid export growth accelerates a country's economic growth. He examined Spearman's rank correlation coefficient between the growth rates of two series that represent, respectively, the average size of annual changes in the ratio of exports to GNP and the average annual change in the ratio of GNP per capita. He concludes that for a number of countries in his sample, this correlation is significant. **Balassa (1978)**, following Michaely's lead, also uses Spearman's rank correlation coefficient to test the correlation that might exist between different export and economic growth ratios for a group of developing countries over the 1960-73 period. He concludes that the addition of exports to the explanatory variables, on the GNP side, increases the overall significance of the model. In addition, the coefficient on exports is found to be statistically significant. **Feder (1983)** notes that the contribution of exports to GDP growth exceeds the simple change in its volume. He constructs two production functions, one for the export sector, and other for the domestic sector. Feder's regression results cover the period 1964-1973 for a sample of 31 countries, 19 of which are defined as semi-industrialized and 22 marginally semi-industrialized. The conclusion of its results asserts that there is a substantial productivity gap between exports and non-exports in addition to the differential due to externalities.

Similarly, **Jlidi (1996)**, in his study on exports, imports and economic growth, shows, after decomposing total exports into manufacturing exports on the one hand and raw materials on the other, that the first type of exports (manufacturing products) generates more externalities than the second. One of the probable explanations for the difference between the externalities generated by each type of export may be the fierce competition on the world market for finished goods. It concludes that the long-term growth of developing countries depends largely on the stability and performance of their export sectors (manufacturing and intermediate inputs) in favourable global conditions. **N'Zue (2003)** has carefully studied the Granger causal relationship between export expansion and economic growth in Ivory Coast and finds its effects on employment creation. He indicates that although there is no cointegration between exports and economic growth, there is a circular relationship between them. **Kpemoua (2016)**, empirically, analysed the impact of exports on economic growth in Togo as well as the existence of a causal relationship between exports and economic growth by applying a model based on a neoclassical production function. The data cover the period 1960-2014. The methodological approach used is based on cointegration and causality techniques. The empirical results show a positive and significant correlation at the threshold of 1% in the long term between exports and economic growth and a causality in the sense of Toda and Yamamoto, of exports to economic growth. According to all these previous studies, exports are an important source of economic growth.

Data collection

The data relating to the variables: Gross Domestic Product per Capita (GDP), Gross Fixed Capital Formation (GFCF) and trade openness (OC) were calculated from data taken from the World Development Indicators (World Bank), while agricultural exports (XA) and non-agricultural exports (XNA) were taken from the database of the Central Bank of West African States. The study covers the period from 1985 to 2015. The choice of this study period is necessary in order to avoid series with missing data. All model variables are in natural logarithms (Appendix 1).

Method of analysis

The analysis is based on the neoclassical growth model originally developed by Solow in 1956. This neoclassical production function is specified in terms of traditional inputs such as labour (L) and capital (K) and is written (Eq. 1):

$$Y = F(K, L) \qquad (1)$$

Taking into account the specificity of the present study, the ARDL model of **Pesaran et *al.* (2001)** was used.
The ARDL (AutoRegressive Distributed Lag) model is one of the time-shift models. The use of this model is justified by the fact that it takes into account both the short-term and long-term relationships of the variables tested. The advantage of the ARDL method, in contrast to the latter, can be found at two levels. On the one hand, it can be applied to any degree of integration of the variables used: pure I (0), pure I (1) or mixed. On the other hand, it has superior statistical properties for small samples. To do this, the ARDL model used is as follows (Eq. 2).

$$GDP = f\,(GFCF, XA, XNA, CO) \qquad (2)$$

The long-term equation can be written as follows (Eq. 3):

$$LGDP_t = \alpha_0 + \emptyset \sum_{i=1}^{p} LGDP_{t-i} + \alpha_1 \sum_{i=0}^{q} LGFCF_{t-i} + \alpha_2 \sum_{i=0}^{q} LXA_{t-i} + \alpha_3 \sum_{i=0}^{q} LXNA_{t-i} + \alpha_4 \sum_{i=0}^{q} LCO_{t-i} + \varepsilon_t \qquad (3)$$

The equation for the cointegrating relationship is obtained from the following error correction model (Eq. 4):

$$\Delta LGDP_t = \alpha_0 + \emptyset_{1j} \sum_{i=1}^{p} \Delta LGDP_{t-i} + \alpha_{1i} \sum_{i=0}^{q} \Delta LGFCF_{t-i} + \alpha_{2i} \sum_{i=0}^{q} \Delta LXA_{t-i} + \alpha_{3i} \sum_{i=0}^{q} \Delta LXNA_{t-i} + \alpha_{4i} \sum_{i=0}^{q} \Delta LCO_{t-i} + \lambda ECM_{t-i} + \varepsilon_t \qquad (4)$$

With ECM_{t-1}, the error correction term (Eq. 5)

$$ECM_{t-1} = LGDP_t - \alpha_0 - \emptyset \sum_{i=1}^{p} LGDP_{t-i} - \alpha_1 \sum_{i=0}^{q} LGFCF_{t-i} - \alpha_2 \sum_{i=0}^{q} LXA_{t-i} - \alpha_3 \sum_{i=0}^{q} LXNA_{t-i} - \alpha_4 \sum_{i=0}^{q} LCO_{t-i} \qquad (5)$$

Taking into account the short and long-term effects, the ARDL representation is as follows (Eq. 6):

Table 1: Variables used

Variables	Descriptions	Expected effect
GDP	Gross Domestic Product per capita expressed in US Dollar	
GFCF	Gross fixed capital formation: this variable is a "proxy" for the investment	+
XA	Agricultural exports expressed in volume	+
XNA	Non-agricultural exports expressed in volume	+
CO	Commercial opening expressed in US Dollars ((Import + Export)/GDP)	+

Source: Author (based on theory)

$$\Delta LGDP_t = \alpha_0 + \alpha_1 \sum_{i=1}^{p} \Delta LGDP_{t-i} + \alpha_2 \sum_{i=0}^{q} \Delta LXA_{t-i} + \alpha_3 \sum_{i=0}^{q} \Delta LXNA_{t-i} + \alpha_4 \sum_{i=0}^{q} \Delta LCO_{t-i} + \beta_1 LGDP_{t-1} + \beta_2 LXA_{t-1} + \beta_3 LXNA_{t-1} + \beta_4 \Delta LCO_{t-1} + \varepsilon_t \qquad (6)$$

Where:
Δ first difference operator;
α_0 a constant;
$\alpha_1 \dots \alpha_4$ short-term coefficients;
$\beta_1 \dots \beta_4$ long-term coefficients;
$\varepsilon_t \sim iid(0, \sigma)$ an error term (white noise);
λ the restoring force towards balance.
Table 1 presents the variables of the study.

RESULTS AND DISCUSSION

Economic growth trends in Ivory Coast

According to Figure 1, the period from 1985 to 2015 is marked by varying degrees of fluctuation in the annual growth rate. Indeed, the first decades of the country's independence were marked by a period of strong growth justified by the coffee and cocoa boom. However, from 1985 onwards, *Ivory Coast* experienced a severe economic crisis due to the fall in the prices of these main export products on the international market. This weakened its economy until 1990.

From 1990 onwards, the structural adjustment programme imposed by the Bretton Woods structures, including the International Monetary Fund, began to take effect, leading to a slight recovery until 1998, when the country fell into a military crisis and economic decline resumed.

From 2000 onwards, the economy rebounded again due to a noticeable stability but was quickly slowed down from 2002 onwards by a socio-political crisis. From 2002 to 2005, peace agreements were signed and the economy recovered slightly.

From 2005 to 2010, the Ivorian economy returns to positive growth rates. However, from 2010 to 2011, Ivory Coast experiences a severe post-electoral crisis. This weakened all economic activities. Moreover, it is the most severe crisis that this country has experienced because the growth rate was negative (-5%).

From 2011 to 2015, the economy recovered to achieve the marvellous performance of the double-digit growth rate (over 10%) and remained somewhat stable, before declining slightly and stabilizing at 8% from 2015 onwards.

Agricultural and non-agricultural exports trends in Ivory Coast

From 1985 to 2010, *Ivory Coast* gradually increased its export volume of agricultural products, reaching a peak in 1990 according to Figure 2. From 2010 to 2014, agricultural exports remained stable. However, the period 2015 is marked by a drop in export volumes due to the effect of climate change, which causes seasonal variations and the appearance of devastating caterpillars. According to this same figure, exports of non-agricultural products increased over time. However, this increase was strong from 1994 onwards because of the policy of diversification of export products implemented by the Ivorian government under the Structural Adjustment Programme.

Descriptive characteristics of the variables

Table 2 shows that variables such as non-agricultural exports and trade openness are more volatile compared to other variables. Moreover, the variables in the study follow a normal distribution law (Prob > 5%).

Variables such as gross domestic product, gross fixed capital formation, non-agricultural export and trade openness are all stationary in first difference and are included in first order, while the variable such as agricultural export remains stationary at the level (Table 3). The series are thus integrated at different orders. This renders Engle's and Granger's cointegration test (multivariate case), as well as Johansen's, ineffective, but makes the cointegration test at the bounds of **Pesaran et *al.* (2001)** appropriate.

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With regard to Table 4, the optimal delay number of the ARDL model is 4, as the AIC and SC information criteria are at their minimum value. Moreover, this makes it possible to estimate the ARDL model.

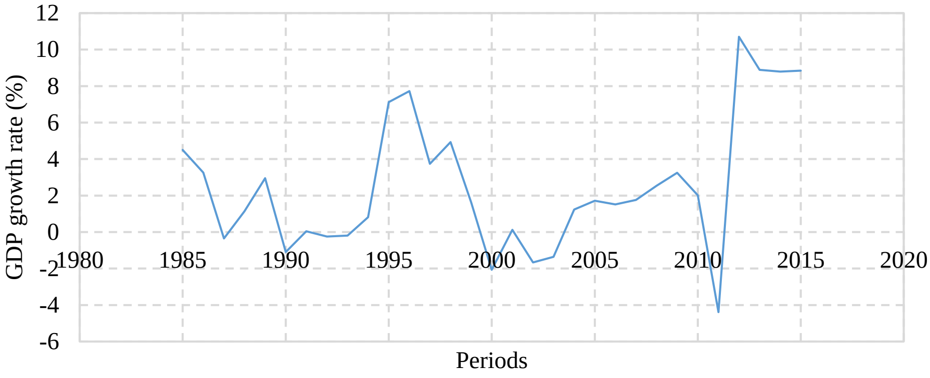

Figure 1: Change in annual GDP growth rate from 1985 to 2015, (%)
Source: Author, estimation using Eviews software.

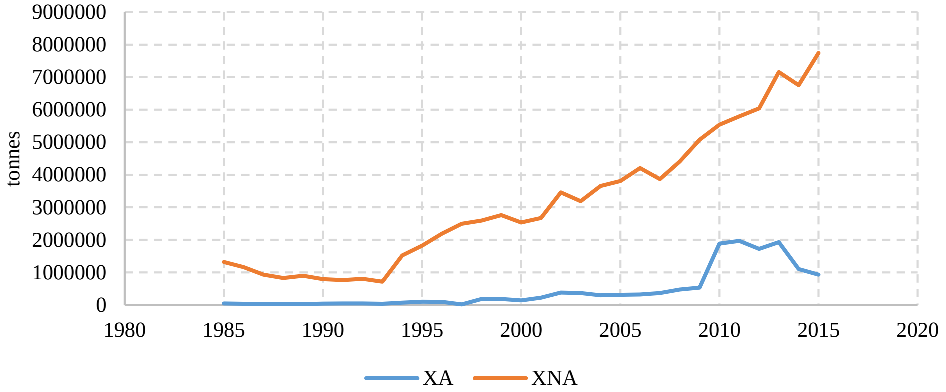

Figure 2: Evolution of agricultural and non-agricultural exports in tonnes over the period 1985-2015
Source: Author, estimation using Eviews software.

Table 2: Descriptive analysis of the variables used

	LGDP	LGFCF	LCO	LXA	LXNA
Mean	7.199415	2.430310	16.29572	12.06866	14.70933
Median	7.180922	2.441029	16.33933	12.12087	14.79737
Maximum	7.402426	2.971941	16,80513	14.49250	15.86215
Minimum	7.037612	2.110633	15.71302	9.598863	13.47756
Std.Dev.	0.096132	0.233446	0.361728	1.478349	0.763264
Skewness	0.512859	0.641897	-0.272761	0.125854	-0.260177
Kurtosis	2.387816	2.749632	1.691272	1.865136	1.780027
Jarque-Bera	1.843038	2.209797	2.596719	1.745394	2.272174
Probability	0.397914	0.331244	0.272979	0.417823	0.321073
Sum	223.1819	75.33960	505.1672	374.1283	455.9892
Sum Sq. Dev.	0.277239	1.634914	3.925406	65.56550	17.47716
Observations	31	31	31	31	31

Source: Author, estimation using Eviews software.

Table 3: Results of stationarity tests (ADF & PP)

VARIABLES	LEVEL		DIFFERENCE 1rst		STATEMENT
	ADF	PP	ADF	PP	
LGDP	-0.83	-0.21	-3.61	-3.62	I(1)
	(0.95)	(0.98)	(0.04)*	(0.04)*	
LGFCF	-1.45	-1.67	-4.96	-4.95	I(1)
	(0.82)	(0.73)	(0.00)*	(0.00)*	
LXA	-4.50	-4.47	-	-	I(0)
	(0.00)*	(0.00)*			
LXNA	1.83	-3.03	-4.61	-5.12	I(1)
	(0.98)	(0.13)	(0.00)*	(0.00)*	
LCO	-0.78	-1.24	-4.62	-4.60	I(1)
	(0.95)	(0.88)	(0.00)*	(0.00)*	

Note: * indicates that these tests are significant respectively at the 5% threshold;
(.) the values in brackets are the different probabilities
Source: Author, estimation using Eviews software.

Table 4: Results of delay number determination

Delay	AIC	SC
0	-2.17	-1.93
1	-7.71	-6.27
2	-7.74	-5.10
3	-9.30	-5.46
4	-11.68*	-6.64*

Note: * indication of the order of the criterion
Source: Author, estimation using Eviews software.

Table 5: ARDL model (1,2,0,3,2)
Dependent Variable: LGDP
Method: ARDL
Sample (adjusted): 1988 2015
Included observations: 28 after adjustments
Maximum dependent lags: 1 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): LGFCF LXA LXNA LCO
Selected Model: ARDL (1, 2, 0, 3, 2)

Variables	Coefficient	Std. Error	t-statistic	Prob.*
LGDP(-1)	0.289764	0.157772	1.836599	0.0862
LGFCF	0.159022	0.020089	7.915872	0.0000
LGFCF(-1)	-0.045540	0.032219	-1.413457	0.1779
LGFCF(-2)	0.075389	0.025384	2.969919	0.0095
LXA	-0.009184	0.005014	-1.831612	0.0869
LXNA	0.002586	0.035314	0.073219	0.9426
LXNA(-1)	-0.001905	0.039108	-0.048706	0.9618
LXNA(-2)	0.075899	0.034811	2.180325	0.0456
LXNA(-3)	0.039018	0.020032	1.947805	0.0704
LCO	-0,142075	0.068777	-2.065719	0.0566
LCO(-1)	0.091950	0.086697	1.060591	0.3057
LCO(-2)	-0.258159	0.085926	-3.004438	0.0089
C	8.091700	1.830391	4.420750	0.0005
R^2	0.973046	Mean of the variable		7.179543
R^2 Adjusted	0.951484			
Akaike Criteria	-5.001424			
Schwarz Criterion	-4.382901			
Stat of Fisher	45.12602			
Fisher's Probability	0.000000			

Source: Author, estimation using Eviews software.

Estimation of the ARDL model. The coefficient of determination (R^2) is 0.973046. This implies that 97.30% of the variation in Gross Domestic Product is explained by the independent variables (Table 6). The value of the coefficient of the restoring force is between 0 and 1 in absolute value. The statistical difference between the variables is eliminated at 71.02% in the study period.
The ARDL model (1,2,0,3,2) is the most optimal among the 19 others presented because it offers the lowest AIC value (Figure 3).

Based on the test results recorded in Table 7, the probabilities associated with the various diagnostic tests are all greater than 5%. The null hypothesis is rejected. There is therefore an absence of autocorrelation of errors, homoscedasticity and normality of errors. The model is then specified, stable and validated.

Terminal cointegration test

Table 8 shows that the F-calculated (3.961271) is higher than the highest value of **Pesaran et *al.* (2001)** at the 5% threshold. Consequently, there is a long-term relationship between the Gross Domestic Product per capita and its determinants in Ivory Coast.

The simple inter-variable correlation matrix (Table 8) shows a relationship between the variable such as trade openness and variables such as agricultural and non-agricultural exports, as the degree of association exceeds 0.50. The correlation matrix is based on a simple correlation between variables. There is also a likely multicollinearity between agricultural exports and trade openness, between non-agricultural exports and trade openness, and between non-agricultural exports and agricultural exports.

The results of the Toda-Yamamoto causality test presented in Table 9 indicate that there is a unidirectional causal relationship at the 5% and 10% threshold for trade openness and agricultural exports respectively.
There is also a unidirectional relationship between Gross Domestic Product and non-agricultural exports. In addition, there is a causal relationship in the Toda-Yamamoto sense between the dependent variable and the independent variable such as non-agricultural exports at the 5% threshold. The same is true between variables such as trade openness and non-agricultural exports at the 10% threshold.

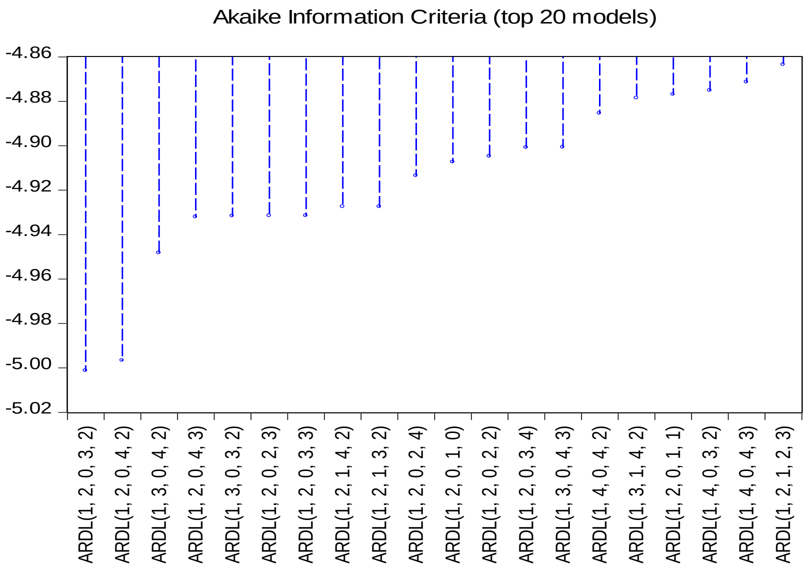

Figure 3: AIC graphical values
Source: Author, estimation using Eviews software.

Table 6: ARDL model diagnostic test results (1,2,0,3,2)

Test Hypothesis	Tests	Values (Probabilities)
Autocorrelation	Breusch-Godfrey	2.46 (0.10)
Heteroskedasticity	Breusch-Pagan-Godfrey	1.07 (0.43)
	ARCH	0.69 (0.60)
Normality	Jarque-Bera	0.90 (0.63)
Specification	Ramsey (Fisher)	0.22 (0.82)

Source: Author, estimation using Eviews software.

Table 7: Results of the cointegration test of **Pesaran et *al.* (2001)**

Variables	LGDP, LGFCF, LXA, LXNA, LCO	
F-Stat Calculated	3.961271	
Critical threshold	Lower terminal	Top terminal
1%	3.29	4.37
5%	2.56	3.49
10%	2.2	3.09

Source: Author, estimation using Eviews software.

Table 8: Simple correlation matrix between variables

	LGDP	LGFCF	LCO	LXA	LXNA
LGDP	1.000000	0.286781	-0.778639	-0.645479	-0.587134
LGFCF	0.286781	1.000000	0.187254	0.246528	0.412640
LCO	-0.778639	0.187254	1.000000	0.885983	0.945356
LXA	-0.645479	0.246528	0.885983	1.000000	0.911469
LXNA	-0.587134	0.412640	0.945356	0.911469	1.000000

Source: Author, estimation using Eviews software.

Table 9: Results of the causality test in the sense of Toda-Yamamoto

k	d_{max}	Dependent variables	Explanatory or causal variables (probabilities) LGDP	LGFCF	LCO	LXA	LXNA
4	1	LGDP	-	1.95 (0.37)	1.59 (0.45)	2.23 (0.32)	0.82 (0.66)
		LGFCF	4.38 (0.11)	-	2.1 (0.23)	0.93 (0.62)	1.44 (0.48)
		LCO	17.46 (0.00)*	1.10 (0.57)	-	5.56 (0.06)**	4.02 (0.13)
		LXA	0.44 (0.79)	0.04 (0.97)	0.39 (0.82)	-	0.58 (0.74)
		LXNA	18.69 (0.00)*	1.37 (0.50)	4.81 (0.08)**	1.45 (0.48)	-

Note: (.): Probabilities (p-value); *: significant at 5%; **: significant at 10%; and values = statistics from $\chi 2$; k: optimal lag of the level VAR (AIC); $dmax$: maximum order of integration of the variables.
Source: Author, estimation using Eviews software.

Short-term coefficients

The results of the short-term coefficients summarized in Table 10 show that agricultural exports have positive and significant effects on gross domestic product, although the effect remains small. Thus, when agricultural exports increase by 1%, per capita gross domestic product increases by 0.35%. These results justify the importance of agriculture in the Ivorian economy.

Moreover, there is a positive and significant relationship between Gross Domestic Product and Gross Fixed Capital Formation (Investment) at the 1% threshold. A 1% increase in gross fixed capital formation stimulates economic growth by 0.16%.

It is also noted that non-agricultural exports have a positive but not significant effect on Gross Domestic Product.

Finally, trade openness has a negative and statistically insignificant coefficient on gross domestic product. However, when it is lagged by one period, it has a positive and significant impact on gross domestic product. Thus, a 1% increase in trade openness leads to a 0.25% increase in GDP. These results could be explained by the fact that the beneficial effects of trade openness fade away very quickly and that there is a deterioration in the terms of trade in most developing countries, which base their exports mainly on primary products.

Table 10: Short-term coefficients

Dependent variable: LGDP		
Variables	Coefficients	Probability
D(LGFCF)	0.159021	0.0000
D(LGFCF(-1))	-0.075405	0.0252
D(LXA)	0.354193	0.0453
D(LXNA)	-0.002608	0.9432
D(LXNA(-2))	-0.039024	0.1001
D(LCO)	-0.142109	0.0536
D(LCO(-1))	0.258203	0.0162
CointEq(-1)	-0.710249	0.0000

Souce: Author, estimation using Eviews software.

Long-term coefficients

According to Table 11, the sign of the coefficient associated with non-agricultural exports is positive and significant at the 1% threshold. In the long run, when non-agricultural exports grow by 1%, gross domestic product also increases by 0.16%. This result is in line with that of **Tokplonou and Ahodode (2009)**. These authors found a positive and statistically significant long-term influence of non-agricultural exports on Benin's economic growth. Moreover, they encourage policies to implement an export diversification policy and not to focus exclusively on agricultural commodities.

The correlation between agricultural exports and long-term GDP is positive and significant. A 1% increase in agricultural exports accelerates economic growth by 0.013%. However, this rate appears to be increasingly weak. This is due to the increasing number of countries exporting the same agricultural commodities such as coffee, cocoa, cotton etc., and the growing number of countries exporting the same agricultural products **(Douillet, 2012)**.

In the long term, trade openness has a significant negative impact on economic growth at the 1% threshold. A 1% increase in trade openness leads to a 0.43% decrease in gross domestic product per capita. This means that trade in its current state negatively affects economic growth. Foreign trade is not a proven source of growth for Ivory Coast in the case of our study. These assertions are similar to those of **Zahonogo (2017)**. Also, other authors such as **Agbahoungba and Thiam (2018)** have analysed the effects of trade opening in the ECOWAS zone. Indeed, in their respective works, the authors concluded that there is a threshold beyond which international trade negatively affects the economic performance of sub-Saharan African countries.

Finally, the long-term coefficient associated with gross fixed capital formation is positive and statistically significant at the 1% threshold. The 1% increase in gross fixed capital formation leads to GDP growth of 0.27%.

This result justifies the importance of investment in the formation of a nation's wealth (**Diagne and Fall, 2007**).

Table 11: Estimation results of long-term coefficients

Dependent variable: LGDP		
Variables	Coefficients	Probability
LGFCF	0.265928	0.0000
LXA	0.012931	0.0384
LXNA	0.162760	0.0013
LCO	-0.434059	0.0000
C	11.392978	0.0000

Source: Author, estimation using Eviews software.

CONCLUSION

The main objective of this study is to assess the contribution of agricultural and non-agricultural exports to the economic growth of Ivory Coast between 1985 and 2015.

The results show that agricultural exports have positive and significant effects on the gross domestic product, even if this effect is less in the long term, due to the volatility of agricultural commodity prices. Moreover, gross fixed capital formation (Investment) stimulates economic growth, but its impact is more interesting in the long term. On the other hand, non-agricultural exports have a positive but not significant effect on GDP because of the non-competitiveness of these manufacturing products and because of unfair and disproportionate competition on international markets for finished products. Nevertheless, in the long run, they improve the country's economic performance.

Finally, trade openness, in its current state, negatively affects the economic performance of Ivory Coast, a country exporting primary products. In fact, the beneficial effects of trade opening are fading away very quickly because of the deterioration in the terms of trade.

As a recommendation, the Ivorian government should diversify its export basket in order to minimize the variability of export revenues, reduce the risks of deterioration in the terms of trade and sustain economic growth.

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Appendix 1: Data used in the study

PERIODS	GDP	GFCF	XA	XNA	CO
1985	1639.95874	11.7710855	44609	1318100	8093456.13
1986	1629.99567	11.8174755	34760	1160400	7399921.37
1987	1565.43783	11.7696985	28199	929100	6947917.32
1988	1527.15612	11.4848529	22501	826500	6669285.52
1989	1517.06964	10.3175226	26851	895700	7232421.17
1990	1448.03364	8.50214187	41609.8	793012.4	7213622.83
1991	1398.22024	8.57419991	42569.3	763073.9	7244427.65
1992	1346.79807	8.50242173	43057.9	801362.7	7901110.75
1993	1298.84419	9.3454645	35135.9	713229	7539980.24
1994	1266.5316	11.5492123	68908.8	1522420	9835523.25
1995	1314.11994	13.6861231	96089	1819297	11080445.7
1996	1372.7902	14.8080272	91554	2188326	11024398.5
1997	1382.62159	13.9048381	14748	2495623	12080004.1
1998	1410.73839	14.3236227	183665	2592600	12130499.2
1999	1396.99955	13.9981885	182488	2758513	12476198.5
2000	1336.42961	10.2724728	137192	2534366	12454482.7
2001	1310.28647	8.64096849	221171	2669423	12533091.8
2002	1264.22231	10.0705501	377130	3456184	13869536.8
2003	1224.96834	8.25346592	364937	3189550	13306806.9
2004	1218.12035	9.34926236	296500	3655377	15227289.9
2005	1216.20847	9.16693807	309520	3809246.33	17221939.4
2006	1210.66821	9.78809632	319800	4206857.08	17777502.4
2007	1207.08719	11.6147757	366219	3865586.91	17070013.6
2008	1211.62384	10.9386765	473900	4409963.64	17016838.7
2009	1223.51062	10.8710167	532000	5077175.36	18098079.5
2010	1219.7491	12.3165364	1883039.97	5539717.56	19168975.2
2011	1138.66496	8.95112015	1967935.29	5797514.61	19047085.5
2012	1229.7782	12.1067893	1720960.82	6041005.82	19878196.1
2013	1305.70923	16.9953189	1930508.95	7157155.79	17600909.4
2014	1384.91035	18.8791961	1102138.89	6752676.31	14052251.3
2015	1469.73018	19.5297912	931132.75	7741831.83	14153737.6

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REGULAR ARTICLE

IS INCREASING INPUT-USE FOR RICE PRODUCTION A PROFITABLE PROPOSITION IN TANZANIA?

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ABSTRACT

Demand for food staples particularly rice has been increasing tremendously especially in Sub-Saharan Africa relative to supply attributed by a continued rise in population. The shortfall in supply is generally considered to be caused by low use of inputs particularly inorganic fertilizer and improved seed among others. Meanwhile, there is limited empirical evidence to support this notion. This paper aimed at estimating the profitability and yield response to inorganic fertilizer and improved rice seed using cross-section data collected from 256 smallholder rice farmers in Mbarali district - Tanzania. Data was analysed using treatment effect model while instrumental variable was used for robustness check. Results shows that inorganic fertilizer use in the study area is not low as generalized by previous studies. It was further revealed that increasing fertilizer and seed use by 1 kg leads to an increase in yield by 6.2 $kgha^{-1}$ and 9.2 $kgha^{-1}$ respectively. Furthermore, rice production is a profitable business though low marginal physical product and high fertilizer price significantly reduce the profitability of fertilizer use. Thus, reducing input costs through well-managed subsidy programs, timely accessibility of inputs coupled with irrigation facilities and good agronomic practices are crucial for sustainable and profitable agricultural development.

Keywords: Inorganic fertilizer; seed; profit; rice; Tanzania
JEL: Q12; Q13

INTRODUCTION

Demand for food particularly staples has been increasing and is projected to further increase in Sub-Saharan Africa (SSA) attributed by a continued rise in population (**FAO, 2019**). One of the most staple food that is rapidly and widely expanding in terms of production and consumption is rice. Its consumption has tripled from about 9.2 million MT in 1990s to 31.5 million MT in 2018 and it ranks the second largest source of caloric intake, nutrition and food security after maize (**USDA, 2018**). However, demand for rice has consistently exceeded supply for the last three decades (**Tanaka *et al*., 2013**). Currently, only 60% of rice consumed in SSA is domestically produced (**Saito *et al*., 2019**). Inadequate and poor input use particularly inorganic fertilizer and improved seed coupled with poor integrated soil nutrient and water resource management has been cited as major limiting variables for rice production in SSA (**Tanaka *et al*., 2013; Ngailo *et al*., 2016; Sheahan and Barrett, 2017**). The rice yield currently observed in the region is far below the potential yield with a yield gap ranging from 30 – 90% (**Van Oort et al., 2015; GYGA, 2019**).

Tanzania as in other SSA countries is not an exception in terms of low rice yield and low input use. The rice sector in the country is dominated by smallholder farmers (up to 5 ha) who account for about 80% of food production with annual consumption per capita of 25.4kg (**URT, 2016**; **Jayne *et al*., 2016**). The average yield ranges between 1.6 tha^{-1} to 2.4 tha^{-1} which is low relative to the potential yield of 4 to 6 tha^{-1} and 7.5 to 10.8 tha^{-1} for upland and lowland irrigation schemes respectively (**Tsujimoto *et al*., 2019**; **Ngailo *et al*., 2016**; **GYGA, 2019**). Low inorganic fertilizer use approximated at (15 – 22 $kgha^{-1}$) and low productive seed varieties attributed by lack of agronomic knowledge, imperfect input markets and untimely delivery are factors behind this yield gap (**Liverpool-Tasie *et al*., 2017** and **Tanaka *et al*., 2017**).

So far, several efforts have been made by the government of Tanzania in collaboration with development stakeholders to increase the adoption of recommended agronomic practices and technologies including improved seed use, irrigation and fertilizer application through various initiatives including the National Agricultural input voucher scheme in 2008 as an input subsidy program that worth 50% of input market price, Kilimo Kwanza initiative (2009), Agriculture sector development program I, establishment of the Southern Agricultural growth corridor of Tanzania (2010) and the current agricultural sector development program II launched in 2018 (**Tsujimoto *et al*., 2019**; **Mligo and Msuya, 2015**).

Despite these efforts, rice productivity and input use is still low in Tanzania averaged at 1.6 $tonha^{-1}$ for the period 1961 – 2017 albeit of the observed positive trend in rice production shown in Fig. 1. The noted increase in rice production in Tanzania has been fuelled by an increase in cultivated land rather than an increase in productivity. A total area of 330,000 ha has been estimated to be suitable for rice production in Tanzania.

It was also further estimated that 92% of all rice produced in the country is under upland and lowland rain-fed system while only 8% is under irrigation schemes (**Kitilu *et al*., 2019; Senthilkumar *et al*., 2018**). Low productive rice seeds including Super India, Bwana and Kamalata have been dominant for a number of decades while improved varieties adoption rate has been low due to several factors including lack of agronomic education, high input prices and inaccessibility thereby causing large yield gap (**Mligo and Msuya, 2015; Saito *et al*., 2019**).

Table 1 indicates a list of selected local and improved rice varieties that are widely grown in the rain-fed and irrigated schemes in Tanzania based on taste, agro-ecological system, researcher's yield potential and estimated realized farmers' yield. The continued use of local productive seeds like super India and Wahi pesa is attributed by their aroma. Meanwhile, the adoption of improved seed including TXD 306 is on the rise since they are highly productive.

