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REGULAR ARTICLE

INTERMEDIARIES AND ASYMMETRIC PRICING: EVIDENCE FROM THE MARKET OF LOCAL MILLET IN MALI

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ABSTRACT

Commodity prices consistently increase in developing countries while they barely decline, affecting negatively poor and vulnerable people. This paper examines the role of intermediaries such as collectors, wholesalers, and retailers in the asymmetric transmission of millet prices from producers to consumers in local millet markets in Mali. We use data of local millet prices from the five most important cities in terms of local millet production in Mali namely; Bamako, Segou, Kayes, Koulikoro and Sikasso. Using the Threshold Auto-Regressive (TAR) method developed by **Enders and Siklos (2001)**, at the exogenous threshold, we found an asymmetrical transmission between Koulikoro and Ségou collectors' market. The result shows that, collectors in Koulikoro promptly transmit price increases while they lately transmit price decline at exogenous threshold. Strong evidence was found to suggest that, collectors in Koulikoro and wholesalers in Sikasso punctually transmit a decrease in millet prices to consumers while they tardily transmit the increase in prices to consumers even though the effect of prices increment are relatively larger than the effect of price decrease at endogenous threshold. By applying a zero exogenous threshold we found a non-asymmetric cointegration between Kayes and Ségou, Sikasso and Ségou 'collectors market and between Sikasso and Ségou wholesalers' market. Regardless of the threshold chosen in retailers market, we found symmetric prices transmissions between all the markets pairs. In order to reduce this asymmetric price transmission and to fight against poverty, the authors suggest that decision-makers should consider introducing millet price control in the local markets, especially when millet prices increase spontaneously.

Keywords: Asymmetric price control, Intermediaries, Local millet, Mali, Price transmission
JEL: R52, R58, H41

INTRODUCTION

Despite the important strides and initiatives for poverty reduction by the Millennium Development Goals (MDGs) over the last decades, Mali remains one of the poorest countries in the world with more than 50 percent of its population are living below US$1.25 per day and more than 10.7% of children are still suffering from hunger and malnutrition (**INSAT, 2017**). One of the explanations of this level of poverty, hunger and malnutrition is the fast rise in commodity prices due to the impact of climate changes, which affects agricultural product. The average price of cereals such as millet has risen more than 21 percent between 1990 and 2010 (**Diarra et *al.*, 2011**). Only within the period 2011-2012, the price of millet increased by 67 present (**Diarra et *al.*, 2011**). The same figure is observed in other developing countries where consumer price level of commodities had risen faster than it is falls, which led to the nutrition crisis in the country. For example, in Burkina Faso, the average price of cereal increased by 4% from 2011 to 2012 (**MASSA, 2013**). This asymmetric increase in commodity prices mainly affects poor and vulnerable people such as children and women, and that may restrain development goals and achievement in terms of poverty reduction.

Taking into consideration the context of UN Sustainable Development Goals (SDGs) which make a development case for reducing poverty and under-nutrition in developing countries, this increase in commodity prices becomes problematic. One major explanation for this persistent increase in commodity prices is the presence of a large number of intermediaries between the producers and the consumer (**Diarra, 2008**). In the developing or middle-income countries, or that will affect worldwide food security and leads to the famine (**Şahinli and Fidan, 2011**). Actually, intermediaries play a central role in the millet market in Mali by engaging in the collection, distribution, import and export of the cereal products between local, regional and international markets. Through these activities, they take advantage of the lack of producer's organization in the cereals markets to influence prices for their benefit.

From literature point of views, many scholars have addressed the issues of price transmission in developing countries, focusing on the transaction cost from international market to local market (**Diarra, 2008**), the role of tax policies (**Meuriot, 2012**), as well as the temporal and spatial inefficiency of the cereal markets

(**Diakité, 2006**). On the role of intermediaries in the asymmetric transmission, **Meyer and Von Cramon-Taubadel (2004)** finds that the market power of intermediaries leads to price asymmetric transmission. Authors such as **Kinnucan and Forker (1987**) have studied the asymmetric price responses applied to commercial value chains, which relate to vertical integration, particularly the relations between operators, retail trade and wholesale trade. They then showed that the price responses are asymmetric, knowing that for retail prices, price increments are reflected faster than its decrease. (**McCorriston *et al*., 2001; Carman and Sexton, 2005; Lloyd *et al*., 2006**) develop empirically the relationship between the market power of intermediaries and the transmission of prices. Moreover, they show that the persistence of asymmetry in price transmission is not only due to the strength of the market only, but is also due to others factors such as lack of market information, the presence of transaction costs, and the degree of risk. **Abdulai (2000)** tested the existence of asymmetry transmission of maize's price in Ghana. His results show that the presence of dealer networks, retailers, semi-wholesalers and larger wholesalers with a large market power induce asymmetric transmission of maize's prices in Ghana. In developed countries as well, studies also found that the market power of intermediaries is one of the most important factors of price transmission (**Miller and Hayenga, 2001; Lass, 2005; and Llyod *et al*., 2006**). **Şahinli and Fidan (2010)** also studied the profit level and price formation in hazelnut production in Turkey and they found the presence of intermediaries is motivated by the profit level in the market. Some years prices received by producer is higher than other is. They show that in some years, prices increase and in some years price decrease in the product market. This variability is probably due to the market imperfection such as the presence of intermediaries who try to increase their profit level. **Abbassi *et al.* (2012)** addressed the issue of the impact of inventories on prices transmission in the Canadian chicken industry and found a strong correlation between sales and wholesalers prices.

In this paper, we address this issue by analysing the role of intermediaries in the asymmetric transmission of the price of local millet in Mali by taking into consideration the five most important cities in of millet production in the country. We focus on the role of collectors and wholesalers as the main intermediaries. We applied TAR method developed by **Enders and Siklos (2001)** to test the price transmission between the central market (Ségou) and the other markets as well as Kayes, Koulikoro and Sikasso and Bamako consumers' market. We distinguished the response to positive shocks and the response to negative shocks to identify the asymmetric transmission. We found strong evidence to suggest that, collectors in Koulikoro and wholesalers in Sikasso punctually transmit a decrease in millet prices to consumers while they tardily transmit the increase in prices to consumers at endogenous threshold. The results shows that, collectors in Koulikoro promptly transmit price increases while they lately transmit price decline at exogenous threshold.

DATA AND METHODS

Data and Stationary Issues

We used data on monthly prices collected over the period 1993-2013 by the OMA (Agricultural Market Observatory at Mali). The dataset contains information about producer prices, the collector's prices, the wholesale prices, and retail prices of millet in Mali. Our analysis focused on the five major regions of Mali, which are Kayes, Koulikoro, Sikasso, Ségou, and Bamako's retail prices of millet in Mali. The region of Ségou is the leading producer of local millet in Mali, while Bamako is more of a consumption region. Figure1 presents the circuit of millet's price transmission from producer's market to consumer's market through the intermediaries. Following this chain, a shock on the producer's price will be transmitted to consumers through the intermediaries.

A major threat to the identification of the role of intermediaries in the asymmetric transmission of price is the presence of non-stationarity nature in the prices series. To avoid the risk of inconsistency and fallacious regression, we first test for the stationarity of the price series. To test for stationarity, we rely on the Augmented Dickey and Fuller (ADF) unit root test, which is based on the null hypothesis of the presence of unit root (non-stationarity). The test is performed sequentially by comparing the value of the ADF statistic with the critical values tabulated by **(Mackinnon, 1991).** If the ADF statistic is greater than the critical values tabulated by **Mackinnon (1991),** we do not reject the null hypothesis of unit root presence, which implies that the series is non-stationary. We then differentiate the series and repeat the test until it is stationary. The results of the stationary test are present in Table 1. These results show that all our series are stationary at level. At this extent, we can analyse the cointegration between these prices.

Identification Strategy

Our empirical strategy uses the cointegration existing between the prices in millet markets to analyse the role of intermediaries in the asymmetric transmission analysis. We employ the TAR model developed by **Enders and Siklos (2001).** Eq. 1 gives the empirical specification.

$$P_{i,t} = \Psi + \Psi_1 P_{j,t} + \mu_t \qquad (1)$$

Where: i = Kayes market or Koulikoro market or Sikasso market; j= Ségou market;

$P_{i,t}$ is the millet's price in market i at time t and $P_{j,t}$ is the millet's price in market j at the time t. Ψ_1 captures the transmission of the millet's price from the market j to the market i.

We focus on price transmission from the market of Ségou, which is the largest producer region, to the other markets (Kayes, Koulikoro and Sikasso). A full price transmission implies $\psi 1=1$ and $\psi 1= 0$ implies that the two markets are not related. Unlike Dickey-Fuller's standard cointegration test, the test of **Enders and Siklos (2001)** assumes that the speed of adjustment depends on the nature of the shock (positive and negative). This property allows us to test the transmission of positive and negative

chocks in the local millet market (Eq. 2).

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\rho_2\mu_{t-1}$$
$$\text{with } I_t = \begin{cases} 1 \; if \; \mu_{t-1} \geq s \\ 0 \; if \; \mu_{t-1} < s \end{cases} \quad (2)$$

Where: $\Delta\mu_t$ Vis the variation of the error at time t; I_t An indicator variable; ϑ_t the error term, **s** represents the value of the threshold.

Trust,ρ_1, and ρ_2 indicate the adjustment of negative and positive sequences in the model. To get a better specification of the model, we add the time-lag values of $\Delta\mu_t$ to allow ϑ_t being a white noise. The criterion for selecting the number of lags is carried out from the Akaike Information Criterion (AIC) or Bayesian Information Criterion (BIC). The number of lags selected is the one that minimizes these criteria. The model is written as Eq.3.

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\rho_2\mu_{t-1} + \rho_3\Delta\mu_{t-2} \ldots\ldots\ldots \rho_p\Delta\mu_{t-p} + \vartheta_t \quad (3)$$

Estimation method

There are two-steps involved to estimate the TAR model. First, the case of null threshold and the case of the unknown threshold. The estimation of the model of **Enders and Siklos (2001)** requires first to estimate the long-term relationship and to collect the residuals resulting from this estimation.

In order to test the validity of TAR, two statistics are used, namely the statistic related to the null hypothesis $\rho_1 = 0$ or $\rho_2 = 0$ and the statistic $\emptyset$ of the joint hypothesis $\rho_1 = \rho_2 = 0$. Indeed, the largest statistic is called t-max and the one with the smallest value is call t-min.

The t-max makes it possible to test that $\rho_1 = 0$ and $\rho_2 = 0$ are significantly negative and the statistic $\emptyset$ makes it possible to test the hypothesis according to which $\rho_1 = 0$ and ρ_2 are jointly different from zero.

Thus, the null hypothesis of the TAR model is non-cointegration. Cointegration occurs when the calculated t-max value is lower than its value read on the table of **Enders and Siklos (2001)**. For statistics, $\emptyset$ cointegration occurs when the calculated statistic is greater than its value read on the table of **Enders and Siklos (2001).** The statistic $\emptyset$ is more relevant than the t-max statistic in the case where all the ρ_i are negative and it has a higher power than the t-max.

The threshold, **s** is generally unknown and can be determined endogenously. The procedure involves estimating the long-term relationship and recovering the residuals from this estimate. In order to avoid the influence of the initial values, 15% of the first residues and 15% of the last residues are eliminated. The search for the potential threshold is done in the 70% of the remaining residues. For each potential threshold, the long-term relationship is estimated and the sum of the squares of the residues are retained. The threshold that minimizes the sum of the squares of the residues is the optimal threshold.

RESULTS AND DISCUSSION

The Role of Collectors in Price Transmission

Following a change in the millet "producer's price" at Ségou, Table 2 presents the price transmission to the "collectors' price" in the markets of Sikasso, Koulikoro, Kayes and Bamako. We consider an exogenous zero threshold. These results indicate that the speed of adjustment depends on the positive and negative nature of shocks. Indeed, ρ_i with i = 1, 2 are all negative and significant across all market pairs. These results indicate a convergent model. According to statistic, the adjustment of the negative shocks is equal to the adjustment of the positive shocks on Kayes-Ségou and Sikasso-Ségou market. There is a symmetrical cointegration relationship between these market pairs with a null threshold. In this threshold, the effects of positive shocks are transmitted in the same proportion as negative shocks. This means that, when a negative shock increases producer prices in Ségou such that the prices on the Sikasso and Kayes collection markets are above their long-run equilibrium levels; Sikasso, Kayes' market will transmit this price increase in the same proportion as it was a price decrease. There is an asymmetrical transmission for Koulikoro-Ségou relationship at exogenous threshold. The negative shocks are more quickly than positive shocks. At the endogenous threshold, there is the existence of a threshold effect only for the Koulikoro-Ségou relationship where the ρ_i (i=1.2) are all negative and significant at the 5% threshold. The negative sign reflects the convergence of the estimated models. Therefore, the positive shocks are more quickly than the speed of thenegative shocks. This concludes that the transmission effects of the shocks of the Ségou market to the Koulikoro market are characterized by an asymmetric adjustment with a threshold of null and -4.25.

The Role of Wholesalers

Stemming from the previous results, the results in Table 3 suggest that wholesaler's adjustment to negative shocks is transmit in the same order as the adjustment to positive shocks on all market pairs at the exogenous threshold. In addition, we observed symmetrical cointegration between all pairs market except for Sikasso-Segou relationship. According to statistics, there is an endogenous threshold effect for the market pairs Sikasso-Ségou. There is also a convergent pattern between the models estimated for these relations (ρ_i are negative and significant). Thus, the responses to positive shocks are more important for the market pairs of Ségou. We observed that wholesalers react more quickly to lower prices than to higher prices. The intermediaries influence the transmission of prices by preventing a return to equilibrium after a positive shock.This leads us to admit that the market price transmission effects from Segou to the Sikasso wholesaler' markets are characterized by an asymmetric adjustment with a threshold of -2.24.

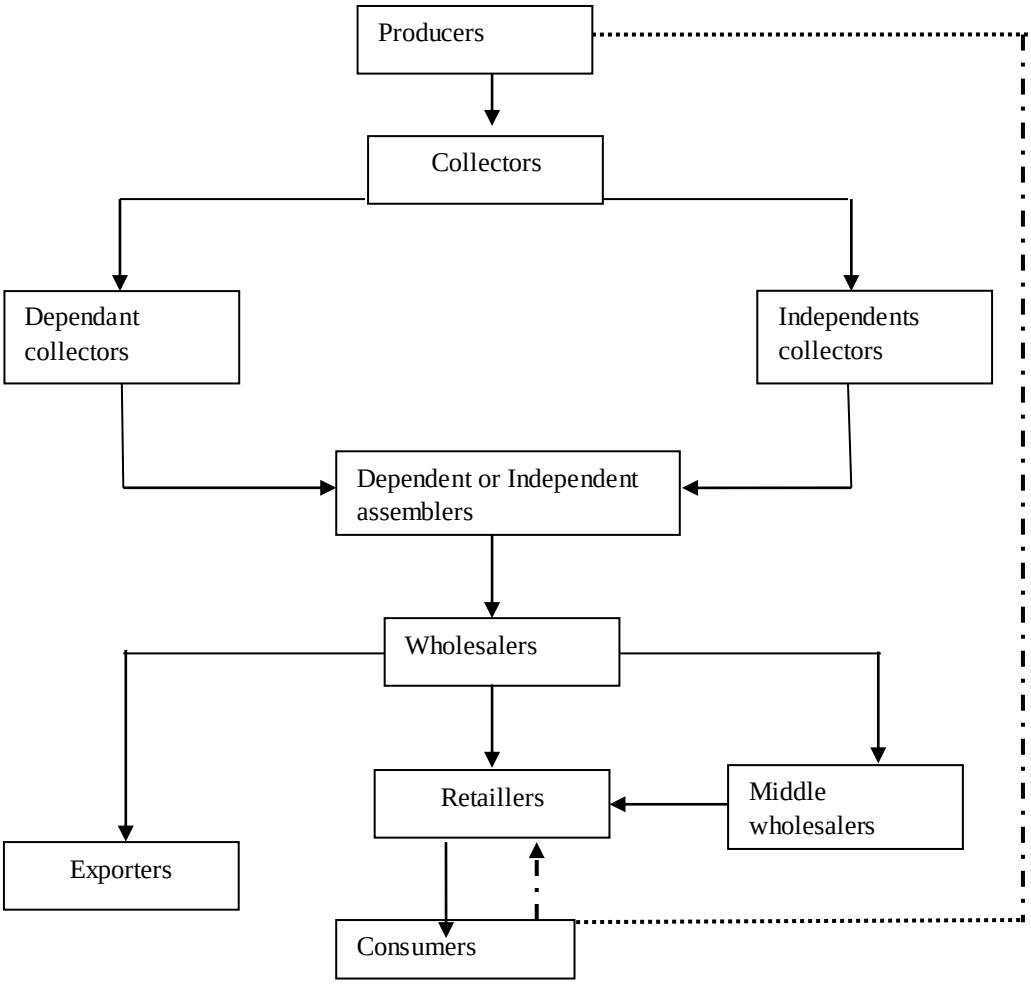


Figure 1: Circuit of price transmission in the millet's market

Table 1: Stationarity Test for Price Series

Regions	Variables	Level	Critical value 5%	Conclusion
Bamako	RPB	-4.092	-3.430	I(0)
Kayes	PPKa	-3.858	-3.431	I(0)
	CPKa	-3.026	-2.880	I(0)
	WPKa	-4.153	-3.4	I(0)
Koulikoro	PPKo	-5.247	-3.430	I(0)
	CPKo	-4.218	-3.430	I(0)
	WPKo	-4.042	-3.430	I(0)
Sikasso	PPSi	-4.371	-3.430	I(0)
	CPSi	-4.181	-3.4	I(0)
	WPSi	-4.027	-3.4	I(0)
Ségou	PPSe	-4.326	-3.430	I(0)
	CPSe	-4.059	-3.430	I(0)
	WPSe	-4.027	-3.430	I(0)

Note: RPB is the retailer Price at Bamako market, PPK the producer price at Kayes market, CPK the collectors price at Kayes market, WPK is the wholesale price at Kayes market; PPSi is the producer price at Sikasso market, CPSi is the collectors price at Sikasso market, WPSi define the wholesale price at Sikasso market; PPSe define the producer price at Segou market, CPSe is the collectors price at Segou market; WPSe is the wholesale price at Segou market.

The Role of Retailers

The results of the estimation of the TAR model are summarized in the Table 4. These results show the existence of price adjustment with a zero and endogenous threshold when the price changes are explained by Ségou's prices. It can be seen that the speeds of adjustment depend on the positive or negative nature of the shocks. There is then a convergent pattern between the models estimated when the threshold is zero because the ρ_i of all the market pairs are significantly negative. On the other hand, the adjustment to negative shocks is equal to the adjustment to zero positive shocks. When the threshold is endogenous,

only the Ségou production market converges to the Bamako's retail market. The reactions to negative shocks are as well equal to that of positive shocks. Positive shocks are also much more persistent that negative shocks. In addition, by referring to the statistic, we conclude there is a non-asymmetric cointegration at zero thresholds between the Bamako's retail market and the Ségou's collection as well as the wholesale and producer' market. Positive shocks are equal to negative shocks. That is, in the event of poor production in the Ségou area, leading to an increase in wholesaler and collection prices in Ségou such that the retail's price of Bamako is lower than its level of long-term production equilibrium. Then retailers (intermediaries) in Bamako will transmit this price increase to the retail's market in Bamako at the same speed that it is price decreasing. Therefore, as a result, our study should have taken all the regions. However, because of the limitation of data, we focused our analysis on the available data.

Table 2: The Role of Collectors in Price Transmission

	CPKa-CPSe	CPKo-CPSe	CPSi-CPSe	CPKa-CPSe	CPKo-CPSe	CPSi-CPSe
ρ_1	-0.58*	-0.41***	-0.5***	-0.09	-0.42**	-0.282
	(-1.79)	(-3.21)	(-5.29)	(-1.34)	(-2.47)	(-1.34)
ρ_2	-0.72*	-0.44***	-0.58***	-0.080	-0.21**	-0.272**
	(-1.69)	(3.39)	(-6.06)	(-1.39)	(-2.13)	(-2.12)
$\rho_1 = \rho_2$	0.48	0.09	1.14	0.12	2.09	0.00
	(0.48)	(0.76)	(0.29)	(0.729)	(0.15)	(0.947)
∅	1.10	6.39	16.48	0.75	3.27	1.53
Threshold	s=0	s=0	s=0	s=-1.41	s= -4.25	s= -2.68

Notes: An asterisk (*) denotes statistical significance at 10% level, (**) denotes statistical significance at the 5% level and (***) denotes statistical significance at the 1% level. Values in parentheses are t-statistics.