However, **Tsujimoto *et al*. (2019**) argued that, farmers in Sub-Saharan Africa can only adopt and increase input use like fertilizer if they are accessible, affordable and profitable. Therefore, it is worth investigating whether the inorganic fertilizer and seed used in rice production is profit maximizing in the study area to inform policy makers on the allocative efficiency level of the two inputs for agricultural and livelihood development.

Considerable attention by previous studies in Tanzania focused mostly on technical efficiency (**Mkanthama *et al*, 2018**) and yield response to fertilizer application but few of them addressed the likelihood of some unobserved characteristics that may affect both fertilizer application and yield leaving allocative efficiency with little consideration (**Adedeji *et al*., 2014; Mhoro *et al*., 2015**). To my knowledge, only one study by **Mather *et al*. (2016)** estimated the profitability of inorganic fertilizer use in smallholder maize production in Tanzania and another study by **Sheahan *et al*. (2013)** for the case of maize in Kenya. Hence this study sought to address the identified gap particularly for rice in Tanzania. This paper had three objectives (i) To examine rice yield response to improved seed and fertilizer application in the study area (ii) To determine the profitability of rice production in the study area and (iii) To determine the fertilizer and rice seed use allocative Efficiency in the study area by addressing the endogeneity problem that is likely to affect input use decision.

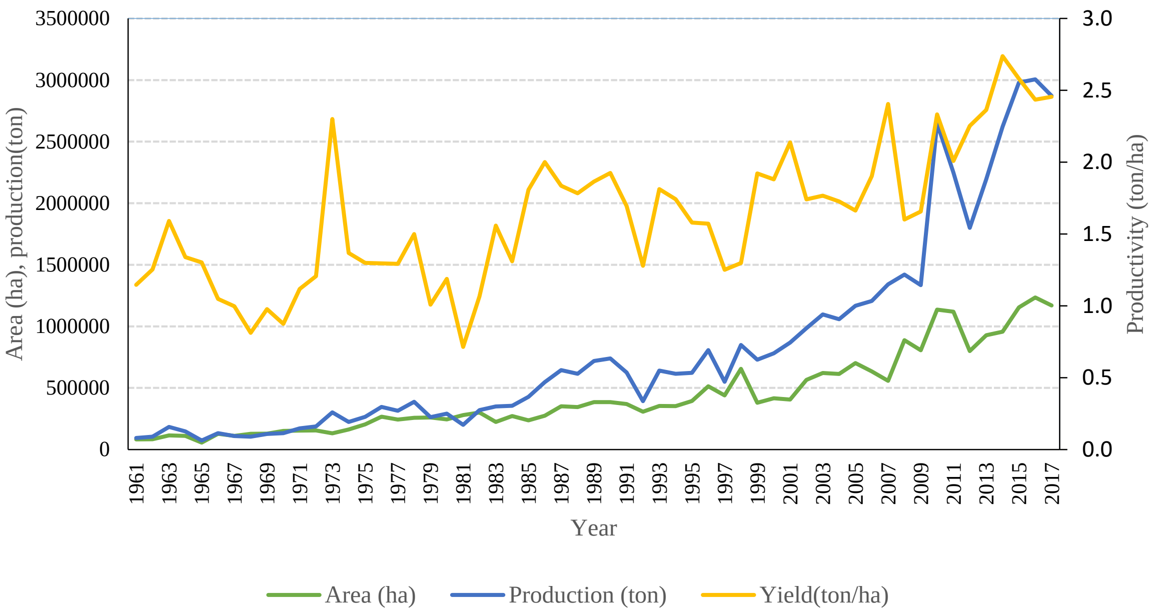

Figure 1: Trends in Rice production, area planted and productivity in Tanzania from 1961 - 2017
Source: **FAOSTAT, 2019**

Table 1: Rice seed varieties, potential yield, maturity period and agro-ecological system

Variety	Aroma	Agro-ecological system	Days to maturity	Researcher Potential yield(t/ha)	Farmer realized yield(t/ha)
TXD306 (2002)	Semi-aromatic	Lowland	120 - 125	7.0 - 8.5	4.5 - 5.5
NERICA1 (2009)	Semi-aromatic	Upland	93 - 101	3.0 - 4.5	2.5 - 3.0
NERICA2 (2009)	Non-aromatic	Upland	90 - 95	3.0 - 4.0	2.0 - 3.0
NERICA4 (2009)	Non-aromatic	Upland	93 - 98	4.5 - 6.0	3.5 - 4.5
Komboka (2012)	Semi-aromatic	Lowland	100 - 110	5.0 - 6.5	3.0 - 4.0
Super India (1950s)	Aromatic	Lowland	120 - 135	2.0 - 3.0	0.5 - 1.5
Wahi pesa	Semi-aromatic	Upland	110 - 120	xxx	0.5 - 1.0
Tai (2012)	Non-aromatic	Lowland	100 - 110	5.5 - 6.8	3.5 - 4.5

Source: **KATRIN (2013),** xxx data not available.

Theoretical Framework

Households' decisions in agriculture are discrete choice made to optimize the use of inputs and output in which a farmer is faced by a constrained utility maximization problem. Farmers have to decide the amount of risky inputs before production begins for each plot level. Inorganic fertilizer, improved seed and water resources are key inputs to increased yield and net revenue (**McArthur and McCord, 2017**). Input demand is a derived demand which is also a function of input prices and output prices in conjunction with household and farm-level characteristics (**Sigh *et al*., 1986**). Following previous studies (**Kouka *et al*., 1995; Liverpool Tasie *et al*., 2017; and Sheahan *et al*., 2013**), the yield function used to estimate the input-output relationship in this study is a quadratic production function specified as Eq. (1).

$$Yield = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2 + \beta_4 X_1{}^2 + \beta_5 X_2^2 + \delta Z_i + \mu \quad (1)$$

Where: yield refers to rice output in kilogram per hectare, the β_s are linear and non-linear parameters that determine the shape of the production function, X_1 is the quantity of inorganic fertilizer in kgha^{-1} and X_2 is the quantity of seed used in rice production in kgha^{-1}, Z_i is a vector of farm level and household characteristics and μ is the error term of unobserved characteristics.

The quadratic production function is an ideal functional form in agriculture since it is a flexible function that allows both increasing and diminishing returns to production (**Kouka *et al*., 1995**). Understanding yield response to fertilizer and seed and input use economics is essential in estimating the relative profitability of input use.

From the economic theory of production, productivity change arises from efficiency in the use of resources. Production efficiency is defined as the performance in transforming available inputs into output given the level of technology (**Kehinde *et al*., 2012**). Production efficiency can further be divided into *technical efficiency*-production of maximum output with a given level of input; *allocative efficiency* –the use of inputs in optimal proportions at least cost of factor prices and given technology while *Economic efficiency* is the combination of the technical efficiency and allocative efficiency (**Salat and Swallow, 2018; Kehinde *et al*., 2012**). Resources are said to be efficiently allocated when the marginal value product of each factor of production is equal to the acquisition price of the factor (**Debertin, 2010; Kehinde *et al*., 2012**). Profitability analysis was performed using the gross margin analysis while profitability maximization analysis was evaluated from the estimated quadratic production function. From the production function in Eq. (1), the marginal physical product for seed and fertilizer was estimated from the coefficients of the fertilizer and seed and their interaction terms as in Eq. (2-3).

$$\text{MPP}_{fertilizer} = \frac{\partial(\text{Yield})}{\partial(\text{Fertilizer})} = F + \beta Fertilizer * Xij \quad (2)$$

$$MPP_{seed} = \frac{\partial(\text{Yield})}{\partial(\text{Seed})} = S + \beta Seed * Xij \quad (3)$$

Where: MPP is the marginal physical product, F and S are the coefficients of fertilizer and seed while the β's are the coefficients of the interaction terms between fertilizer, seed and other farm level characteristics.

The obtained marginal physical product was then used to estimate the marginal value product (MVP) which is the product of the MPP and the output price (Py). The MVP is the value of one unit of output from an additional unit of a variable input. This study also estimated the average physical product (APP) as the ratio of physical output to input used (i.e. APP = Q/X, where Q is the output and X unit of input used). The estimated MPP and APP alongside with the marginal factor cost (MFC) which is the cost of acquiring one unit of input were then used to estimate partial profitability measures namely the Marginal value cost ratio (MVCR) and the average value cost ratio (AVCR) given by Eq. (4) and Eq. (5).

$$\text{MVCR}_x = \frac{(\text{MPPx*Py})}{\text{MFC}} \quad (4)$$

$$\text{AVCR}_x = \frac{(\text{APPx*Py})}{\text{MFC}} \quad (5)$$

When the $\text{MVCR}_x = 1$, implies that profit is maximized from the input use, $\text{MVCR}_x > 1$ implies that inputs are underutilized , $\text{MVCR}_x < 1$ implies that inputs are used above the optimum. Similarly, the profitability of fertilizer application is measured by the average value cost ratio (AVCR) given in Eq. (5). If an AVCR=1, the farmer breaks even and an AVCR>1 implies that fertilizer use is profitable. The AVCR of 2 has been used for profitability studies in Sub-Saharan Africa as a benchmark for an expected increase in profitability derived from mineral fertilizer use by smallholder farmers (**Tsujimoto et al., 2019; Liverpool-Tasie et al., 2017**).

DATA AND METHODS

Study Area, Design, Sampling and Data Collection

This study was conducted in Mbarali District involving irrigated rice farmers in Madibira and Kapunga Schemes on one side and Rain-fed rice farmers in Mbalino village. Mbarali district is among the districts in Mbeya region which is also among the four bread baskets of the country. The district lies in the Usangu basin which is endowed with extensive irrigation schemes suitable for rice production. Agriculture plays a major role in the economy of Mbarali district since it is an activity for more than 80% of the population. The study used cross-sectional design utilizing data collected from May to June 2018 from a list of farmers participating in the irrigation schemes and a list of farmers from rain-fed scheme. A multistage sampling technique was employed where at first stage the two irrigation schemes and the rain-fed scheme were randomly selected from a list of schemes and rain-fed production schemes in Mbarali. At the second stage, a probability proportionate to sample was used to account for strata representation in the sample. Finally, a total of 256 respondents constituted a study sample of which 146 respondents were from the irrigation schemes while 110 were from the rain-fed scheme which was then used as a control group. Questionnaire and focus group discussion were used as tools of data collection.

Analytical Methods

Profitability was measured by using gross margin which is calculated as the difference between total revenue and total variable cost per unit area (ha) and the average value cost ratio described in section 3.1. Gross margin was estimated following **NdaNmadu and Marcus (2013)** by Eq. (6).

$$Gross\ Margin = \frac{\mathrm{TR-TVC}}{\mathrm{ha}}. \qquad (6)$$

Where: TR is total revenue and TVC is total variable cost used in production of rice.

One of the challenges involved in estimating the yield response to fertilizer and seed is endogeneity emanated from the decision to use inputs (**Liverpool-Tasie *et al.*, 2017**). It is also likely that input use can correlate with other farm characteristics. This may affect causal interpretation of the input coefficients. Estimating the production function with OLS would therefore result into biased estimates. To account for the selection bias and endogeneity problem, treatment effect model was employed to estimate the production function while the instrumental variable (IV) was used for robustness check. The treatment effect model contains the regression equation of the outcome and the selection equation constituting the binary endogenous treatment variable that helps in controlling selection bias (**Winship and Mare, 1992**). The model was estimated by STATA's "*etregress"* command and maximum likelihood as a default estimator. Following **Nguimkeu *et al.* (2016),** the treatment effect model was estimated by Eq. (7) (outcome equation) and Eq. (8) (selection equation).

$$\mathrm{Yield}_i = X_i'\beta + \mathrm{G}_i^*\alpha + \mu_i \qquad (7)$$

And the selection equation was modelled as Eq. 8.

$$\mathrm{G}_i^* = 1(\mathrm{C}_i'\theta + \varepsilon_i \geq 0) \qquad (8)$$

Where: X_i is a vector of exogenous covariates, G_i^* is a latent variable for participation in irrigation scheme, α is a scalar that captures the respective treatment effect, β and θ are vectors of size nx1 and mx1 respectively, C is a vector of observed covariates while μ_i and ε_i are error terms.

To account for endogeneity problem, an instrumental variable (IV) following **Woodridge (2010)** and **Bai and NG (2010)** was specified using Eq. (9) and the Eq. (10).

$$\mathrm{Yield}_i = X_{1i}'\beta_1 + \mathrm{X}_{2i}'\beta_2 + \varepsilon_i \qquad (9)$$

Where: X_{2i} is endogenous in the view that E $(X_{2i}\varepsilon_i) \neq 0$, X_{1i} is a vector of exogenous variables. The variable Z_i in this study cooperative membership was used to instrument X_{2i} (participation in irrigation scheme) as the Eq. 10.

$$X_{2i} = \phi' Z_i \dots + \upsilon_i \qquad (10)$$

Endogeneity occurs when $E(\upsilon_i\varepsilon_i) \neq 0$. For validity of the instrument, $E(Z_i\varepsilon_i) = 0$.

RESULTS AND DISCUSSION

Socio-economic Characteristics of the Sampled Rice Farmers

The descriptive statistics presented in Table 2 indicates that rice production in the study area is largely a smallholder activity with an average farm size of 2 hectares. The typical farmer applies on average 203.92 $\mathrm{kgha^{-1}}$ of inorganic fertilizer and seed rate of 58.43 $\mathrm{kgha^{-1}}$. One kilogram of fertilizer and seed used by a farmer costs about 724 and 452 Tanzania shillings respectively. Most farmers (97.8%) in the study area use DAP fertilizer as basal fertilizer while UREA is mostly (82.2%) used as top dressing fertilizer. On average, a rice farmer obtains about 3272 $\mathrm{kgha^{-1}}$ of rice produce which is sold at a market price of about 841 per kilogram. The average value cost ratio for both fertilizer and seed used were greater than the benchmark of 2 for Sub –Saharan Africa (**Tsujimoto *et al.*, 2019; Mather *et al.*, 2016**), implying that rice production in the study area is a profitable business.

However, the use improved seed by rice farmers was minimal which can also be a factor for observed low yield relative to the potential yield of 7.5 to 10.8 $\mathrm{kgha^{-1}}$. Similarly, nearly half of the rice farmers' fields in the study area are still faced by moisture stress due to overdependence on rainfall for rice cultivation and less than 50% of farmers operate their farm activities through producer and marketing cooperative societies. In contrast, a high proportion of farmers used fertilizer in the rice fields. Male household heads dominated rice production in the study area since they are the owner of resources and have more exposure relative to females. A typical household head had an average age of 44 years implying that farmers were still in their productive age (15 – 64 years). Average family size was 5.8 people per household which can be a source of labour if and only if most of the household members are in their productive age, otherwise they can be liability in production process. About 82% of the respondents had formal education. Education is a critical factor in increasing yield since it enables farmers to make informed decisions regarding both production and marketing of agricultural produce (**Ochieng *et al.*, 2016; Nonvide, 2017**).

Gross Margin Estimates

Based on the gross margin analysis (Table 3), rice production in the study area is a profitable business. A typical rice farmer incurs a total variable cost amounting to 1,028,199 Tanzania shillings per hectare. The largest share of the cost is on hiring machinery for harvest, cultivation, labour charges and fertilizer purchases. These inputs are the scarcest resources that are subject to competition in the study area. For example, a high number of labourers used are hired from neighbouring districts due to fewer labour force in the study area relative to productive land leading to an increase in labour cost through transport and labour management.

The farmer's gross margin was found to be about 1,649,492 Tanzania shillings per hectare. However, to increase the gross margin, the government should subsidize inputs particularly fertilizer and machinery including tractors and combine harvesters so that the cost of harvest can be reduced while promoting further fertilizer use. Cultivation cost is high since an increase in production is due to farm size expansion rather than productivity. This is justified by **FAO (2019)** food outlook study which pointed out that strong growth in Sub-Saharan Africa is attributed by area expansion.

Production Function Estimates of Yield Response to Fertilizer and Rice Seed Use

From the production function estimates (Table 4), farm size, the quantity of fertilizer used, household income, market price of fertilizer and access to soil moisture through irrigation were the significant factors that determine variation in the rice yield level in the study area. Rice production was found to exhibit the well-debated inverse farm size-productivity relationship. As the farm size increases by one hectare, rice yield decreased by 292 kgha^{-1} and the coefficient was significant at 5%. This is consistent with findings from other studies on the inverse farm size productivity relationship (**Lipton, 1993; Otsuka, Liu and Yamauchi, 2013; Larson *et al*., 2014; Carletto, Gourlay and Winters 2015; and Sheng *et al*., 2019**). Small farms are said to be more efficient due to the use of family labour that does not require high supervision compared to large farms that tend to use more capital intensive techniques, more land and hired labour that require more supervision thereby increasing total factor cost **(Woodhouse, 2010).**

Table 2: Descriptive statistics on social, farm and resource access characteristics

Variable	Mean	Std. Dev
Farm and access characteristics		
Farm size (ha)	2.03	1.90
Total quantity of fertilizer (kg/ha)	203.92	130.08
Quantity of seed (kg/ha)	58.43	30.99
Price of 1kg of seed	451.72	287.50
Price of 1 kg of fertilizer	723.47	462.97
Land productivity (kg/ha)	3271.75	1741.82
Price of one kg of rice output	840.67	416.41
Average value cost ratio of seed (AVCR seed)	101.01	88.84
Average value cost ratio of fertilizer (AVCR fertilizer)	20.27	30.35
Access to irrigation facilities (1=Yes,0=No)	58.6%	
Improved seed use (1=Yes,0=No)	28.5%	
Applied fertilizer in the field (1=Yes, 0=No)	89.1%	
Cooperative membership (1=Yes, 0= No)	45%	
Household characteristics		
Age of the household head (years)	44	11
Family size	5.8	1.89
Sex of household head (1=male, 0=female)	85.5%	
Education level of household head		
No formal education	18.3%	
Primary education	52%	
Secondary education	22.7%	
Tertiary education	7%	

Source: Field survey

Table 3: Gross margin Analysis of rice production in the study area

Item	Tsh/ha	% Cost
Cost of cultivation	236799.64	23.0
Cost of seed	26735.61	2.6
Total cost of fertilizer	167087.11	16.3
Cost of pesticides + contingencies	112492.19	10.9
Cost of labour	206769.82	20.1
Cost of harvesting	278315	27.1
Total variable cost (Tsh)	1,028,199.37	100.0
Total Revenue (Tsh)	2,677,690.82	
Gross Margin (TR - TVC)	1,649,491.45	

Source: Authors Calculations

However, based on the neoclassical assumptions, farm size –productivity relationship is derived from the farm-size related costs and returns. Given that, the returns obtained from increasing the farm enterprise are larger than the costs the farmer incurs by efficiency loss management, this results into positive farm size-productivity relationship. Some studies conducted in Canada, United states of America, Australia and Brazil found results in favour of the neoclassical theory (**Sheng and Chancellor, 2019; Deininger and Byerlee, 2012**). To date, the findings from various studies are still mixed. For example, the current study by **Bevis and Barrett (2019)** in Uganda shows that the inverse farm size – productivity relationship appears at the plot level rather than farm level and the relationship is more inherent at the periphery of plots relative to the interior due to the agronomic edge effect. The edge effect emanates from increased exposure to sunlight and greater nutrient uptake caused by reduced nutrient competition **(Balagawi *et al*., 2014)**. Furthermore, small farms tend to have higher yield due to factor market failure that force smallholders to allocate inputs more intensively **(Deininger *et al*., 2018; Wineman and Jayne, 2017).**

Similarly, in this study, quantity of fertilizer applied, household income and reduced moisture stress through irrigation tended to increase rice yield while higher fertilizer price had negative effect on yield. The coefficient of fertilizer use in rice production was positive and strongly significant implying that one-kilogram increase in fertilizer use was associated with an increase in rice yield by about 6.2 kg ha^{-1}. This result confirms those findings by previous studies that found also a positive significant relationship between fertilizer use and yield (**Liverpool Tasie *et al*., 2017; McArthur and McCord, 2017; Tsujimoto *et al*., 2019).** The use of fertilizer and organic manure is crucial particularly in Sub-Saharan Africa that exhibits excessive soil nutrient mining caused by increased pressure on productive land.

The positive and squared negative signs in the quantity of fertilizer and seed coefficients implies that initially, when the farmer applied a certain quantity of these inputs, rice yield increased while further increase in the use of these inputs led to the decline in yield. Since increasing and decreasing returns to factors of production is common in agriculture **(Debertin, 2012),** the quadratic production function employed in this study seems to be appropriate. Furthermore, rice yield increased with an increase in household income. As the household income increased by one Tanzania shilling, rice yield increased marginally by about $1.69e^{-4}ha^{-1}$ ceteris paribus. This could be explained by the household income being invested in farming activities including purchase of improved inputs like fertilizer and seed as well as investing in the use of machinery, technology, more land and search for output markets. This is the case for the rice farmers in the study area where more than 40% of income earned from rice selling was invested in purchasing inputs for the next production seasons.

Table 4: Treatment effect model estimates of rice Production Function

Land productivity (kg/ha)	Outcome equation		Selection equation	
	Coefficient	Std. error	Coefficient	Std. error
Farm size (ha)	-292.0*	(129.4)	0.0517	(0.104)
Quantity of fertilizer (kg/ha)	6.232***	(1.322)		
Quantity of fertilizer (kg/ha) squared	-0.00680**	(0.00241)		
Seed rate (kg/ha)	9.293	(8.390)		
Seed rate (kg/ha) squared	-0.0147	(0.0327)		
Fertilizer(kg/ha)*Seed rate(kg/ha)	0.00908	(0.0124)		
Fertilizer(kg/ha) * Farm size (ha)	-0.338*	(0.187)		
Seed rate (kg/ha) * Farm size (ha)	-3.112	(2.931)		
Household income (Tsh)	$1.69e^{-4***}$	($1.93e^{-5}$)		
Price of 1 kg of fertilizer (Tsh)	-0.304*	(0.158)		
Land Ownership(1=yes, 0 = No)	237.2	(323.6)		
Age of the household head(years)	0.452	(6.792)	-0.00458	(0.0128)
Education level of household head	35.65	(32.02)	-0.0346	(0.0572)
Household size	44.80	(37.49)	0.0545	(0.0777)
Access to irrigation (1=Yes, 0=No)	1723.1***	(210.5)		
Cooperative Member (1=Yes,0=No)			2.889***	(0.391)
Access to Extension (1=yes, 0=No)			0.024	(0.245)
Sex (1=Male, 0 = Female)			0.174	(0.366)
Seed (1=Improved, 0= local)			-0.322	(0.247)
Accessed fertilizer (1=yes,0=No)			0.439	(0.345)
Constant	402.9	(541.6)	-1.144	(0.739)
Number of Observations	245		245	
Wald $\chi^2(15)$	469.17			
Log likelihood	-2103.63			
ath (rho)			-0.303	(0.165)
LR test of independent equations				
$\chi^2(1)$			3.21	
Probability> χ^2	0.000		0.0733	

Source: Authors estimations from survey. *p<0.1, **p<0.05, ***p<0.01, Tsh=Tanzania shilling

Similarly, the effect of access to irrigation facilities by rice farmers on yield was positive and significant. Rice farmers with access to irrigation facilities obtained about 1723 kilograms of rice per hectare more than rain-fed rice farmers. Access to irrigation improves investment in rice enhancing inputs since risks associated with moisture stress leading to output failure is reduced. Thus investing in irrigation schemes is important for yield and agricultural development. This result is consistent with previous studies by **Nonvide (2019).** In contrast, rice yield decreased with an increase in fertilizer price. A marginal increase in fertilizer price by one Tanzania shillings is linked to a decrease in productivity by about 0.3 $kgha^{-1}$. An increase in fertilizer by smallholder farmers depend on whether the fertilizer is available, accessible, affordable and profitable **(Tsujimoto *et al*., 2019).** However, as in Other Sub-Saharan African countries, fertilizer use in Tanzania by smallholder farmers is low as indicated earlier since it is more expensive and inaccessible on timely basis and quantity due to market imperfections and underdeveloped physical infrastructure **(McArthur and McCord, 2017).**

This study also finds a positive effect of the quantity of improved seed used on rice yield though not significant. The insignificancy of the coefficient of improved seed use might reflect the marginal use of this input in the study area as it was identified in the descriptive statistics that only about 28% of farmers used improved purchased inputs while the rest used local low productive inputs. Similarly, from the selection equation in Table 4, participation in irrigation schemes was positively and significantly influenced by cooperative membership. Cooperatives provide a platform for social networks where farmers can have access to both input and output markets concurrently with social capital formation **(Camara, 2017).** The results from the treatment effect model were also confirmed by the use of instrumental variable model in Table 5 where the variables used had the similar signs though there was marginal difference in magnitude. The correlation of the disturbance term between the outcome equation and selection equation *ath (rho)* in Table 4 is insignificant implying that participating in the irrigation schemes was not subjected to selection bias and hence this validates causal interpretation. For correct identification based on exclusion restriction, an additional variable that influences participation in irrigation schemes but not the outcome variable except through participation was added in estimating results in Table 5. Cooperative membership was used to instrument participation in irrigation since cooperative membership is expected to increase the probability of participation in irrigation schemes due to social networks that enable farmers to make informed decision on production and market dynamics.

The Wu-Hausman test (p=0.121) indicated that there was no endogeneity problem between participation in irrigation scheme and rice yield. Similarly, the Joint significant first stage F –statistic (F=25. 76) from the Hansen J test indicate that the chosen instrument is strong and valid since it was greater than all critical values and it is above the normal threshold value of 10 for strong instruments specified by **Staiger and Stock (1997).** Furthermore, 69.9% of the variation in the rice yield in the study area is explained by variation in the hypothesized variables.

MPP, APP and Elasticity of Fertilizer and Seed Use

The marginal physical product was estimated by the *margins* command in STATA. The results indicate that the marginal physical product for applied fertilizer and improved rice seed in the study area is quite low estimated at about 5.9 kg and 6.2 kg respectively. This is similar to the study by **McArthur and McCord (2017)** conducted in 75 developing countries on fertilizing growth which found that the marginal physical product of applied fertilizer on cereals (rice, wheat, maize, in developing countries for the period 1965 – 2000 was about 7.85 kg while that of seed was 10 kg. Similarly, a study by **Liverpool-Tasie (2015)** in Nigeria found also low MPPs for rice that ranged between 8.78 kg in 2010 and 8.86 kg in 2012. Based on the MPPs, increasing fertilizer and seed use only is important but not sufficient to increase rice yield since the low yield significantly affect the profitability of both fertilizer and seed use.

The average physical product (APP) are higher than the marginal physical products (MPP) implying that rice farmers in the study area were operating at the economic region of production implying that rice farmers are rational with regard to input allocation. It is a region where farmers get maximum output beyond which output for every additional input diminishes. The elasticities of production are less than a unit and positive confirming also that farmers were operating at the stage II of the production function which is the economic region. It further shows that, one percent increase in the use of inorganic fertilizer and improved seed leads to 0.1 percent and 0.4 percent increase in rice yield ceteris paribus as shown in Table 6.

Profitability of Fertilizer and Seed Use in Rice Production in Mbarali District

From microeconomic principles, the quantity of fertilizer and seed the farmer will use for profit maximization is determined by the level of input price which is equal to the value of additional quantity of rice produced from those unit of used inputs (fertilizer and seed). Based on the AVCRs, the net benefit of applying fertilizer and improved seed in the rice field was positive and greater than 1 implying that it is profitable to use fertilizer and improved rice seed in the study area. However, Since the MVCRs for both fertilizer and seed are greater than one (MVCR>1), it implies that, rice farmers in the study area could maximize profit by increasing fertilizer and improved seed application rates because the current rates are not profit maximizing.

Table 5: IV estimates of a Rice yield response to fertilizer and seed application

Land Productivity (kg/ha)	Coefficient	Standard error	Z	P>|Z|
Farm size (ha)	-302.8*	(130.3)	6.66	0.000
Quantity of fertilizer (kg/ha)	6.601***	(1.328)	-2.32	0.020
Quantity of fertilizer squared	-0.00739**	(0.00243)	4.97	0.000
Seed rate (kg/ha)	6.797	(8.639)	-3.05	0.002
Seed rate (kg/ha) squared	-0.00770	(0.0335)	0.79	0.431
Fertilizer(kg/ha)*Seed rate(kg/ha)	0.00764	(0.0126)	-0.23	0.818
Fertilizer(kg/ha) * Farm size (ha)	-0.230	(0.197)	0.60	0.545
Seed rate (kg/ha) * Farm size (ha)	-2.198	(2.976)	-1.17	0.242
Household income (Tsh)	0.000148***	(0.0000236)	-0.74	0.460
Price of 1 kg of fertilizer (Tsh)	-0.333*	(0.163)	6.29	0.000
Land Ownership(1=yes, 0 = No)	348.3	(333.1)	-2.04	0.041
Age of the household head(years)	0.957	(6.851)	1.05	0.296
Education level of household head	39.04	(32.56)	0.14	0.889
Household size (ha)	40.19	(37.89)	1.20	0.231
Access to irrigation (1=Yes, 0=No)	1819.7***	(273.4)	1.06	0.289
Constant	354.3	(550.7)	0.64	0.52
Wu-Hausman test	F=2.42			P=0.121
Hansen J test	F=25.76			P=0.000
R^2	0.6989			
Wald χ^2 (15)	537.78			
Probability> χ^2	0.000			
Number of Observations	245			

Source: Authors estimations from survey data. *p>0.05, **p>0.01, ***p>0.001, Tsh = Tanzania shilling

Table 6: MPP, APP, Elasticity and Profitability of fertilizer and seed use

Yield(kg/ha)	MPP_{Xfs}	APP_{Xfs}	Elasticity	MVP	$AVCR_{Xfs}$	$MVCR_{Xfs}$
Fertilizer	5.9	62.4	0.095	4959.95	20.27	6.86
Seed	6.2	15.8	0.392	5203.75	101.01	11.52

Source: Authors estimations from production function.

CONCLUSION

This paper aimed at investigating rice yield response to inorganic fertilizer and improved seed and whether the applied input quantities was profit maximizing through the use of quadratic production function. Results indicated that fertilizer rate per hectare, access to irrigation and improved seed had positive effect on rice yield while price of fertilizer and farm size had negative impact on rice yield. For example, increasing fertilizer application rate by 1 kg would increase rice yield by 6.2 $kgha^{-1}$. Furthermore, the study found that rice farming in the study area is a profitable business though currently, farmers are not maximizing profit due to low use in the level of inputs particularly fertilizer and improved seed. Farmers use low quantities of these inputs since they are expensive, unavailable and due to untimely delivery. The introduction of well-managed subsidy program that is directed towards lowering the cost of inputs particularly fertilizer and improved seed can be one of the remedy to increase fertilizer use among smallholder farmers in the study area and Tanzania in general. However, this should be taken with cautious since excessive and mismanaged subsidy program may result into inefficiency in fertilizer use through overdosing the rates, applying fertilizer in less responsive plots and inefficient application techniques as well as diverting resources for other agricultural and economic sub-sectors into subsidy program leading to their underperformance. Similarly, the government should put more efforts in improving transport infrastructure particularly in rural areas to make inputs accessible and reduce transaction costs as well as encouraging farmers to form producer and marketing cooperatives and development of more efficient irrigation schemes.

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REGULAR ARTICLE

EFFECTS OF ILL-HEALTH COST ON MULTIDIMENSIONAL POVERTY: EVIDENCE FROM RURAL HOUSEHOLDS IN NIGERIA

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ABSTRACT

Good health is important in the economy of any nation especially in the fight against poverty, poor health affects productivity and income of the workers and this will further deepen the incidence of poverty and ill-health. This study examined the linkage between ill-health cost and multidimensional poverty of rural households in Ogun state, Nigeria. Multistage sampling was used to select 240 households for the study. Data collected were analysed with descriptive statistics, economic cost of illness, multidimensional poverty index and logistic regression model. The result revealed that majority (95%) of the households experienced malaria infestation, time cost of illness contributed most (92.6%) to the total economic cost. Result revealed that 69% of households are multidimensionally poor. Furthermore, marital status ($p<0.01$), off-farm income ($p<0.01$), financial cost ($p<0.01$), days forgone production ($p<0.1$), time cost ($p<0.01$) and area cultivated ($p<0.1$) positively, and significantly influence multidimensional poverty status while household size ($p<0.01$), cooperative membership ($p<0.05$), public health care services ($p<0.1$) and health extension contact ($p<0.01$) have negative, and significant effect. The study concluded that increase in out of pocket expenditure as a result of ill-health cost increases poverty status, availability and access to public health facilities reduces poverty status, it was therefore recommended that public health facilities should be located nearer to the people with minimum social stratification that might discourage poor masses from its usage, essential drugs should be provided at subsidized rates as this will go a long way in reducing financial cost thereby reducing poverty status.

Keywords: Illness; Multidimensional Poverty; Deprivation
JEL: I32; D01

INTRODUCTION

Agriculture is an indispensable sector in Nigerian economy because it remains the only local source of food and natural fibre in spite of the dominance of petroleum, agriculture still plays vital roles in Nigerians economy, it contributed 23 percent to Nigeria's Gross Domestic Products (GDP) in 2017 (**CBN, 2018**). The sector provides employment for over 70% of Nigeria labour force, however, in spite of contribution of agriculture to national development; the sector has not received the appropriate public and institutional attention and had failed to contribute significantly to poverty alleviation. Poverty is dominant in rural Nigeria as a result of limited social services and infrastructural facilities (**IFAD, 2012**). **OPHI (2017**) reported that incidence of poverty in rural Nigeria rose from 68.4% in 2008 to 70% in 2017.