The interpretation of the model is done using t-max statistics and ∅ tabulated by **Enders and Siklos (2001),** whose critical values for a sample of 250 are -2.53, -2.12 and-1.90 for the t-max statistic and 8.04, 5.87, and 4.92 for the ∅ statistic, respectively at the threshold 1%, 5% and 10%.

Source: Authors computation based on **OMA (2013)** data.

Table 3: The Role of Wholesalers in Price Transmissioon

	WPKa-WPSe	WPKo-WPSe	WPSi-WPSe	WPKa-WPSe	WPKo-WPSe	WPSi-WPSe
ρ_1	-0.30***	-0.16**	-0.46***	-0.52***	-0.11	-0.84***
	(-2.76)	(-2.35)	(-3.37)	(-3.23)	(-1.05)	(-3.32)
ρ_2	-0.31***	-0.25***	-0.59***	-0.35***	-0.32**	-0.63***
	(-3.14)	(-2.82)	(-3.81)	(-2.99)	(-2.32)	(-3.22)
$\rho_1 = \rho_2$	0.05	2.37	3.97**	2.69	6.06**	3.12*
	(0.82)	(0.13)	(0.05)	(0.102)	(0.02)	(0.08)
	3.32	3.48	6.61	4.85	2.32	3.87
Threshold	s=0	s=0	s=0	s= -4.38	s= 5.88	s= -2.24

Notes: An asterisk (*) denotes statistical significance at 10% level, (**) denotes statistical significance at the 5% level and (***) denotes statistical significance at the 1% level. Values in parentheses are t-statistics.

Source: compute by authors, **OMA (2013).**

Table 4: The Role of Retailers in Price Transmission

	RPB-PPSe	RPB-CPSe	RPB-WPSse	RPB-PPSe	RPB-CPSe	RPB-WPSe
ρ_1	-0.25***	-0.31***	-0.33***	-0.34**	-0.44	-0.22
	(-3.15)	(-3.79)	(-4.11)	(-1.80)	(-1.51)	(-1.31)
ρ_2	-0.32***	-0.39***	-0.44***	-0.34***	-0.241*	-0.38**
	(-3.39)	(-3.94)	(-4.07)	(-2.58)	(-1.78)	(-1.97)
$\rho_1 = \rho_2$	1.57	1.72	2.57	0.01	1.05	2.96*
	(0.21)	(0.19)	(0.11)	(0.93)	(0.31)	(0.09)
∅	4.86	8.21	7.38	2.29	1.32	1.55
Threshold	s=0	s=0	s=0	s=-5.21	s= -5.88	s= 4.23

Notes: An asterisk (*) denotes statistical significance at 10% level, (**) denotes statistical significance at the 5% level and (***) denotes statistical significance at the 1% level. Values in parentheses are t-statistics.

Source: compute by authors, **OMA (2013)** data.

Analysis of Commercial Margins on Local Millet Market

As we argued above, intermediaries influence price transmission to increase their profits. In this section, we analyse the evolution of intermediaries' commercial margins. The commercial margin is the difference between the selling price and the purchase price that augmented the transaction cost of a good.

Collector's Margins

Figure 2 shows the evolution of the commercial margins of collectors. Despite a saw tooth evolution of prices, the aggregate collector margin of collectors remains stationary and positive according the Figure 2. Thus, we noted that, between 1993 and 1998, the collectors of Kayes earned an average commercial margin of 31 FCFA per kilogram. Between the periods of 1999 to 2005, the highest collector margin was recorded in the Koulikoro region (35 FCFA per kilogram). In the graph MCSE, MCSI, MCK and MCKO as define as the collectors' margin obtained at Ségou, Sikasso, Kayes and Koulikoro.

Wholesaler's Margins

Figure 3 shows a slight variability of commercial margins of wholesalers in the regions of Ségou, Sikasso, and Koulikoro. Moreover, apart from 1998/2002 and 2003/2004 figures, the wholesalers of Kayes recorded the highest margin over the entire study period with a maximum of 80 FCFA / kg observed in 2005. In addition, the evolution of wholesalers' margins was characterized by hollows and peaks, but stayed stationary and positive.

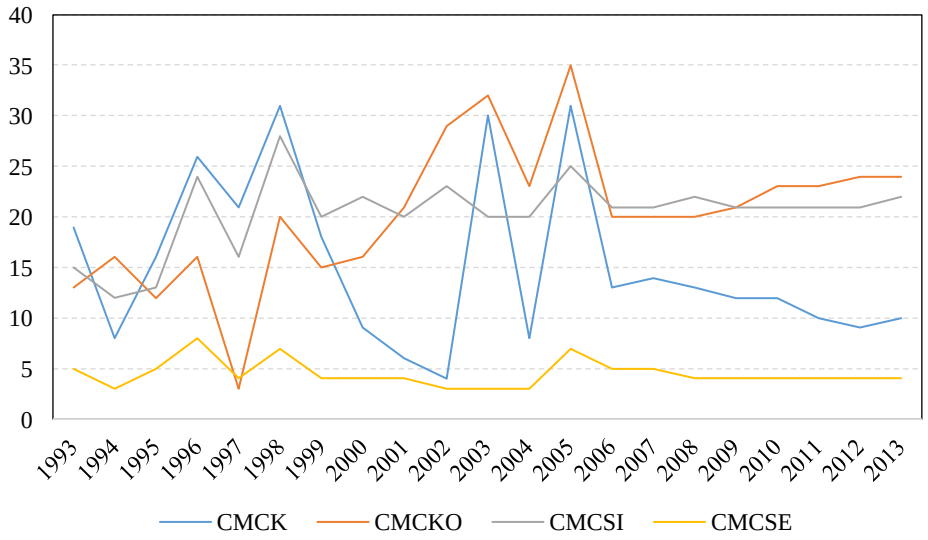
Retailer's Margin

Figure 4 shows the evolution of the commercial margins of retailers. We observed a sawtooth variability of the margins of retailers in all regions, including the district of Bamako. It is much more accentuated in Bamako and sometimes in the region of Kayes. The results suggest a significant difference between the margins achieved by retailers in the district (54 FCFA / kg in 2013 and those in other regions, except for the region of Kayes). In summary, the analysis reveals that intermediaries captured a positive margin over this period 1998- 2013 in the local millet's market despite the food crisis. This margin may explain the asymmetric price transmission in the local millet's market of Mali.

DISCUSSION

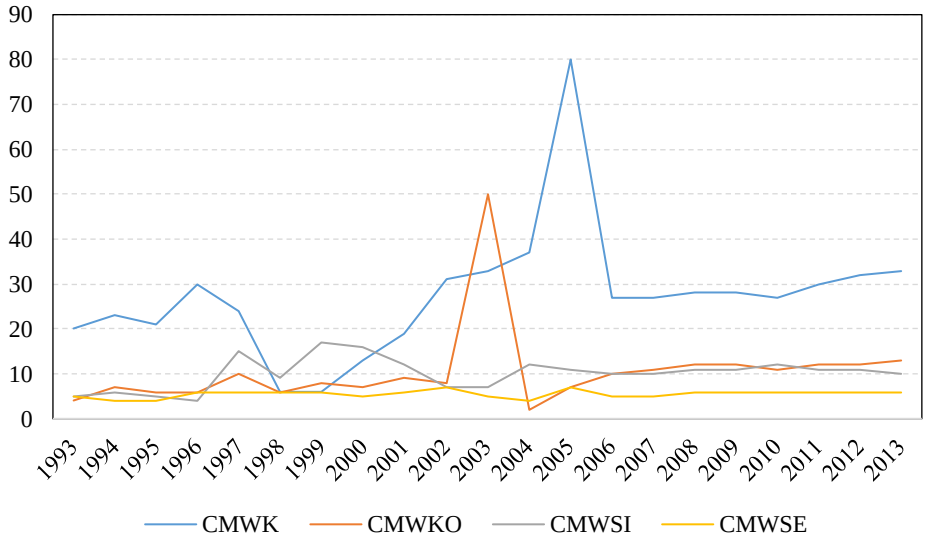
The descriptive analysis shows that intermediaries influence the prices transmission by increasing their commercial margins. This creates asymmetric transmission on Koulikoro-Ségou and Sikasso-Ségou markets pairs. However, we will have had to extend our study to the others regions, but due to the availability of data over the entire period, we have confined ourselves to the five major regions selected.

The analysis of the local millet collection market in Mali shows the existence of a price adjustment with a zero exogenous threshold when the price variations in the Kayes and Sikasso collection market are explained by the Ségou collection market. This result indicates that the speed of adjustment depends on the positive and negative nature of the shocks. Indeed, $\rho_i \; with \; i = 1,2$ are all negative and significant across all market pairs. It means that the estimated models are convergent. So, they is an endogenous threshold when the price variation in Koulikoro is explain by Ségou market. In this threshold, the negative shocks are more quickly than positive shock.The t-max statistic of the market pair Kayes-Segou relationship was -1.69 and is greater than its critical value tabulated in **Enders and Siklos (2001)** at the 1% threshold, which is -2.53. In this case, the hypothesis of asymmetrical cointegration between the Kayes collection market and the Ségou collection market is rejected and the null hypothesis of asymmetric non-cointegration is accepted. The Ø-statistic calculated for the same relationship was 1.10. It is below its critical value at the 1% threshold tabulated in **Enders et Siklos (2001)**.



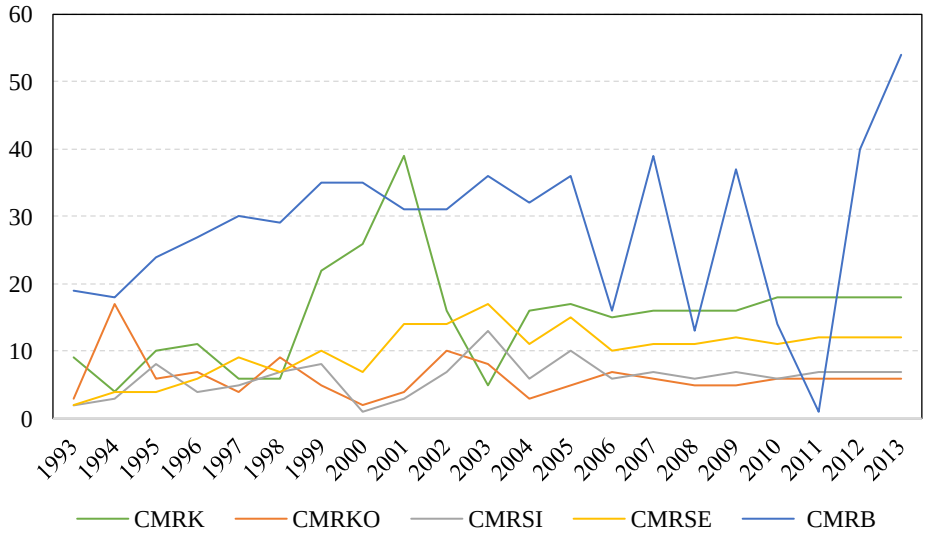
Source: Authors, 2019

Figure 2: Evolution of Commercial Margins of Collectors



Source: Authors, 2019

Figure 3: Evolution of Commercial Margins of Wholesalers



Source: Authors, 2019

Figure 4: Evolution of Commercial Margins of Retailers.

Consequently, we cannot also accept the hypothesis of asymmetrical cointegration between the pair market. If we take the F-statistic that tests the joint hypothesis $\rho_1 = \rho_2 = 0$, we find that this statistic is equal to 0.48 with a p-value of 0.48, which is not significant. So, it mean that ρ_1 *and* ρ_2 are statistically equal. It is concluded that the price transmission effects of Ségou to Kayes are characterized by a symmetrical adjustment with a zero exogenous threshold. However, for Koulikoro-Segou relationship, the t-max is 3.39, and was greater than the critical value at the 1% threshold. For this relationship, we can not accept the hypothesis of asymmetrical cointegration between the Ségou and Koulikoro collection markets. Thus, the Ø-statistic of the same relation is 6.39. This statistic is lower than the statistic read at the 1% threshold. Looking also at the probability of the joint statistic, we see that it is significant at 10%. So the coefficients ρ_1 *and* ρ_2 is different. This then allows us to accept the hypothesis of asymmetrical cointegration between Koulikoro and Ségou' market. Regarding the Sikasso-Ségou relationship, the t-max is -5.29. This value is less than the value read on the table of Enders and Siklos at the threshold at 1%. Therefore, we can not accept the hypothesis of asymmetric non-cointegration (symmetrical cointegration) between the two market. The Ø-statistic analysis allowed us to reject the hypothesis of asymmetric non-cointegration between the market pair. Looking also at the probability of the joint statistic, we see that it is insignificant. So the coefficients $\rho_1 = \rho_2 = 0$. Then, we can deduce the existence of a symmetrical cointegration relationship between the Sikasso and Ségou' market. In conclusion, there is a symmetrical cointegration

relationship between Kayes-Ségou, Sikasso-Ségou pairs markets of zero exogenous at the collectors markets. Thus, the effects of positive shocks are transmitted in the same proportion as negative shocks. This means that, when a negative shock increases producer prices in Ségou so that the prices on the Sikasso, Koulikoro and Kayes collection markets will get above their long-run equilibrium levels, Sikasso, Kayes and Koulikoro' market will transmit in the same proportion in the case of a price decrease.

At the endogenous threshold, there is the existence of a threshold effect only for the Koulikoro-Ségou relationship where the ρ_i (i=1.2) are all negative and significant at the 5% threshold. The negative sign reflects the convergence of the estimated models. The response to positive shocks are twice as fast as the response to negative shocks as this is in contradiction at the previous studies which specifies that the negative shocks are twice as fast as the responses to negative shocks (**Enders et Siklos, 2001; Chen *et al.*, 2005; Abdulai, 2000; Sanogo and Maliki, 2008**). On the other hand, negative shocks are more persistent than positive shocks. For example, following good rainfall in the Ségou region, which decreases colletor prices in Ségou, collectors in the Koulikoro areas will more rapidly transmit this price decreases on the Koulikoro producer markets until prices reach their long-term equilibrium levels.

The t-max calculated for the Koulikoro-Ségou relationship is -2.13, which is higher than the value read on the table at the threshold of 1%. Therefore, we cannot reject the null hypothesis of asymmetric non-cointegration between the market pair. The Ø-statistic value is 16.48, which is greater than its read value at 1%. We then reject the hypothesis of asymmetric non-cointegration in favor of the hypothesis of asymmetric cointegration between the market pair. This is concluded that the transmission effects of the shocks of the Ségou market to the Koulikoro market are characterized by an asymmetric adjustment with a threshold of -4.25. Thus, a shock in Ségou will lead to an asymmetric price response in Koulikoro only if this shock is much larger so that prices in Koulikoro are above or below their long-term equilibrium level plus the threshold.

At the wholesaler's side, the adjustment to negative shocks is much faster than the adjustment to positive shocks on Sikasso-Ségou market pairs at the zero exogenous threshold. At this threshold, positive shocks are much more persistent than negative shocks. On the other market despite that negativity of ρ_i , there are a symmetric prices transmission. The t-max calculated for the Kayes-Ségou, Koulikoro-Ségou and Sikasso-Ségou relationship are -2.76, -2.35 and -3.37 respectively. Comparing with their value read (-2.12) on the table at the threshold of 5%, we note that they are all less than this value. In this case, we cannot reject the hypothesis of asymmetric cointegration between these market pairs at the exogenous zero threshold. The Ø-statistics for the same relationships are also 3.32, 3.48 and 6.61 respectively. They are all also less than the value read at the 1% threshold. Therefore, we cannot accept the hypothesis of asymmetric cointegration between market pairs at the zero exogenous threshold. The statistic of the joint hypothesis for the Sikasso-Segou relation makes it possible to reject the symmetric transmission hypothesis in favor of the hypothesis asymmetric cointegration. From this result, we conclude that there is a symmetrical cointegration relationship between all market pairs except for the Sikasso-Segou relationship. We also note that the effects of positive shocks are equal to the effects of negative shocks. For example, following poor rainfall in the Ségou region, which pushes up wholesale prices in Ségou, wholesalers in the Sikasso areas will transmit this price increase on the Sikasso wholesale price at the same degree that a price decrease, until prices reach their long-term equilibrium levels.

With an endogenous threshold, the estimate also shows that the ρ_i (i=1.2) of the Kayes-Ségou and Sikasso-Ségou relationship are all negative and significant. We find that the adjustment to positive shocks is very important than that to negative shocks for Sikasso-Ségou relationship but negative shocks are much more persistent than positive shocks. In the event of a good agricultural season in the Ségou region, lowering the wholesale price below its long-run equilibrium level, wholesalers in Sikasso will transmit this price decrease much more quickly to their own market until prices return to their long-run equilibrium level. Because the symmetrical transmission, the wholesalers of Kayes will transmit the price increases in the same proportion that the decreases. On the other hand, a bad crop season would cause a price increase above the long-term equilibrium level. By reasoning with the t-max statistic, we note that it is -2.99 for the Kayes-Ségou relationship and -3.22 for the Sikasso-Ségou relationship. These statistics are all below the tabulated critical value in Enders and Siklos (2001) at the critical 1% threshold. This means that we cannot reject the hypothesis of asymmetric cointegration at the 1% threshold. Referring to the Ø statistic, we see that it is 4.85 for the Kayes-Ségou relationship and 3.87 for the Sikasso-Ségou relationship. All of these statistics are less than the value read on the table at the 1% threshold. This allows us to reject the hypothesis of asymmetric cointegration between market pairs. The probability of the joint statistic $\rho_1 = \rho_2 = 0$ is 0.102 for Kayes-Ségou and 0.08 for Sikasso-Ségou. At a threshold of 1%, we cannot reject the hypothesis of asymmetrical cointegration between Sikasso-Segou. This leads us to admit that the market price transmission effects from Segou to the Sikasso wholesaler markets are characterized by an asymmetric adjustment with a threshold of -2.24. Thus, a shock in Ségou will lead to an asymmetric price response in Sikasso only if this shock is much larger so that prices in Sikasso are above or below their long-term equilibrium level plus the threshold.

The analysis of the relationship between the Bamako's retail market and Ségou's production, collection and wholesaler markets shows that all ρ_i of all market pairs are negative and significant at the exogenous threshold zero. This allows us to admit the convergence of the estimated models. Indeed, the speed of adjustment to negative shocks is faster than that of positive shocks for retailer-Collector market. Nevertheless, the positive shocks are more persistent than negative shocks. The calculated Ø -statistics for producers, collectors and wholesalers market are respectively 4.86, 8.21 and 7.38.

Apart from the collection market where there is asymmetrical cointegration, the transmission between the retail market and the other markets is symmetrical at the 1% threshold. The probability of the joint hypothesis $\rho_1 = \rho_2 = 0$ for all market pairs is insignificant. Therefore, we cannot accept the asymmetrical hypothesis between the market pair. We conclude the existence of the symmetrical cointegration between the market pair at the exogenous threshold null. At endogenous threshold, it is found that all ρ_i are negative and significant only for the retail-producer market pair. Therefore, the estimated model is convergent. On the other hand, the response to positive shocks is roughly equal to the response to negative shocks. The $\emptyset$ -statistic is 2.29 that suggests the existence of a non-asymmetric cointegration relationship between all the market pair with a threshold of -5.21.

As a result, the econometric analysis first shows that all the series are integreted of null order. It also confirms the hypothesis of asymmetrical cointegration between the Segou and Koulikoro collection' markets at the exogenous and endogenous threshold, and the Ségou and Sikasso wholesalers' market at the endogenous threshold. In the other markets, symmetrical transmission was observed between the pairs of markets. The symmetrical transmission is explain by the price competitiveness on the market. This mean that the wholesalers at Sikasso and Koulikoro can buying the product from another regions or countries and supply on their own market.

SUMMARY AND CONCLUSION

In this paper, the authors examined the role of intermediaries such as collectors, wholesalers, and retailers in the price transmission of millet in Mali's local millet market. To do so, they considered the most important cities, namely Bamako, Ségou, Kayes, Koulikoro and Sikasso. They used the **Enders and Siklos (2001)**'s Threshold Auto-Regressive method as well as monthly price data collected over the period 1993-2013 from the Agricultural Market Observatory, which contain the producer prices, the collector's prices, the wholesale prices and Bamako's retail prices of millet. The region of Segou is the leading producer of local millet in Mali while Bamako is more of a consumption region. At the exogenous threshold, we found also an asymmetrical transmission between Koulikoro and Ségou collectors' market' market. The result show that, collectors in Koulikoro quickly transmit price increases while they slowly transmit price decline. Strong evidence were found to suggest that, collectors in Koulikoro and wholesalers in Sikasso quickly transmit a decrease in millet prices to consumers while they slowly transmit the increase in prices to consumers even though the effect of prices increment are relatively larger than the effect of price decrease at endogenous threshold.

We found a non-asymmetric cointegration between Kayes-Ségou, and Sikasso-Ségou 'collectors market and between Sikasso and Ségou wholesalers' market when we chose a zero exogenous threshold. Regardless of the threshold chosen in retailers market, we found symmetric prices transmissions between all the markets pairs. The results indicate that intermediaries capture commercial margins leading to this asymmetric price transmission in the market of local millet. In order to reduce this asymmetric price transmission and to fight against poverty, the authors suggest that policymakers should consider introducing millet's price control in the local markets, especially when millet prices increase spontaneously.

REFERENCES

ABBASSI, A., TAMINI, L. D., & GERVAIS, J. P. (2012). Do inventories have an impact on price transmission? Evidence from the Canadian chicken industry. *Agribusiness*, *28*(2), 173-186. DOI: https://onlinelibrary.wiley.com/doi/abs/10.1002/agr.21292

ABDULAI, A. (2000). Spatial price transmission and asymmetry in the Ghanaian maize market. *Journal of development economics*,*63*(2), 327-349. DOI: https://doi.org/10.1016/S0304-3878(00)00115-2

CARMAN, H. F., & SEXTON, R. J. (2005). Supermarket fluid milk pricing practices in the Western United States. *Agribusiness: An International Journal*, *21* (4), 509-530. DOI: https://doi.org/10.1002/agr.20062

CHEN, L. H., FINNEY, M., & LAI, K. S. (2005). A threshold cointegration analysis of asymmetric price transmission from crude oil to gasoline prices. *Economics Letters*, *89* (2), 233-239. DOI: https://www.sciencedirect.com/science/article/pii/S016517650500217X

DIAKITE, L. (2006). Fonctionnement du marché céréalier au Mali. Une analyse néo-institutionnelle de son organisation et son efficacité temporelle et spatiale (Doctoral dissertation, Thèse de Doctorat de Sciences Economiques. Université de Ouagadougou (Burkina Faso)).

DIALLO, A., & DIARRA, S. B. (2011). *Etude sur la stratégie de commercialisation des céréales au Mali;* Bamako. https://docplayer.fr/6511958-Rapport-diagnostic-etude-sur-la-strategie-de-commercialisation-des-cereales-au-mali-consultants.html

DIARRA, S., DIALLO, A., SOULE, B., & STAATZ, J. (2011). Schéma de commercialisation des céréales au Mali. *Ministère de l'Agriculture. Bamako*.http://docplayer.fr/9250828-Schema-de-commercialisation-des-cereales-au-mali.html

ENDERS, W., & SIKLOS, P. L. (2001). Cointegration and threshold adjustment. *Journal of Business & Economic Statistics*, *19*(2), 166-176. DOI: https://doi.org/10.1198/073500101316970395

FIDAN, H., & SAHINLI, M. A. (2010). Profit level and price fixing in hazelnut production. *The Journal of Animal & Plant Sciences*, *20* (2), 117-122. DOI: https://www.researchgate.net/publication/266465875_Profit_level_and_price_fixing_in_hazelnut_production

INSAT. (2017). Enquête Nationale Nutritionnelle et de Mortalité Rétrospective suivant la méthodologie SMART. Mali.https://fscluster.org/sites/default/files/documents/rapport_final_smart_septembre_2018_mali.pdf

KINNUCAN, H. W., & FORKER, O. D. (1987). Asymmetry in farm-retail price transmission for major dairy products. *American journal of agricultural*

economics, *69* (2), 285-292. DOI: https://www.jstor.org/stable/1242278

LASS, D. A. (2005). Asymmetric response of retail milk prices in the northeast revisited. *Agribusiness: An International Journal*, *21*(4), 493-508. DOI: https://doi.org/10.1002/agr.20061

LLOYD, T. A., MCCORRISTON, S., MORGAN, C. W., & RAYNER, A. J. (2006). Food scares, market power and price transmission: the UK BSE crisis. *European Review of Agricultural Economics*, *33*(2), 119-147. DOI: https://doi.org/10.1093/erae/jbl001

MACKINNON, J. G. (1990). Critical values for cointegration tests (pp. pp-267). San Diego: Department of Economics, University of California.http://qed.econ.queensu.ca/working_papers/papers/qed_wp_1227.pdf

MEURIOT, V. (2012). Une analyse comparative de la transmission des prix pour l'orientation des politiques publiques : le cas du riz au Sénégal et au Mali (No.12 04).https://www.researchgate.net/publication/254427491_UNE_ANALYSE_COMPARATIVE_DE_LA_TRANSMISSION_DES_PRIX_POUR_L'ORIENTATION_DES_POLITIQUES_PUBLIQUES_LE_CAS_DU_RIZ_AU_SENEGAL_ET_AU_MALI/stats

MEYER, J., & VON CRAMON-TAUBADEL, S. (2004). Asymmetric price transmission: a survey. *Journal of agricultural economics*, *55*(3), 581-611. DOI: https://doi.org/10.1111/j.1477-9552.2004.tb00116.x

MILLER, D. J., & HAYENGA, M. L. (2001). Price cycles and asymmetric price transmission in the US pork market. *American Journal of Agricultural Economics*, *83*(3), 551-562. DOI: http://hdl.handle.net/10.1111/0002-9092.00177

OMA - Agricultural Market Observatory. (2013). Ministère de l'agriculture et de la sécurité alimentaire. Résultats définitifs de la campagne agricole et de la situation alimentaire et nitruuctionnelle. Ouagadougou. http://cns.bf/IMG/pdf/rapport_general_des_resultats_definitifs_2012_2013.pdf

SANOGO, I., & MALIKI, A. M. (2008). Intégration des marchés du riz entre le Nepal et l'Inde: Application d'un modèle de cointégration à effet de seuil. https://docplayer.fr/20314680-Integration-des-marches-du-riz-entre-le-nepal-et-l-inde-application-d-un-modele-de-cointegration-a-effet-de-seuil.html

ŞAHINLI, M. A., & FIDAN, H. (2012). Estimation of food demand in Turkey: method of an almost ideal demand system. *Quality & Quantity*, *46*(2), 653-663. DOI: https://link.springer.com/article/10.1007/s11135-010-9419-4

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REGULAR ARTICLE

SMALLHOLDER FARMERS' INNOVATIVENESS AND ITS DETERMINANTS IN EASTERN HARARGHE, OROMIYA REGION, ETHIOPIA

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ABSTRACT

The survival of smallholder farming in a socioeconomically and environmentally dynamic environment depends on smallholders' ability to innovatively and dynamically respond to these challenges. This study aims to assess smallholders' innovativeness, and identify its determinants with the intension of providing information on smallholders' innovativeness and its determinants to stakeholders that are trying to improve the life of smallholders. The research design constituted of multi-stage random sampling whereby study districts, farmers' associations and, finally, smallholder farmer household units are selected in that order. The collection of data is carried out using interview schedule, key informants interview and focus group discussion. The estimation of smallholders' innovativeness was carried out with graded response model using cross-sectional data collected from 476 smallholder household units. Multiple linear regression model was used to identify determinants of innovativeness. The results revealed that the majority of smallholders in the study area were classified as less innovative and innovativeness was determined by smallholder's perception of productive safety net program undergoing in the study area, dependency syndrome, perceived farm fertility, perceived job demand, perceived person environment fit, fatalism, external work contact, use of mass media, possession of livestock, possession of farm tools, access to irrigation, agro-ecology and distance to all-weather road. In order to encourage smallholders' innovativeness, the findings underscore the need for stakeholders in the extension service to help smallholders on improving their perceptions about productive safety net program, motivate them to see the potential benefit they can draw from personal efforts and resources they have, provide them with external exposure through either mass media means or interpersonal contact, work with religious leaders to detach religiousness from fatalism.

Keywords: Innovativeness, Smallholder Farmers
JEL: O31, Q100, R21

INTRODUCTION

In Ethiopia, smallholder agriculture is characterized by age-old technologies and agricultural management system **(EPCC, 2016)**. Around eight million people who live on this occupation receive support from productive safety net, a program that is targeted at bringing resilience to shocks and livelihoods enhancement, and food security and nutrition improvement, for rural households vulnerable to food insecurity **(MoA, 2014; NPC, 2016)**. Despite the impediments and self-insufficiency, agriculture's contribution to the overall economic growth of the country is paramount as it accounts for 34.9% of the country's GDP in the year 2017/18 **(NBE, 2018)**, employs about 85% of the labour force and contributes around 90 percent of the total export earnings **(CSA, 2016)**. If the sector is to satisfactorily and sustainably contribute to the ever growing economic demand of the population, it should develop and be able to adapt itself to ever changing and demanding situations. Agricultural development which demands and depends on innovation and innovation system enables agriculture and people to adapt rapidly when challenges occur and to respond readily when opportunities arise **(World Bank, 2012)**. Innovation is widely recognized as a major source of improved productivity, competitiveness, and economic growth throughout advanced and emerging economies **(OECD, 2009a)**. Innovation involves three elements viz. idea generation, idea promotion and realization. It requires combining a creative idea with resources and expertise that make it possible to embody the creative idea in a useful form. **(Janssen, 2000; Schilling, 2017)**. In rural sectors, the efforts of family farmers to adapt their farming system to local conditions by applying indigenous knowledge which they have experimented and accumulated through time can be considered as a source of rural innovation, a perspective that should be considered in order to develop a concept of innovation that strengthens family farming as part of sustainable rural development **(Beduschi *et al.*, 2017)**. Smallholder farmers' innovation like any other firm is mediated by, among other factors, economic capability and a feeling of enthusiasm, interest, or commitment towards farming as the self-determination theory elaborates the necessity for intrinsic motivation in carrying out a task innovatively **(Amabile, 1997) (Deci and Ryan, 1985)**. As a social protection service, productive safety net program (PSNP) provides an enabling environment conducive to

innovative agricultural engagement since it enhances the capabilities of smallholders through financial transfer, provision of livelihood support, skills training and behaviour change communication to its beneficiaries **(OECD, 2009b; Devereux and Sabates-Wheeler, 2004)**. PSNP makes transfer, cash and/or food to beneficiaries through its public work, permanent direct support, livelihood transfer and risk management components. In the public work component, households with able-bodied labour are expected to participate in public work tasks and get six months payment while in the permanent direct support component households without adult able-bodied labour are provided with 12 months of free transfer. The other two components are integral parts of the first two **(MoA, 2014)**.Hence, investigating smallholders' innovativeness and its determinants is crucial if Ethiopian economy has to benefit from agriculture in a dependable manner. Nevertheless, in Ethiopia studies on smallholders' innovativeness that considers the perspective of ingeniousness, creativity or inventiveness has not been adequately addressed as the search for similar studies came up only with the works of **Gebre and Zegeye (2014)** on challenges of farmers' innovativeness and **Tirfe (2014)** on smallholder farmers' innovation and its determinants in northern part of Ethiopia. Besides, smallholders' innovativeness has been seen by researchers, predominantly, from the perspective of adoption of innovation. Therefore, innovativeness as conceptualized by **Lumpkin and Dess (1996)** as an individual's (smallholder's) behaviour that aims to achieve the initiation and intentional introduction of new and useful ideas, processes, products or procedures to enhance personal and/or business performance, and its determinants while controlling for the effect of PSNP need to be sufficiently addressed. Therefore, this study provides evidence on smallholders' innovativeness and its determinants to stakeholders that are trying to improve the life of smallholders.

DATA AND METHODS

Study area

Oromiya regional state consists of 20 administrative zones including east Hararghe zone which comprises 19 districts. The total population of east Hararghe is estimated at 2,723,850 people of whom 211,606 and 2,502,365 are urban and rural dwellers, respectively **(CSA, 2007)**. The zone is found in the eastern part of Ethiopia. Its capital is Harar, located 510 km to the east of the Ethiopian capital Addis Ababa. Although the zone has a significant area of land and a relatively large population, it is ranked as the last among all zones of Oromiya region in terms of surface and ground water potential. The zone has two main drainage basins, namely the Wabishebele and Awash drainage basins. Due to the topography and hydro-geological condition, east Hararghe is a water resource scarce area **(Jema *et al*., 2010)**. It is characterized by plateaus, rugged mountains, deep gorges and flat plains. The altitude ranges from 500 to 3,400 meters above sea level. The zone contains three agro-ecological zones, highlands (elevations above 2,300 m a.s.l), midlands (elevations between 1,500 and 2,300 m a.s.l) and lowlands (below 1,500 m a.s.l). The lowlands occupies the largest area (62.2%), followed by midlands (26.4%) and highlands (11.4%) **(Tolossa and Tafesse, 2008)**. Information collected from zone office of agriculture indicates that PSNP is underway in all districts where there are a total of 115,431 beneficiary households of which 388,036 and 56,729 individuals are supported by the public work and direct support components of the program, respectively. Community member who are chronically food insecure, faced continuous food shortages (3 months of food gap or more per year) in the last 3 years or those who have become suddenly food insecure as a result of a severe loss of assets or those who have no adequate family support and other means of social protection and support are targeted by community food security task force to be PSNP beneficiaries.

Sampling techniques and the data

The overall sampling design followed multi-stage random sampling where study districts, farmers' associations and households have been selected in that order. Since controlling for the effect of agro-ecological zone and participation in productive safety net program (PSNP) was deemed necessary in analysing determinants of innovativeness, the sampling procedure had taken these factors into consideration. To this effect districts were stratified as lowland and midland firstly, whereas households in both strata were stratified again as PSNP participants and non-participants. Hence, the sampling frame at the household level is constituted of beneficiaries of public work component of PSNP and non-beneficiaries. In the first stage two districts, one from lowland and one from midland agro-ecological zones, were randomly selected among the 19 districts found in the zone. In the second stage, 5 farmers' associations, three from lowland and two from midland areas, considering their proportion of geographical coverage, were randomly chosen. Finally, sample households were randomly selected from a list obtained from the district offices of agriculture and farmer associations' development center offices. Cross-sectional data from 476 randomly selected sample households were collected. The survey was conducted during the period of July - September 2018 in Fedis and Haramaya district. Data were collected with the help of interview schedule, key informant interviews (seven informants, one from each farmers' association and one from each districts) and focus group discussions that is consisted of 5-6 members (two groups from each farmers' association) where participants are identified by development agents (DAs). Focus group discussion was conducted with PSNP participants and non-participants separately. Participants of key informant interviews and focus group discussions were selected based on their informative capacity with regard to the study area and implementation of PSNP. The contents of the information delivered by the participants was analysed and summarized.

Methods of data analysis

Smallholders' innovativeness was operationally defined to measure the extent to which smallholders' generate and/or utilize novel ideas, champion it, implement it in practice and evaluate its performance. Its measurement was done

by 8-items 5-point scale ranging from 'never' (1) to 'always' (5) based on **Janssen (2000)**. The instrument was modified to suit survey contextual specificity. Innovativeness was assumed to represent a latent trait construct. The use of multiple-category types of item-response data were justified for estimation of this construct as these data set are more informative and reliable than dichotomously scored items. Hence, polytomous item response theory (IRT) model was used to represent the nonlinear relation between innovativeness level and the probability of responding in a particular category. The estimations of model parameters for these latent variables were carried out by employing graded response model (GRM).The graded-response model (GRM) is appropriate to use when item responses can be characterized as ordered categorical responses **(Embretson and Reise, 2000)**. The GRM allows the ordered categories to vary between items; assuming the outcome levels for all items are given by $k = 0,1, \dots, K$, the model is specified as follows. In the GRM, each item is modeled with its own discrimination parameter and cut-points that identify boundaries between the ordered outcomes. The probability of observing outcome k or higher for item i and person j is given by Eq. 1.

$$Pr(Y_{ij} \geq k|\theta_j) = \frac{exp\{a_i(\theta_j - b_{ik})\}}{1+exp\{a_i(\theta_j - b_{ij})\}} \theta_j \sim N(0,1) \qquad (1)$$

Where a_i represents the discrimination of item i, b_{ik} is the kth cut-point for item i, and θ_j which takes a value of any real number is the latent trait of person j. The cut-point b_{ik} can be considered as the difficulty of responding with category k or higher for item i.

Measure of reliability of the use of the instrument is done based on assessment of internal consistency which investigates the proportion of variance accounted for by the estimator of a respondent's trait level. A direct index of reliability for Bayesian scores for the sample data can be calculated as Eq. 2.

$$Reliability = \left(\frac{s_{\hat{\theta}}^2}{s_{\hat{\theta}}^2 + \bar{s}_e^2}\right) \qquad (2)$$

Where $s_{\hat{\theta}}^2$ is the variance of the score estimates (in other words, the observed score variance) and $\bar{s}_e^2$ is the average squared standard error, calculated as the mean of the squared standard errors for the examinees in the sample.

However, as the metric is scaled such that the direct estimate of the variance of θ is equal to 1, then the variance of the Bayesian score estimates is an estimate of the reliability **(DeMars, 2010)** which, in this case, is the square of the standard deviation of the estimated scores. Validity of the instrument's usage was verified through examination of the correlation between the constructs and other variables which the construct should predict.

Once demonstrated innovativeness for each sample household heads had been estimated, the results obtained were used for further analysis of factors affecting innovativeness using multiple linear regression. The multiple regression model employed was specified as Eq.3.

$$y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots \beta_k X_k + u \qquad (3)$$

Where β_0, is the intercept, β_1 is the parameter associated with explanatory variable X_1 , β_2 is the parameter associated with explanatory variable X_2 and so on. The variable u is the error or disturbance term. It contains factors other than $X_1, X_1, \dots, X_k$ that affect y. In equation 3 y represents innovativeness score. Explanatory variables used in the regression model are described in Table 1.

RESULTS AND DISCUSSION

Prevalence of Innovativeness among Smallholder Farmers

Demonstrated innovativeness among smallholder was assessed through 8-item Likert scale instrument followed by 5-point responses (Never = 1, rarely = 2, sometimes = 3, often = 4, always = 5) that is adapted from **Janssen, (2000)** scale for assessment of individual innovative behaviour in the workplace. A Mokken procedure conducted for ensuring unidimensionality and local independence assumption with the help of msp module in STATA 14 proved that the scale qualified Mokken scale with all items. Smallholders' level of demonstrated innovativeness has been estimated through graded response model. The score distribution was estimated along with the item parameters, on the same metric as the item parameters. The metric was set such that the mean perception level was 0 with a standard deviation of 1 which is one of the standard ways of employing the model **(Embretson and Reise, 2000)**. The graded response model output for innovativeness is shown in Table 2.

The approximate overall goodness of fit of the fitted model has been assessed using limited-information fit statistics as suggested by **Maydeu-Olivares and Joe (2014)** using flexMIRT software program. The estimated sample bivariate root mean square error of approximation was found to be 0.06 which is better than the recommended adequate fit cutoff value ≤ 0.089. A direct index of reliability for Bayesian scores for the sample data is calculated to be 0.88 whereas the Cronbach's alpha measure of reliability is 0.91 based on total number score. It was also attempted to assess the validity of the innovativeness measurement scale by empirically evaluating the correlation between it and dependency syndrome, TLU and farm tool possession. The assumption was that innovative people will not be characterized by dependency syndrome and will possess more productive asset such as TLU and farm tools. On these bases innovativeness was expected to be negatively correlated with dependency syndrome and positively with TLU and farm tool possession. Though weak, the correlation results obtained confirmed the presumed directions giving positive evidence on the validity of the instrument used for measuring innovativeness.