The Nigeria agricultural sector was dominated by subsistence farmers that were exposed to different health challenges which directly or indirectly affect their level of production as well as their living standards. Nigerian subsistence farmers spend as much as 13% of total household expenditure on treatment of malaria alone (**Ajani and Ugwu, 2008**). This gives enough evidence that the cost of combating diseases and health problem by farmers is quite huge. Large out of pocket health expenditure as a result of ill-health can have a major impact on financial status of rural households and can push them to poverty. They are likely to reduce their expenditure on basic items or sell off their productive assets in order to cope with health costs. However, developing countries which Nigeria is inclusive need good health and productive agriculture to fight against poverty; poor health affects the productivity and income of the workers and this will further deepen the incidence of poverty and ill-health (**IFPRI, 2007**). Although there are growing literatures on effect of ill- health on poverty status of farmers, previous studies failed to adopt a holistic approach to the problem of farmers' health and poverty in rural communities, previous studies used uni-dimensional poverty measures such as income and expenditure, this studies differs from other studies as it employs a multidimensional poverty measures that complements money-based measures by considering multiple deprivations and their overlap, as it is related to Sen's conception of capabilities. The study also identifies illness suffered by the households and estimate cost incurred as a result of ill-health.

DATA AND METHODS

The study was carried out in Ogun State Nigeria. Multistage sampling procedure was used for the study; the first stage was a random selection of four (4) Local

Government Areas (LGAs) out of the twenty (20) Local Government Areas (LGAs) in the state, the second stage was a random selection of three (3) villages from the selected LGAs, the last stage was a purposive selection of twenty (20) households from the selected villages making two hundred and forty (240) respondents, however, during data clean up only 225 questionnaire were fit for analysis representing 94% of the total responses.

Cost of illness

This study adopted and modified Cost of Illness (COI) procedure used by **Sauerborn *et al.*, (1996)** and **Akinbode *et al.*, (2011)** with the inclusion of preventive cost, COI was used to capture the economic cost of ill-health, it is as specified in the Eq. (1-3).

Financial Cost

$$F_c = \sum_{j=0}^{n}(F_d + F_m + F_t + F_{su}) \quad (1)$$

Time cost of illness

$$T_c = \sum_{j=0}^{n}[(T_{si} * a_{si} * w) + (T_{ci} * a_{ci} * w)] \quad (2)$$

$$\text{Economic cost} = \sum_{j=0}^{n}(F_c + T_c) \quad (3)$$

The preventive cost P_c was added to the cost and it was specified as the Eq. (4).

$$\text{Economic cost} = \sum_{j=0}^{n}(F_c + T_c + P_c) \quad (4)$$

Where:
F_d financial cost of drugs, herbs, etc. (₦);
F_m financial cost of medical consultancy (₦);
F_t financial cost of travel (₦);
F_{su} financial cost of subsistence (feeding) (₦);
T_c total time cost (number of days forgone production);
T_{si} time cost of sick person (number of days forgone production);
a age coefficients (number);
s sick individual (number);
w daily wage rate (₦);
T_{ci} time cost of caregiver (s) (number of days forgone production);
c caregiver (number);
F_c total financial cost of health care.

To estimate the number of days of forgone production activities required in estimating the time cost of illness, following **Akinbode *et al.*, (2011)** the man days was estimated using the average male adult work for about 8 hours a day. Thus, the actual total hours devoted to farm work was converted to male adult equivalent by multiplying those of male by 1 and those of female by 0.75 and those of children by 0.5, an assumption that average working condition prevail.

The age coefficient "a" represents productivity coefficient and this takes on the following values following **Sauerborn *et al.*, (1996)** and **WB (1993):**
Age < 17years = 0.5
18-40years=1
41-55years=0.75
56-65years = 0.67 and
>65years = 0.5.

Multidimensional Poverty Index

The Multidimensional Poverty Index (MPI) complements money-based measures by considering multiple deprivations and their overlap. Adopting from the MPI of **Alkire *et al.*, (2011)** and **Aboaba *et al.*, (2019)**, two dimensions and seven indicators were added to the 3 dimensions and 10 indicators of the MPI in other to better capture the multidimensional poverty in the study area, these additional dimensions are infrastructure and social capital while the indicators include transportation facilities, hospital, market, roads, group and networks, information and communication, empowerment and political actions, the maximum score is 100% or 1 with each dimension (Education, Health, Standard of Living, Infrastructure and Social capital) are equally weighted. A household was considered multi-dimensionally poor if the total deprivation is equal to or greater than 20% or 0.2

Multidimensional Poverty Indices

Following **Alkire *et al.* (2011)**, the multidimensional poverty index was expressed as the Eq. (5).

$$MPI = \text{H*A} \quad (5)$$

Where:
H the multidimensional headcount ratio which is the proportion of people who are poor, the multidimensional head count ratio (H) is expressed as the Eq. (6).

$$\text{H} = \frac{q}{n} \quad (6)$$

Where:
q the number of people who are multi-dimensionally poor and n is the total population.
A the intensity (or breadth) of poverty which is the average deprivation score of the multi-dimensionally poor people and can be expressed as the Eq. (7).

$$A = \frac{\sum_{i=1}^{n} c_i(k)}{q} \quad (7)$$

Where:
$c_i(k)$ the censored deprivation score of individual i and q a number of people who are multi-dimensionally poor.

Logistic Regression Analysis

Logistic regression analysis was used to estimates the effect of burden of disease on multidimensional poverty status of the households, the model was specified as the Eq. (8).

$$Y_i = \ln(\frac{p}{1-p}) = \alpha_0 + \sum_{i=1}^{16} \alpha Z + e_t \quad (8)$$

Where:
Z independent variables specified in the Table 1.
Y_i the multidimensional poverty status (1= multidimensionally poor, 0=otherwise);

α_0 intercept;
$\alpha_1 - \alpha_{16}$ parameters to be estimated;
e_t error term or disturbance term.

RESULTS AND DISCUSSION

Socioeconomic characteristics

The results (Tab. 2) revealed that the mean age of the household heads was 54 years; this implies that most of the household heads were old, non-energetic and not within their productive age, this may have a positive influence on their poverty status. Larger proportion of the household heads were male. This implies that there were more male than their female counterparts. This can be attributed to the fact that farming is tedious and requires a lot of energy which most female might not be able to provide. The average size of the household is approximately 6 persons; this implies that most of the households have a fairly large household size which they might employ on their farms. More than half of the household heads were married. The implication is that most of the household heads have implanted sense of responsibility as marital status prompts commitment to business because of the family needs that must be met. On the average, the household heads spent 6 years in school. This implies, that most of the household heads had basic education and this might influence their adoption of innovative practices which will improve their poverty status. Lower percent and half of the household heads were members of cooperative society and farmer's organization respectively. The mean farming experience was approximately 26 years. This implies that most of the household heads had enough experience about farming and this may influence their productivity and poverty status. Most of the household heads were smallholders with average farm size of 2.8 hectares. This result revealed that most of the farmers were smallholders and this may have a positive influence on household poverty status.

Table 1: Definition and measurement of variables

Variable	Definition	Measurement	Expected sign
Z_1	age of household heads	(years)	+
Z_2	sex of household heads	(Dummy, 1=male, 0=female)	-
Z_3	household size	(number of persons)	+
Z_4	marital status of household heads	(Dummy, 1=married, 0=otherwise)	+
Z_5	off-farm income	(naira)	-
Z_6	level of education of household heads	(years)	-
Z_7	cooperative membership	(Dummy, 1=member, 0=otherwise)	-
Z_8	farmers organization	(Dummy, 1=member, 0=otherwise)	-
Z_9	farming experience of household heads	(years)	-
Z_{10}	preventive cost	(naira)	±
Z_{11}	financial cost	(naira)	+
Z_{12}	days forgone production	(days)	+
Z_{13}	time cost	(naira)	+
Z_{14}	area cultivated	(hectare)	-
Z_{15}	availability of public health care	(Dummy, 1=available, 0=otherwise)	-
Z_{16}	contact with health extension	(Dummy, 1=had contact, 0=otherwise)	-

Source: Authors review of literatures

Table 2: Descriptive Statistics of the Sample data

Variable	Mean	Standard Deviation
Age	54.3	14.1
Sex$^+$	0.7	0.4
Household size	5.9	2.4
Marital status$^+$	0.6	0.5
Level of education	5.5	4.9
Cooperative membership$^+$	0.2	0.4
Farmers association$^+$	0.5	0.5
Farming experience	26.4	14.9
Area cultivated	2.8	2.8

Note: $^+$ In case of dummy variables, proportions were used instead of means.
Source: Field survey data analysis, 2018

Illness Experienced by the Households

For the period of 6 months (Table 3), back pain illness was suffered by almost all of the rural households, high proportion of the households experienced fever, malaria infestation was suffered by almost all of the rural households. Less than half of the households suffered guinea worm, almost half suffered typhoid infestation, a quarter of the households suffered measles, more than half of the households experienced rheumatism. More than a quarter of the households suffered tuberculosis infestation while proportion of the households suffered waist pain. This implies that majority of the households suffered malaria, followed by back pain, waist pain, fever, rheumatism, typhoid, guinea worm, tuberculosis and measles respectively.

Table 3: Illness Experienced by the Households

Variable	Frequency (Episodes)	Percentage	Rank
Perceived illness			
Back pain	210	93	2nd
Fever	195	87	4th
Malaria	213	95	1st
Guinea worm	82	36	7th
Typhoid	103	46	6th
Measles	56	25	9th
Rheumatism	118	52	5th
Tuberculosis	66	29	8th
Waist pain	200	89	3rd

Source: Field survey data analysis, 2018

Economic Cost of Illness

On the average, the economic cost of illness for the period under consideration (six months) (Table 4) was ₦158,073.72. The total financial cost was ₦11,116.92, the total time cost was ₦146,305.70 and the total preventive cost was ₦651.70. The total financial cost contributed 7.03% to the total economic cost, cost of drugs and herbs contributed 74.24% to the total financial cost and 5.22% to the total economic cost, cost of medical consultancy contributed 12.40% to the financial cost and 0.87% to the total economic cost, cost of sustenance (feeding) contributed 6.76% to the financial cost and 0.48% to the economic cost while cost of travelling contributed 6.59% to the financial cost and 0.46% to the economic cost. The total time cost contributed 92.56% to the total economic cost and the time cost of sick person contributed 59.11% to the time cost and 54.71% to the economic cost, time cost of care giver contributed 40.89% to the total time cost and 37.84% to the total economic cost, preventive cost contributed 0.41% to the total economic cost. This implies that cost of drugs and herbs contributed most to the total financial cost and time cost of sick person contributed most to the total time cost, the total time cost contributed most to the total economic cost followed by financial cost and preventive cost respectively. This result is in consonance with the findings of **Adekunle *et al.*, (2016)** that found out that time cost contributed most (64.08%) to the economic cost of illness, followed by financial cost (28.30%) and preventive cost (7.62%) respectively. The results also support the findings of **Akinbode *et al.*, (2011)** that found out that time cost of illness was a major contributor to the economic cost of illness.

Deprivation Experienced by the Rural Households

Almost all of the households were not deprived adequate nutrition, larger proportion did not experienced child mortality, high proportion have access to basic education, high proportion completed basic education, high proportion were not connected to national electricity grid, more than half were deprived clean water, more than half were deprived adequate sanitation, high proportion were deprived clean cooking fuel, half were deprived clean floor of home, high proportion did not own productive and households assets, more than half did not have hospital available within 2 km of their homes, more than half did not have neighbourhood markets to display their goods, more than half were deprived good transport facilities, high proportion did not received support from non-family members in times of hardship, high proportion were being excluded from social and cultural activities while more than half did not control over decisions affecting their lives (Table 5).

Table 4: Estimates of Cost of Illness

Variable	Amount (₦)	% Cost	% Total Cost
Financial Cost			
i. Cost of drugs and herbs	8,253.48	74.24	5.22
ii. Cost of medical consultancy	1,378.82	12.40	0.87
iii. Cost of feeding	751.64	6.76	0.48
iv. Cost of travelling	732.97	6.59	0.46
1. Total Financial Cost	11,116.92	100.00	7.03
Time Cost			
i. Time cost of sick person	86,486.03	59.11	54.71
ii. Time cost of care giver	59,819.67	40.89	37.84
2.Total Time Cost	146,305.70	100.00	92.56
Preventive Cost			
3. Total Preventive Cost	651.10	100.00	0.41
4. Total Economic Cost	158,073.72		100.00

Source: Field survey data analysis, 2018

Table 5: Deprivation Faced by the Households

Dimension	Frequency	Percentage
Nutrition		
Not Deprived	212	94.22
Deprived	13	5.78
Child mortality		
Not Deprived	197	87.56
Deprived	28	12.44
Access to basic education		
Not Deprived	202	89.78
Deprived	23	10.22
Completion of basic education		
Not Deprived	183	81.33
Deprived	42	18.67
Connected to national electricity		
Deprived	165	73.33
Not Deprived	60	26.67
Clean drinking water		
Deprived	129	57.33
Not Deprived	96	42.67
Adequate sanitation		
Deprived	124	55.11
Not Deprived	101	44.89
Clean cooking fuel		
Not Deprived	72	32.00
Deprived	153	68.00
Clean floor of home		
Not Deprived	112	49.78
Deprived	113	50.22
Ownership of assets		
Deprived	161	71.56
Not Deprived	64	28.44
Availability of hospital within 2Km		
Deprived	130	57.78
Not Deprived	95	42.22
Availability of neighbourhood market		
Deprived	132	58.67
good road network	93	41.33
Good transport facilities		
Deprived	121	53.78
Not Deprived	104	46.22
Support in times of hardship from non-family members		
Deprived	142	63.11
Not Deprived	83	36.89
Exclusion from social and cultural activities		
Deprived	165	73.33
Not Deprived	60	26.67
Control of decision affecting life		
Deprived	125	55.56
Not Deprived	100	44.44

Source: Field survey data analysis, 2018

Poverty Status of Rural Households

The results presented in Table 5 revealed, that the multidimensional head count ratio was 0.69 which implies that 69% of the rural households are multidimensionally poor. That is 69% of people are in households with a malnourished person, no clean water, no electricity, no good health care services, no education, a dirt floor, unimproved sanitation, inadequate infrastructures, etc. The result is in line with the findings of **Amao *et al.*, (2017)** that found out that the multidimensional headcount ratio in south-western Nigeria was 67.4%, the intensity of poverty among the rural households in the study area was 0.41. This implies that on average the rural poor households were deprived 41% of the weighted indicators, that is they are deprived 41% of clean water, electricity, education, health services, improved sanitation. The result is similar to the finding of **OPHI (2017)** that found out that the intensity of poverty in Ogun state was 42.5%. The multidimensional poverty index was 0.28, this implies that the rural households are deprived in 28% of the total deprivations they could experience overall. These findings differ from that of **OPHI (2017)** and **Amao *et al.*, (2017)** that found out that the multidimensional poverty status of Ogun state and south-western Nigeria are 11.2% and 31.8% respectively.

Table 6: Multidimensional Poverty Indices of Rural Households

Variable	Value
Multidimensional Headcount Ratio (H)	0.69
Intensity of Poverty (A)	0.41
Multidimensional Poverty Index (MPI)	0.28

Source: Field survey data analysis, 2018

Effect of Ill-health Cost on Multidimensional Poverty Status

The diagnostic test (Table 7) revealed the overall fit of the model at 1% (p<0.01) level of significance, the Pseudo R squared showed that 91.9% variation in multidimensional poverty status was jointly explained by the explanatory variables. This shows that the model has a very high explanatory power. The marginal effects of household size revealed that if the size of the household increases by 1% the multidimensional poverty status of the rural households will reduce by 1.4%, this result contradicts the findings of **Awan and lqbal (2010)** and **Adekoya (2014)** that reported a positive relationship between household size and probability of being poor, this was because most of the household members are matured enough to be working thereby contributing to the household income. The marginal effects of marital status showed that the poverty status of married household's increases by 12.6% compared to their counterparts. This is so because most of the married households have more of their household members to be children who are unproductive and yet take a big proportion of household income in terms of school fees, medical bills, food and clothing, this result corroborates the finding of **Adekoya (2014).** The marginal effects of off-farm income revealed that increase in off-farm income increases the likelihood of being poor; this was because the level of livelihood diversification among the households is low thereby resulting to low income. The coefficient of cooperative membership revealed that the poverty status of rural household heads that belonged to cooperative society is likely to reduce by 5.6% compared to their counterparts. The marginal effects of financial cost revealed that increase in financial cost would increase the probability of being poor by 0.5%. This implies that increase in financial cost (drugs and herbs, consultancy, feeding and travelling) increase the poverty level of the rural households, this is so because large out of pocket expenditure on (drugs and herbs, consultancy, feeding and travelling) is catastrophic to the wellbeing of the household as they are likely to reduce their expenditure on basic items such as food or sell off their productive assets in order to cope with health costs thereby pushing them into poverty. This results corroborates the findings of **Oparinde *et al.*, (2018)**.

Table 7: Logit Regression Estimate of Effect of Ill-health Cost on Multidimensional Poverty Status

Variable	Coefficient	Standard Error	t-value	P-value	Marginal Effects (dy/dx)
Age	0.130	0.081	1.600	0.109	0.002
Sex	-4.243	2.738	-1.550	0.121	-0.070
Household size	-0.828*	0.439	-1.890	0.059	-0.014
Marital status	7.642***	2.340	3.270	0.001	0.126
Off-farm income	0.000***	0.000	5.740	0.000	0.000
Level of education	-0.047	0.095	-0.500	0.619	-0.001
Cooperative membership	-3.391**	1.599	-2.120	0.034	-0.056
Farmers association	0.375	0.993	0.380	0.706	0.006
Farming experience	-0.077	0.055	-1.400	0.161	-0.001
Preventive cost	-0.002	0.003	-0.740	0.461	0.000
Financial cost	0.003***	0.001	3.570	0.000	0.005
Days forgone production	0.109**	0.045	2.430	0.015	0.002
Time cost	0.000***	0.000	-2.680	0.007	0.002
Area cultivated	0.419*	0.236	1.780	0.076	0.007
Public healthcare services	-9.303**	4.641	-2.000	0.045	-0.154
Health extension contact	-6.453***	1.690	-3.820	0.000	-0.107
Constant	-10.454*	5.897	-1.770	0.076	
Diagnostic test					
Wald $chi^2(16)$	60.53***				
Prob > chi^2	0.000***				
Pseudo R^2	0.919				
Log likelihood	-11.857				
Number of Observation	225				

Note: ***, **, * Significant at 1, 5 and 10%
Source: Field survey data analysis, 2018

The marginal effects of the forgone production days revealed that if the number of forgone production days as a result of ill-health increases by 1%, the poverty status of the rural household will increase by 0.2%. This is so because ill-health reduces the healthy time of the households thereby reducing their level of production and income which will invariably push them into poverty. The marginal effects of time cost showed that increase in time cost of the sick individual and care giver would increase the probability of being poor by 0.1%. This implies that increase in time cost increases the probability of being poor. This is so because the number of forgone production days would increase as a result of ill health thereby reducing their efficiency and income and further deepening the incidence of poverty and ill health (**IFPRI, 2007**). This result corroborates the findings of **Adebayo *et al.*, (2012)** and **Oparinde *et al.*, (2018).** Similarly, **Rhaji and Rhaji (2008)** reported that health related indices had negative relationship with revenue generation and productivity among sampled household farmers.

The coefficient of area of farmland cultivated revealed that if the area cultivated increases by 1% there is likelihood that the poverty status of the poverty status of the household will increase by 0.7%. This may be because larger farm size prevents the farming households from diversifying into off-farm and non-farm activities thereby limiting the amount of income generated which will invariably affect their standard of living. The marginal effects of health care provider revealed that availability of government clinic would reduce the likelihood of being poor by 15.4%. This implies that the poverty status of rice farming households that have access to government clinics is likely to decrease compared with their counterparts that have no access to government clinics. This is so because households that have access to government clinics are likely to receive health care services at a cheaper cost (financial cost). This would increase their healthy time which would invariably translate to increase income and productivity, thereby stamping out poverty. The marginal effects of health extension worker revealed, that the poverty status of households that have contact with health extension worker, is likely to reduce by 10.7% compared to their counterparts that did not have contact with health extension worker.

CONCLUSION AND RECOMMENDATION

The study examined the linkages between ill-health cost and multidimensional poverty status of rural households. The result revealed that majority of the households suffered malaria illness followed by back pain, waist pain, fever, rheumatism, typhoid, guinea worm, tuberculosis and measles respectively. Time cost of illness contributed most to the total economic cost followed by financial cost and preventive cost respectively. It was revealed that higher proportion of people are in households with a malnourished person, no clean water, no electricity, no good health care services, no education, a dirt floor, unimproved sanitation, inadequate infrastructures, etc. it was further revealed that marital status ($p<0.01$), off-farm income ($p<0.01$), financial cost ($p<0.01$), days forgone production ($p<0.1$), time cost ($p<0.01$) and area cultivated ($p<0.1$) positively, and significantly influence multidimensional poverty status, while household size ($p<0.01$), cooperative membership ($p<0.05$), public health care services ($p<0.1$) and health extension contact ($p<0.01$) have negative, and significant effect. The study concluded that increase in out of pocket expenditure as a result of ill-health cost increases poverty status, availability and access to public health facilities, reduces poverty status.

It was therefore recommended, that public health facilities should be located nearer to the people with minimum social stratification that might discourage poor masses from its usage. Essential drugs should be provided to the rural households at subsidized rates, as this will go a long way in reducing their financial cost, thereby reducing their poverty status.

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REVIEW ARTICLE

EFFECTS OF COVID-19 PANDEMIC ON FOOD SECURITY AND HOUSEHOLD LIVELIHOODS IN KENYA

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ABSTRACT

This paper aims to contribute to the understanding of the resultant effects of the new Coronavirus which is known to cause a Severe Acute Respiratory Syndrome in humans (SARS-CoV-2 better known as COVID-19) on food security and household livelihoods in Kenya. This is achieved by providing a comprehensive literature review on past global epidemics, pandemics and natural hazards and disasters; and their effects on food security and household livelihoods. The study reviews articles and reports that have widely discussed the effects of other epidemics that have occurred in contemporary times on food security and household livelihoods. The selection of the materials used in the study was based on authenticity and relevance. The observed impacts of the coronavirus pandemic and previous epidemics, pandemics and natural hazards and disasters call for policy measures to curb future occurrences. Countries' preparedness for pandemics is crucial to prevent adverse economic effects and loss of human lives. There is also a need to put in necessary measures to ensure the sustainability of resources, strengthen infrastructure and food systems to avoid or minimize food crises in the future.

Keywords: COVID-19; Food Security; Household Livelihoods; Epidemics; Pandemics
JEL: C01; C13; C31; Q12

INTRODUCTION

The Novel Corona Virus, causing the Corona Virus Disease 2019 (COVID-19) was first reported in Wuhan, China in December 2019 (**Kumar *et al.*, 2020)**. The disease rapidly spread from country to country and across continents and has continued to cause dramatic loss of human life and unprecedented challenges across the globe. The global infection for the COVID-19 had reached 9,296,202 cases with 479,133 deaths as of 25th June, 2020 (**WHO, 2020)**, while Africa Continent had so far recorded 337,315 cases, 8,863 deaths and 161,254 recoveries (**Africa-CDC, 2020**). Over the same period, Kenya had 5,384 infections that resulted in 132 deaths with 1,857 recoveries as is shown in Figure 1 (**MoH, 2020**). The World Health Organization (WHO) declared the outbreak of COVID-19 to be a Public Health Emergency of International Concern, on 30th January, 2020. The first case of COVID-19 in Kenya was reported by the Ministry of Health officials in Nairobi on 12th March, 2020. The suspected case was tested and confirmed at the National Influenza Centre Laboratory at the National Public Health Laboratories. The patient had arrived at Nairobi from USA on 5th March, 2020 through London, UK. The fear of the spread and the resultant effects of the disease has led to the introduction of curfews, quarantines, movement restrictions, and travel bans among others by countries to contain its spread (**Delivorias and Scholz, 2020)**. These coordinated measures were to mitigate the impacts, halt the spread of the pandemic, and ultimately hinder future recurrence (**Fernandes, 2020**).

These containment measures are not unique to COVID-19 and have been applied in earlier epidemics and pandemics such as Zika Virus, Ebola Virus Disease (EVD), Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS), Spanish Influenza , H1N1 Influenza, among others **(Bloom *et al.*, 2018; Delivorias and Scholz, 2020; Rohwerder, 2020**). Like natural hazards and disasters, disease epidemics have been reported to cause serious negative socio-economic impacts and human loss **(Bloom *et al.*, 2018; Delivorias and Scholz, 2020**). These measures have proven to significantly reduce the spread and effect of epidemics **(WHO, 2015)**. However, their socio-economic effects run to post the epidemics (**WBG, 2019**).

Against this background, the latent effects of COVID-19 in Kenya have been compounded by the fact that the economy was operating below the projection of 5.35

percent annual growth. Analysts project the rate to decline to 3.5 percent due to the pandemic **(Obulutsa and Mohammed, 2020).** Furthermore, the country has been hit by the desert locust invasion and long rains which led to floods across the country, leading to massive destruction of crops and livestock (**Ogega, 2020**). These have posed additional tragedies to the already declining economic performance.

The purpose of this study is to contribute to the understanding of the resultant effects of COVID-19 on food security and household livelihoods in Kenya. This is achieved by providing a comprehensive literature review on global pandemics, epidemics, natural hazards and disasters and their effects on food security and household livelihoods. The paper also seeks to provide an understanding of lessons learnt in times of pandemics, epidemics, and natural hazards and disasters, and provide insights into how the economy is likely to evolve about the subject. Finally, the paper offers policy options available to the government to undertake as a measure to mitigate the resultant effects of the pandemic, related epidemics, and natural hazards and disasters in future occurrences.

DATA AND METHODS

To achieve the purpose of this study, the researchers conducted a systematic literature search by following (**Gough *et al.*, 2012**) through CAB Abstracts, Web of Science, Scopus, Econlit and Google (Scholar, Web and News). This was complemented with a snowball in document reference selection which involves identifying other relevant articles referenced in other published papers. The researchers used search terms developed from the five main keywords which are COVID-19, food security, household livelihoods, epidemics and pandemics. These five keywords were identified with synonyms derived from the literature. These keywords were then combined into a complete search term string, connected with the Boolean operators "OR" for synonyms of the same keyword and "AND" for different keywords. This string was then entered into selected databases to retrieve data. The study focussed on articles and reports that have widely discussed the effects of other epidemics that have occurred in contemporary times on food security and household livelihoods. The notable ones include the Zika virus, Ebola Virus Disease (EVD), Spanish Influenza, Severe Acute Respiratory Syndrome (SARS), Middle East Respiratory Syndrome (MERS), and H1N1 Influenza. It also considered peer-reviewed journals and government working papers on floods and desert locust that infested the country in the recent times. The criteria used in the selection of the materials used in the study were based on authenticity and relevance. The study restricted the retrieved articles on disciplinary basis and specifically focused on articles and studies in the field of agricultural economics, agribusiness management and health economics with an intention to get insights into the economic impact of an epidemic, pandemic and natural hazards and disasters particularly on food security and household livelihoods.

RESULTS AND DISCUSSION

Lessons from past epidemics, pandemics and natural hazards and disasters

An epidemic is an outbreak over a larger geographic area. Examples of an epidemic include the 2014-2016 Ebola Virus Disease outbreaks in West Africa, Zika virus, which started in Brazil in 2014 and spread to most of Latin America and the Caribbean and the US opioid crisis among others **(Grennan, 2019)**. In the most classical sense, once epidemic spreads to multiple countries or regions of the world, it is considered a pandemic. Pandemic is the highest level of global health emergency and signifies widespread outbreaks affecting multiple regions of the world (**Morens *et al.*, 2009**). Examples of pandemics in world history include Spanish influenza in 1918, H1N1 influenza in 2009 and COVID-19 in 2020. In December 2015 the World Health Organization (WHO) published a list of epidemic-potential disease priorities requiring urgent research and development attention (**Bloom *et al.*, 2018).**

Epidemics, pandemics and natural hazards and disasters such as communicable diseases, tsunamis, floods, droughts, landslides, earthquakes, and locust invasion inflict serious challenges on the economy (**Watson *et al.*, 2007**). Specifically, epidemics impact negatively on the economy at different levels of society, from country to households to individuals **(Kastelic *et al.*, 2015; WBG, 2016, 2019)**. Epidemics result in less trade and transportation due to restrictions on the movement of people and goods within a country and between countries (**Mwakalobo, 2007; Rohwerder, 2020**). In 2014, Sierra Leone implemented a 3-days lockdown due to EVD (**Kastelic *et al.*, 2015)**. Limited trade and transportation have direct effects on the source of income of farming communities and food supply chains (**Rohwerder, 2020)**. This is mainly because of restrictions on the movement of people from high risk areas, quarantines and curfews thus affecting accessibility and availability of food especially if food is produced or sold in the areas regarded as high risk (**Gatiso *et al.*, 2018)**. According to the **WBG (2016)**, 43 percent of Africa's population relies on cross border trade which is usually affected the most by imposed travel restrictions. The report further indicates that there was an economic loss of USD 2.8 billion during the EVD outbreak in Liberia, Sierra Leone, and Guinea in 2014-2016.

The EVD epidemic directly or indirectly decreased agricultural production in Liberia, Sierra Leone, and Guinea in 2014-2016 resulting in a significant negative impact on livelihoods (**Gatiso *et al.*, 2018; WBG, 2016)**. Agricultural production is the main source of income for most rural households in developing countries but epidemics result in a stall as farm workers` fear to travel and transportation of food to consumption areas is restricted **(Gatiso *et al.*, 2018; Kastelic *et al.*, 2015)**.

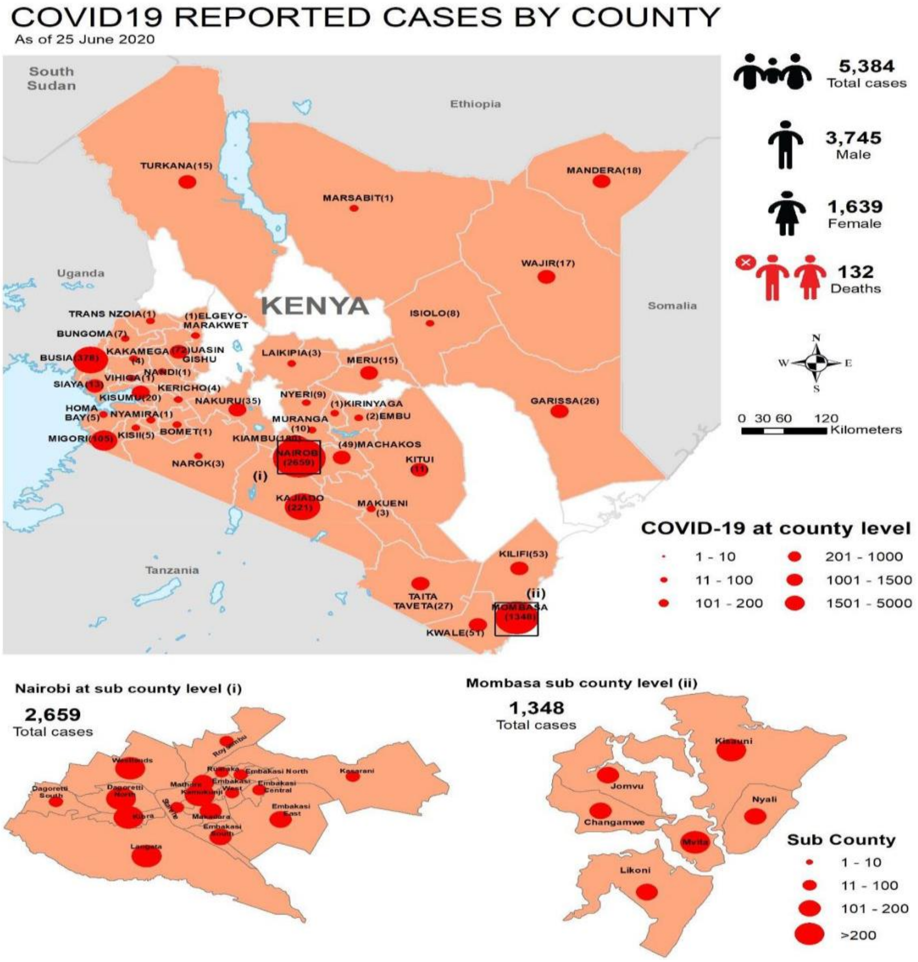

Figure 1: Map of Kenya showing the distribution of COVID-19 cases as at 25th June 2020
Source: **MoH (2020)**

The EVD epidemic in West Africa resulted in a 20 percent decrease in workers, farmers' incomes, and unstable food prices (**Gatiso *et al.*, 2018**). In 1991, the cholera outbreak in Peru resulted in a loss of USD 770 million due to a food trade embargo **(Gatiso *et al.*, 2018; Kastelic *et al*., 2015; WBG, 2016)**.