Table 1 Description of the variables hypothesized to influence smallholders' innovativeness

Variables	Variable description	Measurement	sign
perception	measure of perception about PSNP	scale	+
dependsynd	measure of effort exerted on own farm job	scale	-
psnpmem	participation in PSNP	Nominal (yes=1)	+
agroecol	agro-ecological zone in which the household lives and operates	Nominal (lowland=1)	+
Sex (sex)	sex of the household head	Nominal (male=1)	+
age65	state of being under the age of 65	Nominal (below 65=1)	+
marital	marital status of the household head	Nominal (maried=1)	+
hhheduc	education level of the household head	Scale	+
hmaxed	maximum level of education attained by member of the household other than the head	Scale	+
hhsize	number of member of the household	scale	+
credit	amount of credit taken by the household since 2015	scale	+
training	frequency of participation in extension trainings or field day visits	scale	+
irrgacce	household's access to irrigation	Nominal (yes=1)	-
farmfert	satisfaction on perceived fertility of farm plots	Nominal (satisfied=1)	-
lnfarmtool	possession of farm tools in monetary value	scale	+
lntlu	possession of livestock in tropical livestock units (TLU)	scale	+
massmedi	use of mass media	Nominal (yes=1)	+
lnfarmdist	measure of average distance from homestead to farm plots in travel time units (minutes)	scale	+
lndistmrkt	measure of average distance from homestead to nearest market in travel time units (minutes)	Scale	+
lndistroad	measure of average distance from homestead to all-weather road in travel time units (minutes)	Scale	+
extworcon	measure of external work contact **(De Jong and Den Hartog, 2008)**	scale	+
fatalism	measure of fatalistic outlook **(Esparza, Wiebe, and Quiñones, 2015)**	scale	-
selfeffic	measure of perceived self-efficacy **(Schwarzer, 1992)**	scale	+
jobcontrol	measure of perceived job control **Janssen (2000)**	scale	+
jobdemand	measure of household head's perceived job demand **(Janssen, 2000)**	scale	+
persenvtfit	measure of perceived person-environment fit **(Cable and Derue, 2002)**	scale	+
intrinsic	measure of intrinsic motivation towards farming job **(Ryan, 1982)**	scale	+

Table 2 shows the estimated item parameters. The thresholds, each, indicate the point at which 50% of the smallholders with the same demonstrated innovativeness level with the thresholds would choose the designated option or higher. Everyone has a 100% chance of choosing "Never" or higher, so there is no threshold for that option. For item In1, the probability of choosing "Rarely" is 0.5 for a subject with innovativeness equal to 0.2122; the probability of choosing "Sometimes" is 0.5 for a subject with innovativeness equal to 0.6275; the probability of choosing "Often" is 0.5 for a subject with innovativeness equal to 1.1076 and the probability of choosing "Always" is 0.5 for a subject with innovativeness equal to 1.7221. The metric of these values is set by the innovativeness distribution. The mean innovativeness was set to 0, with a standard deviation of 1. The thresholds are to be interpreted relative to this distribution. The slope is an index of how rapidly the response probability changes as innovativeness increases.

As can be noticed from the pictorial representation of the order of the mean of estimated difficulty levels of the items, in Figure 1 above, it can be said that more than 50% percent of the smallholders in the study area have less than 50% chance of responding positively to all items in the scale for measuring innovativeness. This implies that the majority of the study population has demonstrated innovativeness level below all items in the scale used for measuring innovativeness. Or, 87.5% of the thresholds in the scale are above the midpoint of the distribution (which is 0 mean) of innovativeness in the corresponding population. The same implication could be extracted from the test characteristic curve depicted in Figure 2.

If the study population is arbitrarily categorized based on the expected scores as "less innovative" [8 -18.67] "medium innovative" (18.67-29.34] and "highly innovative" (29.34 - 40], the percentage of respondents who fall in the first class amounts to 69.5% while those who fall in the second and third classes cover 23.42% and 7.08% respectively. All in all, the majority (69.5%) of the study population falls in the "less innovative" class; the proportion that the other two classes cover is only 30.5%.

Determinants of smallholders' innovativeness

In identifying determinants of smallholders' innovativeness, the innovativeness score predicted by the graded response model was used as dependent variable in this analysis. In the independent variables set, factors related with demography, socio-economy, geospatial and access to infrastructural facilities, psycho-behavioural characteristics and other contextual settings have been included. The multiple linear regression (ordinary least square) model outputs are depicted in the Table 3.

Table 2 Graded response model results for estimated parameter of items in the innovativeness scale

			Response categories								
	Slope		Rarely		Sometimes		Often		Always		
Item	Coef.	SE	Threshold	SE	Threshold	SE	Threshold	SE	Threshold	SE	MID
In1	2.9472	0.2665	0.2122	0.0643	0.6275	0.0681	1.1076	0.0827	1.7221	0.1214	0.9174
In2	1.6293	0.1433	-0.6901	0.0974	0.4060	0.0829	1.6919	0.1457	2.8787	0.2755	1.0716
In3	1.5398	0.1840	0.8388	0.1023	1.4880	0.1541	2.2167	0.2304	3.1268	0.3602	1.9176
In4	2.9381	0.2351	-0.5295	0.0733	0.4242	0.0650	1.1039	0.0811	1.8832	0.1322	0.7204
In5	4.1638	0.3863	-0.0275	0.0603	0.6665	0.0634	1.2571	0.0812	1.7727	0.1165	0.9172
In6	4.9134	0.5135	0.1669	0.0578	0.7308	0.0628	1.2820	0.0796	1.8594	0.1251	1.0098
In7	3.1006	0.2601	-0.4036	0.0692	0.5738	0.0667	1.1130	0.0805	1.8855	0.1324	0.7922
In8	3.5000	0.3155	0.0980	0.0621	0.5374	0.0637	0.9525	0.0721	1.3726	0.0925	0.7401

Source: Survey data, 2018.
Note: SE = Standard error MID = Mean item difficulty

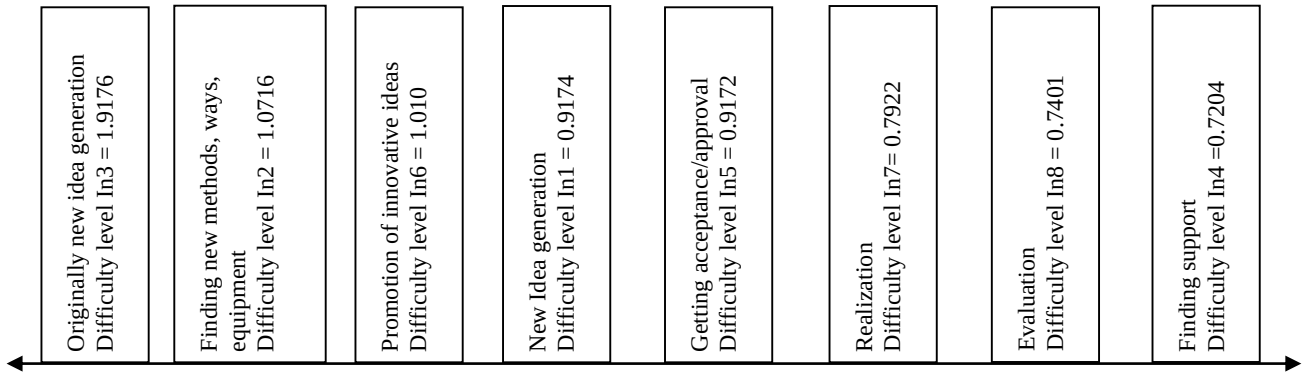

Figure 1 Order of items in the innovation measurement scale based on difficulty level

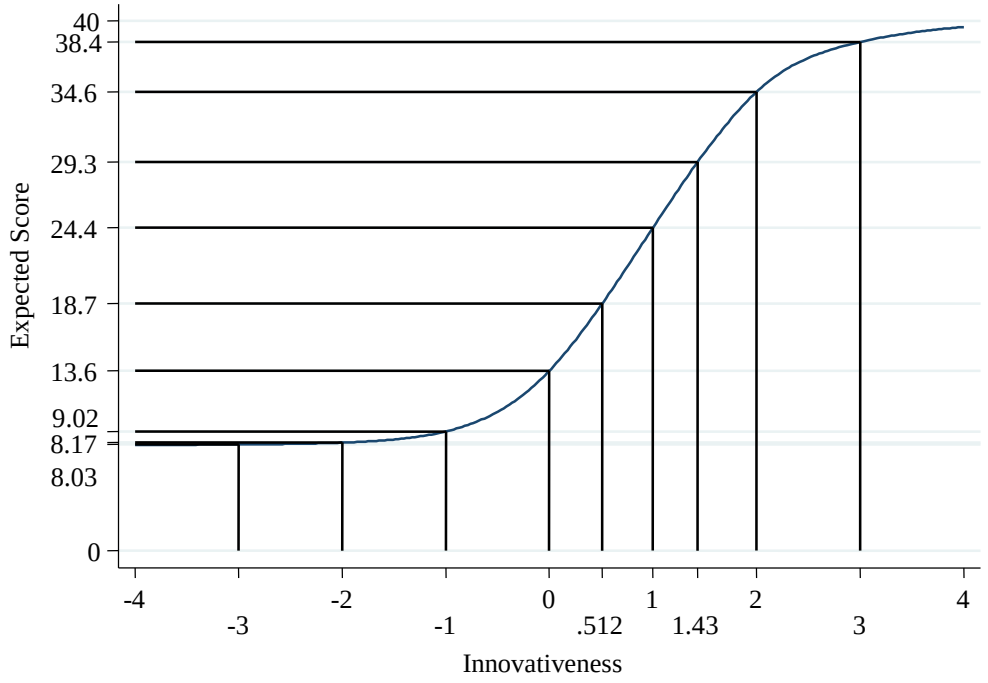

Figure 2 Test characteristic curve of the scale for measuring innovativeness

Among the independent variables included in the model which turned out to be statistically significant at different significance levels, mass media exposure (massmedi), external work contact (extworcon), job-demand (jobdemand), person-environment-fit (persenvtfit), smallholders' perception about PSNP (perception), farm tool possession (lnfarmtool), TLU (lntlu) and distance to all-weather road (lndistroad) are

found to be positive predictors of innovativeness while agro-ecology (agroecol), access to irrigation (irrgacce), perceived farm plot fertility (farmfert), fatalism (fatalism) and dependency syndrome (dependsynd) are identified as negative predictors.

The positive effect of job demand (jobdemand) and person-environment fit (persenvtfit) on demonstrated innovativeness go in line with the finding of **Janssen (2000)**. Literature on the effect of job-demand as a psychological stressor says that workers who are engaged in a stressful work environment tend to look for innovative way outs in dealing with the situation **(Bunce and West 1994; Janssen, 2000; Martín *et al.*, 2007)**. The finding here, in this regard, agrees with the literature in that a farming situation with relatively higher job-demand and farther from all-weather road are associated with higher level of demonstrated innovativeness. On the other hand, the finding on the effect of person-environment-fit on innovativeness agrees with empirical findings of previous studies of **Pee (2012)**, **Sharifirad (2013)**, and **Afsar and Rehman (2015)**.

The positive association between innovativeness and external work contact is also in accord with the empirical finding of **De Jong and Den Hartog (2008)**, **Ndunda and Mungatana (2013)** and **Chindime *et al.* (2017)**. The pieces of informative experience and perspective people may get in their contact with diversified external agents may hint on innovative option **(Hermans *et al.*, 2015)**. Similarly, mass media exposure could play the same role and affect innovativeness positively.

Better possession of farm tools and livestock holding (TLU) and perceiving PSNP as accurately as possible in relation to its intents predicted innovativeness positively. Better possession of farm tools and TLU may imply better flexibility and provision of inputs which might be conducive to innovativeness, a result similar with the findings of **Hermans *et al.* (2015), Lowitt *et al.* (2015)** and **Ndunda and Mungatana (2013)**. On the other hand, the degree to which the introduction of PSNP may affect the economic and other behaviours of smallholders may depend on the extent to which the program is perceived correctly by the community. If it is perceived as a temporary help (i.e. to be discontinued after 5 years once a beneficiary qualify for graduation) to the poor of the poorest that intended to contribute in the prevention of household asset depletion, then given these assumptions beneficiaries of PSNP who perceived the program better may attempt to make use of the help provided to them from PSNP either in kind or cash as a shield for the possible risks associated with innovative engagements. Similarly, non-beneficiaries who better perceive the purpose of the program may stick to their own innovative efforts.

Table 3 Regression model result for estimating factors affecting innovativeness

Regressors	Coef.	Std. Err.	t	P>t
perception	0.0701	0.0417	1.68	0.093*
dependsynd	-0.1702	0.0453	-3.76	0.000***
psnpmem	0.0299	0.0715	0.42	0.676
agroecol	-0.2753	0.1233	-2.23	0.026***
sex	0.0902	0.1549	0.58	0.560
age65	-0.0402	0.1595	-0.25	0.801
marital	0.1201	0.1622	0.74	0.460
hhheduc	0.0132	0.0132	1.00	0.317
hmaxed	0.0146	0.0120	1.22	0.223
hhsize	-0.0221	0.0183	-1.20	0.229
lncredit	-0.0086	0.0136	-0.63	0.531
training	-0.0049	0.0104	-0.47	0.637
irrgacce	-0.2357	0.1295	-1.82	0.069*
farmfert	-0.2230	0.0706	-3.16	0.002***
lnfarmtool	0.0404	0.0171	2.37	0.018***
lntlu	0.1897	0.0711	2.67	0.008***
massmedi	0.2084	0.0984	2.12	0.035**
lnfarmdist	-0.0453	0.0335	-1.35	0.177
lndistmrkt	-0.0770	0.0499	-1.54	0.123
lndistroad	0.0512	0.0296	1.73	0.085*
extworcon	0.3484	0.0530	6.57	0.000***
fatalism	-0.0927	0.0434	-2.14	0.033**
selfeffic	-0.0462	0.0451	-1.02	0.306
jobcontrol	-0.0374	0.0397	-0.94	0.347
jobdemand	0.2122	0.0454	4.67	0.000***
persenvtfit	0.1297	0.0446	2.91	0.004***
intrinsic	0.0683	0.0460	1.49	0.138
_Cons	0.1772	0.3476	0.51	0.610

Number of obs = 476, F(27, 448) = 15.27, Prob > F = 0.0000, R-squared = 0.4792, Adj R-squared = 0.4478, Root MSE = 0.6986

Source: Field survey data, 2018. ;Note: ***Significant at 1% level; **significant at 5% level; *significant at 10% level.

It was assumed that the relatively harsher physical environment in the lowlands of Fedis district **(Magen, 2014; Carmi, 2016)** could be a factor that adds to the stressfulness of the farming occupation which precipitates an innovative way out. However, the result found here turn out to be the opposite. One possible reason can be the unsatisfactory response of the production environment that may affect smallholders' perceived effort-reward fairness. If fairness is not felt, that could be bottleneck to innovative engagement. Crudely, in contrast to Haramaya's midland agro-ecology, the undependability of the lowland agro-ecological nature of Fedis district **(Belaineh and Drake, 2005)** may create the feeling of unrewarding work environment; a sentiment that could possibly discourage innovative engagement.

The fact that fatalism and dependency syndrome affect innovativeness negatively is what is expected. The theory of self-determination emphasizes that internal motivation plays vital role in one's effort to understand his surrounding environment and respond to demanding life situations **(Deci and Ryan, 1985)**. However, one's tendency to believe that people have no control over whatever may happens to them or the expectation that external agents, such as social protection programs, will take care of one's life requirements, may hamper the believer's motivation to innovatively address those demanding situations. What makes it worse is the pervasive tendency of research participants to associate fatalism with religious thoughts.

The other variables that are negatively associated with innovativeness are possession of fertile farmland and access to irrigation. In a work place that is characterized by high job-demand, among the main factors that contribute for employees to approach the stressful work situation innovatively, one is the workers strong desire to relieve themselves from the stress by finding innovative ways of accomplishing their task **(Janssen, 2000)**. With this assumption in mind and keeping other things constant, farmers with possession of fertile farmland and access to irrigation may not opt for thinking out of the box to fulfil their household consumption. Running their business as ordinarily as possible may be enough to satisfy their household needs. The person with possession of fertile farmland and/or access to irrigation, in relative terms, may not be in a pressing situation to find an innovative way out. This means that possession of fertile farmland or having access to irrigation may not encourage innovativeness.

Information from key informants and focus group discussion indicated that it is not customary to observe smallholders carrying out their farming activity differently (innovatively) from the usual traditional way. Additionally, it was said that, generally, let alone supporting innovative engagement, the meagreness of the support provided by PSNP to beneficiaries made it impossible for the vast majority of beneficiaries to escape the problems of food insecurity in a way presumed by the program. Besides, it was indicated that beneficiaries of PSNP are not that much committed to make necessary efforts to utilize the favourable condition created by the program and change their life condition.

CONCLUSION

In this study, it was intended to assess smallholder farmers' innovativeness and identify its determinants. The results indicated that innovativeness level was found to span, predominantly, the "less innovative" class. The portion that "high innovative" class cover is less than one tenth. Innovativeness is found to be positively predicted by smallholders' perception of PSNP, farm tools possession, livestock holding, external work contact, perceived person-environment fit, job demand and distance to all-weather road, and negatively by agro-ecology (lowland), access to irrigation, farmland fertility and fatalism. The finding here signal a big threat to the portion of the rural farming community, and the country at large, who might be depending on outdated backward ways of agricultural production techniques. It is mandatory that the farming community looks for new and innovative ways of production to cope up with the dynamics in the economic, social and physical environment or continue facing the extant food insecurity problems. Therefore this is a big assignment to the government. The findings of this research point out the following recommendations.

Program owners of PSNP should work to enhance smallholders' perception about the program, as better perception encouraged them to be better innovative. Motivational extension work to raise the level of trust smallholder should envision regarding the dependability of their farming occupation should be planned and effected as these have influence on their innovative engagement.

It is instrumental to provide smallholders with external exposure and training to improves their skill so as to make them better fit with their farming occupation and motivating them to have confidence on their own ability to tackle life challenges which can help them learn better ways of doing agriculture, avoid dependency syndrome and exploit their innovative potential

It is helpful to expand the level of exposure that smallholders have to mass media programs that initiate and strengthen innovative engagements. Extension service provider should be able to provide smallholders with audio visual documentation of others' successful works.

Strong motivational extension service has to be implemented to aware smallholders to exploit the productive potential they have as it is observed that those with access to irrigation and better farm fertility to be less creative to find better ways of production.

The extension service institution in the study area need to work in collaboration with Muslim religious leaders in the study area since fatalistic outlook was found to impede smallholders from being more innovative and as smallholders associated fatalism with religious thoughts.

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REFERENCES

AFSAR, B., & REHMAN, M. (2015). The relationship between workplace spirituality and innovative work behavior: the mediating role of perceived person – organization fit. *Journal of Management, Spirituality & Religion*, 12(4), 329–353. DOI: 10.1080/14766086.2015.1060515

AMABILE, T. M. (1997). Motivating creativity in organizations. *California Management Review*, *40*(I), 39–59. DOI: 10.2307/41165921

BEDUSCHI, L.C., CONTRERAS, R., & HOLZ, R. (2017). Innovation for Sustainable Rural Development: Towards a theoretical framework. In FAO / Imanol Camblor, *Innovation for Sustainable Rural Development* (pp. 1–8). Santiago, Chile: Retrieved from http://www.fao.org/3/a-i7769e.pdf

BELAINEH, L., & DRAKE, L. (2005). Determinants of smallholder farmers' perceptions of risk in the Eastern Highlands of Ethiopia. *Journal of Risk Research*, 8(5), 383–416. DOI: 10.1080/1366987042000192426

BUNCE, D., & WEST, M. (1994). Changing work environments: Innovative coping responses to occupational stress. *Work & Stress*, 8(4), 319–331. DOI: https://doi.org/10.1080/02678379408256539

CABLE, D. M., & DERUE, D. S. (2002). The Convergent and Discriminant Validity of Subjective Fit Perceptions. *Journal of Applied Psychology*, 87(5), 875–884. DOI: 10.1037//0021-9010.87.5.875

CARMI, D. (2016). *The Gender Dimensions of Drought in Fedis Woreda District, Ethiopia (No. 2016–8)*. Geneva, Switzerland.

CHINDIME, S., KIBWIKA, P., & CHAGUNDA, M. (2017). Determinants of sustainable innovation performance by smallholder dairy farmers in Malawi. *Cogent Food & Agriculture*, 3(1), 1–11. DOI: 10.1080/23311932.2017.1379292

CSA (Central Statistical Agency). (2007). *The 2007 Population and Housing Census of Ethiopia: Statistical Report for Oromiya Region; Part I: Population Size and Characteristics*. Addis Ababa.

CSA (Central Statistical Agency). (2016). *Key Findings of the 2015/2016 (2008 E.C) Agricultural Sample Surveys*. Addis Ababa.

DE JONG, J., & DEN HARTOG, D. (2008). *Innovative Work Behavior: Measurement and Validation (EIM Research Reports referrence No. H200820)*. Zoetermeer, The Netherlands.

DECI, E. L., & RYAN, R. M. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior*. New York: Springer Science+Business Media.

DEMARS, C. (2010). *Item Response Theory: Understanding Statistics Measurement*. (N. Beretvas & P. Leavy, Eds.). New York: Oxford University Press, Inc.

DEVEREUX, S., & SABATES-WHEELER, R. (2004). *Transformative social protection.* Institute of Development Studies Working Paper 232. Brighton, England.

EMBRETSON, S. E., & REISE, S. P. (2000). *Item Response Theory for Psychologists*. Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc.

EPCC (Ethiopian Panel on Climate Change). (2015). *First Assessment Report, Agriculture and Food Security*. Addis Ababa: Ethiopian Academy of Science.

ESPARZA, O. A., WIEBE, J. S., & QUIÑONES, J. (2015). Simultaneous Development of a Multidimensional Fatalism Measure in English and Spanish. *Curr Psycho*, 34, 597–612. DOI: 10.1007/s12144-014-9272-z

GEBRE, G. G., & ZEGEYE, D. M. (2014). Challenges of farmers' innovativeness in central zone. *International Journal of Agricultural Policy and Research*, 2(5), 215–223.

HERMANS, F., KLERKX, L., & ROEP, D. (2015). Structural Conditions for Collaboration and Learning in Innovation Networks: Using an Innovation System Performance Lens to Analyse Agricultural Knowledge Systems. *Journal of Agricultural Education and Extension*, 21(1), 35–54. DOI: 10.1080/1389224X.2014.991113

JANSSEN, O. (2000). Job Demands, Perceptions of Effort-Reward Farness and Innovative Work Behaviour. *Journal of Occupational and Organizational Psychology*, 73(3), 287–302. DOI: 10.1348/096317900167038

JEMA, H., MENGESHA, Y., TAMIRU, D., & ALEMU, G. (2010). *Aid effectiveness in the WASH sector in Oromia region, Eastern Hararghe zone: The case of Goro-Gutu and Babile wordeas*. Addis Ababa.

LOWITT, K., HICKEY, G. M., SAINT VILLE, A., RAEBURN, K., THOMPSON-COLÓN, T., LASZLO, S., & PHILLIP, L. E. (2015). Factors affecting the innovation potential of smallholder farmers in the Caribbean Community. *Regional Environmental Change*, 15(7), 1367–1377. DOI:10.1007/s10113-015-0805-2

LUMPKIN, G. T., & DESS, G. G. (1996). Clarifying the Entrepreneurial Orientation Construct and Linking It to Performance. *The Academy of Management Review*, 21(1), 135–172. DOI: 10.2307/258632

MAGEN, C. (2014). *Nutritional Causal Analysis*. East Hararghe Zone, Fedis and Kersa Woredas, Ethiopia.

MARTÍN, P., SALANOV, M., & PEIRÓ, J. M. (2007). Job demands, job resources and individual innovation at work: Going beyond Karasek's model? *Psicothema*, 19(4), 621–626.

MAYDEU-OLIVARES, A., & JOE, H. (2014). Assessing Approximate Fit in Categorical Data Analysis. *Multivariate Behavioral Research*, 49(4), 305–328. DOI: 10.1080/00273171.2014.911075

MOA (Ministry of Agriculture). (2014). *Productive Safety Net Programme Programme Implementation Manual Version 1.0*. Ministry of Agriculture. Addis Ababa, Ethiopia.

NBE (National Bank of Ethiopia). (2018). *2017/18 Annual Report*. National Bank of Ethiopia. Addis Ababa.

NDUNDA, E. N., & MUNGATANA, E. D. (2013). Determinants of farmers' choice of innovative risk-reduction interventions to waste water-irrigated agriculture. *African Journal of Agricultural Research*, 8(1), 119–128. DOI: 10.5897/AJAR12.1679

OECD (Organisation for Economic Co-operation and Development). (2009a). *Growing prosperity: Agriculture, economic renewal and development. DCD/DAC(2009)36*. Organisation for Economic Co-operation and Development. Paris, France.

OECD (Organisation for Economic Co-operation and Development). (2009b). *Promoting Pro-Poor Growth: social protection*. Organisation for Economic Co-operation and Development. Paris, France.

PEE, L. G. (2012). The Effects of Person-Environment Fit on Employees' knowledge Contribution. In M.-H. Huang, G. Piccoli, & V. Sambamurthy (Eds.), *Knowledge Management and Business Intelligence* (pp. 1–19). Orlando. Retrieved from http://aisel.aisnet.org/icis2012/proceedings/KnowledgeManagement/1 /

RYAN, R. M. (1982). Control and Information in the Intrapersonal Sphere: An Extension of Cognitive Evaluation Theory. *Journal of Personality and Social Psychology*, 43(3), 450–461. DOI: apa.org/journals/psp/43/3/450.pdf

SCHILLING, M. A. (2017). *Strategic Management of Technological Innovation* (5th ed.). New York: McGraw-Hill Education.

SCHWARZER, R. (1992). *Self-Efficacy: Thought Control of Action (Hemisphere)*. Washington DC: Hemisphere.

SHARIFIRAD, M. SADEGH. (2013). Transformational leadership, innovative work behaviour, and employee well-being. *Global Business Perspective*, 1(3), 198–225. DOI: 10.1007/s40196-013-0019-2

TIRFE, A. G. (2014). Smallholder farmers' innovation and its determinants the case of Hirity Mekan seed producers' cooperative, Tigray, Ethiopia. *Developing Country Studies*, 4(21), 104–114.

TOLOSSA, D., & TAFESSE, T. (2008). *Linkages between Water Supply and Sanitation and Food Security: A case study in four villages of East Hararghe zone, Oromia region (No. 6). Research-inspired Policy and Practice Learning in Ethiopia and the Nile region.* Addis Ababa.

WORLD BANK. (2012). *Agricultural Innovation Systems: An Investment Sourcebook*. Washington, DC: The World Bank

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REGULAR ARTICLE

EFFECTS OF CHILD POVERTY ON CHILD LABOUR AND DEPRIVATION AMONG RURAL FARMING HOUSEHOLDS IN ENUGU STATE, NIGERIA

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ABSTRACT

Both government and non-governmental organisations have been making efforts in the fight against the menace of child labour, child poverty and deprivation. Despite these efforts, 70% of world's child labour still work in agricultural sector. This study examined the nexus and impact of child poverty, deprivation and other socio-economic variables on child labour among rural farming households in Enugu State of Nigeria. Data for the study were collected using survey research design with the aid of structured questionnaire and interview. Descriptive statistics and multinomial logit regression was applied for data analysis. The result of the study shows that majority (92%) of the farming households were engaged in crop farming, majority (69%) of the children aged between 4 and 17 combined both schooling and agricultural labour. For children who were completely out of school, 5% we found to be idle while 16% engaged in agricultural labour. A significant number of children were engaged in agricultural labour, and 62.3% of them had access to primary school only. About 49.4% of children cannot obtain primary health services. Age, household size and gender of children had positive and significant ($p < 0.10$) relationship with child labour. We recommended a redesign of poverty alleviation programmes for rural active farmers and public schools make attractive, accessible and affordable in the rural areas.

Keywords: child labour, child poverty, rural farming households, Nigeria
JEL: R13 R23, R51

INTRODUCTION

It is alarmingly worrisome that agricultural sector holds about 70 per cent of world's child labour (**UNICEF, 2011**). The cause of this abysmal situation may be partly due to the prevalent poverty level among rural households **(Okpukpara and Odurukwe, 2006).** As more children engaged in agricultural labour, it is expected to increase agricultural productivity and possibly reduce child poverty momentarily but may cause more harm to the future of the children by depriving them access to basic education, social protection, sanity to life and consequently trap them in the vicious circle of poverty in the long run. The interpretation of child labour from International Labour Organization (ILO) standards as contained in Conventions 138 and 182 means all children below 12 years of age working in any economic activities and those children between 12 and 14 engaged in more than light works. According to **UNICEF (2011),** an estimated 246 million children are engaged in child Labour in the world, with over 70% involved in agricultural labour. In Nigeria, about 70 per cent of its rural population are engaged in agriculture and grossly characterized by poverty and low income (**Okunmadewa and Omonona, 2006; Omeje and Okoye, 2013**). All tangible farming works and operations undertaken by labourers in the sector are referred to as agricultural labour. An individual is therefore said to be an agricultural labourer if the person derives more than 50 per cent of his or her annual income from agricultural sources (**Reddy *et al.*, 2009)** further classified agricultural labour into farmer's own labour, family labour, and hired labour. Hired labour could further be classified according to the nature of its remunerations.

It is therefore, imperative to approach this study from the perspective of establishing linkages among labour, poverty and deprivation of children in agricultural labour since the sector holds almost 70 per cent of child labour. Everywhere in the world and specifically in Africa where family labour is perceived to be traditional in agriculture, no one would reasonably oppose the engagement of children in such economic activities provided that the work does not negatively affect their health, education and development. Such light work is not only recommended for proper upbringing of the child especially in Nigeria but is also permitted from the age of children of 12 years under ILO Convention No.138.

Poverty among other factors is responsible for such huge number of children involvement in agricultural labour. According to **UNICEF (2011),** child poverty entails a child who is deprived of the material resources needed to develop and thrive, leaving them unable to enjoy their rights, achieve their full potentials, or participate as full and equal member of the society (**UNICEF, 2009).** Poverty leads to deprivation and child labour. Most often, those found to have led their children into hard labour do so as a coping strategy. Child Poverty level could be estimated from the amount of money spent daily or based

on deprivations from these dimensions such as: safe drinking water, sanitation, housing, health and nutrition. According to **UNICEF (2009**), child poverty is not only money metrics but also multidimensional. According to sanders (2003), poverty entails lack of needed resources which causes social exclusion. Individuals, families and groups in the population can be said to be in poverty when they lack the resources to obtain the type of diet needed, participate in social activities and have the living conditions and amenities which are customary, or at least widely encouraged of children, or approved, in the societies to which they belong. This paper therefore examined the incidence and interconnectivity of child labour, poverty and deprivation among rural farmers in Nigeria. It investigated the engagement of children between 4-14years in agricultural labour and estimates child poverty among children of 4-14years using International Poverty Line (IPL) bases on current World Bank Purchasing Power Parity (PPP). Literature on child labour and poverty considered from the (agricultural) sectoral perspective in Nigeria are few. **Ofuoku *et al.* (2014**) determined the level of child labour involvement in arable crop farming and found that children participated in field preparation, planting, weeding, pesticide, fertilizer and herbicide application, harvesting, transportation and processing. Many (43.33%) of the children combined schooling with farming operations. The decision of the farming, household heads to use child labour was influenced by socioeconomic variables such as gender, age, level of education, household size, farm income, farm size, culture, economic factors and political factors. Closely too, **Okpukpara and Odurukwe (2006),** reported a two-way link between child labour and household poverty in Nigeria but the study did not specifically investigate what transpired within the agricultural sector only. However, various studies conducted on poverty in Nigeria in the past include **Onah (1996), Ogwumike and Ekpeyong (1996), Anyanwu (l997), Odusola (1997), Englama and Bamidele (1997)** and many by UNICEF and other organizations. None of them quantified the specifics of child labour and poverty and the factors that influence them within agricultural sector. Others include the Global Study on Child Poverty and Disparity by UNICEF which employed the use of the MICS 2007 to examine well-being of children and introduced Alkire and Foster dual cut-off identification methodology for poverty classification across different sectors and highly polarized poverty gaps without recourse to the specifics of rural agrarian societies. This paper adopted the IPL based on PPP by World Bank to classify the focused group into categories. The threshold was pegged at the World Bank's recommended USD1.90/person/day. The encumbrances and ambiguities associated with estimating poverty in the rural areas were nailed by valuing the alternative costs of all the food, water, and other essential commodities sourced by the households without buying them. Of course, some of the rural farmers produce their own food and buy only little from the market, source clean water from streams and make provisions for other essential needs without going to market. So, this study did not leave out the values of what they produced and provided by themselves for household consumptions.

According to **Omeje *et al.* (2019),** Nigeria is one of the developing economies with significant expenditures on agricultural protection through interest and exchange rates differentials, price mechanisms, input subsidies, researches, embargos and regulations promulgated in various protectionist policy reforms, projects and programmes. The reason for such protection policy and other interventions as shown in Figure 1, was to improve the livelihoods of the rural farmers and their households. Apart from the special interventions in agriculture, governments and non-governmental organizations have spent fortunes and rolled out policies promulgated towards reducing these global challenges of child labour, poverty and deprivations but those 'one-for-all approaches' or policies seem to be inappropriate in dealing with specific sectors and locations with varying degrees of custom, norms, political, environmental and socioeconomic factors, hence the situation worsens. The peculiarities of agricultural labour and factors affecting farming households especially in the rural areas demand that a new and distinct approach other than a blanket solution be given a trial in this our fight against child deprivations.

The broad objective of this paper is to examine the interconnectivity of child labour, child poverty and deprivation among rural farming households in Enugu State, Nigeria. The specific objectives are to:

- describe the socioeconomic and other characteristics of the farming households,
- identify various forms of child labour in the sector,
- profile poverty statuses of the children (4-14years), and
- estimate the effect of child poverty and other socioeconomic characteristics on child labour.

DATA AND METHODS

The Study Area

The study area is Enugu State in south-eastern part of Nigeria. Enugu State is located between latitude 6.459964, and the longitude is 7.548949 with the GPS coordinates of 6° 27'35.8704" N and 7° 32' 56.2164" E. It has a total of seven thousand, one hundred and sixty-one kilometre square (7,161 Km^2 or 2, 764.9 sq.m) land and lies south of Benue and Kogi States as well as east of Anambra State.

It is also bounded in the east of Ebonyi State and South by Abia State. The state has a climate marked with two major seasons including rainy season which lasts between April and October; and dry season lasting from November to March **(ESG, 2010).** 70% of its rural population are engaged in agriculture, with about 18% and 12% of its working rural population engaged in trading and services (**Omeje and Okoye, 2013).** The state has good soil-land climatic condition all year round, making it suitable for agriculture, sitting at about 223 meters above sea level and the soil is well drained during rainy season **(ESG, 2010).**

Sampling Techniques

This study employed purposive and multistage random sampling techniques for selecting the respondents (First 2

stages were purposive while last 2 stages were random). Purposively, the six agricultural zones in Enugu State were selected for convenience. One Local Government Area (LGA) was selected from each of the 6 agricultural zones making a total of 6 LGAs. These LGAs were selected using purposive random sampling to ensure that only predominantly rural farming households were the respondents. From the six (6) selected LGAs, five (5) communities were selected using systematic random sampling to make up 30 communities. Lastly, fifteen (15) households were also selected using systematic random sampling from each of the 30 communities, making a total of 450 rural farming households. These respondents comprised of both faming households with/and those without child or children between 4 to 5 years.

Data Collection

The data used for analysis in this study was collected from primary source between September 2017 and February 2018. The data were gathered by the researchers using a structured questionnaire and interview schedule administered on the rural households' heads and children between 4 and 14 years. The socio-economic characteristics used in the study include: age of children, gender of children, marital status, and years of education of heads, household size, poverty status, group membership and farm size.

Data Analysis

Objectives 1-3 were realized using descriptive statistics, and objective 4 was realized using multinomial logit regression model. The model used is specified by the Eq. 1-4.

$$\Pr(y=1) = \frac{1}{1} + \lambda^{XB(2)} + \lambda^{XB(3)} + \lambda^{XB(4)} + \lambda^{XB(5)} \ldots + \lambda^{XB(n)} \quad (1)$$

$$\Pr(y=2) = \frac{\lambda^{XB(2)}}{1} + \lambda^{XB(2)} + \lambda^{XB(3)} + \lambda^{XB(4)} + \lambda^{XB(5)} \ldots + \lambda^{XB(n)} \quad (2)$$

$$\Pr(y=3) = \frac{\lambda^{XB(3)}}{1} + \lambda^{XB(2)} + \lambda^{XB(3)} + \lambda^{XB(4)} + \lambda^{XB(5)} \ldots + \lambda^{XB(n)} \quad (3)$$

$$\Pr(y=4) = \frac{\lambda^{XB(4)}}{1} + \lambda^{XB(2)} + \lambda^{XB(3)} + \lambda^{XB(4)} + \lambda^{XB(5)} \ldots + \lambda^{XB(n)} \quad (4)$$

Where:
$\Pr(Y = 1)$ neither schooling nor engaged in child labour (idle group),
$\Pr(Y = 2)$ child labour only,
$\Pr(Y = 3)$ schooling only and,
$\Pr(Y = 4)$ child labour and schooling combined.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of the Farming Households

The socioeconomic characteristics and other relevant statuses of the respondent are discussed. Majority (92%) were engaged in crop farming; 75% were married; 31%, 33%, 21% and 15% had no formal education, primary, secondary and tertiary education respectively. Among the households, many of them had family sizes of 12-14 (5%), 8-11 (22%), 0-3 (25%), and 4-7 (39%). Both the age distribution and household size suggest that many of them are still in their active years of reproduction and faming.