Following the outbreak of EVD in West Africa, the WHO developed guidelines on preparedness for countries to adapt to avert global epidemics (**WHO, 2015)**. This involves the ability of countries to respond timely, detection of infections, containment, and treatment of cases (**WHO, 2015)**. The report further states that effective, accessible, and efficient local health systems are essential for the prevention and control of infectious diseases. Adoption of these recommendations contributed to early detection of the Zika virus in 2016, the first EVD case in Uganda, and new EVD cases in the Democratic Republic of Congo (DRC) in 2018 **(WBG, 2019**). Key aspects of preparedness in the health sector include surveillance, laboratory capacities, and mobile health units and community involvement. These, coupled with political will, enabled Korea to contain a potential second MERS outbreak in 2018 and India was able to identify and contain the Nipah virus in 2018 **(WBG, 2019; WEF, 2019)**.

The effects of COVID-19 in Kenya and especially in her agricultural sector cannot be over-emphasized. The fears of the spread and socio-cultural interruptions, as well as change in factors of production such the agricultural labour force and input supply, have been mentioned to be affected. However, it must be noted that as a country, there are also serious health challenges that have been witnessed and seem to pose a greater challenge in the agricultural sector than the COVID-19. They include cholera which has claimed 37 lives across the country over the same period of COVID-19, floods that resulted in 250 deaths, among other illnesses such as typhoid, malaria, cancer among others. In as much as the government tries to stop the spread of the disease by injecting billions of Kenya Shillings, there is also a need to address these other outbreaks if the agricultural sector is to be re-energised.

Impact of COVID-19 on Food Security

Food insecurity remains a major concern for numerous rural households in Sub-Saharan Africa who rely on agriculture as their main source of livelihood. The 1996 World Food Summit defines, food security as existing „when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life," as in **(Mutea *et al*., 2019).** In the past two decades, epidemics and natural disasters have claimed millions of lives, adversely impacted dozens of people, and resulted in significant health, social, and economic consequences (**UNESCO, 2007**). The report further states that there were 404 disasters between June 2005 to May 2006 with nationwide consequences in 115 countries, including the death of 93,000 people and economic losses totalling 173 billion US dollars. Infectious diseases such as COVID-19, Ebola Virus Disease (EVD), Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS), their associated mortalities, and desperate control and prevention measures, remain a significant threat throughout the world, thereby deteriorating the production capacity of the world food chains as well as food and nutrition security status of many households (**Bloom *et al.*, 2018**). Since the first case of the COVID-19 was reported in Kenya, the pandemic continues to deepen pre-existing inequalities as well as exposing vulnerabilities in social, political, and economic systems which are in turn amplifying the impacts of the pandemic on food and nutritional security (**Cytonn, 2020**).

As COVID-19 continues to advance, it is difficult to know the extent of the impact on food production and distribution systems. Looking at past infections as well as China's way of dealing with COVID-19, might guide policymakers and development partners in future policy formulation and programming. Also, many studies have been conducted to evaluate the impact of epidemics and natural disasters on food security. Most studies posited that many households are most likely to be hit due to negative impact of epidemics on crop production, incomes, movements and food chains which increases the problem of food and nutritional insecurity throughout the world (**Kodish *et al.*, 2019; Agrilinks, 2020**). For instance, the 2013-2016 Ebola outbreaks in West Africa negatively disrupted the food system and markets, primarily in Sierra Leone, Guinea, and Liberia (**Gatiso *et al.*, 2018; FAO, 2015a)**. Research conducted by the Food and Agriculture Organization on the effect of the Ebola Virus Disease outbreak in West Africa revealed that the epidemic significantly impacted food security, where approximately half a million people were declared severely food insecure in the three worst-hit western African countries in 2014 (**FAO, 2015a**).

Kodish *et al.* (2019) on a related impact study of Ebola Virus Disease revealed that the epidemic effects and the accompanying response measures, especially forced community quarantine, and movement restriction policies, directly and indirectly, contributed to the disruption of food value-chains in Sierra Leone. The Ebola Virus Disease outbreak negatively affected agricultural production, food storage, processing, and distribution, transportation, trade in agricultural commodities, and retailing in Sierra Leone. According to **Kodish *et al.* (2019)** and **Gatiso *et al.* (2018)**, as governments' Ebola Virus Disease response strategies were being implemented to curtail people's movements via forced quarantines and police road blockages, food markets were disrupted which led to less food availability, fewer varieties of food, as well as higher food prices, especially on scarce and staple foods. For example, when Ebola Virus Disease began to hit these West African counties, the prices of major staple food such as rice and cassava skyrocketed by 30percent and 150 percent, respectively **(Chen *et al.*, 2020)**. **Gatiso *et al*. (2018)** reported that the impact of the Ebola Virus Disease outbreak is not limited to communities directly affected, but also affect communities in areas where it was not reported. They added that community-level incidence of Ebola Virus Disease negatively affected crop production and incomes of farm households thus increasing the problem of food insecurity throughout the country.

On natural disasters, many studies have reported direct and indirect impacts of droughts and floods on food security **(Awange *et al*., 2007; Kotir, 2011; Week and Wizor 2020**). However, it is worth noting that the agriculture and food sector absorbs about 22 percent of the total damage and losses caused by natural hazards such as floods (**FAO, 2015b). Devereux (2007)** categorized the impact of droughts and floods on food security in Malawi as follows; failures of production-based entitlement (harvest failure), labour-based entitlement (a decline of employment opportunity and real wage), trade-based entitlement (market failure and declining terms of trade) and transfer-based entitlement (Food and informal settlement failure). In a related study, **Akukwe *et al.* (2020)** opined that the flooding exacerbates food insecurity by increasing the number of already food-insecure households in the South-Eastern region of Nigeria. They added that flooding results in food insecurity hotspots and can weaken the efforts to achieving Sustainable Development Goals (SDGs), especially SDG 2 which emphasizes ending hunger, achieving food security and improving nutrition, and promoting sustainable agriculture.

Based on historical documents from 1978–2014, **Jingpeng *et al.* (2019)** studied the spatial-temporal variation of five major kinds of natural disasters and grain losses in China and found that drought and flood were the most serious types of national disaster over the last four decades which accounted for over 50 percent grain loss that subsequently led to food insecurity in China. This is not different in other countries but the intensity of the impacts is not similar between developed and developing countries due to disproportionate differences in infrastructure, resources, and disaster preparedness **(Agrilinks, 2020).** This is so particularly because vulnerable populations in developing countries such as children, women, the elderly, and the poor are most affected by epidemic induced food and nutritional insecurity because they lack the power and resources to adapt to unpredictable crisis events (**Chen *et al.*, 2020).**

As noted by **(IFPRI, 2020),** unlike developing countries, China has maintained stable food prices since the beginning of COVID-19 in December with supplies of fruits, vegetables, other staples, and meats being sufficient. This could be attributed to the sustained and continuous supply of agricultural produce to towns under lockdown. However, price hikes and shortages have been reported in some isolated locations. In other countries, studies have shown that the poultry industry has been adversely affected, and it is expected to worsen over time without proper response strategy **(Chen *et al.*, 2020).** This results from input shortages, transportation blockages, difficulties in product delivery, and labour shortages. According to **Agrilinks (2020)**, market input estimates indicate that the supply of ducklings and chicken has decreased by about 50 percent following a ban on the movement of live poultry. This implies that supplies of meat and related products could reduce. Like the case of the 2003 SARS outbreak, it is estimated that if the virus is not controlled quickly, the associated food panics can increase thus prolonging temporary food shortages **(Chen *et al.*, 2020);** many lessons can be learned from China's food availability especially in Wuhan, where COVID-19 was first detected. In Italy on the local consumer front, there was an immediate instinctive response in the hoarding of basic necessities and food **(Barcaccia, 2020**). According to **(Zurayk, 2020)**, in regions of conflict and crisis, such as the Middle East and East Africa, the COVID-19 threat is compounded by sieges and embargos and obstacles to food access created by political and military pressures. Millions of Syrian refugees live in camps in Turkey, Lebanon, Syria, and Jordan over this COVID-19 period, where they rely on food aid and are unable to practice social distancing.

Before the emergence of the COVID-19 pandemic, food insecurity was already on the rise in Kenya due to factors such as climatic shocks and livestock pests and diseases **(Okoth *et al.*, 2020).** The desert locust outbreak added to the already growing concerns. COVID-19 has worsened the situation by hampering efforts to fight one of the largest locust swarms in recent times **(UN, 2020**). This reflects vast spending on response measures and humanitarian food assistance. According to (**Kariuki, 2020)**, the Kenya National Bureau of Statistics estimates that about 12 million people are food poor. These are people whose income doesn't enable them to consume enough calories for a healthy lifestyle and two-thirds of the food poor individuals are found in rural areas. In most Sub-Saharan Africa countries, the pandemic has already crippled the entire food system and Kenya has not been left behind. This is because of restricted movement which affects the entire aspects of food security (availability, affordability, utilization, and accessibility). Similarly, the movement of agricultural labour has been hampered, which will adversely affect food production. Much as agricultural-related logistics have been largely considered essential, not all people can afford logistical services, and this may ultimately result in high post-harvest losses. However, a significant reduction in the export market also has significant challenges in agriculture since most of the Kenyan export is agricultural output **(Odhiambo, Weke and Ngare, 2020).** This means that the government through the ministries concerned needs to have concerted efforts to reinforce inter-country cooperation through proper policies, at least in the short run to address these challenges.

In terms of agricultural production, COVID-19 could disrupt the availability and affordability of agricultural inputs, particularly as devalued currencies and higher-cost logistics may make inputs more expensive. At the same time, contraction in remittances might impede farmers' ability to purchase inputs, and disruptions in port and inland logistics could affect distribution.

The long-term effects of new coronavirus deaths, curtailment of movements, the disruption of food production and systems, and among other factors are not yet known. However, many lessons can be learned from past epidemics and natural disasters and management strategies that have been undertaken by Wuhan, China. The immediate effects have been witnessed in many areas where people scramble and kill one another during the distribution of humanitarian aid. Additionally, many food processing enterprises have been forced to shut down due to strict response strategies, and this can further escalate the food insecurity in the country if these firms cannot restart production soon.

Regardless of the effects of COVID-19, several beneficial inventions have been improvised to support business operations. One of the most embraced innovations is online businesses between farmers and customers, especially in cities or aggregators. Social media has also been used in marketing activities. Home deliveries from agricultural shop outlets as well as fresh horticultural product supplies are among the ideal mechanisms that have been used during the pandemic and may aid in future business transactions. Beyond addressing the immediate concerns surrounding health and food emergencies, COVID-19 pandemic offers an opportunity for decisive collective action towards building resilient food systems (**Shikomboleni, 2020).** Thus, as various policy-makers in different countries engage on how to meet the food security demands of their nations considering disruptions caused by the COVID-19 pandemic; this is also the time to consider system-wide reconfigurations that can build greater resilience in local and national food systems.

Impact of COVID-19 on Household Livelihoods

Livelihoods are the assets, capabilities, and the activities through which an individual acquires necessities of life **(Mutea *et al.*, 2019).** A sustainable livelihood is considered when it can cope with shocks such as pandemics while maintaining or enhancing its capabilities and assets without undermining the natural resources. Since WHO declared COVID-19 a global pandemic on 11th March, 2020 a lot of changes have been instituted throughout the world to curb the spread of the virus including lockdowns, curfews, flights ban, closure of borders between countries and restrictions of movements which in turn has affected the livelihoods of a large population. The uncertainty as to when the global pandemic will end and predictions of exponential growth of the number of infections in Africa further renders the livelihoods of households unsustainable as economic impacts are predicted to last until 2021 **(IMF, 2020).**

The vulnerable people living in densely populated slums, peri-urban, and urban areas are hardest hit in developing countries since urban areas were an entry point of the disease. With the inception of COVID-19 virus containment measures such as curfew, quarantine, lockdown, isolation, cessation and restriction of movements, comes the ripple effect of diminished livelihoods of households. These restrictions have led to socio-economic repercussions through disruption of economic activities; trade, loss of jobs, both formal and especially informal jobs.

About 61% of the world's population and 86% in Africa are involved in the informal economy therefore vulnerable to economic shocks if unable to work. Approximately 5 to25 million people are estimated to lose jobs whereas loss of labour income is estimated at USD 860 billion to 3.4trillion due to the pandemic **(ILO, 2020a).** Countries like Kenya with large informal sectors coupled with minimal social protection programs are hardest hit. The pandemic has led to the loss of jobs for both employed and self-employed individuals in the service industry, hospitality, tourism, transport, and SMEs. The majority of households in the urban areas are dependent on informal jobs characterized by low skill labour that require face to face interactions **(Brookings, 2020)**. Partial closure of hotels has reduced the demand for agricultural products hence loss of farm income for farmers who supply their produce. Workers sent on compulsory unpaid leaves and those on pay cuts have also been negatively affected.

Remittances are a source of income for households in Africa, directly for urban households and indirectly to rural households. According to **GAIN (2020)**, remittances to Sub-Saharan Africa are expected to decline by 23.1% due to COVID-19. In Kenya for instance, remittances amounted to USD 259.4 million in January 2020 **(CBK, 2020)**. A significant drop in volumes of remittances is expected following the loss of jobs and containment measures such as lockdown, illness, and disruption of economic activities, therefore, migrants are unable to support the livelihood of their families **(IFRC *et al*., 2020)** This is likely to impact households whose livelihoods rely largely on remittances hence posing threat to essential services, access to healthcare and food items. Households, therefore, face potential food and nutrition insecurity, increased poverty levels due to low purchasing power. Household and business spending is estimated to fall by 50% in 2020 as a result of disruptions caused by COVID-19 according to a global report by **McKinsey and Company (2020**). The absence of social protection programs to cushion households against loss of income is evident in developing countries like Kenya, and, the ability to adopt coping strategies such as subsistence farming is not possible in urban slum areas. The households may be forced to engage in livelihood coping strategies that predispose them to contract the virus or sale of their productive assets to afford a living.

Recent reports by OXFAM indicate that COVID-19 could push about half a billion people into poverty. Urban slum dwellers' livelihoods are at risk following the pandemic. The densely populated slums are characterized by poor sanitation, high prevalence of poverty, and dependent on informal sector employment which makes them more vulnerable to the effects of the virus. The containment measures have significantly impacted their livelihoods hence loss of income, the reduced purchasing power of essential food items, and inability to provide essentials for their families following the absence of social protection programs to cushion against loss of jobs. In major African cities such as Nairobi, Kinshasa and Lagos where up to two-thirds of the population rely on the informal sector for their livelihoods, millions of people have been left without income to purchase food due to the abrupt loss of jobs that often provide daily earnings (**Shikomboleni, 2020)**. The potential impact of the pandemic on rural livelihoods is yet to be felt following the lockdown of high-risk urban areas and the implementation of curfew, restriction of movements at border points. Farmers face a potential risk of losing farm incomes through reduced demands and perishability of farm produce. Restriction of movements and closure of markets also limit access to essential farm inputs hence could potentially result in a reduction of agricultural production and loss of income for casual farm labourers **(IFRC *et al*., 2020).**

Kenyan Level Initiative

To curb the spread of the virus, the Kenyan government instituted several measures including administrative, economic, and behavioural. Administrative measures have included the closure of produce markets, international borders, and dawn to dusk curfews. These have been highly disruptive for food delivery. This is because Kenya's food system is heavily dominated by small, independent transporters as the link between producers and consumers. Produce markets, which are at the heart of distribution in urban areas, serve consumers, and smaller retailers. This traditional informal system accounts for about 90 percent of the market. The closure of many of these markets in the urban and peri-urban areas, while a reasonable measure to avoid crowding, has disrupted food supply systems, especially for fresh produce. The impact is felt most in low-income urban households that rely on these informal food markets. The ministry of agriculture agreed to categorize the transport of foodstuff as an essential service, to improve food supply in urban areas.

The border restriction, especially from neighbouring countries such as Kenya-Tanzania and Kenya-Uganda borders, is also reducing fresh food supply in Kenyan markets. This is because of the more time needed in border screening of goods on transit as well as drivers before getting into the country, to avoid further spread of the pandemic. Delays have also been reported due to a shift from manual documentation to online working as some employees are currently working from home. Again, there has been a partial closure of internal container depots due to lean staff handling cargo. These constraints eventually affect the competitiveness of the produce being transited to the destination markets. There are also losses due to delays in logistics before delivering goods to the destination markets, brought about by the nature of the high perishability of agricultural products **(Okoth *et al*., 2020)**. The border restrictions have been overcome by negotiations between Kenya and the affected countries on the modalities to allow the free flow of agricultural produce while minimizing and curbing the spread of COVID-19.

The Kenyan government through its various stakeholders has established the Kenya COVID-19 Fund called GiveDirectly which is an emergency cash transfer. GiveDirectly is aimed at delivering cash to low-income Kenyans to help them get through COVID-19, as part of the Shikilia initiative. Shikilia is a collaboration between

Kenyan private sector and non-profit organizations to raise funds and provide emergency cash transfers to low-income Kenyan communities to replace lost income due to COVID-19 and prevent a widespread humanitarian crisis. Shikilia initiative coordinates with community organizations and geographic targeting data to identify and prioritize vulnerable communities and groups.

As reported by **Wanjala (2020**), other fiscal economic policy measures instituted by the government include individual income tax reduction from 30 percent to 25 percent; corporate income tax reduction from 30 percent to 25 percent; 100 percent tax waiver to individuals earning less than USD 240; VAT reduction from 16 percent to 14 percent; injection of a USD 10 million social protection stimulus package for the elderly and underprivileged citizens; and a temporary delisting of loan defaulters from the Credit Reference Bureau (CRB). Other measures included reduction of turnover tax rate from three- percent to one percent for all micro, small and medium enterprises

Despite the country's effort to impose tax laws and instigate safety nets and related incentives to vulnerable families, the implementation mechanism has been reported to be inadequate, untargeted, and benefitting the wrong people. This is probably due to poor planning, corruption, and embezzlement of public coffers by those entrusted to manage public funds. The humanitarian and recovery assistance to vulnerable groups has also proven to be unsustainable in the long run. This is so because most agricultural communities are in interior parts of the country, most of whom are not easily accessible by road **(Okoth *et al.*, 2020)**

The behavioural measures have included an indefinite closure of recreational facilities such as bars; imposition of a dusk to dawn curfew; ban of public gatherings and events; issuance of a directive to Public Service Vehicles (PSVs) to implement social distancing among passengers; as well as suspension of international flights from landing or flying out of Kenya except for cargo flights **(Wanjala, 2020).** These have greatly affected the free flow of agricultural commodities in the country.

CONCLUSION

The observed effects of the COVID-19 pandemic and previous epidemics and pandemics call for policy measures to curb future occurrences. The exceptional extent and duration of the 2014 Ebola Virus Disease (EVD) outbreak in West Africa had significant adverse effects on food security in Guinea, Sierra Leone and Liberia, the countries most affected. Countries` preparedness for pandemics is crucial to prevent adverse economic effects and loss of human lives. Developing countries for instance need to enhance their preparedness through establishing efficient, accessible health systems, mobile health units, and increased laboratory facilities, to improve prevention, early detection, treatment and containment of diseases. This will reduce the fatalities in future occurrences and pandemics.

The pandemics largely impacts on food security and nutrition. Therefore, it is necessary to ensure sustainability of resources, strengthen infrastructure and food systems to avoid or minimize food crises in the future. Governments need to put measures geared towards promoting smallholder farming, which accounts for the highest percentage of production for developing countries, such as accelerating e-commerce platforms connecting farmers and consumers. Sustainable, resilient food systems need to be established to boost food safety and minimize transmission of pathogens. This will also reduce future food and health crises worldwide. One of the key ways in which the Kenyan economy can build resilience to mitigate and manage shocks is to create buffers with one vital safeguard being strategic food reserves. Food reserves are required as a buffer to support adjustment in times of drought and subsequent famines that put pressure on fiscal reserves, as well as for other crisis situations such as the current COVID-19 pandemic. The government should also decide whether to reconsider biotech seeds, which might provide greater resilience against climate and pest threats to improve the overall health of the system in the longer term.

Additionally, emphasis should be placed on protecting supply chains from any form of disruptions in the short term. This is especially so with the current partial lockdown, there is also need for facilitated inter county and inter country border crossing through a coordinated approach of testing and social distancing measures to ensure free flow of staple food commodities.

Social protection programs need to be enhanced in developing countries. This is important in maintaining livelihoods and reducing food and nutrition insecurity among households as well as complementing effectiveness of containment measures such as lockdowns and curfews that are meant to reduce social interactions in the community. Among them should include targeted emergency cash transfers and distribution of food items to the most vulnerable in society. Fiscal policy measures such as tax reliefs to avoid disruption of food supply chains; revision of budget for healthcare to enhance disaster preparedness; providing stimulus packages for SMEs and other businesses also reduce the economic impacts of pandemics.

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REGULAR ARTICLE

FOOD AS MEDICINE: FOOD CONSUMPTION PATTERNS AND REPORTED ILLNESSES AMONG HOUSEHOLDS

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ABSTRACT

Rapid changes in climate and urban growth, changing demographics and heterogeneity of urban lifestyles are resulting in a shift in food consumption patterns, with a preference for foods with minimal processing time, quality and taste in Nigeria; but does there exist any relationship between food consumption pattern and reported illnesses among households? For better understanding, this study uses cross-sectional primary data, to thus, examine the relationship between food consumption patterns and the reported illnesses among households in Nigeria. Using a multistage sampling procedure, 250 households in two different local government areas were randomly selected. The study revealed that male household head consumed more plant-based whole food (0.6064) and therefore reported a lower incidence of illnesses (2.18) as compared to the female head whose consumption is lower (0.5644) with higher reported illnesses (3.13). The study further revealed that household members (41-50 years) are most aware of a plant-based whole food (54.17%) with lower reported illness (2.18), whereas members (61-80 years) have the highest reported illness (2.62) because they are the least aware (0.6189). Results also showed that people in the urban areas are prone to more sickness (2.04) than rural areas (1.79) because they are exposed to more choices of processed foods as compared to fresh farm foods available in the rural areas. Households' consumption patterns were influenced by household head sex, income, location, level of awareness of plant-based whole food, and total food expenditure. Therefore, while the existence of rural-urban food linkages will ensure wider households' access to quality whole foods needed to reduce reported illnesses; increasing households' income will enhance diet diversity and reduction in Nigeria's food insecurity. Also, more attention should be given to educating the people especially through media channels on the benefits of consuming plant-based whole food.

Keywords: food consumption pattern; diet diversity; urbanisation, whole food
JEL: E21; H31; I12; P46; Q18

INTRODUCTION

A vital concept for explaining development strategies in Africa is food security, which is seen as unrestricted access to enough nourishing food for everyone at any time to maintain a healthy and active life **(FAO, 2008).** Despite recent concerted efforts to alleviate poverty and its multifaceted dimensions in Sub-Saharan Africa (SSA), undernourishment persists as a widespread and severe problem. Every individual requires a minimum amount of food for survival and in a balanced ration to maintain sound health because food is one of the basic essential requirements of life. **Hubbard and Onumah (2001)** assert that a well-balanced diet has a tremendous bearing on a person's vitality, emotional stability, and enthusiasm for life. The importance of a good diet cannot be overlooked because food and eating well can make the difference between being alive or dead and being well or sick. Some researchers, **Omonona and Adetokunbo (2007), Obayelu (2010),** and **Omotesho and Muhammad-Lawal (2010)** have shown that food or a good diet can prolong life, well-being, and promote human development. This is because a healthy population means a healthy productive force. While food production and consumption are significant to the development and economic growth of both developed and developing nations, there is an alarming prevalence of double-burden of malnutrition (undernutrition and overnutrition) in Nigeria, as many homes rely on insufficient staple foods which do not provide them with a balanced diet leading to massive importation of foods making her incur huge foreign debts **(Makinde, 2000).** Evidence from literature shows that while the estimated population growth rate is increasing at 2.5% yearly, food production growth is below 2% annually **(Aku, 2012).** Therefore, the scenario of the ever-increasing population and its accompanying food production availability has become a contentious empirical question. This problem may likely lead to an increase in food insecurity, causing food demand-supply gap as a result of the low rate of food production compared to high population growth currently being experienced in Nigeria.

Globally, the right consumption pattern is a fundamental challenge to human health status and welfare. According to **Arulogun and Owolabi (2011),** health researchers and market analysts for the past few years have diverted their efforts into understanding why people chose to consume foods they ate, and in the way and form, they ate such food. Similarly, while there has been a lot of changes to households' food consumption pattern globally, the rate of change in Nigeria is disturbing. Consumption of nutrient-poor and energy-dense fast foods (food high in fat, sugar, and salt) has increased in rate **(Adair and Popkin, 2005; Duffey, Pereira and Popkin, 2013**). This has resulted in the increasing number of people eating away from home, in restaurants and take-away foods. The meals are majorly composed of fried and processed food **(Meng, 2017; Wang, Zhai, Du, and Popkin, 2008)** which are poor in nutrients and quality but rich in fats and oil. While these poor diets contain high sugar, salt, refined grains, and unhealthy fats, they are however low in fruits, whole food grains, fish, animal proteins, vegetables, and nuts. People make them their choices because they are typically packaged, ready to eat, and enabled by the modern food environment **(Popkin, Adair, and Ng, 2012; WCRF, 2007);** a problem that is now visible in not only urban but also rural areas across Nigeria. However, the challenge of this trend is that without care for methods and nutritional quality of the food ingredients, this shift to processed foods often ladened with high salt and sugar content have increased the percentage of persons with non-communicable diseases such as for overweight (35.2%), obesity (22.2%), hypertension (28%), cancer (15%), and diabetes mellitus (8%) in the urban cities, which is now getting prevalent in some rural areas in Nigeria, and other Africa countries **(Awosan *et al*., 2014).**

Although the supermarket revolution has been attributed to be the main cause of this nutrition transition in developing countries especially in Nigeria, it is not fully understood **(Ameye and Swinnen, 2019).** However, incidences of the double burden of malnutrition are becoming prevalent due to increasing urbanisation, technological developments, and changes in food consumption patterns. Evidence from literature shows the increase in consumption of dietary energy, fat, sugars, and protein but lower consumption of fruits and vegetables across West Africa **(Bosu, 2015).** Therefore, there is a need for more research into how this transition may affect food security and consumption patterns. Nevertheless, there remains a knowledge gap in research on super-marketization, rural consumption patterns, and food security in Nigeria. Moreover, the urban-rural nexus in this region is not fully understood, with most of these studies focusing on urban areas only. Similarly, with the rate of urbanization and economic development in the past decades in this region, there is a need for more holistic research. Understanding household's food consumption pattern, nutritional status, and reported illnesses in the South-West zone, especially in Ogun State is therefore very important for consumers of agricultural products. Arising from the foregoing, the general objective of the study was to determine the wholesome food consumption patterns and the reported illness associated with food consumption among households in Ogun State. The specific objectives are to: Identify the socioeconomic factors influencing the reported diseases in households; Determine the awareness level of households on a plant-based diet; Determine the pattern of consumption of whole plant food (whole food plant based diet - WFPBD) and reported illnesses among household members and Examine the factors influencing the level of awareness of whole plant food.

DATA AND METHODS

The Study Area

This study was conducted in Ogun State, Nigeria. Ogun State is situated within the tropics, with a total land area of 16,762 square km which lies within latitude 6°N and 8°N and longitude $2^1/2°$ E and 5°E of the Greenwich Meridian, and has an estimated population of 4,054,272. The state borders Lagos state to the south, Oyo and Osun state to the north, Ondo State to the east, and the Republic of Benin to the west. The state is situated in the tropical rain forest which is suitable for agricultural production making the people of the state predominantly farmers who grow both commercial and food crops. The state is blessed with abundant natural resources like gold, kaolin, and others which are being extracted for the benefit of the state and the entire country at large. The people of the state just like other southwest states are predominantly Yoruba, which is one of the three largest ethnic blocks in Nigeria **(Ogunmodede and Awotide, 2020).**

Data

A multi-stage sampling technique was used for this work. The first stage involved the random selection of one local government that is densely populated or urban (Abeokuta south) and one sparsely populated or rural local government (Odeda). The second stage involved the selection of four areas from each local government. And the last stage involved the random selection of 150 households from the urban areas and 100 households from the rural area, making a total of 250 households. Although two hundred and fifty questionnaires were administered for this research, a total of two hundred and six (206) had complete information and were returned in time and used for the analysis.

Primary data was used for this study. Data was collected with the aid of a well-structured questionnaire that was administered to households in the study area. Household food consumption patterns and reported illnesses data were collected from a cross-section of selected households in selected rural and urban communities in the two local government areas sampled (Odeda and Abeokuta South) in Ogun State, Nigeria. Other information obtained with the questionnaire includes socioeconomic characteristics of the households and household heads, the awareness level of households on plant-based lifestyle, consumption patterns, and reported illnesses.

Methods

The analytical tools used in this study include descriptive statistics, probit regression, Tobit regression, and Ordinary Least Squares regression.

Descriptive statistics such as frequencies, percentages, means, and the standard deviation were used to describe the awareness level, consumption pattern, and reported illnesses among the households in the study area. The probit model was used to determine the factors influencing the level of awareness of the households. The model is given as Eq. 1- Eq. 2.

$$Z = \partial_0 + \partial_1 X_1 + \partial_2 X_2 + \partial_3 X_3 \dots X_n + \phi \quad (1)$$

$$Z = \begin{cases} 1 \; if \; Z > 0 \\ 0 \text{ otherwise} \end{cases} \quad (2)$$

Where:

Z is the dependent variable, which represents the awareness or not by households of a plant-based diet;

$\partial_0, \partial_1, \partial_2, \partial_3, \dots \partial_n$ are the coefficients that were estimated while examining the factors affecting households' awareness of the plant-based diet;

φ is the residual term;

$X_1, X_2, X_3 \cdots, X_n$ are the explanatory variables, where:

Y Awareness of plant-based food (1 = aware; 0 = not aware);

X_1 Level of Education of Household head (Years);

X_2 Occupation of the Household head (Farming=1, Non-farming=0);

X_3 Marital status of the Household head (Married=1, Single=0);

X_4 Household head income (NGN);

X_5 Household size (Number of persons);

X_6 Reported illnesses (Numbers);

X_7 Location (Urban=1, Rural=0).

Tobit Model was employed to examine factors influencing the extent of consumption of wholesome food. The Tobit model is specified as Eq. 3.

$$Y_i = [\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots \beta_n X_n + \varepsilon_i] \quad (3)$$

Where:

Y_i is the extent of consumption of wholesome food plant-based diet (WFPBD) (proportion);

X_1 Age of household head (Years);

X_2 Level of Education of Household head (Years);

X_3 Total food expenditure (NGN);

X_4 Sex of the Household head (Male=1, Female=0);

X_5 Total household income (NGN);

X_6 Household size (Number of persons);

X_7 Reported illnesses (Number);

X_8 Location (Urban=1, Rural=0);

X_9 Awareness (Aware=1, not aware=0).

Ordinary Least Squares Regression model was used to analyse the socio-economic factors influencing the reported illnesses in the households. The OLS model is specified as Eq. 4.

$$Y_i = f[\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots \beta_n X_n + \varepsilon_i] \quad (4)$$

Where:

Y Reported illnesses (Numbers);

X_1 Age of household head (Years);

X_2 Level of Education of Household head (Years);

X_3 Sex of the Household head (Male=1, Female=0);

X_4 Marital status of the Household head (Married=1, Single=0);

X_5 Household head income (NGN);

X_6 Household size (Numbers of persons);

X_7 Location (Urban=1, Rural=0);

X_8 Awareness (Aware=1, not aware=0);

X_9 Spouse age (Years).

RESULTS AND DISCUSSION

Description of socio-economic characteristics of the households

This section presents the discussion of results to describe the socio-economic characteristics of the households in the study area. The selected socio-economic characteristics in this study include sex, age, marital status, household size, location, education level, household occupation household income of both household head and spouse. They are hereby discussed.

Gender of household head

The result in Table 1 shows that 88.35% of the household heads were male while 11.65% of the household heads were female. This agrees with **Mfikwa and Kilima (2015), Obayelu *et al.* (2009)** that a larger percentage of the household head being male would improve the quality of food consumed by the household members because 85.52% of the male household head has full knowledge of plant-based whole food consumption compared to 14.58% of the female that was aware of it. Male household head averagely consumed 0.6064 proportion of plant-based whole food while the female household head averagely consumed 0.5644 proportion of plant-based whole food. The male household head had a less average number of reported illnesses of 2.18 compared to that of the female household head with 3.13.