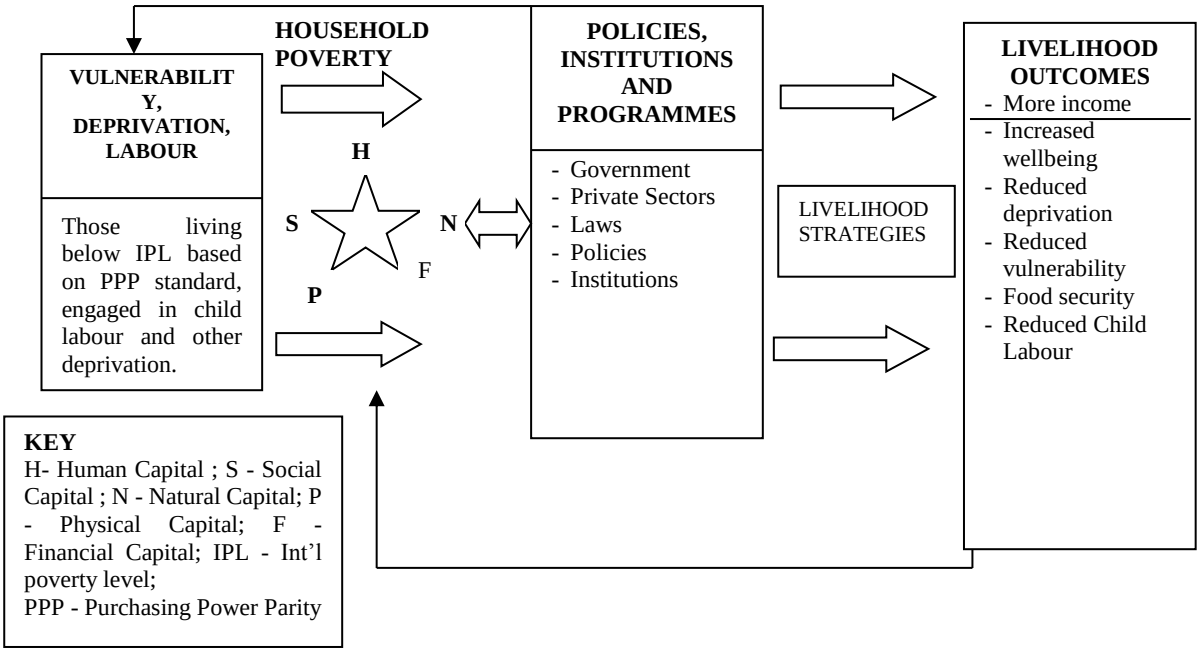

Figure 1: Conceptualization of child labour-poverty Framework
Source: Adapted from Department for International Development (**DFID, 2003**)

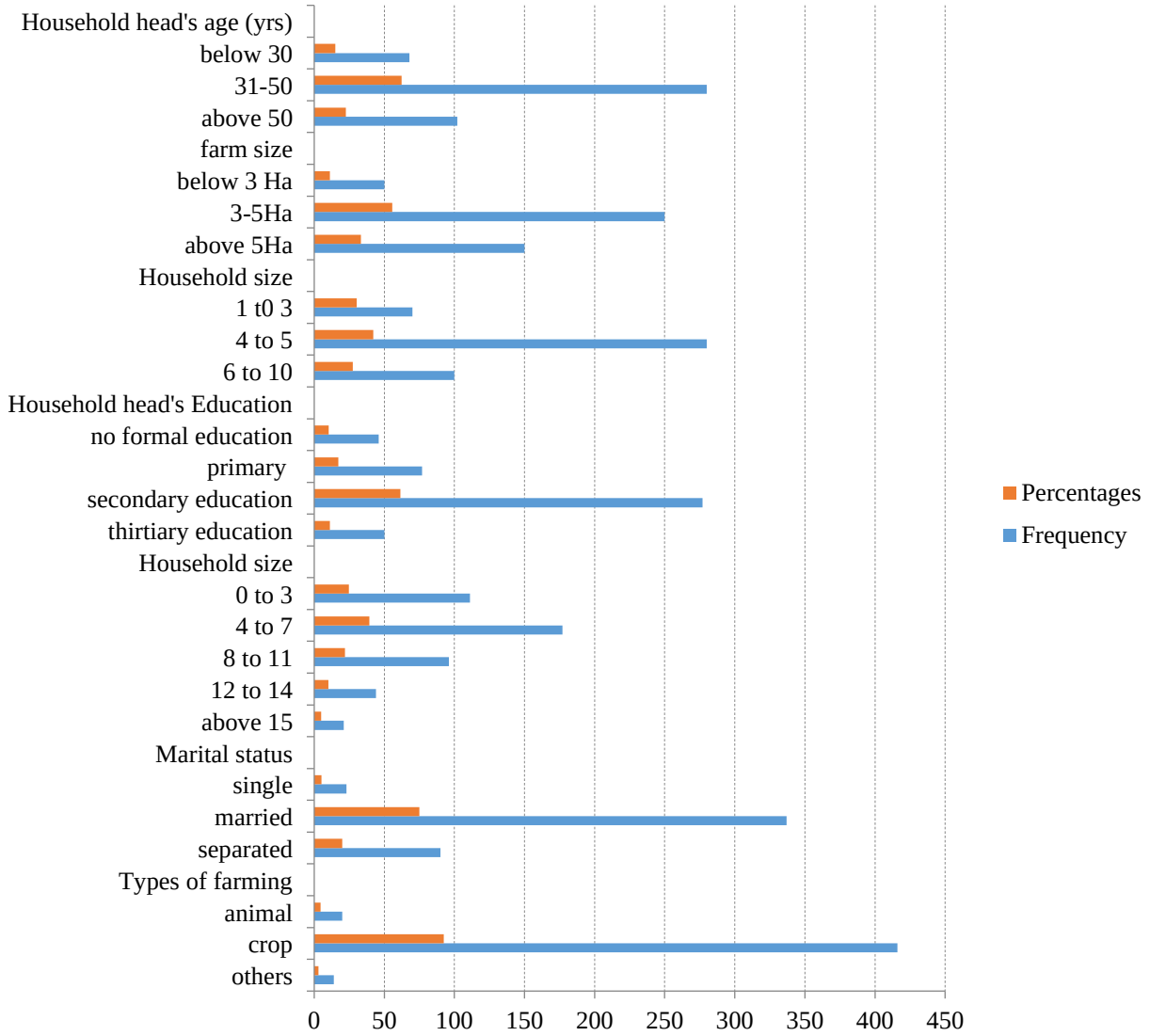

Figure 2: Socioeconomic characteristics of the farming households in the sample
Source: Own work based on field survey, 2018.

Groups and Forms of Children engagement in Agricultural Labour

Out of the 450 sampled rural farming households, 36 percent of them had children between 04-14 years of age, which is our major concern in this study (Table 1). Households without children were 82, and those households with children between 0-3 and above 14 years-children were 80 and 126 respectively.

Majority (69%) of the children combined both schooling and agricultural labour. However, some children (21%) were completely out of school of which 5% was completely idle (i.e., not engaged in labour and agriculture labour) (Figure 2). Out of all the respondents, 36% (162) of the households had children aged between 4 and 14 (Table 1). 128 respondents were deeply engaged in agricultural labour.

Child's family owned most of the labour contributed by children (Table 2). Family labour took about 40.6%, hired labour 39.1%, own labour 4.7% and combined family and hired labour 15.6%. All paid labour (44.7%), was further grouped into four categories including piece wage (85.2%), time wage (0.00%), kind wage (7.4%) and cash wage (7.4%).

Child Poverty and deprivation profiles

Our results revealed that slightly more than halve of the rural farming households (51.2%) still live in poverty using the IPL standard based on World Bank PPP (Table 3). However, poverty is correlated with level of deprivation from certain social amenities which are more pronounced in the rural area than urban. This study further showed that out of the 162 households, only 62.3% agreed to have had good access to primary school while 37.7% felt deprived of primary education. 50.6% agreed to have accessed primary health services while 48.8 felt deprived. Barely half of the children under review are living below poverty line (Table 3), while 37.7% and 49.4% of the children had no access to primary school and primary health centres, respectively (Table 4).

Table 1: Grouping of child labour according to labour intensity

Households' children data	Frequency	Percentage
Household with kids 4-14years	162	36
Household without kids at all	82	18.2
Household with kids 0-3 years	80	17.7
Household with kids above 14years	126	28
Intensity of child labour, N=162	162	100
Idle children	8	5
Children engaged in labour only	16	10
Children engaged in labour and schooling	112	69
Children engaged in school only	26	16

Source: Own work based on field survey, 2018.

Table 2: Grouping of children according to ownership of the farms where child labour was engaged

Agric. labour, N=128	Frequency	Percentage
Family labour only	52	40.6
Hired labour only	50	39.1
Own labour only	6	4.7
Family and hired labours	20	15.6

Source: Own work based on field survey, 2018.

Table 3: Child poverty profile of households bearing child labourers in line PPP based IPL

Poverty status of HH N 162	Frequency	Percentage of children
In poverty	83	51.2
Not in poverty	79	48.8

Source: Own work based on field survey, 2018.

Table 4: Child deprivation profile of households bearing child labourers

Child deprivation indexes, N-162	Frequency	Percentage of children
Access to primary school		
Yes	101	62.3
No	61	37.7
Access to primary health centres		
Yes	82	50.6
No	80	49.4

Source: Own work based on field survey, 2018.

Effect of child poverty, deprivation and socioeconomic characteristics on child labour

Child labour among children were grouped into four categories: category one - those who were neither in school nor in child labour; category two - those who were engaged in child labour only; category three - those who were in school only and; category four - those who were in school and engaged in child labour simultaneously. However, category one (those who were neither in school nor in child labour) was used as the base category ($P_r(Y_1) = 0$) in the analysis. The following variables were used as the political, environmental and socio-economic characteristics: age of children, gender of children, marital status, household size, and years of education of household heads, poverty status, group membership, and proximity to hospital and farm size.

Results of how rural households' political, environmental and socio-economic characteristics influenced child labour engagement among rural farming households in Enugu State are presented in Table 5. For the whole sample, the following variables: age of children, gender of children, marital status of the household heads, household size, group membership, proximity to hospital and farm size were statistically significant.

Age of children

Age of children had a positive and significant ($p<0.10$) relationship with the probability to engage in child labour (Table 5). This implies that an increase in age of children among the households would increase the probability of involvement in child labour and schooling category.

Gender of children

Gender of children (male children) had positive and significant influence ($p<0.10$) on their probability to engage in child labour (child labour only) among the rural farming households of Enugu state. This is expected since male children are more likely to engage in child labour both in rural and urban areas.

Household Size

Household size had positive and significant ($p<0.01$) relationship with the probability of children been engaged in agricultural labour (Table 5). **Muturi (1994)** showed that a relationship exists between child labour and family size. This implies that further increase in the number of people in the rural households would lead to an increase in number of children in child labour (child labour only). This may be true since increase in household size would lead to demand for more food, wellbeing, health services, and poverty the people may become more vulnerable to poverty if household size increases without commensurate increase in livelihood outcomes. This is also in line with the results of the **DFID (2003).**

Poverty Level

In this analysis, poverty level had negative but significant relationship at 5% level of probability ($p<0.05$) with both 'schooling and child labour' category. This suggests that as poverty level of the households increases, more children were made to combine their schooling with agricultural labour. This is in accordance with the *a priori* expectation and that of **Naeem *et al.* (2011**) which found that children work mainly due to poverty and that poor parents are forced to send their children to work instead of school.

Table 5: Effect of child poverty, deprivation and socioeconomic characteristics on child labour

Explanatory Variables	Child labour only	Schooling only	Combined child labour and schooling
Age of children	0.03	0.323	0.0828***
	(0.309)	(408.33)	(0.0293)
Gender of children (1/0)	4.56***	29.101	0.365
	(1.097)	(7713.959)	(0.814)
Marital status	0.98**	9.726	-0.158
	(0.460)	(4294.485)	(0.448)
Years of education of heads	-0.04	0.729	0.632
	(0.077)	(580.067)	(0.698)
Household size	0.35*	2.868	0.152
	(0.177)	(1680.15)	(0.1504)
poverty status (1/0)	-0.0000	-1.03e	-0.0000**
	(0.0000)	(0.002)	(0.0000)
Group membership (1/0)	-3.54***	-43.298	2.00735***
	(10.946)	(4884.51)	(0.917)
Proximity to hospital (1/0)	0.00***	0.000	0.0000***
	(0.000)	(0.0343)	(0.0000)
Farm size (ha)	4.30***	90.45	4.3816***
	(1.348)	(17355.34)	(1.277)
Constants	-9.02***	65.604	-9.59***
	(12.445)	(4880.36)	(2.518)
No of observations	162		
Chi square (X^2)-(22) = 217.97			
Prob >X^2 = 0.0000			
Pseudo R^2 = 0.4918			

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: Own work based on field survey, 2018.

Group membership

Those children whose household heads belonged to one or more groups like *Isusu*, age of grade, political parties and cooperatives had negative and significant ($p<0.10$) relationships with 'child labour' category and in both 'schooling and child labour' category which was positive and significant at 10% levels of probability (Table 5). This suggests that those households whose heads were engaged in social and political groups seem to be more aware of the dangers of child labour and it reflected in their lifestyle.

Proximity to hospital

Proximity to hospital had negative and significant relationship at 1% level of probability with 'child labour' category. This implies that as the proximity to hospital of the respondents is increasing, their tendency to encourage child labour reduces. This suggests that as the households were saving more from sicknesses and treatments as a result of availability of health centres, more children were saved from joining agricultural labour.

Farm size

Farm size had positive and significant relationship with both categories of child labour ('child labour only' and 'schooling/child labour') (Table 5). This implies that as the farm size increases, the need for child labour also increases among the rural farming households.

RECOMMENDATIONS AND CONCLUSION

To proffer workable policies and address the challenges identified in this research, the following recommendations are presented for action:

- Since over 70% of the rural population is engaged in agriculture, and studies have shown that 70% of child labour is found in agricultural sector, it is pertinent that UNICEF and stakeholders consider a change from the current 'one-for-all' policy approach to a more specific policy for the rural farming households towards the fight against child labour. This will go a long way in reducing this huge number of children engaged in agricultural labour.
- Deliberate efforts should be made to target rural (agriculture) extension officers, religious and community cum opinion leaders with appropriate programs, workshops and trainings that can improve their understanding of child welfare, so that they can also educate other rural farmers.
- Access to both primary health care (PHC) and primary schools were put at 50.6% and 62.3% respectively. Both health and education ministries and agencies should try to improve access to these facilities by making PHC more affordable and primary schools attractive.
- Sequel to the result that as more household heads acquire basic education, they tend to pull their children out from child labour. Ministry of education should reconsider adult education policy for the rural people since education is pivotal in this fight.
- Finally, poverty has direct link with child labour

and deprivation. Ministry of agriculture should address the poverty issues among rural farmers by designing special agricultural protection policy for them. This can be done through some agricultural protection instruments such as subsidies and market/price bylaws.

This study has examined the nexus and impact of child poverty, deprivation and other socio-economic variables on child labour among rural farming households in Enugu State of Nigeria. In most rural African communities where poverty is prevalent, child labour is often viewed as an economic activity to augment family income. However, this has serious implications on child growth and development, as it could affect their health and impinge on their education. This study found that there is an inverse relationship between poverty and child schooling. As the poverty status of the family or household deepens, the likelihood of sending their children to engage in child labour also increases. Again, the findings of the study suggest that the male child had more probability to engage in child labour. All these have policy implications for the fight against child labour and deprivation in Nigeria. First, a blanket 'one size fits all' policy may not be effective in eradicating the menace.

REFERENCES

ANYANWU, J.C. (1997). Poverty in Nigeria: Concepts, Measurement and determinants. In: Proceedings of the Nigerian Economic Society Annual Conference on Poverty Alleviation in Nigeria 1997. Nigerian Economic society, Ibadan. PP. 93-120

DFID - DEPARTMENT FOR INTERNATIONAL DEVELOPMENT (2003). Sustainable livelihoods: guidance sheet prepared by the DFID, the British Government's department responsible promoting development and reduction of poverty. http://www.livelihoodscentre.org/documents/20720/100145/Sustainable+livelihoods+guidance+sheets/8f35b59f-8207-43fc-8b99-df75d3000e86

ENGLAMA, A., & BAMIDELE, A. (1997). "Measurement Issues in Poverty." In the Annual Conference Proceedings of the Nigerian Economic Society (NES): Poverty in Nigeria, pp. 141-158.

ESG - ENUGU STATE GOVERNMENT (2010). Learn about Enugu State, Nigeria. Retrieved from http://www.ngex.com/nigeria/places/states/enugu.htm 2/10/2019

KATHURE, M. G. (2016). Child labour in rural and urban Kenyan Settings: A comparative study of Kakuzi Location, Murang'a County and Kibera Slum, Nairobi County. A thesis submitted to the Department of Sociology and Social Work, University of Nairobi. Accessed online on 5/10/2019 from http://erepository.uonbi.ac.ke/bitstream/handle/11295/97321/Mugo%20Grace%20Kathure%2C%20MA%20Thesis.pdf?sequence=1&isAllowed=y

NAEEM, Z., SHAUKAT, F., & AHMED, Z. (2011). Child labor in relation to poverty. *International Journal of Health Sciences*, *5*(2 Suppl 1), 48–49.

NPC - NATIONAL POPULATION COMMISSION (2017). Nigeria's current estimated population. Accessed online through population.gov.ng on 6/2/2018.

ODUSOLA, A. F. (1997), Poverty in Nigeria: An eclectic appraisal: Poverty Alleviation in Nigeria, Selected Papers for the 1997 Annual Conference of Nigerian Economic Society. https://www.nigerianeconomicsociety.org

OFUOKU, A. U., IDOGE, D. E., & OVWIGHO, B. O. (2014). Child labor in agricultural production and socioeconomic variables among arable farming households in Nigeria. *Journal of Rural Social Sciences, 29(2), 2014, pp. 67–81*. Southern Rural Sociological Association. http://journalofruralsocialsciences.org/pages/Articles/JRSS%202014%2029/2/JRSS%202014%2029%202%2067-81.pdf

OGWUMIKE, F.O., & EKPENYONG, D. B. (1995). Impact of structural adjustment policies on poverty in Nigeria. Final Report, AERC, Nairobi, May.

OKUNMADEWA, F.Y., YUSUF, S.A. AND OMONONA, B.T. (2006). Social capital and poverty reduction in Nigeria revised report submitted to Africa Economic Research Consortium (AERC) Nairobi, Kenya. https://sarpn.org/documents/d0002275/Social_capital_AERC_Sept2005.pdf

OKPUKPARA, B. C, & ODURUKWE, N. (2006). Incidence and determinants of child labour in Nigeria: implications for poverty alleviation. AERC research paper 156, Nairobi: AERC. http://opendocs.ids.ac.uk/opendocs/handle/123456789/2667

OMEJE, E. E., & OKOYE, C. U. (2013). Critical constraints limiting the engagement of graduates of agriculture in commercial agricultural production in Nigeria. *African Journal of Development and Research, AJDRE*, vol.No.2, 2013. (Pages 108-116). https://oer.unn.edu.ng › download › critical-constraints-limiting-the-engage...

OMEJE, E. E. (2014). Effects of microcredit on the livelihood of rural households in Enugu state, Nigeria. An M.Sc dissertation submitted to the Department of Agricultural Economics, University of Nigeria, Nsukka. https://oer.unn.edu.ng/read/effects-of-micro-credit-on-the-livelihood-of-rural-households-in-enugu-state-nigeria-2

OMEJE, E. E., ARENE, C. J., & OKPUKPARA, B. C. **(**2019). Impact of agricultural protection on agricultural growth in Nigeria: political economy perspective (1980-2016). *Review of agricultural and applied economics, ISSN* 1336-9261, XXII (number 1, 2019): 41-50, DOI:10.15414/raae.2019.22.01.41-50

ONAH, F. E. (1996). Post Adjustment Policies toward Poverty Alleviation in Nigeria. *Nigerian J. Econs. Social Stud.*, 38 (1, 2, 3) pp. 97-2l8.

SAUNDERS, P. (2003). Can Social Exclusion Provide a New Framework for Measuring Poverty? SPRC Discussion Paper No. 127, October 2003. The Social Policy Research Centre. University of New South Wales, Sydney NSW 2052, Australia. ISSN: 1447-8978, ISBN: 0 7334 2075 3.

UNICEF - UNITED NATIONS CHILDREN'S FUND (2009). United Nations Children's Fund, "Millennium Development Goals. Eradicating extreme poverty and hunger" [online] http://www.unicef.org/spanish/mdg/poverty.html, 2009

UNICEF - UNITED NATIONS CHILDREN'S FUND (2011). Unicef: child labour factsheet. Accessed online on 27/03/2018 on https://www.unicef.org/protection/files/child_labour.pdf

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REGULAR ARTICLE

MODELLING THE DETERMINANTS OF ADOPTION OF MULTIPLE CLIMATE CHANGE COPING AND ADAPTATION STRATEGIES: A MICRO ANALYSIS OF SMALLHOLDER FARMERS IN NORTHERN GHANA

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ABSTRACT

Climate change coping and adaptation (CCCA) mechanisms have become more relevant in the north of Ghana where there is evidence of severe impacts of climate change and poverty. In this study, we modelled the determinants of adoption of multiple CCCA strategies by smallholder farmers in northern Ghana using primary data collected from 230 households. Count data models including endogenous switch Poisson and generalized Poisson regression were estimated to account for potential endogeneity of credit, as well as dispersion errors. The credit variable did not show signs of endogeneity, neither was there evidence of significance dispersion errors in the data. Age, sex, extension visits, and farm size were significant across the various count data models and should be considered by policy makers when designing national climate change response and mitigation plans.
Keywords: Climate change, Adaptation, Count data, Poisson regression, Smallholder farmers
JEL: R52, R58, H41

INTRODUCTION

Although there have been several interventions aimed at improving the livelihoods of people, poverty is still widespread in many countries including Ghana **(GSS, 2013)**. Poverty reduction has therefore, become the core challenge for development in recent times. A lot has been achieved since the millennium declaration to halve extreme poverty by 2015, with a shift now towards Sustainable Development Goals (SDGs). However, climate change poses a serious challenge to poverty reduction, and could undo the successes of developmental efforts in the last few decades that are aimed at achieving a resilience for rural households.

The **IPPC (2001)** defined climate change as a "change in the statistical properties of the climate system when considered over long period of time, regardless of cause". In poverty endemic countries, climate change manifest in many forms especially as naturally occurring disasters that cause great destruction to livelihoods. Climate change also manifest in floods and droughts and can increase the incidence of pest and waterborne-related diseases, as well as cause lower crop yields among resource poor farmers **(Hallegatte *et al.*, 2016)**. **Hallegatte *et al.* (2016)** further asserts that vulnerability to poverty will persist should climate change continue.

Addressing poverty situations without recourse to the impacts of climate change on livelihoods of poor households in developing countries will lead to failed poverty management and reduction processes. This concern stems from the overly dependence of many developing countries on natural resources (for example, agriculture and fishing) that are prone to the effects of climate change for their livelihoods and sustenance, and the fact that many of these developing countries do not have enough technical and financial capacities to adequately deal with increasing risk of climate change **(Skoufias *et al.*, 2011)**.