Age of Household members

The result in Table 2 shows that about 49.51% of the respondents were within the age bracket 41-60 years and they have the highest percentage of awareness level of 54.17%. Also, they averagely consumed 0.6562 proportion of plant-based whole food with about 2.18 average number of reported illnesses. About 28.64% of the respondents were within the age group of 21-40 years and had a 33.33% awareness level. They averagely consumed 0.6524 proportion of plant-based whole food with about 2.36 average number of reported illnesses. About 20.39% of the respondents were within the age group of 61-80 years and had a 12.50% awareness level. They averagely consumed 0.6189 proportion of plant-based whole food with about 2.62 average number of reported illnesses. About 0.97% of the respondents were within the age group of 81-90 years but no awareness level. They averagely consumed 0.6038 proportion of plant-based whole food with about 2 average number of reported illnesses. The mean age of the household head is 49.83 years which aligns with **Mustapha (2014)**. Age could be an important determinant in the quality and quantity of protein requirement of an individual and households because food consumption patterns generally follow the body consumption **(Amao *et al.*, 2006).**

Marital status of Household Head

The result in Table 3 shows that 75.73% of the respondents were married, 70.83% of them were aware of plant-based whole food and they consumed a larger proportion of 0.6625 plant-based whole food with 2.19 average number of reported illness which is lesser compared to those that were single. About 24.27% of the respondents claimed to be single, whereby 29.17% of them were aware of plant-based whole food, 0.6321 consume plant-based whole food and had 2.58 average number of reported illnesses. This shows that respondent that are married are more aware and most likely have the highest chance of being aware since at least one of the household members can influence the consumption patterns in the house compared to a single person. This result is in tandem with the study of **Ogunmodede *et al.* (2020)**.

Household Size

The result in Table 4 shows that 57.28% of respondents have a family size that ranges between 1-5 people of which 54.17% of them were aware of plant-based whole food, they consumed 0.6575 proportion of plant-based whole food and reported an average number of 2.18 illnesses. About 42.72% of the respondents have a family size that ranges between 6-10 people of which 45.83% of them were aware of plant-based whole food, they consumed 0.6519 proportion of plant-based whole food and reported an average number of 2.43 illnesses. This implies that families with less Household size may have better chances of consuming plant-based whole food due to the smaller number of members they catered for. The mean household size is 5.17 people. This result agrees with the findings of **Mfikwa and Kilima (2014)** that families with large household size may not have proper consumption of plant-based whole food due to a large number of members to cater for.

Education Level of Household Head

The result in Table 5 shows that about 6.8% of respondents had no formal education with 6.8% of them were aware of plant-based whole food. They consumed 0.5652 proportion of plant-based whole food and have a 2.85 average number of reported illnesses. About 15.05% of the respondents had primary education with 4.17% of them aware of plant-based whole food, 0.6848 proportion of plant-based food was consumed by them and 2.19 average number of reported illnesses was recorded. The highest level of education is tertiary education (46.14%), of which 72.92% of them were aware of plant-based whole food, they consumed 0.6555 with an average number of reported illnesses of 2.29. It is expected that education would improve awareness level and consumption of plant-based whole food, but the result is on the contrary. The justification for this could be that households are burdened with different responsibilities like rent on shelter, school fees, charges on utilities. The result showing that tertiary education is the largest educational attainment of the respondents goes in line with the postulation of **Awosan *et al.* (2013).**

Table 1: Distribution of households by sex of head

Gender of household head	Frequency No. (%)	Awareness (%)	Mean proportion of plant-based whole food consumption	The average number of reported illnesses
Male	182 (88.35)	85.52	0.6064	2.18
Female	24 (11.65)	14.58	0.5644	3.13
Total	206 (100)			

Source: Based on own field survey, 2019

Table 2: Distribution of households by age

Age of household members (years)	Frequency No. (%)	Awareness (%)	Mean proportion of plant-based whole food consumption	The average number of reported illnesses
1-20	1 (0.49)	0.00	0.6402	2.22
21-40	59 (28.64)	33.33	0.6524	2.36
41-60	102 (49.51)	54.17	0.6562	2.18
61-80	42 (20.39)	12.50	0.6189	2.62
81-100	2 (0.97)	0.00	0.6038	2
Total	206 (100)			
Mean age	49.83			
Standard Dev.	13.51			

Source: Based on own field survey, 2019

Table 3: Distribution of households by marital status of head

Marital Status	Frequency No. (%)	Awareness %)	Mean proportion of plant-based whole food consumption	The average number of reported illnesses
Single	50 (24.27)	29.17	0.6321	2.58
Married	156 (75.73)	70.83	0.6625	2.19
Total	206 (100)			

Source: Based on own field survey, 2019

Table 4: Distribution of households by household size

Household Size	Frequency No. (%)	Awareness (%)	Mean proportion of plant-based whole food consumption	The average number of reported illnesses
1-5	118 (57.28)	54.17	0.6575	2.18
6-10	88 (42.72)	45.83	0.6519	2.43
Total	206 (100)			
Mean	5.17			
Standard Dev.	2.80			

Source: Based on own field survey, 2019

Table 5: Distribution of household by educational level of head

The educational level of the household head	Frequency No. (%)	Awareness (%)	Mean proportion of plant-based whole food consumption	Average number of reported illnesses
No formal	14 (6.80)	6.80	0.5652	2.85
Primary	31 (15.05)	4.17	0.6848	2.19
Secondary	66 (32.04)	20.83	0.6667	2.44
Tertiary	95 (46.12)	72.92	0.6555	2.29
Total	206 (100)			

Source: Based on own field survey, 2019

Table 6: Distribution of household by occupation of head

Household Head Occupation	Frequency No. (%)	Awareness (%)	Mean proportion of plant-based whole food consumption	Average number of reported illnesses
Non-farming	107 (51.94)	58.33	0.6488	2.54
Farming	99 (48.06)	41.67	0.6619	2.06
Total	206 (100)			

Source: Based on own field survey, 2019

Household Head Occupation

The result in Table 6 shows the distribution of the household head occupation, about 48.06% of the respondents were farmers, 41.67% of them were aware of plant-based whole food, they consumed more proportion of plant-based whole food of 0.6619, with 2.06 average number of reported illnesses. About 51.94% of the respondents were non-farmers of which 58.33% were aware of plant-based whole food, they consumed 0.6488 proportion of plant-based whole food having the largest average number of reported illnesses of 2.54. This study reveals that though the farmers were not aware of what plant-based whole food is all about, they do more of the consumption because they plant it and it is readily available to them compared to other households with the non-farming occupation which makes them less exposed to diseases.

Household Head Income

The result in Table 7 that the mean income of the household heads is 97,528 NGN per month. About 74.76% of the household heads had their income ranging between 1,000 NGN - 100,000 NGN per month. 72.92% of them are aware of plant-based whole food and they consumed 0.6527 proportion of plant-based whole food with 2.23 average number of reported illnesses. About 16.99% of the household heads had their income ranges between 101,000 NGN - 200,000 NGN per month with 22.29% of them aware of plant-based whole food and they consumed 0.6622 proportion of plant-based whole food with 2.49 average number of reported illnesses. About 4.37% of the household heads had their income ranges between 201,000 NGN - 300,000 NGN per month with 4.17% of them aware of plant-based whole food and they consumed 0.6739 proportion of plant-based whole food with 2.77 average number of reported illnesses which is the highest compared to all. About 0.49% of the household heads had their income greater than 500,000 NGN per month, none was aware of plant-based whole food and they consumed 0.5395 proportion of plant-based whole food with 2 average number of reported illnesses. Income is a major driver of demand and budget share allocation among households. Tertiary education graduates will get more paying jobs than people with just primary certificates which makes room for them to consume more processed foods than plant-based whole food.

Age of Spouse

The result in Table 8 shows that about 50.51% of the respondent's spouses were within the age bracket 41-60 years and they were with a 29.08% level of awareness. They consumed 0.6554 proportion of plant-based whole food with a 2.37% average number of reported illnesses. About 30.64% of the spouses were within the age group of 21-40 years and had a 68.67% level of awareness and they consumed 0.6536 proportion of plant-based whole food with 2.35% average number of reported illnesses. About 18.85% of the spouses were within the age group of 41-60 years and had a 2.25% level of awareness and they consumed 0.6625 proportion of plant-based whole food with 2.85% average number of reported illnesses. Age could be an important determinant in the quality and quantity of protein requirement of an individual and households because food consumption pattern generally follows the body consumption **(Amao *et al.*, 2006).** The mean age of spouses is 31years.

Education Level of Spouse

The result in Table 9 shows that about 18.45% of spouses had no formal education with 22.92% of them were aware of plant-based whole food. They consumed 0.6781 proportion of plant-based whole food and have 2.05 average number of reported illnesses. Only 16.50% of them had primary education with 2.08% are aware of plant-based whole food, 0.6226 proportion of plant-based food was consumed by them and 1.29 average number of reported illnesses was recorded. About 31.55% of the spouses had a secondary school certificate with 22.92% of them were aware of plant-based whole food, they consumed 0.6591 proportion of plant-based whole food and 2.03 average number of reported illnesses. About 33.50% of them had tertiary education, 52.08% of them were aware of plant-based whole food, they consumed 0.6478 with an average number of reported illnesses of 2.36. Education improves the level of awareness as it was expected but contrary in the case of consumption of plant-based whole food. The justification for this could be that households are burdened with different responsibilities like rent on shelter, school fees, charges on utilities. The result showing that tertiary education is the largest educational attainment of the spouse goes in line with the postulation of **Awosan *et al.* (2013).** In addition, the educational level of the spouses who are mostly females increases their skills in, health care practices related to disease treatment and prevention, hygiene, and nutrition, and thus improving chances for survival. But this result shows that the higher the educational level the spouse attains, the less they consume plant-based whole food and are exposed to diseases because they tend to prefer to consume processed foods as they are in full employment.

Location

The result in Table 10 shows that about 45.57% of respondents reside in a rural environment with 45.83% of them were aware of plant-based whole food. They consumed 0.6765 proportion of plant-based whole food and have a 1.79 average number of reported illnesses. About 52.43% of them reside in the urban environment with 54.17% of them aware of plant-based whole food, 0.6356 proportion of plant-based food was consumed by them and 2.04 average number of reported illnesses were recorded. This result follows *a priori* expectation, though people in rural areas may not be aware of plant-based whole food. Nevertheless, they consume it more than those who reside in urban areas since it is readily available and sometimes get it at a lower cost.

Table 7: Distribution of household by income of head

Household Head Income (NGN)	Frequency No. (%)	Awareness (%)	Mean proportion of plant-based whole food consumption	Average number of reported illnesses
1,000 - 100,000	154 (74.76)	72.92	0.6527	2.23
101,000 - 200,000	35 (16.99)	22.92	0.6622	2.49
201,000 – 300,000	9 (4.37)	4.17	0.6739	2.77
301,000 – 400,0000	4 (1.94)	-	0.6125	1.75
401,000 – 500,000	3 (1.46)	-	0.5727	2
Above 500,000	1 (0.49)	-	0.5395	2
Total	206 (100)			
Mean income	97,528			
Standard Dev.	130,663.2			

Source: Based on own field survey, 2019

Table 8: Distribution of households by age of spouse

Age of spouse (years)	Frequency No. (%)	Awareness (%)	Mean proportion of plant-based whole food consumption	Average number of reported illnesses
21-40	48 (30.64)	68.67	0.6536	2.35
41-60	79 (50.51)	29.08	0.6554	2.37
61-80	29 (18.85)	2.25	0.6625	2.85
Total	156 (100)			
Mean age	30.73			
Standard Dev.	20.53			

Source: Based on own field survey, 2019

Table 9: Distribution of households by educational level of spouse

Educational level of Spouse	Frequency No. (%)	Awareness (%)	Proportion of plant-based whole food consumption	Average number of reported illnesses
No formal	29 (18.45)	22.92	0.6781	2.05
Primary	26 (16.50)	2.08	0.6226	1.29
Secondary	49 (31.55)	22.92	0.6591	2.03
Tertiary	52 (33.50)	52.08	0.6478	2.36
Total	156 (100)			

Source: Analysis based on own field survey, 2019

Table 10: Distribution of households by location

Location	Frequency (%)	Awareness No. (%)	Proportion of plant-based whole food consumption	Average number of reported illnesses
Rural	47.57	98 (45.83)	0.6765	1.79
Urban	52.43	108 (54.17)	0.6356	2.04

Source: Analysis based on own field survey, 2019

Factors influencing the level of awareness of plant-based whole food among households.

In the Probit model, the Log-Likelihood ratio, given by the Chi-square statistic test was highly significant at 1% level indicating that the chosen independent variables fit the data reasonably well. It is interesting to note that 4 out of the 7 estimated coefficients of the outcome equation are statistically significant and explained the variation in the probability of awareness level of whole plant food as explained by the explanatory variables included in the model. The results indicate that the household head years of education, household head income, reported illnesses, and location significantly influenced households' level of awareness of whole plant-based food (Table 11).

The coefficient of household head years of education has a positive and significant effect on the level of awareness of plant-based whole food and given the role of education in raising awareness level, it seems that having access to more years of education by the household's head appears to have a significant impact on the level of awareness of plant-based whole food among households, increasing the probability of the level of awareness by 8.41% at the sample mean. This implies that a year's increase in the education of household heads will increase the likelihood of awareness about WFPBD by 2.9%. This result aligns with the findings of **Babatunde *et al.* (2007).** Therefore, education enables people to have access to greater information on the nutritive values of different food types including vegetables.

Similarly, the coefficient of household head income was also positive and have a significant effect on the household level of awareness implying that as the household head income increases by a thousand naira, there is a 5.6% probability that their awareness will be increased. The result shows that higher-income enables the family to afford to buy more fresh vegetables and whole food grains.

Furthermore, the coefficient of the variable reported illnesses, have a positive influence on the awareness level, and statistically significant ($p \leq 0.05$). The coefficient of the marginal effect shows that a unit increase in reported illnesses has a 4.2% probability of increasing the awareness level. The positive sign of the reported illnesses might be confusing but increases in the number of reported cases of household illnesses will increase the likelihood of being aware of plant-based whole food among the household members. In other words, when a household member falls sick and visits the hospital, there is a high tendency that he would be informed about consuming a plant-based whole food, especially when the illness is related to nutrition. This result is similar to the findings of **Ogunkunle and Oludele (2013).**

The location is a dummy variable indicating rural and urban residence. The location dummy variables are included primarily to control for location fixed effects including regional differences in prices, market, income, infrastructure, and economic activity. Unexpectedly, the location variable has a positive influence on the awareness level and statistically significant ($p \leq 0.05$). The coefficient of the marginal effect shows the likelihood of being aware of the WFPBD is 4.4% higher for urban households than their rural counterparts. It means that living in an urban area would lead to an increase in the probability of the level of their awareness. This may be because, in the urban area, there is the predominance of NCDs and households are getting to know that a change in lifestyle will be of help. This result is consistent with the findings of **Mustapha (2014).**

Factors influencing the extent of consumption of plant-based whole food among households

Table 12 presents the result of the factors influencing the extent of consumption of plant-based whole food among household members. The result indicated that household size, household head sex, location, and awareness level of plant-based whole food, were all significant at 1%, 5% and 10% probability level with different signs. The Log-likelihood ratio = 324.27 and the corresponding Prob > chi^2 = 0.0863, indicating that the model has a good fit to the data. Also, the Pseudo-R^2 statistic (0.0507) is not notably different from what has been recorded in similar investigations. Expectedly, there is an inverse relationship between household size and the extent of consumption of plant-based whole food and statistically significant ($p \leq 0.05$). The coefficient of the marginal effect shows that an increase in the size of households by one person will reduce the likelihood of the extent of consumption of WFPBD by 0.35%. Therefore, having more household members has a strong, although diminishing effect, on the extent of consumption of plant-based whole food. This could probably mean that as household size increases, expenses increase and there is the tendency to allocate more of the family budgets to other food items that are unwholesome for better satisfaction. This result corroborates the findings of **Mfikwa and Kilima (2014)** that an increase in the number of family members would reduce their chances of consuming wholesome food. There exists a direct relationship between household head sex and the extent of consumption of plant-based whole food and statistically significant ($p \leq 0.05$). The probability of the extent of consumption of WFPBD is 5.65% higher for male-headed households than female-headed households. As expected, the influence of the household head on the extent of consumption was equally positive, suggesting that male-headed households tend to consume more of a plant-based whole food than female-headed households which could be attributed to differentials in income, status, etc. This result is following the findings of **Mfikwa and Kilima (2014)** that male-headed household is the typical situation in Africa. The coefficient of location had a negative relationship with the extent of consumption probably because people in rural areas have direct access to fresh food and other plant-based food compared to those in urban areas. So, the probability of the extent of consumption of WFPBD is 3.3% lower for urban households than their rural counterparts. Finally, the awareness level of plant-based food was positively associated with the extent of consumption. The explanation is that households that are aware of the benefit of consuming plant-based food have a higher probability (3.81%) to consume wholesome plant-based food than those who are not aware of these benefits.

Socio-economic Factors Influencing the Reported Illnesses among Households in Ogun State.

Table 13 presents the socio-economic factors influencing the reported illnesses among household members. This result indicated that spouse age, total expenditure on wholesome food, location, household head years of education, marital status, and awareness level of plant-based foods were all significant at 1%, 5%, and 10% probability level with different signs. The Adjusted R^2 indicates that 50.10% variation in reported illnesses of households was explained by the explanatory variables while the remaining 49.90% was explained by variables not included in the model. The Prob >F= 0.0005, shows that the model fits the data well.

Table 11: The result of Probit model regression analysis

Variables	Coefficient	Standard error	Z	Marginal effect
Household head years of education	0.08407***	0.00613	4.71	0.02889
Household head income	0.17457*	0.00000	1.77	0.05653
Reported Illnesses	0.03899**	0.01828	2.28	0.04177
Occupation	0.12037	0.05932	1.41	0.08343
Marital status	-0.24286	0.07594	-1.02	-0.07751
Household size	0.01675	0.01047	1.00	0.01045
Location	0.70270**	0.01862	2.34	0.04362
LR chi^2(6)				31.47
Prob > chi^2				0.0000
Pseudo R^2				0.1407
Log-likelihood				-86.77188

Note: *, ** and *** denote significant at the 10%, 5% and 1% levels respectively; Pr y=1 the base category; the figures in parentheses are robust standard errors.
Source: Analysis based on own field survey, 2019

Table 12: The result of Tobit model regression analysis

Variables	Coefficient	Standard error	Z	Marginal effect
Household head Age	0.008742	0.00064	0.53	0.00034
Household head income	-6.05e-06	0.00000	-0.92	-5.94e-08
Household size	-0.009746**	0.00210	-1.66	-0.00349
Household head sex	0.024922**	0.02011	1.99	0.05653
Location	-0.008706*	0.01712	-1.93	-0.03299
Household head education	0.006902	0.00191	0.66	0.00126
Reported illness	-0.00416	0.00292	-1.20	0.00441
Awareness level of plant-based food	0.017805*	0.02011	1.89	0.03808
Spouse education	0.00126	0.00191	0.66	0.00126
LR chi^2(9)				17.90
Prob > chi^2				0.0863
Pseudo R^2				0.0507
Log-likelihood				324.26892

Note: *, ** and *** denote significant at the 10%, 5% and 1% levels respectively; Pr y=1 the base category; the figures in parentheses are robust standard errors.
Source: Analysis Based on own field survey, 2019

Table 13: The Result of Ordinary least square regression analysis

Variables	Marginal effect	Standard error	T	P>|t|
Household head Age	0.17242	0.16752	-1.03	0.305
Household head income	0.05868	0.13444	0.44	0.663
Spouse Age	0.38197	0.11528	3.31	0.001***
Marital status	-0.61403	0.32725	-1.88	0.062*
Household Head years of education	-0.31398	0.14206	-2.21	0.028**
Household size	0.03998	0.03999	1.00	0.319
Household Head occupation	0.26523	0.22374	1.19	0.23
Expenditure on wholesome food	-1.07307	0.48556	-2.21	0.025**
Location	0.57695	0.23671	2.44	0.016**
Awareness level of plant-based food	-0.77371	0.12374	-6.30	0.000***
Constant	1.62079			
Adj R-squared	0.5010			
Prob > F	0.0005			

Note: *, ** and *** denote significant at the 10%, 5% and 1% levels respectively; Pr y=1 the base category; the figures in parentheses are robust standard errors.
Source: Analysis based on own field survey, 2019

There is a positive relationship between the age of the spouse and reported illnesses and statistically significant ($p \leq 0.01$). The sign on the coefficient follows the *a priori* expectation. The coefficient shows that a 1% increase in spouse age would lead to a 38.19% increase in their number of reported illnesses. This implies that women are prone to several diseases as they grow older, thus they get infected with illnesses. This result is in tandem with the findings of **Nagla (2007)** that age can be attributed to reported diseases in women.

There is a negative relationship between marital status and reported illnesses and statistically significant ($p \leq 0.1$). The sign on the coefficient follows the *a priori* expectation. The coefficient shows that a 1% increase in the number of married respondents would lead to 61.40% decrease in the number of reported illnesses. This implies married respondents are conscious of what they consume as per nutritional contents than single respondents, which has a significant effect on their health status. This result corroborates the study of **Adeyanju, (2014)** that married respondents are more informed of plant-based whole food consumption which improves their health.

There is a negative relationship between household head years of education and reported illnesses and statistically significant ($p \leq 0.05$). The sign on the coefficient follows the *a priori* expectation. The coefficient shows that a 1% increase in household head years of education would lead to a 31.39% decrease in several reported illnesses. This implies that the household head level of education improves the choices of food been consumed within the family, as this could tell on their health status. This result agrees with the result of **Mfikwa and Kilima (2014),** which opined that level of education significantly influence consumption pattern as this may have a similar effect on reported illness.

There is a negative relationship between expenditure on whole food and reported illnesses and statistically significant ($p \leq 0.05$). The sign on the coefficient follows the *a priori* expectation. The coefficient shows that a 1% increase in expenditure on whole food would lead to a 100.1% decrease in the number of reported illnesses. This implies that households who spend more on wholesome food will have a minimal occurrence of reported illness compared to otherwise. This result supports the postulation of **Awosan *et al.* (2013)** that households with a smaller number of reported illnesses are those that are aware and consume plant-based whole food.

CONCLUSION AND POLICY IMPLICATIONS

Rapid changes in climate and urban growth, changing demographics, coronavirus pandemic and heterogeneity of urban lifestyles are resulting in a shift in food consumption pattern, with a preference for foods with minimal processing time, quality and taste in Nigeria; but does there exist any relationship between climate change, food consumption pattern and reported illnesses among households? This study, therefore, examined the nexus between consumption patterns and the prevalence of reported illnesses among households. It demonstrated the occurrence of a high prevalence of unhealthy eating habits and lifestyle; together with a high prevalence of reported illnesses as a result of the type of consumption patterns adopted among various households in Ogun State. From the findings of this study, it is established that years of education, income, reported illnesses and location improved the level of awareness of plant-based whole food. It is further established that household size and location impede the extent of consumption of plant-based whole food while the level of awareness of plant-based whole food, household head sex, and total expenditure on food improves the extent of consumption of plant-based whole food. Similarly, we established that years of education, consumption of plant-based whole food, and level of awareness of plant-based food negatively influence reported illnesses. The educational attainment of the household head and gender is an important influence on household food consumption patterns. Education allows individuals to make more informed food choices and to recognize the importance of population control. Hence, it is necessary to ensure that all Nigerians become better educated to improve society as a whole. Similarly, the significance of household size as a determinant of food consumption also points to the fact that the government needs a more serious population control strategy. Generally, our results show that achieving a sustainable diet would entail a high reduction in the intake of meat and vegetable oils and a moderate reduction in cereals, roots, and fish products, and increased intake of legumes, nuts, seeds (whole grains), fruits and vegetables.

Policy recommendations

Based on the findings of this study, the following recommendations are given as: Due to poor knowledge and awareness of the consumption of whole plant food in the study area, the government should employ more community dietitians and health professionals to educate and promote knowledge of community dietetics and healthy living. The government needs to create an enabling environment conducive for job creation so that the vast majority of the people can be gainfully employed. Closely linked to this is the fact that employers should pay wages that are commensurate with the productivity of labour. The fact that income is a strong determinant of food consumption patterns in both the urban and rural areas means that the government should design special social interventions and empowerment programmes aimed at providing economic protection to low-income earners who spend the bulk of their income on food consumption. Establishment of programs the strengthen rural-urban food linkages will ensure wider households' access to quality whole foods needed to reduce reported illnesses. The significance of household size as a determinant of food consumption patterns also points to the fact that the government needs a more serious population control strategy. At the household level, there should be an awareness of the need to adopt birth control measures. Policymakers should develop a diet action plan to work across all sectors of the food, retail, and health services such as creating leaflets and radio programs as an information source. The government should make policies that promote and support plant-based whole food production and consumption, especially in rural areas as they seem to have a lower level of awareness. This could be in the form of education and behavioural change programs to promote plant-based whole food consumption. Such should be based on local knowledge regarding the demographic and socio-cultural factors that may affect consumer choice.

Suggestion for further research: A systematic investigation of the relationship between household food consumption differential and prevalence of diseases is worth undertaking to identify empirically the nature and magnitude of relationships.

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PROFITABILITY AND EFFICIENCY OF BAMBARA GROUNDNUT PRODUCTION IN NIGERIA: A CASE STUDY

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ABSTRACT

Research Background: Although it is a highly nutritious and climate resistant crop, bambara groundnut is described as a neglected and under-utilized crop in most countries including Nigeria where its production is in the hands of some smallholder farmers. Empirical facts on the profitability as well as the technical efficiency of bambara groundnut production in Kogi state, Nigeria, where it serves as an important source of food and income, are unknown. These facts, when known, can draw the attention of stakeholders to intervention areas.
Purpose of the article: The research was undertaken to provide factual data through empirical analyses on the cost, returns and technical efficiency of smallholder bambara groundnut farmers in the area, in to order elicit interest in the neglected crop. Such attention may aid in the expansion of the crop's production through interventions in identified areas of concern.
Methods: A five-stage sampling technique was employed in the random selection of 120 farmers for questionnaire administration in order to obtain the requisite data. Data on cost and returns were subjected to Gross Margin and Net Return on Investment analyses while the Cobb-Douglas Stochastic Frontier Production Function was employed in analysing technical efficiency.
Findings and value added: Producers of bambara groundnut in the area are small scale farmers who are old, poorly educated and have large families. Cost and returns analysis showed that labour had the highest percentage of Total Variable Cost (78.00%). The venture, with a gross margin of -11,601.87 Nigerian Naira (-60.31 USD) and Net Returns on Investment of 0.79, is unprofitable. Experience and education affect the moderately high technical efficiency level which on the average is 71.2%. Bambara groundnut production in the area can be made profitable through labour cost reduction and improvement in average efficiency level by 28.8%. The provision of machinery to help reduce labour cost, in addition to special policy attention that will enhance improvements in education and extension services will reduce inefficiency and improve profitability.

Key words: profitability; efficiency; bambara groundnut; production
JEL: Q12; C13

INTRODUCTION

Bambara groundnut (*Vigna subterranean (l) verdc*) is a seed of Africa origin used locally as a vegetable. It is a herbaceous short-leaved annual crop plant of about 15cm high with numerous nitrogen fixing nodules on the roots, thus contributing to land improvement (**Yakubu *et al.*, 2010)**. The crop is special for a number of reasons. First it is an important legume in semi-arid Africa and is resistant to high temperature and drought (**Abejide *et al.*, 2017; Mabhaudhi and Modi; 2013**). Second, it is also suitable for marginal soils where other leguminous crops cannot be grown as it makes very little demand on the soil (**Yamaguchi, 1983**). Thus, it is not prone to the risk of total harvest failure even in low and uncertain rainfall regions as it can perform reasonably in the event of drought (**Mayes *et al.*, 2019**). Furthermore, this crop's susceptibility to insect and disease infestation is low (**Tweneboah, 2000**). In addition, **Mayes *et al.* (2019)** and **Berchie *et al.* (2010)** have describe it as climate resilience crop. Again, the plant is useful in sustaining the plant habitat as it increases the fertility of soil and brings about high yields of other crops cultivated around it without the application of fertilizer. Hence it is a reliable alternative food and income source in the face of the negative consequences of climate change.

Nutritionally, the crop holds great promises. As the quest for plant with nutritional properties continues to receive attention, bambara groundnut which contains protein (15-25%), carbohydrate (49-63.5%) and lipids (4.5-7.4%) (**Murevanhema and Jideani, 2013**) and can be consumed at different stages of maturation has become handy in some areas. Its high level of lysine (**Mune *et al.*, 2011**) makes it a good complement for other food sources. Nutritionally, in comparison with other protein sources, bambara groundnut performs well. The raw crop contains 390 calories per100 grams, making it higher in energy than cowpea (343 calories), kidney (333 calories), broadbean

(341 calories) and chickpea (364 calories). It is also higher than any of the above mentioned food items in terms of carbohydrates and fats and is a rich source of protein (**Azam-Ali *et al.*, 2001; Mazahib *et al.*, 2013**). Thus, it can be utilized in the preparation of baby food (**Atiku *et al.*, 2004**). The roots, leaves and seeds contain high levels of macro nutrients which are suitable for use in the production of animal feed (**Food and Agriculture Organisation, n.d, Atiku *et al.*, 2004)**. In fact, as a "complete food" (**Murevanhema and Jideani, 2013**), which can be depended on for all the nutritional requirements for healthy livings, it is an important addition to the diet of poverty stricken folks who are unable to sustainably afford expensive animal protein sources **(Food and Agriculture Organisation, n.d)**. It has also been reported that bambara groundnut has potentials for industrial purposes (**Ibrahin and Ogunwusi, 2016, Atiku *et al.*, 2004**) and has been experimented with in feeding of livestock (**Nji *et al.*, 2003, 2004**).

Unlike cowpeas, and some other legumes, but like groundnut, damage to seeds by insects is uncommon because the pods are buried underneath the soil. This makes the production of bambara groundnut less costly in terms of the use of insecticides which is heavily dependent up on in the cultivation of other legumes. In relation to this, the rejection suffered by cowpeas in international market owing to presence of chemical residuals beyond acceptable limits is not likely to be experienced by bambara groundnut. Furthermore, the cost of these chemicals which increases production cost in cowpeas and some other legumes is also minimized in bambara groundnut production. The yield of bambara groundnut which ranges from 300kg-600kg/ha compares well with its closest rival, cowpeas, which has a yield of 400kg - 600kg/ha (**Azam-Ali *et al.*, 2001**). Hence on climatic, nutritional, health, foreign exchange earnings, input cost and production potentialities considerations, bambara groundnut is a reliable alternative source of plant protein and income.

Bambara groundnut is common in Cameroon and Central African Republic and has been introduced to several African countries. Cultivation is however not common in Nigeria where it comes behind beans, groundnut and soybeans in terms of production. In fact, it doesn't appear to be a crop that elicits national policy attention. Hence, the huge potentials of this crop continue to elude Nigeria and Nigerians. **Dansi *et al.* (2012)** observed that despite the nutritional value of bambara groundnut it is still considered, neglected and under-utilized in most countries and Nigeria where its production like most food crops, is in the hands of some smallholder framers. Generally, it is one of the Neglected and under-utilized species (NUS). Its position in Nigeria may be similar to what obtains in some African countries like in Ghana and Benin where it is considered a neglected crop (**Adzawla *et al.*, 2015, Dansi *et al.*, 2012**), in Tanzania, where it is relegated to second fiddle crop (**Mkandawire and Sibuga, 2002**) or in Kenya, where it is going into extinction (**Korir *et al.*, 2011)**.

It has however found appreciable attention in eastern Kogi state, eastern and north-eastern part of the country where it is used in the preparation of a lot of local delicacies including cake, dumpling (okpa), porridge, pan cake, snacks (boiled fresh or roasted dry), milk, baby food, among others. In Kogi east, it is of strategic economic value during yuletides as farmers rely on its sales to buy Christmas items. The crop also has medicinal value among locals (**Atiku, 2000**). The underutilization of this dependable alternative energy and protein source with the aforementioned agronomic, nutrition and derived economic advantages over its rivals needs to be overturned (**Dansi *et al*., 2012, Azam-Ali *et al*., 2001 Mkandawire and Sibuga, 2002, Adzawla *et al*., 2015, Ibrahim *et al*., 2018).**

While making a case for increased production of this crop in Nigeria is important, caution should be exercised in the ordering of priorities. It is important to know how producers of this crop have been faring in terms of profits and how efficient they have been in the production process, technically speaking. For, if the production of this crop is unprofitable, how can we convince farmers to increase their production or encourage others to engage in its production? And, if resources are wasted in the production process- as seen in below-the-frontier output scenario, how sustainable will it be to continue to produce at the same level of use of existing technique in the application of resources?

A poor profit margin can be a discouraging factor and could cause farmers to reduce their production scale and prevent others from venturing into it. Hence an understanding of the profitability of the crop is important. Aside profitability, another factor that can engender the understanding of the sustainability of a crop enterprise is the production efficiency. Low agricultural productivity has led to the poor performance of the food subsector leading to unfavourable food balance sheet (**Oyinbo *et al.*, 2015**). Technical efficiency indicates whether a farm makes the best use of available technology. It reflects the ability of a farm to obtain maximum output from a given set of inputs (**Coelli and Rao, 2005**). Studies on technical efficiency of other commodities in different location across the country and elsewhere have revealed varying levels of technical efficiency estimates (**Onuche *et al.*, 2015; Ekunwe and Emokaro, 2009; Ali and Khan 2014; Ogundari, 2008; Ogundari and Ojo, 2007**). The results of these studies cannot be extrapolated for other parts of the country and in fact other crops. Area specific and in fact crop specific studies are better positioned to provide peculiar information as regards the commodity in the area in order to furnish policy makers with the right information for a specific area **Asrat and Simane (2018)** and commodity. In Nigeria little research has been conducted on this crop. Empirical findings on profitability and technical efficiency have been reported by **Mohammed (2016)** and **Ani *et al.* (2013)** for some states in Nigeria, while technical efficiency estimates have also been reported for other African countries like Ghana (**Adzawla *et al.*, 2015**) and Kenya (**Korir *et al*., 2011)**. As at yet, we are not aware of any study on profitability and, or technical efficiency of bambara groundnut production in Kogi state, central Nigeria. It is imperative therefore to also examine how efficiently farmers in the study area are using existing bundle of farm inputs and the factors influencing their efficiency levels, in addition to the profitability of the venture. Hence, the objectives of this study were to analyse the cost, returns and the technical efficiency of small holders bambara groundnut farmers in eastern Kogi state.

A study of this nature is important for the sustainability of agricultural production. Traditionally, profit maximization and efficiency are important issues that small holder farmers do not pay serious attention to. **Schultz (1964)** hypothesized that farm households in developing countries are "poor but efficient". This gave rise to a long debate among economists and the advent of empirical works for testing it. He described the peasant production system as having a profit-maximization behaviour, where efficiency is defined in a context of perfect competition. But it must be borne in mind that, against the profit maximization theory, exists arguments on trade-offs of profits for other household goals, as well as the role of uncertainty and risk in farm household production decisions. It however largely remains that rural farm households in Nigeria are generally profit maximizers.

Maximization of returns is an important factor in the sustainability of farm ventures especially where the goal is to make money. In the absence of good profit margin, discouragement may set in, restricting production to subsistence level. This in turn constrains economic development by way of under-production and attendant unemployment. Works on arable production in Nigeria have revealed positive margins **Ohajianya and Onyenweaku (2003)**, **Ewuziem and Onyenobi (2012), Segun-Olasami and Bamire (2010)**.

Efficient allocation of resources in order to assist farmers attain their objectives has been one of the frontline issues in micro level agriculture. The level of technical efficiency of a firm is characterized by the relationship between observed output and some ideal expected output (**Onuche *et al.*, 2015)**. The measurement of firm specific technical efficiency is based on the deviation of observed output from efficient production frontier (**Battese and Coelli, 1995)**. Technical efficiency can either be output or input oriented. An output oriented technical efficiency is achieved when the maximum amount of an output is produced for a given set of input while an input –oriented technical efficiency concerns the minimum amount of input are required to produce a given output level (**Farrell, 1957)**. Therefore, technical efficiency is derived from production function or production possibility frontiers. The closer a farmer's output is to this frontier, the more technically efficient he is.

Several approaches have been developed and followed in estimating firm level technical efficiency. These include the Data Envelopment Analysis (DEA), the Malmquist productivity index and the stochastic frontiers. **Charnes *et al.* (1978)** was the first to apply the DEA in efficiency measurement technique. Characteristics of this approach to efficiency measurement have been reported by (**Onuche *et al.*, 2015**). The approach has been adopted by **Nin *et al.* (2003)** and **Coelli (1995)**. Its shortcomings are basically that recommendation of input or output levels are in fixed proportions and its inability to identify sources of inefficiency.

The Malmquist productivity index introduced by **Caves *et al.* (1982a, 1982b)**, is a binary comparison of two entities. **Farrell *et al.* (1957)** extended the index to allow for productivity into change in technical efficiency and technological change. The approach measures productivity change, by comparing observed change in output with the imputed change in output that would have been possible from the observed input changes. The imputation is based on the production possibility set for either the current or the subsequent period. During the computations, it makes use of DEA to generate the ratio of two distance functions (input and output distance functions) and their geometric means.

The stochastic frontier approach specifies the relationship between output and input levels using two error terms: normal error term and technical inefficiency. The approach estimates technical efficiency through maximum likelihood of the production function subject to these error terms **(Aigner *et al*., 1977**) and **Meeusen and Van den Broeck (1977)**. The stochastic frontier approach to technical efficiency estimation is the most preferred in agricultural economics because the basic assumption of the non –parametric approach and deterministic frontiers that all deviations from the frontier are due to farms inefficiency is highly unrealistic in the agriculture. Also, aside estimating firm level efficiencies, it is capable of identifying the factors of technical inefficiency. **Mulinga (2013) Njeru (2010) Onuche *et al.* (2015)** have estimated levels and factors of technical efficiency in agricultural production using this approach. **Korir et al. (2011)** have applied the stochastic frontier to the study of bambara groundnut in Ghana (**Adzawla *et al.* (2015)** and Kenya (**Korir *et al.*, 2011)** and in Nigeria **(Mohammed, 2016, Ani *et al.*, 2013)**

DATA AND METHODS

Sampling Procedure

A five stage purposive and random sampling procedure was used for this study. First, Kogi state was purposively selected due to the presence of sizeable bambara groundnut production and trade. Then Kogi east senatorial district was also purposively selected out of the three senatorial districts of the state. It was selected because the district is known for more cultivation of bambara groundnut than the other two districts. Two local governments- Ankpa and Olamaboro- where the production of bambara groundnut is pronounced were then selected. Two wards were then selected from each of these local governments. Thereafter, 2 farming communities were selected from each of the 2 wards making 8 farming communities in all for the study. Sampling frame was obtained from the Agricultural Development Programme (ADP) office covering the area. An average of 15 farmers from each of the selected community were randomly selected for questionnaire administration. Thus the total number of farmers selected was 120. To make room for loss or poor completion 5% additional questionnaire were added. In all, a total of 126 bambara groundnut farmers were interviewed using a structured questionnaire. Only 122 were however duly filled and returned. Analysis was however based on 120 completed questionnaires.

Method of Data Analysis

The cost and returns of the smallholder bambara nut farmers was analysed using Gross Margin (GM) and Net Return on Investment (NRI) (**Nkamigbo *et al.*, 2014),** while the Cobb-Douglas Stochastic Frontier Production Function was employed in the analysis of the technical efficiency. Estimated farm level technical efficiencies were presented using frequency table and bar chart.

Gross Margin (GM) analysis is used to estimate the cost and returns or profitability enterprises under the assumption that fixed cost constitute a negligible components of the Total Cost-TC in small scale production (**Abubakar and Olukosi, 2008)**. In crop enterprises, analysis is conducted on per hectare basis. The Total Revenue (TR) is the farm gate value of the output from the farm. It is given by physical quantity of output multiplied by the unit price. Total Variable Cost (TVC) on the other hand includes total expenditure on variable inputs like seeds, agrochemicals, labour etc. The Gross Margin (GM) of bambara groundnut production enterprises in the area was expressed as: GM=TR–TVC; A positive GM is indicative the profit while a negative one indicates loss. Gross Margin analysis is plausible in the understanding of farm firm profitability in situations where fixed costs are minimal as is the case with small holder bambara groundnut production in the area. Net Return on Investment (NRI), is the ratio of the TR to Total Cost (TC) and is an indicator of returns to investment. An estimated NRI greater than unity is indicative of positive profit while a lower-than unity NRI points to negative profit or loss. An NRI of unity indicates that TC=TR. Note, that at the time of this study in 2015, 1 US dollar (USD) =192.4 Nigerian Naira (NGN) on the average.

A stochastic frontier production function (SFPF) can be specified for cross-sectional data with an error term consisting 2 components: one that accounts for technical inefficiency (V_i) and the other which accounts for random effects (U_i).

Following **Korir *et al.* (2011),** the SFPS used for the analysis of the technical efficiency of bambara groundnut farmers was presented in term of Cobb- Douglas production functional form as in Eq. 1.

$$Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_4 \ln X_4 + \beta_5 \ln X_4 + V_i - U_i \quad (1)$$

Where:

Y Bambara groundnut output (kg);

X_1 Farm size (ha);

X_2 Labour input (man-days);

X_3 Quantity of seed planted (kg);

X_4 Quantity of pesticides (litres);

X_5 Quantity of fertilizer used (kg);

$V_i - U_i$ error term;

β_i are the coefficients.

Error term; (i.e. the unknown scalar parameter to be estimated. This error term accounts for random variation in output due to factors outside the farmer's control such as weather, diseases. It is assumed to be independently and identically distributed $(U, \delta^2 U)$, a one sided component and independent of U. $U = 0$ reflects non-negative random variable associated with technical inefficiency in production and is assumed to be half normal (independently and identically distributed (iid)) $\mathrm{N}(U, \delta^2 U)$ where the conditional mean is assumed to be related to term and farmers-related socio-economic characteristics.

The inefficiency model is specified as Eq. 2.

$$U_i = \delta_0 + \delta_1 \ln Z_1 + \delta_2 \ln Z_2 + \delta_3 \ln Z_3 + \delta_4 \ln Z_4 \quad (2)$$

Where:

U_i inefficiency effect;

Z_1 Family size (number of persons in a household);

Z_2 Farming experience (years of bambara groundnut production);

Z_3 Level of education (years of formal schooling);

Z_4 Age (in years);

δ_i parameters to be obtained through maximum likelihood estimation.

All variables were analysed in their natural logs (ln).

RESULTS AND DISCUSSION

Key demographic characteristics of bambara groundnut farmers in Kogi state

The key demographic variables used in this study are summarized in Table 1. The average land used for bambara groundnut cultivation in the area is half a hectare and reflects the small holder nature of the enterprise in the area. Average age of 43 years suggests an aging population. This is close, to 39 years found by (**Mohammed, 2016**) in Kaduna state.

This is a common observation in Nigerian agriculture where production is in the hands of the aging segment of the population. Furthermore, formal education level is about 5 years of formal schooling and indicates a poor level of education among the farmers in the area. Formal education has serious implication for efficiency because of the ability and exposure it confers on the farmer in the understanding of improved techniques. The household size which ranges from 3 to 15 (the average number of usual residents - household members per household) and has a mean of 8, is generally higher than the nation average which is about seven. On the average, experience in bambara nut production (14.6 years) is high. In sum, bambara groundnut production is undertaken on small scale basis by an experienced aging population who are poorly educated and have large family sizes.

Cost and return of small holder bambara groundnut production Kogi state

Profitability analysis of bambara groundnut production in the study area indicate a farmer on the average incurred variable costs of 89,600.77 NGN (Nigerian Naira) (465.71 USD), with labour accounting for as high as 78% of TVC (Table 2). This is contrary to the 26% found in Kaduna state by Mohammed (2016). Explanation for this may be found in the fact that the two states are dissimilar demographically and agro-climatologically.

Table 1: Descriptive statistics of key demographic characteristics of bambara groundnut farmers in Kogi state.

Variable	Sample Mean	Std.Dev.	Minimum	Maximum
Cultivated land size (ha)	0.49	0.42	0.30	1.25
Age (years)	42.73	17.4	18	67
Years of formal education	4.66	6.63	0	15
Household size	7.67	6.94	3	15
Experience (years)	14.6	7.91	3	23

Source: Authors' computation from field survey, 2015

Table 2: Average per ha cost and return of small holder bambara groundnut production Kogi state.

Variable Inputs	Cost, revenue (NGN/ha) and ratio	Cost, revenue, (USD/ha) and ratio
Variable costs		
(a). Labour	69,890.71 (78.00% of TVC)	363.23
(b). Seed	15,929.55	82.79
(c). Agrochemicals	3,049.59	15.85
(d). Others	730.92	3.80
TVC	89,600.77	465.71
Fixed Cost		
Depreciation	8,938.18	46.46
TFC	8,938.18	46.46
REVENUE	77,998.90	405.40
TC=TVC+TFC	98,538.90	512.16
GM =TR-TVC	-11,601.87	-60.31
Net Returns on Investment (TR/TC)	0.79	0.79

Source: Authors' computation from field survey, 2015.

According to the 2006 census, Kaduna state's population is 6,133,503 persons, while that of Kogi is 3,314043 persons. Furthermore, discrepancies in poverty and unemployment rates between the two states have been documented. While the poverty rate based on Purchasing Power Parity as at 2010 was 74.2% for Kaduna state **(Nigeria-Kaduna, n.d),** that of Kogi state was 72.5% **(Nigeria-Kogi, n.d)**. In addition, estimate for unemployment rate in Kaduna state as at 2018 was 26.8% **(Nigeria-Kaduna, n.d)** while that of Kogi state was 19.7% **(Nigeria-Kogi, n.d)**. The difference in labour cost components in bambara groundnut production in these states may not be unrelated to the dissimilarities in the key indices mentioned above. For instance, compared to Kaduna state, lower population, poverty and unemployment rates in Kogi state may put some pressure on her available supply of labour, pushing up labour costs. In addition, the agro-climatic conditions of the two areas may play a role in total costs of labour. Kogi is in the guinea savannah which is characterized by wooded land, thicker bushes and higher rainfall and may require more labour for land clearing and weeding than Kaduna state in the Sudan savannah which characterized by shorter trees and less dense vegetation and lower rainfall.

The average per hectare revenue of bambara groundnut revenue is 77,998.9 NGN (405.40 USD). Thus, bambara groundnut production in the area returns a margin of -11,601.87 NGN (-60.31 USD) and an NRI of 0.79, implying non-profitability. While the GM indicates per ha loss of 1,601.87 NGN (60.31 USD), the NRI indicates a loss of 21k for every naira invested. **Ani *et al.* (2013)** found a GM of 18,958.83 NGN (98.54 USD) /ha in Benue state while a margin of 113,155 NGN (588.12 USD) was found in Kaduna state **(Mohammed, 2016**) who also reported a Return on Naira Invested of 2.27.

Considering the proportion of labour cost in the total variable cost, in comparison with that of the Kaduna state survey, a reduction in labour cost will definitely increase the profitability level of the crop. It is to be noted that the approach to measuring cost of labour was the opportunity cost approach as the labour was basically provided by family members.

Maximum likelihood estimator (MLE) estimates of technical efficiency of bambara groundnut production in Kogi state.

The result of the Cobb–Douglas stochastic frontier estimation using maximum likelihood estimation is presented in Table 3. The statistical significance of sigma squared indicates the appropriateness of the model. The result of the MLE estimates on bambara groundnut production shows that the performance of the model in terms of sigma squared and gamma are significantly different from zero at 10 % and 1% level of significance. The variance parameter for sigma squared and gamma are 0.441 and 0.848 respectively. The sigma squared indicates the goodness of fit and correctness of the distributional form assumed for the composite error term. The gamma estimates indicate the systematic variance that is unexplained by the production function and is the dominant source of random errors the value of gamma 0.848 means that about 84.8% of the variation in bambara groundnut output is attributed to variation in technical efficiency of farmers. The maximum likelihood estimates of the stochastic production indicate that the elasticity of production with respect to farm size, labour, quantity of seeds and quantity of fertilizer (0.777, 0.271, 0.366, and 0.027) respectively were positive and significant at 1% level of significance and are therefore the major determinants in bambara groundnut production. This is consistent with the findings of **Nwaru and Ndukwu (2011)** that fertilizer, capital and farm size positively affects output. The sum of the coefficients (output elasticity) of the variables is 1.381, indicating an increasing return to scale.

Contrary to a priori expectation, farming experience has positive relationship with technical inefficiency. This relationship means that farmers' experience increases inefficiency in bambara groundnut production. It might also be related to the profitability level of the crop. This could be attributed to the reluctance of farmers to adopt innovation or knowledge required to increase the efficiency of agricultural production. This contrast the finding of **Amodu *et al.* (2011), Simonyan *et al.* (2012), and Nurudeen and Rasaki (2011)**. Education on the other hand has a negative relationship with technical inefficiency, implying that inefficiency of bambara groundnut production reduces with increase in farmers' educational attainment. Among other things, education enhances the capacity of farmers to comprehend literature on agronomic practices and better organise their enterprises. This finding agrees with **Ali and Khan (2014), Adzawla et al. (2015), Mulinga (2013), Musaba and Bwacha (2014), Amodu *et al.* (2011)** and **Simonyan *et al.* (2012)**, but contrasts **Onuche *et al.* (2015)**.

Levels of technical efficiency of bambara groundnut farmers in Kogi state

The levels of technical efficiency of bambara groundnut farmers presented in Table 4 show that the farmers differ substantially in their level of technical efficiency which range from less than 0.31 to 0.91 and above. Ungrouped figures reveal a minimum efficiency of 0.21 (21%) and a maximum efficiency level of 0.95 (95%) while mean efficiency was 71.2%. The result shows that 3.3% of bambara groundnut farmers in the area have technical efficiency level of less than 0.31, while 61.7% have estimates ranging from 0.71 to 0.9. Only 3.3% have technical efficiency level of 0.91 and above.

Table 3: Maximum likelihood estimator (MLE) estimates of technical efficiency of bambara groundnut production in Kogi state.

Variable	Parameter	Coefficient	t-ratio
Production function			
Constant	β_0	4.96	13.7
Farm size	β_1	0.777***	7.48
Labour	β_2	0.271***	3.68
Quantity of seed planted	β_3	0.306***	3.21
Quantity of pesticides	β_4	0.0004	0.018
Quantity of fertilizer	β_5	0.027***	2.81
Inefficiency model			
Constant	δ_0	7.44	1.99
Family size	δ_1	0.14	0.46
Farming experience	δ_2	0.92*	1.65
Age	δ_3	-0.01	-0.19
Education	δ_4	-2.75*	-1.86
Diagnostic statistics			
Sigma square	S^2	0.441*	1.85
Gamma	Γ	0.848***	7.36
Log likelihood function = -58.02; LR test= -25			

Note: ***significant at 1% level, *significant at 10% level.
Source: Authors' computation from field Survey, 2015

Table 4: Levels of technical efficiency (TE) of bambara groundnut farmers in Kogi state.

TE estimate	Frequency	%	Cum. %
Up to 0.30	4	3.3	3.3
0.31-0.50	16	13.3	16.7
0.51-0.70	22	18.3	35.0
0.71-0.90	74	61.7	96.7
Above 0.90	4	3.3	100.0
Total	120	100.0	
Minimum	0.21		
Maximum	0.95		
Mean	0.712		

Source: Authors' computation from field survey, 2015

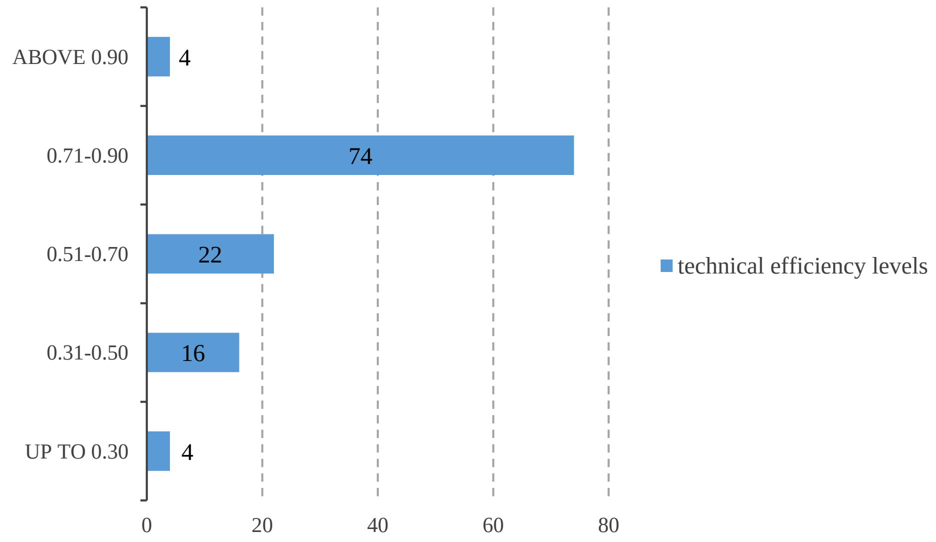

Figure 1: Levels of Technical Efficiency of the Respondents
Source: Analysis of Field data, 2015

The mean efficiency of 71.2% above implies that the average small holder farmers in the study area will have to reduce inefficiency by 28.8% in other to operate on the frontier. In another way, the average technical efficiency of 71.2% indicate that the average farmer will have to increase output by 28.8 % with the present level of inputs bundle in order to reach the production frontier. For the most inefficient small holder farmers with minimum technical efficiency of 21% to be on the frontier, they will need to achieve 79% more productivity or efficiency. In the case of the most technically efficient smallholder farmer with a maximum technical efficiency of 95%, he needs to reduce inefficiency by 5% to be on the frontier. Technical estimates of 80% of the farmers range from 51 to 95%, implying a good level of utilization of prevailing bambara groundnut production technology in the area. **Ani *et al.* (2013)** found a mean technical efficiency of 70% for the same crop in Benue state. **Mohammed (2016)** found a mean technical efficiency 70% for the crop in Kaduna state, Nigeria. **Korir *et al.* (2011)** found a poorer Technical efficiency of 38.4% indicating that bambara groundnut production was more in inefficient in Kenya where the crop is going into extinction. **Adzawla *et al.* (2015)** in Ghana, found a much higher average Technical efficiency of 83%.

In this study, the average farmer needs about 25.1% i.e. $[1 - \frac{0.712}{0.95} * 100]$ increase in his total production to be at par with the most technically efficient farmer. The least efficient farmer needs 77.9% i.e. $[1 - \frac{0.21}{0.95} * 100$ to attain the efficiency level of the most technically efficient farmer. In all, for the average farmer to attain the frontier, an average of 28.8% increase in output is required. The high level of inefficiency of about 30 % may not be unconnected to the poor attention given to bambara groundnut production by government, researchers, breeders and extension agents. While researchers are deeply involved in the development of higher yielding strand of legumes as in cowpeas and soybeans, it is not on records that serious attention is being given to bambara groundnut. Obviously the importance of this crop has not been appreciated by Nigerian policy makers.

CONCLUSION

The study found negative profitability estimates for bambara groundnut production in Kogi state. Technical efficiency estimate however compares well with those found elsewhere in the country and on the continent. While profitability was poor, efficiency was moderately high and encouraging. The negative profitability could be a discouraging factor for primary producers although it may favour other segments of the production-marketing chain. Technical inefficiency on the other hand connotes poor productivity which translates to resource wastage and attendant poverty. There is therefore the need to improve on the profitability of the venture and its technical efficiency in order to ensure sustainable production so that the nation can benefit from the nutritional and economic advantages the crop confers-especially as a climate change resilient, and dependable malnutrition mitigating crop. Intervention by government in making the production of the crop less labour intensive through the provision of farm machines will help reduce labour cost and improve its profitability. Improving opportunities for formal education will positively impact technical efficiency. Availability of improved extension services and technology will also elicit reduction in technical inefficiency. Government and researchers will also need to improve the prospects of the crop through serious commitment to research and production technology. As it stands now, the crop suffers neglect from government in that while many tropical crops like cassava, yam, and cowpea, among others are mandate crops for research institutes across the country, bambara groundnut has not enjoyed such attention. The crop will benefit from its inclusion as a mandate crop in related research institutes. Aside research activities in these institutes for yield improvements, due publicity should be given to this crop given its importance as a highly nutritious food crop that does not make much demand on soil and water but helps in soil improvement.

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AGRICULTURAL CREDIT GUARANTEE SCHEME FUND AND ITS EFFECT ON AGRICULTURAL OUTPUT IN NIGERIA

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ABSTRACT

Research Background: Agricultural production in Nigeria experiences the challenge of inadequate funding particularly by farmers in rural areas. In an attempt to enhance farmers' access to credit, the federal Government of Nigeria set up Agricultural Credit Guarantee Scheme Fund (ACGSF) to boost funding in the sector. But to what extent the Scheme has affected the output of agricultural sectors in the Country for the period under review is of great concern especially to policy makers in the Country.
Purpose of the article: The study analysed trends and effect of Agricultural Credit Guarantee Scheme Fund (ACGSF) on farmers' agricultural output (GDP) in Nigeria. The specific objectives of the study were to examine the trend in volume of loans guaranteed by ACGSF to farmers and determine the effect of ACGSF on agricultural output for the period under review.
Methods: Secondary data were sourced from Central Bank of Nigeria bulletins, National Bureau for Statistics data base and other financial bulletins. The data were analysed using descriptive and inferential statistics.
Findings and value added: The trend revealed that the supply of funds to agricultural sector from the scheme has always increased in a wobbly pattern. It was found that funds guarantee to crop-sub sector increased steadily from 1998 to 2009. The result shows that credit supplied to livestock sub-sector by ACGSF rose consistently in the period under review but initially declined from 1998-2007. The multiple determination coefficients (R^2) of 0.8523was obtained and the coefficients of ACGSF on crop sector, livestock sector and fishery sector were 0.1607, 0.2320 and 0.2110 respectively. The signs were all positive and significant at 1% and 5% levels. The study concludes that ACGSF has a positive effect on agricultural output in Nigeria. Hence, it is recommended that government, agricultural agencies and allied bodies should give more preference to the scheme to boost agricultural production. Government should increase funding to the scheme in order to diversify the earnings to eliminate her dependency on oil export.

Key words: credit; agricultural credit guarantee scheme fund; farmers; output; Nigeria.
JEL: R52; R58; H41

INTRODUCTION

Agricultural Credit Guarantee Scheme Fund (ACGSF) came into existence in 1977 to motivate financial institutions to increase lending to the agricultural sector in the country. The essence was to ameliorate the challenges encountered by farmers in their attempts to access credit which would eventually translate to increased agricultural productivity in the country. Financial institutions view agricultural sector as a high risk sector, also most of the farmers particularly the poor farmers do not have the collateral required to obtain credit from financial institutions. As a result of these, financial institutions are usually not interested in lending to agribusinesses. AGCSF in an endeavour to enhance farmers' access to credit has put in place a strategy that assures financial institutions the recovery of 75% of the defaulted amount (in case borrowers default). From the beginning of the scheme, loans were issued at reduced interest rates but eventually market-determined rates are applied under the now operational Interest Drawback Programme (IDP). In the 34/35 years of operation, precisely in June 2012, the scheme had guaranteed about 55 billion NGN (347,452,541USD) of agricultural loans to 770,438 projects (farmers) (**CBN, 2013**).

There is thus a need to evaluate the activities and the performance of the scheme in relation to domestic food supply. Various studies have shown that Credit plays an important role in enhancing agricultural productivity of the farmer (**Nwosu *et al.*, 2010**). The general purpose of the Nigerian Agricultural Credit Guarantee Scheme Fund is to encourage banks to lend to those engaged in agricultural production and agro-processing activities. Thus, the specific objective of the scheme is the stimulation of total agricultural production for both domestic consumption and export; by encouraging financial institutions to participate in increasing the productive capacity of agriculture through a capital lending programme. The scheme provides guarantee on loans granted by financial institutions to farmers for agricultural production and agro-allied processing. The fund's liability is limited to 75% of the amount in default net of any amount realized by the lending bank from the sale of the security pledged by the borrower. Since the inception of the scheme in 1978, the aggregate number of loans to agriculture hasalways been on the rise from a negligible number of 341 loans amounting to 11.28 million NGN (18,613,861 USD) in 1978 to 3,571 loans valued at 218.60million NGN (1,679,600.46 USD) as at May, 2006 (**Yusuf *et al.*, 2015**).

Accessing agricultural credit in Nigerian has been a challenge to most farmers because they do not have the collateral required to obtain credit from financial institutions. Another challenge is that financial institutions shy away from lending to agricultural sector because they perceive it to be a high risk sector. Socio-economic characteristics of Nigerian farmers also contribute to inaccessibility to credit. Furthermore, considering the nature of farming in a subsistence economy like Nigeria, where agriculture is still characterized by low mechanization, high labour input, low productivity, poor skills and production inefficiency, it has not been easy to maintain serious private sector participation in the sector without some form of incentives. Thus, in order to set in motion, the needed desire towards the agricultural sector, the government initiates and implements policies that encourage the elevation of agriculture from subsistence to commercial level. It was in acknowledgment of these realities that the Federal Government at various periods put in place credit policies and established credit institutions and schemes that could enhance the flow of agricultural credit to farmers (**Udoka, 2015**). One of such laudable Schemes has been the Agricultural Credit Guarantee Scheme Fund (ACGSF).

Agricultural production in Nigeria experiences the challenge of inadequate funding particularly by farmers in rural areas. In an attempt to enhance farmers' access to credit, the federal Government of Nigeria has put in place several schemes. Despite the huge efforts to ease farmers' access to agricultural credit, the average farmer still experiences the challenge of inaccessibility to agricultural credit. This has been compounded the unwillingness of commercial banks to lend to the sector based on the perceived risk and low returns related to the sector. Agricultural Credit Guarantee Scheme Funds (ACGSF) is particularly a safe saver for the small scale farmers as it encourages financial institutions to partake in financing agricultural production. More so, the scheme is aimed at moving farmers from subsistence level of farming to commercial agriculture in the country. In spite of all these efforts, the average Nigerian farmer still experiences the challenge of inadequate funds for agribusiness. Accordingly, this study was carried out to examine effect of the scheme on agricultural output in Nigeria from 1998 - 2017.

The research questions to answer in this work are: What are trends in the annual volumes of credits guaranteed by ACGSF from the year 1998 - 2017? What is the effect of ACGSF on the agricultural output in Nigeria?

The broad objective of the study was to analyse trend in the flow of ACGSF credit to farmers and its effect on agricultural output in Nigeria. The specific objectives were to examine the trend in the annual volume of credits guaranteed by ACGSF from the year 1998 - 2017 and to analyse the effects of credit volumes guaranteed by ACGSF on agricultural output in Nigeria.

LITERATURE REVIEW

Concept of agricultural credit

Sodeeq*et al.* (2019) defined credit as means of providing fund by an organisation or individual to another organisation or group of persons in an understanding that the collected sum will be paid back as contained in the agreement signed by both parties. It is the exchanging of legal tender with an agreement to pay back at a later date. If the borrower lacks the desire and capacity to payback, the agreement to payback at later date may not be kept. Credits could be cash or materials in form of inputs or services rendered to the lender. Credit could lead to increase in productivity and profitability in agribusiness **(Ashaolu *et al.*, 2011). Anthony (2010)** stated that credit is a good means of acquiring facilities for improving agricultural production to increase participants' income and better standard of living in Nigeria. Furthermore, it will generate confidence in farmers the optimism and determination to venture into new fields of agricultural production.

Accessed funds have to be properly managed in order to yield the desired results. Proper management ensures that funds are used appropriately otherwise they will be misappropriated or diverted. Previous studies have shown that when agricultural funds are used appropriately, adoption mechanization which will eventually result to expansion of the agricultural business and income is achievable **(Olagunju and Ajiboye, 2010). Yunus (2011)** observed that unavailability of credit to peasants and privileged farmers hinder diversification of agricultural production as such retarded economy growth of the country. The rules of engagements set by the borrowers in terms of character, capability, collateral, and confidence constraints so many beneficiaries from accessing it. Furthermore, the costs involved in obtaining loans from the lenders couple with the rate of decay in our infrastructures reduce the level of agricultural production in the country. The consequence effect of high cost of obtaining loan made farmers not to achieve their target production level and hence government policy and effort in improving farmers' standard of living frustrated.

Accessing agricultural loans in Nigeria remains one of the farmer's greatest nightmares in the development of agricultural production in Nigeria. The reasons for the limited access to agricultural loans by farmers are often linked to the high cost of administering such loans and the perceived high default rates among farmers **(Nwankwo, 2017)**. Commercial banks in Nigeria, as major players in the country's credit intermediation sector are expected to be very visible in the provision of agricultural loans, hence the decision of the government to channel their agricultural schemes through them. But the expected change for increased accessibility to agricultural loans and consequently increase in agricultural production remains a mirage as small holder farmers still do not have access to adequate finance **(Badiru, 2010).**

Theoretical review

The structural change theory designed by Nobel laureate W. Arthur Lewis in the mid-1950s was subsequently changed and redesigned and used by economist in developing agriculture activities. This actually reduce the over reliance on small peasant means of agricultural production in most of the developing countries **(Orok and Ayim, 2017).** Another aspect of this theory mentioned that has continuous improvement in agricultural productivity could be achieved when there is a good supporting structure to develop and gives the required motivations and opportunities to the agricultural sector.

Chamber and Conway (1991) further developed the reliable livestock theory for capabilities, which encompasses capital and other social inputs as well as other farming activities needed for a means of living. It further stated that the theory forecasted that increased output can only be obtained by ensuring secured ownership of, or access to capital inputs and income earning activities such as; reserves and assets to offset risk ease stocks and meet contingencies as well as improvement and maintenance of productive resources on a long term basis. Therefore, raising agricultural productivity (good output) is not just food affordability but the effort to produce food and obtain more income on a long term basis by farmers. In order have a successful attainment in agricultural productivity, the economic development theory emphasised that a technical, institutional and financial supports in terms of incentives needed to boost productivity level of peasant small holder farmers (**Orok and Ayim (2017).** They further added that an effort to raise the economic development of agricultural activities, financial scheme act dual function of increasing the purchasing power and making inputs available for industrial development in any given country.

Role and problems of ACGSF in economic development

Agricultural funds are regarded as essential tool for agricultural expansion and rural development, this is because they increase productivity and improve standard of living thereby, breaking the vicious cycle of poverty of small scale farmers. Agricultural credits are issued based on the confidence in the users promise and ability to pay back at a specified future date. It is the monetization of exchanging of cash in the present for a promise to repay in future with or without interest. Without the willingness and ability to repay, the promise to repay at a future date would be futile. For any aspect of agricultural production needs funds, since it enhances acquisition of all other resources required for reasonable and effective operation **(Olagunju and Ajiboye, 2010).** On the role, duties and functions of ACGSF and its impacts enhancing economic development in Nigeria, **Ojo and Oluwaseun (2015)** found that ACGSF scheme has the tendency of improving macro-economic development when efficiently managed and harnessed**.**

Accessibility to credit has to be backed up with good management in order to achieve the desired expansion in agricultural production, increased income and eventually prompt repayment of loans. **Udoka *et al.* (2016)** posited that inadequate funds constitute a hindrance to investment activities and income growth of poor households in developing countries of the world. Access to credit is a very useful tool in ameliorating poverty among rural poor as it aids the adoption of new and improved technologies required to enhance farmers' levels of income thereby, alleviating poverty. **Makarfi and Olukosi (2011)** reported that there is a link between growth in livestock rearing, farming and equipment financing for the acquisition of capital assets and Micro Finance Institutions in Kano.