According to **FAO (2016)**, small-scaled farmers in Ghana's poor rural areas have poor access to the productive assets that could facilitate agricultural modernization and commercialization. Some constraints to rural livelihoods include the lack of infrastructure and mechanization equipment such as storage facilities, harvesting and processing machines, as well as dysfunctional market system. There is also limited financial and technical support services such as agricultural extension and research.

The northern regions of Ghana have experienced variable and unpredictable climate in the past few decades. Floods and droughts occur in the area just within some few months apart, posing serious threat to food security for smallholder led households. Some coping and adaptation measures are therefore needed to mitigate against the effects of climate change. Contextually, CCCA strategies are said to be actions that people take in response to, or in anticipation of changing climate conditions. These actions purport to reduce the adverse impacts of climate change on exposed households **(Tompkins and Adger, 2003)**. While adaptation measures are long term in nature, coping strategies are short term measures **(Azumah *et al.*, 2017)**. The **UNFCCC (2007b)** projected that, agricultural

productivity and for that matter, access to food would be seriously affected due to the changing climate in many African countries. Similarly, a report by the **FAO (2016)** affirms that climate change is influencing and will continue to pose a serious threat to crop yields; and will account for a 5% and 30% reduction in overall yields by 2030 and 2080 respectively. This challenge will further compound when variability in climatic conditions increases. For instance, changes in rainfall pattern and temperature levels can lead to crop and asset losses, further exacerbating the poverty levels especially for rural and marginalized groups due to their inability to adapt and cope with adverse climatic conditions.

In the last few decades, the climate in Ghana has changed drastically. Excessive heat and torrential rains have caused massive destruction of most arable lands and crops. The northern regions of Ghana have started experiencing this phenomenon and have been identified as highly vulnerable to the impacts of climate change **(Antwi-Agyei *et al.*, 2012)**. A forecast report by the World Bank indicates that, for the periods 2010 – 2050 Ghana would experience warming with high temperatures recorded in northern Ghana **(Asante and Amuakwa-Mensah, 2015)**. Similarly, a recent study **(Fagariba *et al.*, 2018)** indicates that extreme temperature and drought occurrences are eminent in northern Ghana. This has a profound effect on food security, poverty and malnutrition **(Azumah *et al.*, 2017)**. Extant studies have identified and assessed CCCA mechanisms used by rural smallholder households in northern Ghana to mitigate the effects of prolong droughts on their livelihoods **(e.g. Bawakyillenuo *et al.*, 2016; Antwi-Agyei *et al.*, 2014; Codjoe *et al.*, 2012)**. For instance, the authors found that most smallholders in northern Ghana used coping and adaptation strategies such as migration (temporary), planting drought tolerant crop varieties, agriculture intensification, and extensification, application of chemical fertilizer, diversifying agriculture among many others. Earlier studies including **Teye *et al.* (2015)** and **Codjoe *et al.* (2014)** have paid attention to some indigenous strategies employed by farmers in mitigating the effects of the changing climate by smallholder farmers towards building resilient livelihoods. Recent studies including **Lawson *et al.* (2019), Antwi-Agyeia *et al.* (2018), Assan *et al.* (2018)** and **Fagariba *et al.* (2018)** also explored CCCA opportunities and strategies used by farmers in northern Ghana. Whilst these studies have documented sufficient literature on appropriate adaptation strategies, specific studies that focus on factors that influence farmers' intensity of adoption of CCCA strategies in northern Ghana is very limited.

Many studies relating to intensity of adoption have found interesting results using the Poisson regression model, however, the findings may not be entirely reliable because of failure to account for potential incidence of endogeneity. This study therefore presents an econometric model that in our opinion, best investigates factors that influence adoption intensity of CCCA strategies in northern Ghana while considering critically, the nature of dispersion and potential incidence of endogeneity that may affect the efficiency and consistency of the estimates.

DATA AND METHODS

Study location

The study was conducted in the north of Ghana. The northern Savannah regions lie between latitudes 8°N and 11°N and covers almost two third of Ghana's land mass **(Amikuzuno and Donkoh, 2012)**. The rainfall pattern of the region is erratic and characterized by a long dry period of about seven months from October to May each year. Annual precipitation in the north of Ghana ranges between 400mm and 1200mm. Agriculture in the area is largely under rainfed conditions, and employs close to 70% of the employable population **(GSS, 2013)**. Land degradation is eminent in the area, resulting declining soil fertility which has impact on the farming systems. The choice of the region for this study is based on the sensitivity of the area to climate variability and climate change **(Amikuzuno and Donkoh, 2012)**, especially erratic rainfall and high temperature **(Kranjac Brisavljevic *et al.*, 1999)**. The region is also blessed with agricultural activities but with high percentage of subsistent poor farmers **(GSS, 2013)**.

Sampling and data collection

A multi-stage sampling procedure was employed to select the target farmers. The first stage involved the use of purposive sampling technique to select six districts that are adversely affected by the impacts of climate change. A simple random sampling method was then used in the second stage to randomly pick two communities from each of the six districts, totally 12 communities. Again, simple random sampling technique was employed to select 20 respondents from each of the 12 communities, resulting to a sample size of two hundred and forty (240). However, a total of 230 of the questionnaires that were returned contained all the necessary information for analyses. Primary research data was collected from farm households using semi-structured questionnaire which allowed for some flexibility in the responses provided by respondents, such that their views could be captured totally. Additionally, secondary data was sourced from a few Government and Non-governmental Organisations such as MoFA, ACDEP, and the Presbyterian Agricultural Services, using interview guides.

Analytical framework

Increasingly, count data models are becoming valuable econometric models for analysis of data with count events **(Miranda, 2004)**. Several count data models have been used in many studies to explain intensity of adoption of various technologies. Many of these count data models can produce reliable estimates only when the regressors exhibit exogeneity. The reverse can be said when the regressors are endogenous in nature. Dealing with endogeneity and selection bias requires the choice of an appropriate and efficient estimator. Many studies have explored a good number of estimators that address potential endogeneity and sample selection bias in count data analysis **(Wooldridge, 2010; Terza *et al.*, 2008; Mullahy, 1997; Van Ophem, 2000; Schellhorn, 2001; Miranda, 2004; Li and Trivedi, 2009)**. These estimators are different in their structural formulation and parameterization.

In this study, several count data models where applied to deal with different estimation errors that may come about. The endogenous switch Poisson (ESP) is applied to deal with potential endogeneity associated with access to credit. The analysis of the effect of credit access on intensity of adoption of CCCA strategies provides a perfect case scenario of the problem of endogeneity. The endogenous switch count data model follows a two-stage estimation procedure. First, an exogenous switching is performed to show the extent of dispersion, a significant sigma shows that the data is over dispersed and insignificant sigma gives an indication of either under dispersed or equi-dispersed data, which may call for a generalized Poisson model to correct. In the second stage of estimation, endogenous switching is performed to confirm the presence of endogeneity. A significant *rho* indicates the presence of endogeneity and therefore confirms the appropriateness of the endogenous switch Poisson regression model.

The Endogenous Switching Poisson (ESP) model

Given the i^{th} farmer from a random sample $I = \{1 \ldots\ldots n\}$ conditional on a vector of explanatory variables x_i, an endogenous dummy c_i, and a random term ε_i, the dependent variable y_i, which is a count, is supposed to follow a standard Poisson distribution (**Miranda, 2004; Terza, 1998** (Eq.1).

$$f(y_i/\varepsilon_i) = \frac{exp\{-exp(x_i'\beta+\gamma c_i+\varepsilon_i)\}\{exp(x_i'\beta+\gamma c_i+\varepsilon_i)\}^{y_i}}{y_i!} \quad (1)$$

Where: β and γ are coefficient to be estimated. The error term ε_i measures omitted and unobserved variables as well as any measurement error. Given a vector of explanatory variables z_i (which may contain some or all elements) and x_i, c_i is characterised by an index process (Eq. 2).

$$c_i = \begin{cases} 1 if\, z_i\alpha + v_i > 0 \\ 0 otherwise \end{cases} \quad (2)$$

Where: α is a vector of coefficients to be estimated. Suppose that w_i denotes all endogenous variables and ε_i and v_i are jointly normal with mean zero and covariance matrix $\sum = \begin{pmatrix} \sigma^2 \sigma p \\ \sigma p 1 \end{pmatrix}$, given that ε_i, c_i and y_i are independent. Hence, the joint conditional probability density function of y_i and c_i, given w_i, can be written as Eq. 3.

$$f(y_i, c_i/w_i) = \int_{-\infty}^{\infty}\{c_i f(y_i/c_i = 1, w_i, \varepsilon_i) Pr(c_i = 1/w_i, \varepsilon_i) + (1 - c_i) f\big((y_1/c_1 = 0, w_i, \varepsilon_i)\big) Pr(c_i = 0/w_i, \varepsilon_i)\} f(\varepsilon_i) c_i \varepsilon_i \quad (3)$$

Where: $f(\varepsilon_i)$ represents the probability density function for the random error term, ε_i.

The Generalized Poisson Model

The Generalized Poisson Regression (GPR) model has been suggested as it is a flexible count data approach in handling count data of any nature to cover dispersion errors (**Famoye *et al.*, 2004**). If the generalized Poisson distribution function is normalized, given a random variable Y then its probability mass distribution function can be mathematically written as Eq. 4.

$$f(y_i, \pi_i, \delta) = \frac{\pi_i(\pi_i+\delta y_i)^{\lambda_i^{-1}}\lambda^{-\pi_i-\delta y_i}}{y_i!}, y_i = 1,2\ldots\ldots n \quad (4)$$

Where $\pi_i > 0 and\ max(-1, \pi_i) < \delta, 1.$ ^{y_i} denotes the various practices adopted by farmers. The variance and mean of the random variable y_i can be computed as Eq. 5.

$$u_i = E(y_i) = \frac{\pi_i}{1-\delta}, var(y_i) = \frac{\pi_i}{(1-\delta)^3} = \frac{1}{(1-\delta)^2}E(y_i) = \alpha E(y_i) \quad (5)$$

The $\alpha = \frac{1}{(1-\delta)^2}$ represents the dispersion factor in the GPR model. So, if we have $\delta = 0$ then there is evidence of equi-dispersion and standardized PR model is preferred. Conversely, if it is found that $\delta > 0$ then over-dispersion is presence. Again, if $\delta < 0$ it indicates under-dispersion which supports the use of GPR model as in this study. The log likelihood estimation of the GPR model is given by the Eq. 6.

$$L = \sum_{i=1}^{n} L(\pi_i, \delta; y_i) = \sum_{i=1}^{n} InL(\pi_i, \delta; y_i) = \sum_{i=1}^{n}\{In\pi_i + (y_i - 1)In(\pi_i + \delta y_i) - (\pi_i + \delta y_i) - Iny_i!\} \quad (6)$$

RESULTS AND DISCUSSION

Measurement of variables

Table 1 shows the description and statistics of variables used in the study. The average age was found to be 39.7 years. About 73.4 percent of the respondents were male. The average extension visits received by farmers was 2.51 times per season, implying farmers had some significant visits which could result in adoption of CCCA strategies**.** The results from Table 1 show that about 69 percent of farmers had access to credit either in the form of cash or farm inputs. This has an implication of impacting on the number of CCCA strategies adopted. The average farm size cultivated by farmers was estimated as 0.80 hectares, implying farmers cultivate relatively small sizes of farmland. Also, the average household size in the study area was found to be 13.59, suggesting a high household size which potentially could affect adoption of multiple CCCA strategies. The results also show that the average number of CCCA strategies adopted by farmers was 5.33.

Factors influencing intensity of adoption of CCCA strategies

Before discussing the factors that influence farmers' multiple subscription to various CCCA mechanisms, we first present the distribution of the identified coping and adaptation mechanisms (Table 2), as well as the adoption intensity (Table 3). In all, fourteen CCCA were identified and included for analysis. The results from Table 2 reveal that 2.71 percent of farmers adopted income diversification strategies to cope with the effects of climate change.

Table 1. Summary statistics of variables (n=230)

Definition of Variable	A priori Expectation	Mean	Std. Dev.
Age (years)	+	39.7	10.95
Sex	+/-	0.734	0.442
Extension (number of contacts)	+	2.51	1.86
Credit (farmers' access to credit)	+	0.69	0.46
Farm size (in hectares)	+	0.8	0.41
Household size	+	13.59	7.93
Intensity of adoption of Climate change coping strategies (0-12)	n/a	5.33	2.62

Source: Analysis of field data, 2019

Table 2: Adoption of CCCA strategies by farmers **(**n=230)

Strategy	Freq. No. of farmers who adopted	Percent
Mulching	30	13.04
Spraying	204	88.7
Mixed cropping	151	65.65
Mixed farming	162	70.43
Crop rotation	116	50.43
Improved seed	97	42.17
Dug out	9	3.91
Irrigation	3	1.30
Changing planting time	53	23.04
Diversification	5	2.71
Raised beds	111	48.26
Manual ploughing	103	44.78
Row sowing	172	74.78
Bunding	12	5.22

Source: Analysis of field data, 2019

Table 3: Adoption intensity of CCCA strategies

Intensity of adoption	Freq.	Percent
0	7	3.0
1	20	8.7
2	11	4.8
3	24	10.4
4	26	11.3
5	24	10.4
6	23	10.0
7	23	10.0
8	63	27.4
9	6	2.6
10	1	0.4
11	1	0.4
12	1	0.4
Mean adoption		5.33
Variance		6.86
N		230

Source: Analysis of field data, 2019

Also, just 1.3 percent of farmers used irrigation to cope with climate change. The results also show that about 88.70 percent of farmers adopted spraying to kill weeds and insects to cope with the effects of climate change. Also, 65.65 percent, 70.43 percent, 50.43 percent and 42.17 percent adopted mixed cropping, mixed farming, crop rotation, and improved seed respectively. Also, a good number of farmers (74.78%) adopted row planting to increase crop density in order to cope with climate change effects.

The dependent variable was modelled as intensity of adoption of CCCA strategies premised on the number of strategies adopted. The results from Table 3 reveal that 3.04 percent of farmers did not adopt any of the CCCA strategies. Also, 8.70 percent of farmers adopted only 1 strategy. The results also reveal that 4.78 percent of farmers adopted only 2 of the strategies, whereas 10.43 percent, 11.30 percent and 10.43 percent adopted 3, 4 and 5 CCCA strategies respectively. Similarly, 27.39 percent of the farmers adopted 8 of the CCCA strategies while only 0.43 percent adopted 12 of the climate change coping strategies. No farmer adopted 13 or all 14 identified mechanisms at the same time.

Several diagnostic tests were also performed to choose the appropriate model. The results from Table 3 show that the conditional mean of the outcome variable is 5.33 and its associated variance is 6.86, indicating that the data may be over-dispersed. The over-dispersed nature of the data was unjustified in the sense that the probability of *sigma* in the exogenous switch (EXS) and endogenous switch (ES) models was insignificant (Table 4). The result therefore suggests that the Poisson model may be an appropriate measure for the data. However, in order to validate the correctness of our estimates in the Poisson model, we estimated the endogenous switch (ENS) which corrects for both endogeneity and sample selection bias, by assuming the credit variable to be endogenous. The *rho* as presented in Table 5 was found to be insignificant, implying that that there was no reported incidence of endogeneity, therefore, still supporting the use of a standard Poisson model in estimating the data.

Also, a comparison of the AIC and BIC values of the four models appears to be consistent with the decision to settle on the Poisson model. The estimated results in the EXS and ENS did not produce any significant difference in the loglikelihood value or did not result in any improvement in the estimates. Furtherance to this shows that the estimates of the Poisson are not significantly different from that of the EXS and ENS since the estimates were virtually the same.

Following the arguments **(Erdman *et al.*, 2008; Greene, 2002; Cameron and Trivedi, 1999)** of an almost impossible occurrence of equi-dispersion in real life data, we further estimated the Generalized Poisson Regression (GPR) model (Table 5) to check for potential under-dispersion of the data. Further diagnostics of the models suggest otherwise, the dispersion parameter (-0.067) reveals that the data was seemingly under-dispersed, with the standard errors of the normal Poisson model quite larger than those of the generalized Poisson model. Also, the loglikelihood value of the generalized Poisson model was found to be larger than that of the standard Poisson model, thereby, supporting the appropriateness of the generalized Poisson model over the standard Poisson model. Following the work of **Nkegbe and Shankar (2014)**, the presence of under-dispersion means that both equi-dispersion and over-dispersion will produce inefficient estimates. Therefore, our discussion of the estimates (Table 5) is based on the generalized Poisson regression model.

All estimated variables except for credit and household size were significant at 1% in explaining adoption intensity (Table 5). The direction of the signs of the coefficients were also consistent with the *a priori* expectations in all three models. Age had a significant and positive effect on intensity of adoption of CCCA strategies, implying that older farmers have higher probability of adopting many strategies than younger farmers.

As expected, there was a positive relationship between extension visits and intensity of adoption of CCCA strategies, implying that the more farmers received visits by extension agents the more likely they are to adopt multiple climate change coping/adaptation strategies. This result is supported by finding of **Azumah *et al.* (2017)**, and **Obeng *et al.* (2016)** who also found a positive and significant association between extension services and adoption of CCCA strategies in the northern region of Ghana. Other findings that show a positive association between access to extension and adoption of CCCA strategies in northern Ghana include **Fagariba *et al.* (2017)**.

Similarly, farm size had a positive influence on intensity of adoption of CCCA strategies. This finding did not come as a surprise because increase in farm size comes with a lot of commitment in terms of investment in new strategies to either sustain or increase yields. **Azumah *et al.* (2017)** also found a positive association between farm size and adoption of CCCA strategies in northern region of Ghana. The positive association of farm size with the of multiple CCCA strategies is corroborated by **Fadina and Barjolle (2018)**. Even though **Fagariba *et al.* (2018)** reported an insignificant effect of farm size on adoption of CCCA strategies in the Sissala West district of the Upper West Region, the coefficient of farm size was positive indicating a relationship of a potential of increase in adoption of climate change adaptation strategies by farmers with larger farm sizes. This means that if farmers with larger farms are to combat the adverse effects of climate change effectively, adoption of a combination of coping strategies is key.

Table 4. Results of Exogenous and Endogenous Switching Poisson Models

Model	Exogenous-switch Poisson		Endogenous switch Poisson	
Variable	Coeff.	Std	Coeff.	Std
Credit	0.014	0.064	0.011	0.126
Age	0.010***	0.002	0.010***	0.002
Sex	-0.242***	0.072	-0.242***	0.072
Household size	-0.004	0.003	-0.004	0.003
Extension visits	0.071***	0.018	0.071***	0.018
Farm size	0.518***	0.09	0.518***	0.09
Constant	0.819	0.135	0.819	0.135
Switch				
Age	-0.015*	0.008	-0.015*	0.008
Sex	-0.162	0.211	-0.162	0.211
Farm size	0.089	0.233	0.089	0.233
Constant	1.176	0.355	1.176	0.355
Sigma	0	0.024	0.002	0.076
rho	-	-	0.831	2.821
LR Chi^2 (13)		127.98		127.71
Prob>Chi^2		0		0
Pseudo R^2		-		-
Log likelihood		-636.551		-636.551
AIC		1297.103		1299.102
BIC		1338.36		1343.797

Note: * p<0.1; ** p<0.05; *** p<0.01
Source: Analysis of field data, 2019

Table 5. Parameter estimates of determinants of adoption intensity of CCCA strategies

Model	Standard Poisson		Generalized Poisson	
Variable	Coeff.	Std	Coeff.	Std
Credit	0.014	0.064	0.011	0.059
Age	0.010***	0.002	0.010***	0.002
Sex	-0.242***	0.072	-0.241***	0.067
Household size	-0.004	0.003	-0.004	0.003
Extension visits	0.071***	0.018	0.069***	0.017
Farm size	0.518***	0.09	0.519***	0.085
Constant	0.819	0.135	0.847	0.128
LR Chi^2 (13)		133.62		125.66
Prob>Chi^2		0.000		0.000
Pseudo R^2		0.118		0.112
Log likelihood		-497.26		-496.366
AIC		1008.532		1008.733
BIC		1032.598		1036.237
Dispersion		-		-0.067
Likelihood-ratio test of delta=0: chi2(1) = 1.8 Prob>=chi2 = 0.0899				

Note: * p<0.1; ** p<0.05; *** p<0.01
Source: Analysis of field data, 2019

Sex of the respondent had a negative and significant effect on the adoption intensity of CCCA strategies, corroborating with **Fadina and Barjolle (2018)**, and **Obeng *et al.* (2016)**. This finding means that female farmers are more likely to adopt more CCCA strategies and adaptation compared to their male counterparts. Similarly, a qualitative study conducted by **Antwi-Agyei *et al.* (2018)** in northern Ghana found that more female headed households were more likely to adopt climate change adaptation strategies than those headed by males. A plausible explanation to these findings including that of this study is the fact that adverse climate change has a detrimental effect on food security, income and livelihoods which translates to increasing poverty levels. Many studies have linked poverty to women as the worst affected. This implies therefore that any strategies aimed at reducing the effect of climate change on livelihoods will have more females adopting than males.