In management of the fund made for agricultural activities known as fund's operations, several challenges bound to occur which were identified as confronting smooth performance. **Nwosu *et al.* (2010)** enumerated some of the challenges of the agricultural loan scheme as lack of good administration of credits, loan repayment defaults by beneficiaries, high transactions cost, inappropriate legal securities, and lack of commitment on the part of formal lending institutions to lend to farmers for better productivity

Empirical review

In Nigeria studies were undertaken by some scholars on the Impact of Agricultural Credit Guarantee Scheme Fund on agricultural sector development. **Orok and Ayim (2017)** in their study found that the scheme had impact in improving the productivity level of crop farmers. It was further revealed that more funds were granted to crop sector than that of other sectors. **Oparinde *et al.* (2017)** in their research on influence of ACGSF on fishery development in Nigeria affirmed that less fund was allocated to fishery sub-sector than crop sub sector of agricultural production. The Gross Domestic Product (GDP) and agricultural output in the crop sector was said to have been increased tremendously with the ACGSF in Nigeria (**Olajide *et al.*, 2012). Zakaree (2014)** in a study on the impact of Agricultural Credit Guarantee Scheme Fund (ACGSF) in domestic food Supply in Nigeria revealed that the ACGSF scheme has negative and statistically significant impact on the domestic food production. He further expressed that the negative impact can be attributed to a long delay in disbursement of loan to the farmers in the rural areas. Since most of the banks are located in the cities, in some cases where loans are approved, it arrives too late for it to fulfil the purpose for which it was intended. In a study on Economic revitalization through agriculture: role of Agricultural Credit Guarantee Scheme Fund in Nigeria, **Tiamiyu *et al.* (2017)** reported that a significant proportion of change in agricultural GDP was due to increase in Credit Funds supplied to farmers.

On the site of the government efforts in boosting the agricultural scheme, **Olajide *et al.*, (2012**) however focused on government spending as the only explanatory variable for agricultural output. In another work**, Udoh (2011)** investigated the relationship between public expenditure, private investment and agricultural output growth in Nigeria over the period 1970-2008, using the error correction model and revealed that increased in public expenditure has a positive influence on the growth of the agricultural output. **Isiorhovoja (2017)** in his studies on the effects of Niger Delta Development Commission (NNDC) on ACGSF in the oil producing states for the period 1991-2011, found that there were no much changes in the number and value of loans guaranteed among the nine states for the period under review. **Igwe and Esonwume (2011)** examined the role of Abia State government as it affects agricultural output in Nigeria using Ordinary Least Squares (OLS) regression analysis and found that total land area cropped, total annual rainfall and total population were strong factors that majorly influenced total crop output in the states. However, since the study only focused on one out of thirty-six (36) states in Nigeria, it may not accurately represent the true situation of the country. Hence, this study addressed these gaps. Using aggregated approach, considered Agricultural Credit Guarantee Scheme Funds as an important variable that affects food supply in Nigeria.

DATA AND METHODS

Study area

The study area is Nigeria, which is one of the West African countries. It shares land border with Cameroon and Chad in the east, republic of Benin in the west and Niger republic in the north. The boundary at the southern part is the coast Gulf of Guinea and with Lake Chad at the north-east. The country is located in the tropics and approximately at latitude$10^0$00'N and longitude 8^0 00'E with annual rainfall ranges from 2000-4000mm in the south and less than 2000mm in the north. Nigeria has a mean minimum temperature of 30-32ºC in the Southern and 30-35ºC in northern parts and three prominent vegetation belt found in different part. The vegetation distribution is dense forest in the south, savannah in the middle region and Sahel savannah in the northern region. (**Oruonye, 2014**). The country has an estimated population of over 182 million people in 2015 **(NBS, 2017**) and is an agrarian nation with variety of crops grown across the country.

Method of data collection

Secondary data were collected from published materials by Central Bank of Nigeria (CBN) and National Bureau for Statistics (NBS) on ACGSF annual reports for the period under consideration. The data collected include annual report on the number and volume of loan guaranteed and the output of various agricultural sectors.

Analytical techniques

Descriptive statistics and multiple regressions were used to analyse the data collected. Graphs and percentages were used to address objective (i) while multiple regression analysis was used to address objective (ii) using Statistical Package for Social Sciences (SPSS).

In this study, the four functional forms, linear, semi-log, double-log and exponential equations were used and the equation with best fit or lead equation was picked for interpretation.

The general functional form adopted for this analysis is given as in Eq. (1):

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + U \quad (1)$$

Where:

Y Total Gross Domestic Product (GDP) of crop sector, livestock sector and fishery sectors in NGN;

β_0 Constant;

$\beta_1 - \beta_3$ Coefficient of volumes of credits guaranteed by ACGSF to various agricultural sectors;

x_1 Volume of credits guaranteed by ACGSF to (CS)crop sector (NGN);

x_2 Volume of credits guaranteed by ACGSF to (LS) livestock sector (NGN);

x_3 Volume of credits guaranteed by ACGSF to (FS) fishery sector (NGN);

U Error term.

The explicit forms of the equations tried are presented in Eq. (2) to (5).

Linear function as in Eq. (2)

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + U \quad (2)$$

Semi- log function as in Eq. (3)

$$Y = \beta_0 + \beta_1 \log x_1 + \beta_2 \log x_2 + \beta_3 \log x_3 + U \quad (3)$$

Double log function as in Eq. (4)

$$\text{Log}Y = \beta_0 + \beta_1 \log x_1 + \beta_2 \log x_2 + \beta_3 \log x_3 + U \quad (4)$$

Exponential function as in Eq. (5)

$$\text{Log}Y = \beta_0 + \beta_1 x_1 + \beta_2 \log x_2 + \beta_3 \log x_3 + U \quad (5)$$

The dependent variable is the aggregate GDP of crop sub-sector, livestock sub-sector and fishery sub-sector in Nigeria from 1998 to 2017 measured in naira (NGN). The independent variable is the volume of credits guaranteed by ACGSF to various sub-sectors from 1998-2017 measured in naira (NGN).

RESULTS AND DISCUSSION

Trend in annual volume of credits guaranteed by ACGSF (1998 -2017)

Figure 1shows the trend in total credit supply by ACGSF to agricultural sector. It revealed that there was a steady and consistent rise in Agricultural credit supply by the scheme. However, in 2010, there was a decrease in the credit supply from 8,349,509.28 NGN (52,844 USD) of 2009 to 7,740,507.63 NGN (48,990.55 USD) and a further drop from 9,706,761.23 NGN (61,320.70 USD) to 9,424,449.95 NGN (29,813.83 USD) in 2012 and 2013 respectively. This is in line with the findings of **Orok and Ayim** (2017) who reported that credit supply to agriculture by ACGSF has been rising in an inconsistent trend. The highest volume of credit guarantee was in 2014 with a value of 12,997,004.15 NGN (70,444.47 USD). This increase was caused by the incentive put in place by the scheme to achieve development in agricultural sector and thus improve domestic food supply. This incentive involves the increase in the limit of the credit guarantee to individuals and corporate bodies. For example, the limit granted to individuals was increased from 5,000 NGN (27.10 USD) to 20,000 NGN (108.40 USD), without collateral while the limit guarantee for those with collateral was increased from 100,000 NGN (542.00 USD) to 500,000 NGN (2,710.02 USD). On the other hand, for corporate bodies and cooperative societies, the guarantee limit was increased from 1million NGN (920.42 USD) to 5 million NGN (34602.07 USD) (**Zakaree, 2014**). Nevertheless, in 2015, the newly elected government, in its first tenure focused its attention on fighting corruption thereby neglecting the agricultural sector, which might have resulted in the sharp drop in the credit guarantee to 3,880,672.60 NGN (15,553.79 USD) in 2017.

Trend in ACGSF volume of credits guaranteed to crop sub-sector (1998-2017)

Table 1 indicated the changes in volume of agricultural credit guaranteed to crop sub-sector. It shows that there had been a consistent increase in the volume of funds guaranteed to crop sub-sector from 79,114.66 NGN (3,614.19 USD) in 1998 to 5,816,197.46 NGN (36,811.37 USD) in 2009. Though the period between 2002 and 2005 witnessed substantial increase in the volume of credit guaranteed to crop subsector from 939,556.60 NGN (8,464.47 USD) to 2,665,725.70 NGN (19,893.47 USD), the increases were not proportionate to that in volume of credit guarantee to agricultural sector. This is explained by the decline in the percentage change in volume of credit guaranteed to crop subsector (from 89.3% to 87.5%). In the year 2006 there was a percentage increase to 88.5%, in the period from 2010 to 2017, there was a sporadic rise and fall in the volume of credit guaranteed and percentage changes in the volumes as well.

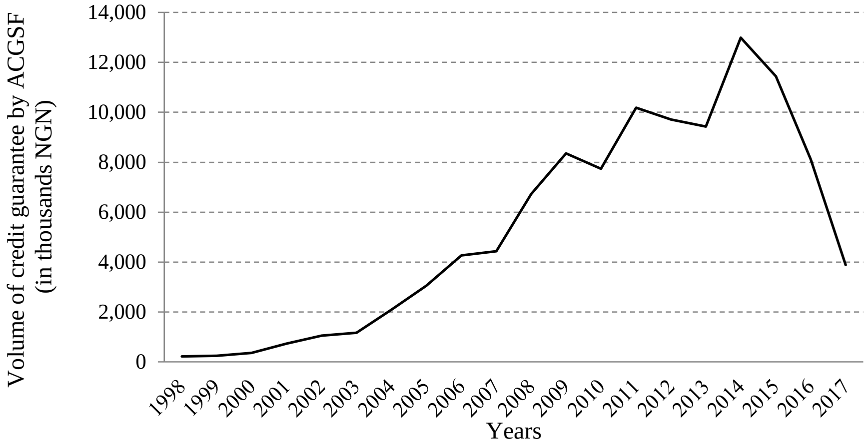

Figure 1: Trend in ACGSF annual volume of credits guaranteed (1998 -2017)
Source: CBN and NBS database, 2018

Table 1: ACGSF volume of credits supply by to crop sub-sector (1998-2017)

S/N	Year	Volume of credit guaranteed by ACGSF in thousands NGN	Volume of credit guaranteed by ACGSF to crop sub-sector in thousands NGN	% Volume of credit guaranteed by ACGSF to crop sub-sector
1	1998	215,697.20	79,114.66	36.7
2	1999	246,082.50	157,801.20	64.1
3	2000	361,450.40	308,606.20	85.4
4	2001	728,545.40	622,694.70	85.5
5	2002	1,051,589.80	939,556.60	89.3
6	2003	1,164,460.40	1,023,901.60	87.9
7	2004	2,083,744.70	1,824,664.70	87.6
8	2005	3,046,738.50	2,665,725.70	87.5
9	2006	4,263,060.30	3,771,179.28	88.5
10	2007	4,425,861.84	3,914,174.29	88.4
11	2008	6,721,074.56	5,189,080.28	77.2
12	2009	8,349,509.28	5,816,197.46	69.7
13	2010	7,740,507.63	5,511,322.13	71.2
14	2011	10,189,604.24	6,906,662.61	67.8
15	2012	9,706,761.23	6,762,283.92	69.7
16	2013	9,424,449.95	5,978,827.70	63.4
17	2014	12,997,004.15	7,999,413.60	61.5
18	2015	11,441,978.83	7,439,662.73	65.0
19	2016	8,104,810.63	5,906,403.74	72.9
20	2017	3,880,672.60	2,351,267.22	60.6

Source: Analysis from Own calculation based on CBN and NBS database, 2018

Trend in ACGSF volume of credit guaranteed to livestock sub-sector (1998-2017)

Table 2 and Figure 2 depict the movement in agricultural credit supply by ACGSF to the livestock sub-sector. It revealed that credit supply by ACGSF directed to livestock increased consistently in the period under review, from 17, 054.34 NGN (779.09 USD) in 1998 to 368,151.00 NGN (2,828.67 USD) in 2006. In 2007 there was a drop in the volume of credit guaranteed to livestock sub-sector. This position changed in 2008 where the funding began to fluctuate until it peaked at 2,342,247.00 NGN (12,695.10 USD) in 2014 then started declining from 2015 up to 2017. Despite the steady rise in volume of credit guaranteed to the sub-sector between 1998 at 17,054.34 NGN (779.09 USD) and 2006 at 368,151.00 NGN (2,828.66 USD) there was continues fluctuation in the percentage changed in the volume of credit guaranteed to the livestock sector.

ACGSF volume of credits guaranteed to fishery sub-sector (1998-2017)

Table 3 and Figure 3 show the trend in Agricultural Credit Guarantee Scheme Fund supply to the fishery sub-sector from 1998-2017. It shows that there was a consistent but meagre increase in credit supply to this sub-sector from 1998-2007 however, in 2008 and 2009 there was a sharp increase from 140, 690.00 NGN (1,194.81 USD) to 368, 630 NGN (2,333.10 USD) and then 708,621.20 NGN (4,484.94 USD). Table 3 indicates an erratic movement in the percentage change in the volume of credit guaranteed to fishery sub-sector. The Figure3 also indicates that the fishery sub-sector is the least guaranteed by the ACGSF. The result agreed with the findings of **Oparinde *et al.* (2017)** that fishery sub-sector was the least financed in all agricultural sectors ACGSF in Nigeria. This implies that little importance is attached to sustainable increase in fish production by the scheme. It is important to state that failure to increase the volume of loan allocated to the fishery sub-sector implies inviting international communities to flood Nigerian markets with both healthy and unhealthy fishes and this will be detrimental to the citizens of the Nation both economically and medically.

Trend in the volume of credit guaranteed to various sub-sectors

Table 4 shows the trend in agricultural credit guaranteed to crop, livestock and fishery sub-sectors. It shows that agricultural sector recorded the highest volume of credit guarantee in the year 2014 with the value of 12,997,004.15 NGN (70,444.46 USD) it further revealed that the distribution among the sub-sectors favoured crop sub-sector the most as it always recorded the highest volume of credit guaranteed, followed by livestock sub-sector, then fishery sub-sector. In the year 2014, crop sub-sector recorded the highest volume of credit guaranteed with the value of 7,999,413.60 NGN (43,357.25 USD) representing 61.5% of the volume of credit guaranteed to agricultural sector. It was followed by the livestock sub-sector with the value of 2,342,247.00 NGN (12,695.10 USD) represented 18% of the volume of credit guaranteed to agriculture while fishery subsector had the least value of 453,426.00 NGN (2,457.5 USD) represented 3.5% of the total volume of credit guaranteed to agriculture. This implies that the scheme gave little attention to fishery sub-sector as compared to the other two sub-sectors. In Table 4, it was also depicted that the highest credit guaranteed to fishery sub-sector in the period under review was 708,621.20 NGN (4,484.94 USD) represented 8.49% in the year 2009, thought was still the least funded sub-sector in that year as compared to the credit guaranteed to other sub-sectors.

Table 2: ACGSF volume of credit guaranteed to livestock sub sector from 1998-2017

S/N	Year	Volume of credit guaranteed by ACGSF in thousands NGN	Volume of credit guaranteed by ACGSF to livestock sub-sector in thousands NGN	% Volume of credit guaranteed by ACGSF to livestock sub-sector
1	1998	215,697.20	17,054.34	7.9
2	1999	246,082.50	17,630.20	7.2
3	2000	361,450.40	27,307.20	7.6
4	2001	728,545.40	60,415.70	8.3
5	2002	1,051,589.80	64,449.60	6.1
6	2003	1,164,460.40	106,962.80	9.2
7	2004	2,083,744.70	191,659.00	9.2
8	2005	3,046,738.50	250,677.80	8.2
9	2006	4,263,060.30	368,151.00	8.6
10	2007	4,425,861.84	353,487.60	8.0
11	2008	6,721,074.56	1,108,484.00	16.5
12	2009	8,349,509.28	1,725,801.00	20.7
13	2010	7,740,507.63	1,305,433.00	16.9
14	2011	10,189,604.24	1,882,283.00	18.5
15	2012	9,706,761.23	1,878,043.00	19.3
16	2013	9,424,449.95	1,883,008.00	20.0
17	2014	12,997,004.15	2,342,247.00	18.0
18	2015	11,441,978.83	1,444,013.00	12.6
19	2016	8,104,810.63	1,169,448.00	14.4
20	2017	3,880,672.60	546,820.00	14.1

Source: Analysis from Own calculation based on CBN and NBS database, 2018

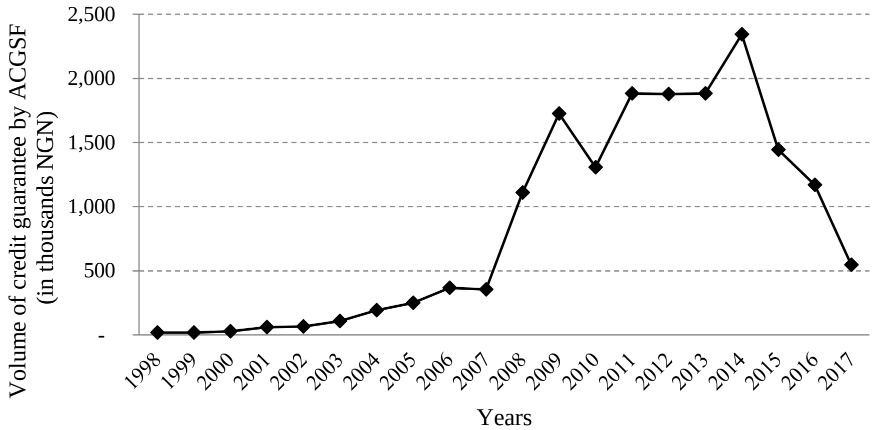

Figure 2: Movement in the volume of agricultural credit guaranteed to the livestock sector (1998-2017)
Source: CBN and NBS database, 2018

Table 3: ACGSF volume of credit guaranteed to fishery sub-sector (1998-2017)

S/N	Year	Volume of credit guaranteed by ACGSF in thousands NGN	Volume of credit guaranteed by ACGSF to fishery sub-sector in thousands NGN	% Volume of credit guaranteed by ACGSF to fishery sub-sector
1	1998	215,697.20	428.60	0.20
2	1999	246,082.50	599.10	0.24
3	2000	361,450.40	899.00	0.25
4	2001	728,545.40	15,742.20	2.16
5	2002	1,051,589.80	12,069.30	1.15
6	2003	1,164,460.40	13,150.00	1.13
7	2004	2,083,744.70	18,240.00	0.88
8	2005	3,046,738.50	77,490.00	2.54
9	2006	4,263,060.30	114,400.00	2.68
10	2007	4,425,861.84	140,690.00	3.18
11	2008	6,721,074.56	368,630.00	5.48
12	2009	8,349,509.28	708,621.20	8.49
13	2010	7,740,507.63	461,128.00	5.96
14	2011	10,189,604.24	590,167.50	5.79
15	2012	9,706,761.23	378,311.90	3.90
16	2013	9,424,449.95	371,403.00	3.94
17	2014	12,997,004.15	453,426.00	3.49
18	2015	11,441,978.83	485,089.00	4.24
19	2016	8,104,810.63	444,763.00	5.49
20	2017	3,880,672.60	275,454.00	7.10

Source: Analysis from CBN and NBS database, 2018

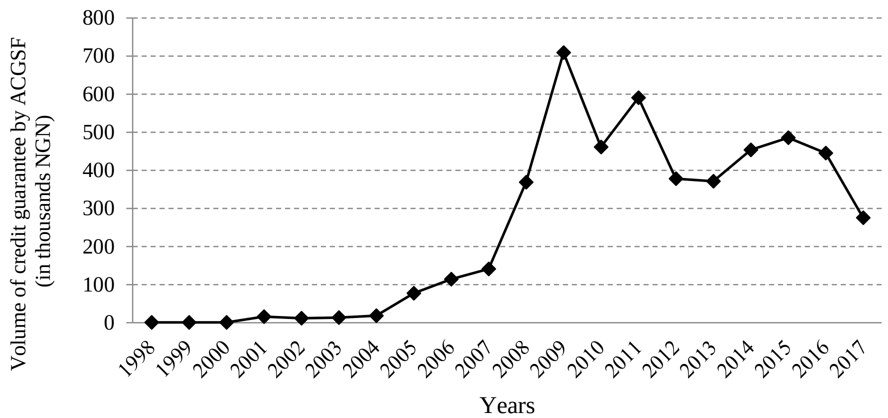

Figure 3: ACGSF volume of credit to fishery sub- sector (1998-2017)
Source: CBN and NBS database, 2018

Table 4: Credit guaranteed to various agricultural sub-sectors from 1998-2017

S/N	Year	Volume of credit guaranteed by ACGSF to agric. sector in thousands NGN	Volume of credit guaranteed by ACGSF to crop sub-sector in thousands NGN	% Volume of credit guaranteed by ACGSF to crop sub-sector in %	Volume of credit guaranteed by ACGSF to livestock sub-sector in thousands NGN	% Volume of credit guaranteed by ACGSF to livestock sub-sector in %	Volume of credit guaranteed by ACGSF to fishery sub-sector in thousands NGN	% Volume of credit guaranteed by ACGSF to fishery sub-sector in %
1	1998	215,697.20	79,114.66	36.7	17,054.34	7.9	428.60	0.20
2	1999	246,082.50	157,801.20	64.1	17,630.20	7.2	599.10	0.24
3	2000	361,450.40	308,606.20	85.4	27,307.20	7.6	899.00	0.25
4	2001	728,545.40	622,694.70	85.5	60,415.70	8.3	15,742.20	2.16
5	2002	1,051,589.80	939,556.60	89.3	64,449.60	6.1	12,069.30	1.15
6	2003	1,164,460.40	1,023,901.60	87.9	106,962.80	9.2	13,150.00	1.13
7	2004	2,083,744.70	1,824,664.70	87.6	191,659.00	9.2	18,240.00	0.88
8	2005	3,046,738.50	2,665,725.70	87.5	250,677.80	8.2	77,490.00	2.54
9	2006	4,263,060.30	3,771,179.28	88.5	368,151.00	8.6	114,400.00	2.68
10	2007	4,425,861.84	3,914,174.29	88.4	353,487.60	8.0	140,690.00	3.18
11	2008	6,721,074.56	5,189,080.28	77.2	1,108,484.00	16.5	368,630.00	5.48
12	2009	8,349,509.28	5,816,197.46	69.7	1,725,801.00	20.7	708,621.20	8.49
13	2010	7,740,507.63	5,511,322.13	71.2	1,305,433.00	16.9	461,128.00	5.96
14	2011	10,189,604.24	6,906,662.61	67.8	1,882,283.00	18.5	590,167.50	5.79
15	2012	9,706,761.23	6,762,283.92	69.7	1,878,043.00	19.3	378,311.90	3.90
16	2013	9,424,449.95	5,978,827.70	63.4	1,883,008.00	20.0	371,403.00	3.94
17	2014	12,997,004.15	7,999,413.60	61.5	2,342,247.00	18.0	453,426.00	3.49
18	2015	11,441,978.83	7,439,662.73	65.0	1,444,013.00	12.6	485,089.00	4.24
19	2016	8,104,810.63	5,906,403.74	72.9	1,169,448.00	14.4	444,763.00	5.49
20	2017	3,880,672.60	2,351,267.22	60.6	546,820.00	14.1	275,454.00	7.10

Source: Own calculation based on CBN and NBS database, 2018

Table 5: The effect of ACGSF on agricultural output in Nigeria

Variable	Coeff.	Std. error	t-Statistic	Prob.
C	0.8958	0.8515	1.0519	0.3085
LOG X1 (CS)	0.1607	0.0408	3.9309	0.0112*
LOG X2 (LS)	0.2320	0.1243	1.8665	0.0537**
LOGX3 (FS)	0.1920	0.0790	2.4303	0.0181*
R-squared	0.8523		Mean dependent var	5.5056
Adjusted R-squared	0.8214		S.D. dependent var	0.6713
S.E. of regression	0.2928		Akaike info criterion	0.5500
Sum squared resid	1.3606		Schwarz criterion	0.7492
Log likelihood	-1.5009		Hannan-Quinn criter.	0.5889
F-statistic	28.2373		Durbin-Watson stat	1.8503
Prob(F-statistic)	0.000001			

Note: (*) and (**) denote significance of results at 1% and 5% levels respectively.
Source: Own calculation based on CBS and NBS database, 2018

The effect of ACGSF on agricultural output in Nigeria

The result in Table 5 shows the multiple regression results on the influence of ACGSF on the agricultural output in Nigeria. The results in the led equation with best fit (Eq.5) was picked and interpreted for the analysis. It revealed that ACGSF credit guaranteed to farmers had a significant effect on the farmers' output (farmers' GDP) in the country. The results indicated that the coefficients of ACGSF on Crop Sector (CS), Livestock Sector (LS) and Fishery Sector (FS) variables were positive and significant at 1% and 5% levels. The coefficient of the ACGSF on crop sector (CS) was 0.1607, meaning that a unit increase in the volume of credit supply to crop production would lead to 16.07% increase in the GDP of the farmers in the crop sector. The coefficient of the ACGSF on livestock sector (LS) variable was 0.2320, meaning that a unit increase in the volume of credit supply to livestock production would lead to 23.20% increase in the GDP of farmers in livestock production. Also, the coefficient of the ACGSF on fishery sector (FS) variable was 0.1920 at 1% level of significance, meaning that a unit increase in the volume of credit supply to fishery production would lead to 19.20% increase in the GDP of fishery farmers in Nigeria.

The multiple determination coefficients (R^2) of 0.8523 implied that credit supply by ACGSF to the various sectors accounted for 85% of variations in the output of the farmers in various sub-sectors. Furthermore, the signs of the coefficients were positive and in conformity with *a priori* expectations that access to credit are expected to empower farmers to procure more inputs at the right time to boost agricultural production. The result agreed with the findings of **Orok and Ayim (2017)**, that the AGCSF effect on Crop sector was positive with great impact on the GDP of the farmers involved in crop production in the country The higher proportionate increase in agricultural GDP for every unit increase in ACGSF implied that credit supply by the scheme has multiplier effects on the growth of agricultural share of GDP. It therefore means that credit supply is an appropriate strategy to stimulate agricultural production for economic revitalization. The finding was in consonance with that of **Okezie and Erendu (2016)** who found a higher coefficient of multiple determinations (R^2) value of 0.928, indicating that credit supply to the agricultural sector over time accounted for about 93% variations in the output of the farmers in the Country.

CONCLUSIONAND RECOMMENDATIONS

The study assessed the trends in the flow of ACGSF credits to farmers and its effects on agricultural output in Nigeria. The specific objectives of the study were to; examine the trend in the volume of agricultural loans guaranteed to different sectors of agriculture by ACGSF from the year 1998 to 2017, and analyse the effects of credit volumes guaranteed by ACGSF on agricultural output in Nigeria. Secondary data were sourced from Central Bank of Nigeria, Nigeria Bureau for Statistics, Nigeria Agriculture, Cooperative and Rural Development Bank and other commercial institutions in the Country. The data were analysed using descriptive and inferential statistics.

The result revealed that there was appreciably definite pattern in government's financing of the agricultural sector, through the volume of loans supplied to the sectors in the time period under review (1998 – 2017). Credit supply to agriculture from the scheme has been increasing but in an inconsistent trend. It was observed in the crop sub-sector that there was a consistent increase in credit from 1998 to 2009. The result revealed that credit supply by the scheme directed to livestock sub sector rose consistently in the period of study but there was no reasonable increase in credit supply to the sub-sector from 1998-2007 as compared to other agricultural sub-sectors. It was also found that the fishery sub-sector was the least funded sub-sector.

The multiple determination coefficients (R^2) of 0.8523 was obtained, implying that credit supply by ACGSF to the various sectors accounted for 85% of variations in the output of the sub-sectors. The coefficients of ACGSF on crop sector (CS), livestock sector (LS) and fishery sector (FS) were 0.1607, 0.2320 and 0.2110 respectively. The signs were all positive and significant at 1% and 5% levels. The results are in conformity with *a priori* expectation that access to credit is expected to empower farmers to procure more inputs at the right time to boost agricultural production.

Based on the findings, the study concludes that ACGSF has a positive effect on agricultural output in Nigeria as evident in the result of regression analysis. It is observed that there has been increased in the volume of agricultural credit guaranteed to the various sub-sectors of agriculture. ACGSF has significant impact on agricultural output and is seen to be a vital element in agricultural development in Nigeria. Furthermore, it was revealed that the fishery sub-sector was the least funded sub-sector but with more impact on the GDP of the farmers in the sector. Therefore, it is expected that farmers, government, agricultural agencies, financial institutions and allied bodies such as agricultural companies, should give more preference to the scheme to boost production capabilities and consequently improve farmers' standard of living.

Based on the findings, it was recommended that with relative low level of funding to the fishery sub-sector effort should be made by ACGSF to step up more funding to the sub-sector. Private sector investment into agriculture should be encouraged by all tiers of governments in utilizing the scheme for better standard of living of the farmers. Financial institutions should encourage agricultural sector by partnering more with the CBN on the ACGSF for developing and making facilities available to the farmers at low interest rates to enable them embark on large scale production. Finally, research on effect of ACGSF on other agricultural sub-sectors like forestry and horticultural sectors should be encouraged.

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IS ORGANIC AGRICULTURE MORE SCALE EFFICIENT THAN CONVENTIONAL AGRICULTURE? THE CASE OF COCOA CULTIVATION IN GHANA

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ABSTRACT

Research background: Despite the growing social recognition of the positive role played by organic farming in the conservation of natural resources and the reduction or elimination of the negative externalities of modern agriculture, the economic competitiveness of organic versus conventional agriculture is a contentious issue. Studies on scale efficiency in the agricultural economics literature, in general, did not address the differences in production practices such as organic and conventional production.
Purpose of the article: We estimated scale efficiency of organic and conventional production, tested for differences between organic and conventional agriculture scale efficiency, and explored the sources of inefficiencies.
Methods: This was accomplished using cross-sectional data on 658 organic and conventional cocoa farmers, for the 2012/13 production season in the Eastern Region of Ghana. The analysis accounted for selection bias and recognised the fractional property of the scale efficiency measure.
Findings & Value added: Organic agriculture is less scale efficient than conventional agriculture. Whilst we recommend that both producer groups improve scale efficiency, organic producers require greater work to do to make up for the almost 50% scale inefficiency. We also found farmer-based organisations to significantly influence scale efficiency. This calls for the need to strengthen farmer-based organisations to increase participation, among other reasons. We departed from the existing scale efficiency literature in a three of ways. We accounted for selection-bias using propensity score matching in the organic and conventional samples in analysing scale efficiency, modelled scale inefficiency using fractional regression and empirically selected the appropriate link function using a battery of tests. Finally, we accounted for an important policy variable; farmer-based organisation. We employed propensity score matching that accounted from observable biases. Further research may consider other methods that account for both observed and unobserved variations.

Key words: conventional cocoa; organic cocoa; fractional regression; scale efficiency; selection-bias
JEL: C21; D24; Q12; Q29

INTRODUCTION

In food production, the fertilisation and accomplishment of other agronomic practices, using chemicals has become conventional practice around the world. However, a move towards organic agriculture (OA) has emerged. This involves maximum reliance on self-regulating ecological or biological processes and renewable resources. OA makes systematic efforts to reduce reliance on external inputs partly to create a sustainable agricultural production system (**Paull, 2013; Beltrán-Esteve and Reig-Martínez, 2014**). Despite the growing social recognition of the positive role played by this type of farming in the conservation of natural resources and the reduction or elimination of the negative externalities of modern agriculture, the economic competitiveness of organic versus conventional agriculture is a contentious issue (**Beltrán-Esteve and Reig-Martínez, 2014; 2016**). Whilst the dimension on efficiency holds that; OA is more technically efficient than conventional agriculture (CA) (**Oude Lansink *et al.*, 2002; Poudel *et al.*, 2015**), there is counter-evidence, that, OA is more technically inefficient than CA (**Madau, 2007; Tiedemann and Latacz-Lohmann, 2013**). The latter has been attributed to restrictions on resources and technology, emanating from regulations and guidelines governing OA (**IFOAM, 2008, 2014; Mayen *et al.*, 2010; Beltran-Esteve and Reig-Martinez, 2014; Lakner and Breustedt, 2016**).

Productivity (efficiency) change depends partly on scale of operation (**Ray, 1998; Rasmussen, 2010**), the effectiveness of which is measured by scale efficiency and how close an observed firm or farm unit is, to the optimal scale (**Ray, 1998; Karagiannis and Sarris, 2004**). In the light of the contention regarding organic and conventional technical efficiency, would OA be more scale inefficient than CA or otherwise?

We address this research question by estimating scale efficiency (SE) of organic and conventional agriculture, test for differences between organic and conventional agriculture, and explore the sources of inefficiencies, using data on organic and conventional cocoa production in Ghana.

Studies on SE in the agricultural economics literature, in general, did not address the differences in production practices; organic and conventional production (**Bremmer *et al.*, 2008; Madau, 2011; Mgeni and Henningsen, 2012; Kelly *et al.*, 2013; Watkins *et al.*, 2014**). Only, **Karagiannias *et al*. (2012)** did. However, they failed to account for selection bias. While some studies did not model SE at all (**Pantzios *et al.*, 2002; Karagiannis and Sarris, 2004; Hussiani and Abayomi, 2010; Karagianni *et al*., 2012; Baran, 2013; Karagiannis and Melfou, 2015**), others that modelled SE, did not appropriately account for the fractional property of SE estimates (**Paul *et al*., 2004; Sengupta and Kundu, 2006; Bremmer *et al*., 2008; Madau, 2011, 2015; Kelly *et al*., 2013**). **Rahman and Awerije (2015)** is an exception, yet they specified logit *a priori* and did not empirically select the appropriate link function.

This article departs from other SE studies in three ways. First, it takes account of selection bias in the organic and conventional samples. Second, SE is parametrically modelled, using fractional regression with an empirical selection of the appropriate link function of the fractional regression model. Finally, we accounted for an important policy variable; farmer-based organisations.

Conventional cocoa production involves the use of inorganic fertilisers, chemical weed control as well as chemical pest and disease control. On the contrary, organic production bars the use of these. Alternatives may involve manual and operations that could limit the size of a farm operation to be undertaken by organic cocoa farmers (**Paull, 2013; Beltrán-Esteve and Reig-Martínez, 2014**). Thus, scale efficiency has implications for input use, revenue, cost and ultimately the profitability of farm operations. For organic farmers who have adopted new production technology with associated management practices that could affect optimal farm size, which may differ from conventional farmers, it is important to compare the scale efficiency of organic and conventional cocoa farms. Results of this study will establish what the scale efficiency of organic farms is, how it differs from conventional cocoa farms and what policy recommendations will be apt.

DATA AND METHODS

Data

Cocoa farmers were sampled from Suhum-Craboa-Coalter (SCC) district in the Eastern Region of Ghana, because at the time of data collection in 2014, only farmers in this area had practised organic cocoa production in Ghana, for a decade after certification. The district falls within the semi-equatorial forest zone and experiences a major (March to June) and a minor (September to October) rainy season. The temperature varies between 24 and 29 0C, and the annual rainfall is between 1270 and 1650 mm (**Abekoe *et al.*, 2002; Ayenor *et al*., 2004**). SCC has a total land area of about 850km^2, with 20% of this area under cocoa cultivation, contributing more than 500 metric tonnes of beans (**YGL, 2008**).

Two populations were defined; growers of conventional cocoa and growers of organic cocoa. Ten thousand organic cocoa farmers were operating in the SCC District as of 2014, according to the Yayra Glover Limited (YGL), the firm that facilitates organic cocoa production in the study area. The Cocoa Health and Extension Division (CHED) of COCOBOD, responsible for extension services to cocoa farmers, put the number of conventional cocoa farmers in the district at 18,425. From these populations, the sample size of organic and conventional farms was determined to be 278 and 378 respectively.

Twenty-six and 37 communities respectively, in which organic and conventional cocoa farmers resided were selected. For the organic cocoa community, 26 farmers were selected whilst 12 farmers were selected for conventional cocoa based on the number of communities in the sampling frame. The total respondent targeted for each production technology was approximately 10% above the determined sample size, to make room for non-response. A pre-tested questionnaire was administered with the assistance of Agricultural Extension staff from CHED. Returned and usable questionnaires for organic and conventional cocoa producers were 280 and 378 respectively.

The specific conventional communities were same as those of the organic, where possible, or closest to organic cocoa communities, to control for environmental differences and have analogous sample composition (**Tzouvelekas *et al.*, 2002; Madau, 2007; Guesmi *et al.*, 2012**). A cocoa farm was operationalised as a crop farm that has more cocoa plants than any other cultivated plant in the field. For organic farms, these were certified as organic and organic practices were applied to the other plants in the same field, with the cocoa plants.

Methods

Production function

The production functions were estimated by Stochastic Frontier Analysis (SFA), owing to the inherent stochasticity in the model, which is akin to stochasticity in agricultural production (**Kumbhakar and Lovell, 2000, Mayen *et al.*, 2010; Djokoto, 2016**), with a composed error term (**Aigner *et al*., 1977 and Meeusen and van den Broeck, 1977**). The production function was specified as Eq. 1.

$$y = f(X, \beta)e^{v-u} \quad (1)$$

Where: ***y*** represents output, measured in kilogrammes; **X** is a vector of production inputs. In our case, farm size (ha) is *FARMSIZE*, labour (man-days) is *LABOUR* and tree age (years) is *FARMAGE*, as in Table 1. Possible omitted variable bias is addressed later.

β is a vector of parameters we estimated, *v* and *u* are error terms. The frontier production function is a measure of the maximum potential output attainable given the production inputs. Both *v* and *u* cause actual production to deviate from this frontier. The random variable in the production that cannot be influenced by producers and captures omitted variables such as weather and represented by *v*, is identically and independently distributed (iid) as $N(0, \sigma^2_v)$. The non-negative error term *u* represents the deviation from the maximum potential output, attributable to technical inefficiency, which is independent of *v*. The stochastic terms *v* and *u* are assumed to be uncorrelated. We assumed the half-normal distribution of the errors.

We estimated both the Ordinary Least Squares (OLS) and SFA forms of the Cobb-Douglas (CD) and translog functional forms and selected the SFA translog form based on the loglikelihood ratio test. Important variables; fertiliser and pesticides were omitted from the variable list. In the case of the former, the series was collinear with the land. This is because the governments' fertiliser programme supplied fertiliser to farmers based on the size of the plot a farmer reported. Also, farmers who followed the recommended fertiliser application regimen related the fertiliser requirements to the size of the plot. For the latter, pesticide, the data for conventional was unreliable whilst organic farmers did not formally apply pesticides. These may lead to omitted variable bias (OVB) which we tested. Square and cubic powers of the prediction of output were included as additional explanatory variables in the production function. The joint significance of the parameters of the additional terms was performed (**Ramsey, 1996**).

Selection-bias

A three-step procedure was used in accomplishing PSM (**Rosenbaum and Rubi, 1983; Imbens, 2004**). In the first step, a probability model for the adoption of organic production standards was estimated and used to calculate the probability or propensity score of being organic, for each observation. In the second step, the required estimation of the stochastic frontier model on the unmatched sample was performed. In the third step, matching of the organic and conventional subsamples was performed. The reverse of step two and three was necessary to ensure that matching of the subsamples that could lead to data attrition does not negatively impact the frontier estimates (**Mayen *et al*., 2010; Rao *et al*., 2012**).

Scale efficiency

Following the specification of the production function in (1), we adopted the **Ray (1998)** approach to estimating the SE.

$$SE_i = Exp\left[\frac{(1-E_i)^2}{2\beta}\right] \quad (2)$$

Where: the elasticity of scale (E_i) was computed as the sum of the first-order partial derivatives of the explanatory variables of the production function, evaluated at their mean values and β is the sum of the coefficients of the cross terms.

β was hypothesised to be negative definite, to be sure that $0 \leq SE_i \leq 1$. Although negative definiteness of β was sufficient condition, it was not a necessary condition (**Ray, 1998**). E and β are both equal to one, only at the most productive scale size (MPSS); the point where there are constant returns to scale (**Ray, 1998**). Indeed, when x^i, the input bundle itself is MPSS, then $E(x^i) = 1$ and ln $SE_i(x^i) = 1$. With increasing returns to scale, $E_i > 1$ and $SE(x^i)$ rise with a rise in output. On the other hand, a farm that exhibits decreasing returns to scale or supra-optimal scale ($E_i < 1$), there should be a contraction in output for optimal scale to be achieved.

Conventional and organic scale inefficiency effects

Socio-economic variables; specifically farm and farmer characteristics offer an important avenue to identifying drivers of scale inefficiency (*SIE*). Since *SIE* is defined within the unit interval, we employed fractional regression modelling (**Papke and Wooldridge, 1996**), and selected the appropriate link function, from a set of plausible link functions.

Let the conditional expectation of *SIE* given *x*, be $E(SIE|x)$, then

$$E(SIE|x) = G(x\theta) \quad (3)$$

where $G(\bullet)$, which is some nonlinear function satisfying $0 \leq G(\bullet) \leq 1$, could be any cumulative distribution function, such as logit, probit, loglog, complementary loglog (cloglog) and cauchit (**Papke and Wooldridge, 1996; Ramalho *et al*., 2010**). *SIE* is 1 – *SE* and *x* are farm and farmer characteristics. The link functions are specified in Eq. 4- Eq. 8.

Logit,

$$G(x\theta) = \frac{e^{x\theta}}{1+e^{x\theta}} \quad (4)$$

Probit,

$$G(x\theta) = \Phi(x\theta) \quad (5)$$

Loglog,

$$G(x\theta) = e^{-e^{-x\theta}} \quad (6)$$

Cloglog,

$$G(x\theta) = 1 - e^{e^{x\theta}} \quad (7)$$

Cauchit

$$G(x\theta) = \frac{1}{2} + \frac{1}{\pi} arctan(x\theta) \quad (8)$$

The various link functions were estimated using *frm* (**Ramalho, 2013, 2014**).

Following **Ramalho *et al.* (2010; 2014)**, three groups of tests were employed to select the appropriate link function; Ramsey RESET test (**Ramsey, 1969**), generalised goodness of functional form test (GGOFF) (**Ramalho *et al.*, 2014**) and *P* test (**David and MacKinnon, 1981**). The RESET test examined the presence of misspecification in the model, specifically, the presence or otherwise of power terms in the model. Although the RESET test was originally developed for use with linear functions, **Pagan and Vella (1989), Ramalho *et al.* (2010, 2011)** and **Cameron and Trivedi (2013, p. 52)** have shown that it is also applicable to any type of index models.

The GGOFF, tests for how well the data fit the link function specified. More than one link function could be selected by the RESET and GGOFF tests. Therefore, the *P* test provided an opportunity for one-on-one (pairwise) test using the selected link function(s) from the first two stages, as alternative hypotheses. Interpretation of the *P* test followed that of the usual hypothesis test, unlike the other two tests, for which the rejection of the H_0 was evidence of absence of misspecification. Statistical methods of selection offer a viable alternative, in the absence of *a priori* theoretical formulation of the appropriate functional form for the FRM.

RESULTS AND DISCUSSION

Background of data

The difference in years of education of 0.04 years and 0.02 members of household between conventional and organic cocoa farmers were so small to be statistically significant (Table 1). The strongest statistically significant differences related to farm age (FARMAGE), access to credit (CREDIACC), cocoa farming experience (FARMEXP), the incidence of CSSVD attack (CSSVD) and access to extension services (EXTNACCESS). On the contrary, the weakest statistically significant differences were participation in a farmer-based organisation (FBOPARTICIPATION), plot size (FARMSIZE), labour use (LABOUR), gender (GENDER) and age of farmer (FARMERAGE). Whilst the average age of organic cocoa farms was 29 years that for conventional farms was 18 years. Fewer conventional cocoa farmers had access to credit (19%) than organic cocoa farmers (49%). This is to be expected as credit is a determinant of organic cocoa technology adoption (**Djokoto, Owusu and Awunyo-Vitor, 2016**). Organic cocoa farmers have been farming on average for about 20 years whilst conventional cocoa farmers registered an average of 16 years.

Omitted variables test

Following the non-use of fertiliser and pesticide from the model, due to reasons adduced earlier, a test of omitted variables was performed (Table 2). The null hypothesis that power terms (other terms) in the test model were jointly significant, could not be rejected in the case of the organic sample. By implication, there are no omitted variables in the organic model, thus the exclusion of the fertiliser and pesticide variables did not have a discernible effect on the model. In the case of the conventional sample however, the χ^2 test statistic is significant at the 1% level of significance. Impliedly, there is an omitted variable in the conventional model. The solution to omitted variables in the agricultural production function literature is to use financial variables (**Apergis, 2007**).

Table 1: Variables definitions and descriptive statistics

Variable	Variable name	Definition	Conventional Mean (Standard Error)	Organic Mean (Standard Error)	*t*-test
CREDIACC	Access to credit	Yes = 1, 0 otherwise	0.19 (0.020)	0.49 (0.029)	-8.411***
CSSVD	CSSVD attack	Incidence of CSSVD=1 and 0 otherwise.	0.19 (0.020)	0.32 (0.027)	-3.751***
EDUCATION	Education	Number of years of schooling	8.58 (0.176)	8.62 (0.187)	-0.157
EXTNACCESS	Access to Extension	Yes=1, 0 otherwise	0.84 (0.018)	0.93 (0.015)	3.512***
FARMAGE	Farm Age	Years since the cocoa farm was planted until 2014	18.09 (0.506)	29.34 (0.951)	-10.442***
FARMERAGE	Age of farmer	Years	48.28 (0.582)	49.29 (0.751)	-1.063**
FARMEXP	Farming Experience	How long farmer cultivated cocoa (years)	16.26 (0.47)	19.83 (0.897)	-4.115***
FARMSIZE	Farm Size	Area of land area (Ha)	2.03 (0.096)	2.32 (0.100)	-2.180**
FBOPARTICIPATION	Participation in Farmer-based organization	Participation=1, 0 =otherwise	0.86 (0.017)	0.92 (0.015)	2.841**
GENDER	Gender	Male =1 and 0 otherwise	0.82 (0.020)	0.88 (0.019)	-2.046**
HHS	Size of Household	Number of persons living in the household	6.40 (0.181)	6.42 (0.174)	-0.101
LABOUR	Number of man-days	Quantity of labour/day	1.54 (0.091)	1.92 (0.049)	-2.166**
N			378	280 [1]	

Note: [1] Provision for invalid questionnaires resulted in 280 questionnaires, two more than the 278-sample size estimated.

Beyond this, is to include the omitted variable (**Greene, 2012; Asteriou and Hall, 2015**). The approach of **Apergis (2007)** could not be followed because data on financial variables were not reliable. Due to the reasons adduced above, data on fertiliser and pesticides could not be included in the production function. Considering the omitted variable problem as part of the general misspecification problem, the power terms included in the test production function were considered as control variables for the misspecification (**Ramsey, 1969; Asteriou and Hall, 2015**). This raised another challenge; the sufficient condition that the sum of the coefficients of the cross terms in the translog production function, should be negative semi-definite, in the **Ray (1998)** SE formula (Equation 2), could not be met. Thus, for purposes of calculating the SE based on **Ray (1998)**, the omitted variables problem is accommodated for the conventional model. It must be noted that **Sherlund *et al.* (2002)** and **Rahman and Hasan (2008)** have argued that omitted variables can inflate individual technical efficiency estimates. However, the random error, *v*, capture the errors including omitted variables (**Aigner *et al*, 1977; Mussa, 2014; Mujawariya *et al.*, 2017; Njikam and Alhadji, 2017**). Further, the use of farm age (age of trees) is a capital variable. Thus, we accommodate the omitted variables error on two grounds; the capture of the omitted variable error within the random error term and the fact the technical efficiency measure is not an ingredient in the calculation of scale efficiency. And finally, the role of *FARMAGE* as capital.

Production function

The estimations that generated results for technical efficiency of conventional and organic cocoa farms, required the testing of some hypotheses. First, the use of OLS is a better representation of the data than SFA. Second, that CD production function is preferred to the translog function. Third, that inefficiency is absent in the models. The results of the hypotheses tests are provided in Table 3. The rejection of the null hypotheses for both organic and conventional functions shows that there is technical inefficiency based on CD production function. Similarly, the rejection of the null hypotheses that there is no technical inefficiency in the translog production function is desirable. Comparing the CD to translog, the latter is preferred to the former. Further, the sigma squared values showed the existence of technical inefficiency in both the conventional and organic models. Aside from the empirical suitability of the translog SFA production function, estimating the SE by the **Ray (1998)** approach is conditioned on a translog functional form and existence of technical inefficiency. The marginal products (Table 5) generated from the selected production functions (Table 4) are positive in line with theoretical expectations. Both production practices show increasing returns to scale. Due to space limitations, technical inefficiency effects are not presented and discussed.

The production practices of organic and conventional cocoa production differ as noted earlier. Moreover, the computation of the scale efficiency measure relies on production function parameters which necessitate the estimation of separate production functions. The *a priori* estimation of the separate production functions hinges on these.

Table 2: Omitted variables test

Description	Conventional χ^2 statistic	Organic χ^2 statistic
H_0 Power terms are not jointly significant	11.53***	1.77
H_1 Power terms are jointly significant		
Degrees of freedom	2	2
Decision	Reject	Accept

Note: *** denotes statistical significance at 1%.

Table 3: Functional form selection test

		Conventional	Organic
H_0: There is no technical inefficiency	OLS (Restricted)	-418.83696	-231.04506
H_1: There is technical inefficiency		-407.80759	-213.53219
	SFA- Cobb-Douglas (Unrestricted)		
	Loglikelihood ratio	22.05874**	35.02654***
	Decision	Reject	Reject
H_0: There is no technical inefficiency	OLS (Restricted)	-376.22986	-219.74919
H_1: There is technical inefficiency		-367.43498	-202.78204
	SFA- Translog (Unrestricted)		
	Loglikelihood ratio	17.58976*	33.9343***
	Decision	Reject	Reject
H_0: Cobb-Douglas is a better representation of the data	SFA- Cobb-Douglas (Restricted)	-407.80759	-213.53219
		-367.43498	-2002.78204
H_1: Cobb-Douglas is not a better representation of the data	SFA- Translog (Unrestricted)		
	Loglikelihood ratio	80.74522***	21.5003**
	Decision	Reject	Reject

Note: ***, **,* denotes statistical significance at 1%, 5% and 10% respectively.

Table 4: Estimation of production function and inefficiency effects

Variables	Conventional	Organic
FARMAGE	1.5082***	0.0950
	(0.5578)	(0.5332)
FARMSIZE	0.9900***	0.9760**
	(0.3519)	(0.4533)
LABOUR	2.2659***	1.1243***
	(0.4463)	(0.3447)
FARMAGE^2	-0.2126***	-0.0405
	(0.0786)	(0.0651)
FARMSIZE^2	0.0455***	-0.0220
	(0.0051)	(0.0782)
LABOUR^2	-0.2053***	-0.1188***
	(0.0415)	(0.0356)
*FARMAGE*FARMSIZE*	0.0405	0.1933
	(0.08830	(0.2331)
*FARMAGE*LABOUR*	-0.1142	0.0871
	(0.1474)	(0.12580
*FARMSSIZE*LABOUR*	-0.2386*	-0.3263**
	(0.1312)	(0.1286)
CONSTANT	-2.4015*	1.9335
	(1.4084)	(1.2380)
Sigma squared	0.4291***	0.4650***
N	378	280
Wald	168.21***	85.4***
Loglikelihood	-367.4350	-202.7820

***, **,* are 1%, 5% and 10% levels of significance respectively. Figures in parenthesis are standard errors

Table 5: Elasticities and returns to scale

	Conventional	Organic
Land	1.3994	0.0025
Labour	0.9147	0.6578
Farm Age	0.4448	0.4721
Returns to scale	1.2994	1.1324

Selection-bias

The generation of the propensity scores from the binary choice model, and matching these for organic to conventional farms, resulted in new sub-samples of 161 organic and 161 conventional farms. The binary model estimation is reported and discussed in **Djokoto *et al*. (2016)**. All other farms from the 658 were discarded. Matching after estimation of technical efficiency was performed following **Rao *et al*. (2012)**, to avoid the influence of data attrition on technical efficiency estimation. For the discussion of the technical efficiency model, see **Djokoto *et al*. (2017)**.

Scale efficiency

The mean SE for organic cocoa production is 0.5332, corrected for selection bias, whilst a slightly higher value of 0.5351 was obtained with selection biased sample (Table 6). In the case of the conventional cocoa sample, the values are respectively 0.6601 and 0.6681. In both cases, the mean values are less than 1, indicating a sub-optimal scale of operation. Indeed, the inspection of the individual farms showed that in both production practices, most farms operate at sub-optimal scale; 153 for organic and 151 for conventional (Table 7). The SE values less than 1, in the presence of increasing returns to scale imply, the farms analysed failed to take advantage of the increasing returns-to-scale to increase their inputs for increased output (**Karagiannis and Sarris, 2004**). Our findings show a marked lower scale efficiency, indeed, quite pronounced SIE unlike studies on Africa (maize farms in Nigeria, 0.880 -**Karimov *et al.*, 2014**) and rice in Ghana, 0.8200 (**Anang and Rezitis, 2016**). Since our findings relate to cocoa, we cautiously conclude that cocoa production is less scale efficient than other agricultural products. As scale economies are usually a consequence of the better and more efficient use of production factors, an increase in firm size first leads to higher marginal returns and lower marginal costs. Beyond a certain size, however, marginal returns will decrease, and marginal costs will rise although not contemporaneously. Optimal size is reached when marginal returns equal marginal costs.

Comparing organic and conventional SIE values, both production practices posted the same extreme values; 0.00 and 1.00. The mean for organic cocoa is 0.5332, significantly lower than that of conventional; 0.6601. This finding does not depart from that of **Karagiannis *et al.* (2012)** for dairy in Austria. This is irrespective of whether the complete sample is corrected for selection bias or not. Restrictions on types of resources and technology may be responsible for the higher scale inefficiency in organic production (**IFOAM, 2008, 2014; Mayen *et al.*, 2010; Beltran-Esteve and Reig-Martinez, 2014**).

Scale inefficiency effects

Aside from the differences in SIE for the production practices, there exists variability within the SIE of each production practice (Table 7). We, therefore, investigated the drivers of this variability using fractional regression modelling. For conventional cocoa production (first panel of Table 8), the statistical significance of the RESET test statistic for logit, probit, loglog and cloglog suggest these functional forms are misspecified. Since the cauchit link function is the only well-specified link function, the next two tests for selecting the appropriate link function have become redundant. Therefore, the cauchit link function is selected. The second part of Table 8 on organic cocoa, presents an interesting situation. By the RESET test, all link functions are well specified except cloglog. Thus, the cloglog function is out of contention. By the GGOFF, all link functions are appropriate. For the one-to-one *P*-test, the null hypotheses that the loglog is preferred to logit, probit and cauchit link functions are rejected. Therefore, loglog link function is also out of consideration. Logit, probit, and cauchit link functions are indifferent to one another, based on the alternative hypothesis tests, thus any of these could be selected for discussion. However, only one of these could be used, thus we proceed to choose one. A close examination of the magnitudes of the test statistics for each of the link functions, as null hypotheses, shows that those of cauchit is the lowest. Thus, whilst all are indifferent, cauchit test statistics demonstrate 'strongest indifference' or non-rejection of the null hypothesis. Thus, the decision is in favour of the cauchit link function, for the organic SIE model.

Table 6: Scale efficiency

	Conventional			Organic			Conventional-Organic
	N	SD	Mean	N	SD	Mean	Difference
Selection biased	378	0.3106	0.6688	280	0.3690	0.5351	1.3519***
Non-selection biased	161	0.3020	0.6601	161	0.3632	0.5332	0.1269***
Min			0.00			0.00	
Max			1.00			1.00	

*** implies 1% level of significance of the student's *t* test. S.D.- standard deviation

Table 7: Optimality of scale efficiency

Category	Organic	Conventional
Supra-optimal	0	0
Optimal	8	10
Sub-optimal	153	151
N	161	161

Table 8: Hypothesis tests for model selection for conventional and organic cocoa

	Logit	Probit	Loglog	Cloglog	Cauchit
Conventional cocoa production					
Ramsey test					
RESET	9.442***	8.961***	8.407***	9.461***	2.474
Goodness-of-functional form tests					
GGOFF	10.823***	11.678***	8.207***	9.946***	3.803
P-test					
H_{1Logit}	-	7.206***	9.902***	8.456***	0.755
$H_{1Probit}$	6.478***	-	10.144***	7.254***	0.747
$H_{1Loglog}$	6.063***	7.099***	-	5.056**	0.778
$H_{1Cloglog}$	12.227***	11.568***	12.533***	-	0.820
$H_{1Cauchit}$	13.982***	15.644***	18.626***	11.035***	-
Organic cocoa production					
Ramsey test					
RESET	2.291	2.217	1.586	2.795*	2.281
Goodness-of-functional-form tests					
GGOFF	2.352	2.417	1.601	2.563	2.033
P-test					
H_{1Logit}	-	0.062	3.142*	0.611	0.024
$H_{1Probit}$	0.029	-	3.029*	0.216	0.004
$H_{1Loglog}$	1.029	0.987	-	0.815	0.281
$H_{1Cloglog}$	4.251**	4.596**	5.445**	-	1.901
$H_{1Cauchit}$	0.569	0.534	2.955*	0.064	-

Note: ***,**.* denotes statistical significance at 1%, 5% and 10% respectively.

Table 9: Hypothesis tests for model selection for the combined sample

	Logit	Probit	Loglog	Cloglog	Cauchit
Ramsey test					
RESET	2.916*	3.277*	4.307*	2.583	1.854
Goodness-of-functional-form tests					
GGOFF					
P-test	3.788	3.968	4.398	2.384	3.498
H_{1Logit}	-	4.129**	5.279**	1/188	1.108
$H_{1Probit}$	3.572*	-	4.941**	1.517	0.926
$H_{1Loglog}$	2.495	2.682	-	1.031	0.442
$H_{1Cloglog}$	3.348*	4.330**	5.976**	-	0.223
$H_{1Cauchit}$	6.086**	6.376**	7.285***	3.829*	-

Note: ***,**.* denotes statistical significance at 1%, 5% and 10% respectively.

Table 10: Scale inefficiency effects

	Conventional Cauchit ME (δ-method SE)	Organic Cauchit ME (δ-method SE)	Pooled sample Cauchit ME (δ-method SE)
ADOPTION	-	-	0.0989**
	(-)	(-)	(0.0384)
CREDIACC	0.0355	-0.0303	-0.0199
	(0.0641)	(0.0627)	(0.0415)
CSSVD	-0.0748	-0.2164***	-0.1433***
	(0.0718)	(0.0735)	(0.0513)
EDUCATION	-0.0054	0.0188*	0.0020
	(0.0054)	(0.0089)	(0.0057)
EXTNACCESS	0.2862***	0.0591	0.1887***
	(0.0821)	(0.0949)	(0.0609)
FARMAGE	-0.0140	0.0845	0.0271
	(0.0706)	(0.0670)	(0.0389)
FARMERAGE	0.0046**	0.0054	0.0043***
	(0.0022)	(0.0035)	(0.0020)
FARMEXP	-0.0098	-0.0075**	-0.0080**
	(0.0082)	(0.0032)	(0.0035)
FBOPARTICIPATION	-0.0925***	-0.0225	-0.0461***
	(0.0180)	(0.0151)	(0.0123)
GENDER	0.0167	-0.0823	-0.0592
	(0.0474)	(0.0836)	(0.0453)
HHS	-0.0337**	0.0123	-0.0020
	(0.0166)	(0.0113)	(0.0050)
Model properties			
N	161	161	322
R^2-type measure	0.2662	0.1082	0.1191
Log pseudolikelihood	-74.6410	-88.0993	-168.5314

Note: ***, **, * denotes statistical significance at 1%, 5% and 10% respectively. SE- standard errors. ME- Marginal effects

For the combined sample (Table 9), the RESET test statistics for logit, probit and loglog are statistically significant. This implies these link functions are misspecified whilst the other two; cloglog and cauchit are not. The earlier three link functions are therefore eliminated from consideration. Using the cloglog as a null hypothesis with cauchit as the alternative hypothesis, the cloglog is rejected in favour of the cauchit link function. Consequently, the marginal effects for conventional, organic and combined sample for the cauchit link function are presented in Table 10.

The R^2 measures appear low. However, these are the highest among the five link functions and the best attainable, as the OLS estimates; the default posted values lower than these. Moreover, as the R squared-type measure is a relative measure unlike the standard R-squared value, the absolute value is less important, rather how this compares to those of competing functional forms (**Ricci, 2010; Ricci and Martinez, 2008**; **Wei Shi, 2018**). The positive marginal effect of *ADOPTION*, 0.0989 indicates organic cocoa producers are less scale efficient than conventional cocoa producers. This finding from a multivariate analysis confirms the outcomes of the univariate analysis of the previous section. The existence of *CSSVD* enhances scale efficiency. CREDIACC should allow farmers to acquire resources to increase input levels thereby increasing the scale of operation. This may appear to be the case for the conventional cocoa producers. However, the marginal effect of *CREDIACC* for both organic and the combined sample showed negative signs.

Since in all three models, the magnitude for the *CREDIACC* is statistically insignificant, CREDIACC does not have any discernible effect on scale efficiency. **Wongnaa and Awunyo-Vitor (2019)** however found a positive effect of credit on scale efficiency.

The role of *CSSVD* on SE is rather interesting. CHED, the Ghana Cocoa Board agency that addresses issues of the disease, undertakes disease control programmes involving cutting and burning of diseased trees. This does not reduce land area but number trees, lower labour use for husbandry practices as well as output. By this, the levels of input, for example, a lower level of labour leads to reduced output. This then culminates in the appropriate scale of operation. Formal education had no discernible effect on SIE for conventional cocoa and the combined sample, consistent with the conclusions of **Paul *et al.* (2004)** and **Rahman and Awerije (2015)**. However, formal education increased SIE for organic cocoa producers. Formally educated farmers may be motivated to cultivate larger farms, however, they engage in other livelihoods, which compete with organic cocoa production, may lead to less attention given to the organic cocoa farm. Thus, the input and output results may be inappropriate for the chosen farm size. The findings of **Wongnaa and Awunyo-Vitor (2019)** for conventional maize in Ghana, concurs with the findings of this study.

EXTNACCESS strongly reduced SE. This finding is surprising, as access to extension should improve farm management skills and capacity of farmers. This notwithstanding, **Madau (2015)** and **Paul *et al.* (2004)** reported a neutral effect whilst **Anang *et al*. (2016)** and **Wongnaa and Awunyo-Vitor (2019)** reported a positive effect. The age of the farm (FARMAGE) has no discernible effect on scale inefficiency for all three models. **Gimbol *et al.* (1994)** and **Currey *et al.* (2007)** acknowledged the parabolic distribution of the output of cocoa over time. Thus, with the relatively aged farms noted in Table 1, the output will decline irrespective of increased input use. This explains the positive sign of the coefficient of the *FARMAGE*. However, the effect is not strong enough to result in a statistically significant value of the marginal effect. Farmer age (FARMERAGE) exacerbates SIE for the conventional and combined sample. As cocoa farmers age, their inability to pay attention to the cocoa farms result in absenteeism and sometimes, turning the farm over to caretakers, who may not provide adequate attention, thereby failing to ensure the appropriate scale of operation. The conclusions of **Wongnaa and Awunyo-Vitor (2019)** for maize confirms these findings.

The coefficient of *FARMEXP* has a negative sign for all three models. Increased experience in cocoa farming should lead to accumulation of knowledge resulting in a better combination of input and their levels relative to farm size. Therefore, farm experience enhances scale efficiency. The effect was however significant for the organic sample and the combined sample but not so for the conventional sample. For **Rahman and Awerije (2015)** and **Wongnaa and Awunyo-Vitor (2019),** farmer experience enhanced scale efficiency. Membership and participation in FBO, whilst providing the platform to receive knowledge and acquire skills from subject matter specialists, it also provides opportunities to network, share ideas and communicate at the level of peers. This creates the platform to deliberate on common problems to find solutions. This is useful in enhancing scale efficiency (**Wongnaa and Awunyo-Vitor, 2017**), thus, it is no wonder that *FBOPARTICIPATION* enhances SE. Gender does not distinguish SIE of OA and CA, in all three cases, whilst *HHS* promotes SE for conventional cocoa. Increased *HHS* provides opportunity for more labour that can be combined with land, to maintain an appropriate farm scale. This finding agrees with the recent findings of **Wongnaa and Awunyo-Vitor (2019)**.

CONCLUSIONS

In this study, we departed from the existing SE literature in three ways: We accounted for selection-bias in the organic and conventional samples. We modelled parametrically estimated SE, using fractional regression and empirically selected the appropriate link function and considered an institutional variable, participation in farmer-based organisations.

Both organic and conventional producers are scale inefficient. However, organic producers' mean SE of 0.5332 is significantly less than 0.6601, for conventional producers, thus OA is not more scale efficient than CA. Although it is recommended that both producer groups improve SE, organic producers require greater work to do to make up for the almost 50% SIE. Until the organic regulators increase the latitude for resources to be used in production, organic agriculture researchers must come up with quality inputs whilst organic producers need to improve their capacity in farm management, to improve input allocation on the farm. SE in organic cocoa can be further increased through increased efforts by CHED to control CSSVD. Younger persons should be encouraged to go into and remain in cocoa production. Revenue side factors such as increased producer price as well as cost side factors including availability of cost-effective production inputs, leading to improved profitability, could be useful. Organic cocoa producers should increase farm hectares to reduce SIE. Farmer-based organisations should be further strengthened, particularly focusing on activities that will increase participation.

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