CONCLUSIONS

The impact of climate change is being felt across Africa with significant negative effects recorded among resource poor stallholder farmers in the north of Ghana. Adaptation mechanisms are therefore necessary to reduce vulnerability. This study presents an econometric model that in our opinion, best investigates the factors that influence adoption intensity of CCCA strategies among smallholder farmers in northern Ghana, while considering critically, the nature of dispersion and potential incidence of endogeneity that may affect the efficiency and consistency of the estimates. However, one important limitation is worth noting. Count data models do not account for how different factors affect adoption of specific CCCA strategies. With this adopted approach all strategies are treated equally, independent of whether a particular CCCA strategy is more or less important to cope with climate change (CC) than other ones. From the empirical results, the study concludes that without correcting for errors, the estimates of coefficients of the standard Poisson model appear inefficient. Credit did not exhibit endogeneity as the test statistic *(rho)* was insignificant. Age, extension visits, and farm size positively and significantly influenced the adoption of multiple CCCA strategies and should be given credence by policy makers when designing national climate mitigation and adaptation documents. Female farmers in northern Ghana must be targeted too, as they have been found to adopt many coping and adaptation mechanisms to improve resilience at household level.

REFERENCES

ANTWI-AGYEI, P., STRINGER, L.C., & DOUGILL, A.J. (2014). Livelihood adaptation to climate variability: insights from farming households in Ghana. Reg. *Environ. Change*, 14: 1615–1626. DOI: https://doi.org/10.1007/s10113-014-0597-9

ASANTE, F. A., & AMUAKWA-MENSAH, F. (2015). Climate Change and Variability in Ghana: Stocktaking. *Climate*, 3:78-99. DOI: http://dx.doi.org/10.3390/cli3010078

AZUMAH, S.B., DONKOH, S.A. & ANSAH, I.G.K. (2017). Contract farming and the adoption of climate change coping and adaptation strategies in the northern region of Ghana. *Environment, Development and Sustainability. Springer*. 1-21. DOI: http://dx.doi.org/10.1007/s10668-016-9854-z

BAWAKYILLENUO, S., YARO, J.A., & TEYE, J. (2016). Exploring the autonomous adaptation strategies to climate change and climate variability in selected villages in the rural northern savannah zone of Ghana. *Local Environ*. 21, 361–382. DOI: http://197.255.68.203/handle/123456789/6099

CAMERON, A. C., & TRIVEDI, P. K. (1999). Essentials of Count Data Regression (Chapter 15). In B. B.H. (Ed.), A Companion to Theoretical Econometrics. Malden, MA: Blackwell Publishing Ltd. http://cameron.econ.ucdavis.edu/research/CTE01preprint.pdf

CODJOE, S.N.A., ATIDOH, L.K., & BURKETT, V. (2012). Gender and occupational perspectives on

adaptation to climate extremes in the Afram Plains of Ghana. *Climate Change*, 431–454. DOI: https://doi.org/10.1007/s10584-011-0237-z

CODJOE, S.N.A., OWUSU, G., & BURKETT, V. (2014). Perception, experience, and indigenous knowledge of climate change and variability: the case of Accra, a Sub-Saharan African city. Reg. *Environ. Change*, 14: 369–383. DOI: https://doi.org/10.1007/s10113-013-0500-0

ELSIE ASSAN, E., SUVEDI, M., OLABISI, L.S & ALLEN, A. (2018). Coping with and Adapting to Climate Change: A Gender Perspective from Smallholder Farming in Ghana. *Environment*. 5 (86). DOI: http://dx.doi.org/10.3390/environments5080086

ERDMAN. D, JACKSON, L., & SINKO, A. (2008). Zero-Inflated Poisson and Zero-Inflated Negative Binomial Models Using the COUNTREG Procedure. *SAS Institute Inc., Cary, NC.* Paper 322. https://support.sas.com/resources/papers/proceedings/pdfs/sgf2008/322-2008.pdf

FADINA, A.M.R., & BARJOLLE, D. (2018). Farmers' Adaptation Strategies to Climate Change and Their Implications in the Zou Department of South Benin. *Environment*. DOI: https://doi.org/10.3390/environments5010015

FAGARIBA, C.J., SONG, S., & BAORO, S.K.G.S. (2018). Climate Change Adaptation Strategies and Constraints in Northern Ghana: Evidence of Farmers in Sissala West District. Sustainability. DOI: https://doi.org/10.3390/su10051484

FAMOYE, F., WULU, J.T., & SINGH, K.P. (2004). On the Generalized Poisson Regression Model with an Application to Accident Data. *Journal of Data Science*, 2: 287-295. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.456.629&rep=rep1&type=pdf

FAO (2016). Leaving no one behind. Addressing climate change for a world free of poverty and hunger. FAO's work on climate change poverty and hunger. http://www.fao.org/3/i6371en/I6371EN.pdf.

GHANA STATISTICAL SERVICE (GSS) (2013). Regional Analytical Report. Northern Region. Ghana Statistical Service. Accra, Ghana. https://s3-us-west-2.amazonaws.com/new-ndpc-static1/CACHES/PUBLICATIONS/2019/01/21/2010_PHC_Regional_Analytical_Reports_Greater_Accra_Region.pdf

GSS. GHANA STATISTICAL SERVICE (2013). *2010 Population and Housing Census*. Non-Monetary Poverty in Ghana. Ghana Statistical Service, Accra, Ghana. July 2013. http://www.statsghana.gov.gh/

GREENE, W.H. (2002). Econometric Analysis: fifth edition. New York University. https://spu.fem.uniag.sk/cvicenia/ksov/obtulovic/Mana%C5%BE.%20%C5%A1tatistika%20a%20ekonometria/EconometricsGREENE.pdf

HALLEGATTE, S., MOOK, B., LAURA, B., MARIANNE, F., TAMARO, K., ULF, N., JULIE, R., DAVID, T., & ADRIEN, V-S. (2016). Shock Waves: Managing the Impacts of Climate Change on Poverty. Climate Change and Development Series. Washington, DC: World Bank. License: Creative Commons Attribution CC BY 3.0 IGO. DOI: https://doi.org/10.1596/978-1-4648-0673-5

IPCC (2001). Glossary– Climate Change. Education Centre – Arctic Climatology and Meteorology. NSIDC National Snow and Ice Data Centre. Glossary, in IPCC TAR WG1 2001

LAWSON, E.T., ALARE, R.S., SALIFU, A.R.Z., & THOMPSON-HALL, M. (2019). Dealing with climate change in semi-arid Ghana: understanding intersectional perceptions and adaptation strategies of women farmers. *Geo Journal, 1-14*. DOI: https://doi.org/10.1007/s10708-019-09974-4

LI, Q., & TRIVEDI, P. K. (2009). Impact of prescription drug coverage on drug expenditure of the elderly evidence from a two-part model with endogeneity. Mimeo Paper available at: https://pdfs.semanticscholar.org/8f4b/50a49e1ac988c70ba17c15a4daad5c392fdd.pdf

KRANJAC-BERISAVLJEVIC, G., BLENCH, R.M., BAYORBOR, T. B., TURTON, C. N., ABDULAI, A. S., BOYD, C., OBENG, F., & DRAKE, E. (1999). Rethinking natural resource degradation in semi-arid sub-Saharan Africa: The case of semi-arid Ghana. London, *Overseas Development Institute*. http://www.odi.org.uk/rpeg/soil_ degradation/ghlit.pdf

MIRANDA, A. (2004). FIML estimation of an endogenous switching model for count data. *The Stata Journal* 4 (1), 40–49. https://pdfs.semanticscholar.org/2393/49d86031f2ad74434a9864d4a32154209d75.pdf

MULLAHY, J. (1997). Instrumental-Variable Estimation of Count Data Models: Applications to Models of Cigarette Smoking Behaviour. *Review of Economics and Statistics*, 79, 586-593. DOI: https://doi.org/10.1162/003465397557169

NKEGBE, P., & SHANKAR, B. (2014). Adoption intensity of soil and water conservation practices by smallholders: evidence from Northern Ghana. *Bio-based and Applied Economics*, 3(2): 159-174. DOI: https://doi.org/10.13128/BAE-13246

OBENG, F. K, AWASINA R. A. & AYAMBILA S. N. (2016). Factors Influencing the Adoption of Climate Change Adaptation Strategies by Smallholder Farmers in East Mamprusi District of Northern Region. *Ghana. Ghana Journal of Science, Technology and Development*, 4 (2), 84-95.

SCHELLHORN, M. (2001). The Effect of Variable Health Insurance Deductibles on the demand for Physician Visits. *Health Economics*, 10: 441-456. DOI: https://doi.org/10.1002/hec.630

SKOUFIAS, E., RABASSA, M., OLIVIERI, S., & BRAHMBHATT, M. (2011). *The Poverty Impacts of Climate Change*. Poverty Reduction and Economic Management Network (Prem). Economic Premise. The World Bank.

TOMPKINS, E. L., and ADGER, W. N. (2003). Building resilience to climate change through adaptive management of natural resources. Tyndall centre for climate change research working paper 27.

TERZA, J. V., KENKEL, D. S., LIN, T.-F., & SAKATA, S. (2008). Care-giver advice as a preventive measure for drinking during pregnancy: Zeros, categorical outcome responses, and endogeneity. *Health Economics*, 17, 41–

54. DOI: https://doi.org/10.1002/hec.1232
TERZA, J. (1998). Estimating count data models with endogenous switching: Sample selection and endogenous treatment effects. *Journal of Econometrics*, 84: 129–154. DOI: https://doi.org/10.1016/S0304-4076(97)00082-1
TEYE, J.K., YARO, J.A., & BAWAKYILLENUO, S. (2015). Local farmers' experiences and perceptions of climate change in the Northern Savannah zone of Ghana. *International Journal of Climate Change Strategies and Management*, 7 (3):327-347. DOI: https://doi.org/10.1108/IJCCSM-05-2014-0066
UNFCCC (2007b). Report on the African Regional Workshop on Adaptation. FCCC/SBI/2007/2. UN Office at Geneva, Switzerland. http://unfccc.int/resource/docs/2007/sbi/eng/02.pdf
VAN OPHEM, H. (2000): Modelling Selectivity in Count Data Models. *Journal of Business & Economic Statistics* 18: 503-511. DOI: https://doi.org/10.1080/07350015.2000.10524889

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REGULAR ARTICLE

DRIVERS OF CLIMATE CHANGE ADAPTATION IN ARTISANAL FISHERIES: A CASE OF MALAWI

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ABSTRACT

This study was conducted to understand fishers' climate change adaptation decisions in order to move climate informed policy for artisanal fisheries in developing economies forward. Data were collected from a random sample of 220 fishers in Mangochi District in Malawi. A binary probit model and a multivariate probit model were used to assess factors that affect fishers' decision to adapt to climate change and their choice of adaptation strategies respectively. The study found that factors such as sex, education level, fishing experience, household size, fishing income, perception of catch rate trend, social capital and access to extension service corresponded in an increase in the probability of fishers adapting to impacts of climate change by increasing fishing effort, engaging in migratory fishing, investing in improved gear and livelihood diversification. The study recommends strengthening the education system in riparian communities to equip fishers with skills employable outside fishing and at the same time relive pressure off aquatic ecosystems.

Keywords: climate change; fisheries; adaptation; probit; Malawi
JEL: C13; D91, Q22, Q54

INTRODUCTION

A fishery's productivity is closely linked to the functioning and health of its aquatic ecosystem on which it depends for survival. Growth, mortality and reproduction of fish are indirectly affected by changes in their physical environments caused by a change in climate, while feeding, migration and breeding are directly affected by the same (**Ogutu-Ohwayo *et al.*, 2016**). Due to their poikilothermic nature, fish are very sensitive to their surrounding environment as such, fish always seek an external environment which is in synchrony with their preferred internal environment, a term referred to as behavioural thermoregulation (**Cheung *et al.*, 2009; Keefer *et al.*, 2018**). This behavioural response has been predicted to contribute to decline in catches in developing economies by about 40% as it results in migration of fish stock mainly from areas experiencing warming (**Cinner *et al.*, 2009; Cheung *et al.*, 2009; Daw *et al.*, 2012**).

The decreases in the availability and quality of fish in warmer areas has caused fishery-dependent communities to face heightened vulnerability resulting in unstable livelihoods. To maintain their livelihood source, fishers implement various adaptation strategies. Adaptation enhances resilience and reduces vulnerability of individuals, communities or activities to climate change (**Galappaththia *et al.*, 2018**). Research has shown that climate change would not immediately slow down economic growth and that is a window of opportunity for the development of smart and forward looking adaptation policies (**Arndt *et al.*, 2014**). In spite of that, little is known about the socio-economic environment in which fishers make their decisions with respect to climate change adaptation. This study attempts to fill this gap by assessing the socio-economic, institutional and demographic factors which affect fishers' climate change adaptation decisions.

In modelling determinants of adaptation, binary choice models have been the most widely used models while the multinomial logit model has been widely used to model factors that affect choice of adaptation strategies (**Pradhan and Leung, 2004; Sanga *et al.*, 2013**). The shortcoming of the multinomial logit model is that it assumes Independence of Irrelevant Alternatives (IIA). The problem of IIA can be avoided by using the multinomial probit model which allows different scale parameters across alternatives. However, both the multinomial logit and multinomial probit models are not good fits for adaptation studies because first, a respondent may choose more than one strategy; second, the error terms among strategies may be correlated. Using the multinomial logit or multinomial probit models does not portray the reality faced by decision makers who are most times faced with alternatives which might be adopted simultaneously and/or sequentially as complements or substitutes. This research opted to use a multivariate probit model which allows error terms to be freely correlated (**Capellari and Jenkins, 2003; Hassan and Nhemachena, 2008; Pangapanga and Jumbe, 2012; Mulwa *et al.*, 2017; Thoai *et al.*, 2017**)

DATA AND METHODS

Theoretical Model

Fishers' climate change adaptation decisions can be analysed on the basis of alternative decision models. Two main elements comprise this decision; the choice set – options to be considered, and the objective function – criteria for choosing among options. The objective function defines the decision making process which seeks to find an option that yields the best value of the objective function, subject to constraints present. This is governed by the Random Utility Theory (**Ben-Akiva and Boccara, 1995**).

When predicting choices, human behaviour cannot be approximated by deterministic parameters. Hence it is stated that human behaviour has a probabilistic nature (**Ben-Akiva and Boccara, 1995**). It is further argued that while a decision maker knows their utility function, the researcher does not know the exact form of that function. In this case, the decision maker, chooses an alternative if utility (U) of that alternative is greater than that of the next, expressed as $U_{in} > U_{jn} \, \forall \, j \neq i$, where j are the different choices from the choice set C_n and the decision maker is labelled n. Since the researcher does not know all the aspects of the decision maker's utility function, a representative utility function $V_{jn} = V(x_{jn}, S_n)$ is introduced, with $x_{nj} \, \forall \, j$ the attributes of the alternatives and S_n, some attributes of the decision maker. Utility V is dependent on characteristics the researcher cannot know, hence it follows that $V_{jn} \neq U_{jn}$. The utility can be decomposed as $U_{jn} = V_{jn} + \varepsilon_{jn}$, where ε_{jn}captures the factors that affect utility but are not known to the researcher and therefore are not included in V_{jn}. Is simple terms, ε_{jn} is the difference between U_{jn} and V_{jn} and could be considered an error term. The form of $\varepsilon_{jn}$is unknown because $\varepsilon_{jn}$are factors that affect the utility, but are not known by the researcher as such, these terms are treated as random. The probability that the fisher chooses a certain alternative is expressed by the Eq. 1.

$$P(i|C_n) = Pr(U_{in} \geq U_{jn}, \forall j \in C_n) \quad (1)$$

Following **Ben-Akiva and Lerman (1985)**, the most insightful way of expressing the choice probabilities in choice set C_n is to reduce them to a binary problem, alternatives i and j. The probability that the fisher, n, who is the decision maker will select alternative i, or j (Eq. 2).

$$P_n(i) = \Pr\left(U_{in} \geq U_{jn}\right) \text{ and } P_n(j) = 1 - P_n(i) \quad (2)$$

Random utility theory can be made operational by first breaking down the aggregate utility into its deterministic and random components, then specify the deterministic component and the random component (Eq. 3 - Eq.4).

$$U_{in} = V_{in} + \varepsilon_{in} \quad (3)$$
$$U_{jn} = V_{jn} + \varepsilon_{jn} \quad (4)$$

V_{in} and V_{jn} are the systematic components they are assumed to be deterministic because it is the part of the utility that can be observed by the researcher. After separating utility into deterministic and random parts, both parts can now be defined. The term V is not only dependent on the underlying attributes, but also on the attributes of the decision maker, it can be defined as $V(Z_{in}, S_n)$. Because vectors Z and S are combined to describe V, a new vector $x_{in} = h(Z_{in}, S_n)$ is defined, h being some vector-valued function. The term V can now be re-written as $V_{in} = V(x_{in})$ and $V_{jn} = V(x_{jn})$. A second function which reflects the theory about how the elements in x influence utility and with parameters that can be easily estimated, we choose functions that are linear in parameters. ß $= (\beta_1, \beta_2, \ldots, \beta_k)$ is defined as a vector of K unknown parameters (Eq. 5 – Eq.6).

$$V_{in} = \beta_1 x_{in1} + \beta_2 x_{in2} + \cdots + \beta_K x_{inK} \quad (5)$$
$$V_{jn} = \beta_1 x_{jn1} + \beta_2 x_{jn2} + \cdots + \beta_K x_{jnK} \quad (6)$$

Finally, there is a need to specify the disturbances before obtaining an operational binary choice model. It is usually assumed that the mean of the disturbance is zero and their scale is consistent with the scale of the functions V. The disturbances can be viewed as being the sum of a large number of unobserved and independent components. Following the law of central limit theorem, the disturbances tend to be normally distributed. It can now be stated that ε_{in} and ε_{jn}, both have a normal distribution with mean zero and variances σ_i^2 and σ_j^2 respectively, and the difference between the disturbances also has a normal distribution with zero mean and variance $\sigma_i^2 + \sigma_j^2 - 2\sigma_{ij} = \sigma^2$. When $V_{in} = \beta' x_{in}$ and $V_{jn} = \beta' x_{jn}$, it can be stated for the choice probabilities (Eq.7).

$$P_n(i) = \Phi\left(\frac{\beta'(x_{in} - x_{jn})}{\sigma}\right) \quad (7)$$

Where Φ denotes the standardized cumulative distribution. The choice probability is only reliant on σ, and not on the variance of either the disturbance or covariance. Further, the choice of σ is arbitrary, rescaling σ or β by any positive constant cannot affect the choice probability. Normally $\sigma = 1$ is chosen (**Ben-Akiva and Lerman, 1985; Macfadden, 1986**).

Empirical Framework

Sample Selection Probit Model

Climate change adaptation is a two-stage process: first, one has to perceive climate as changing; second, deciding the course of action to take in response to the changing climate, as such analysis of data to assess to determinants of adaptation followed a two stage procedure. This is the equivalent of the Heckman sample selection model as it was used by **Maddison (2007)**. In the first probit, the regressand was whether a fisher perceived climate change, taking a value of 1 for yes and 0 otherwise. Then an Inverse Mill's Ratio (IMR), a ratio of the probability density function over the cumulative distribution function of a distribution, was derived which was then included in the second probit as a regressor whose regrassand was

whether a fisher adapted to impacts of climate change, taking a value of 1 for yes and 0 otherwise. This was done to take care of any potential selection biasness at the first stage of decision making. Heckman's sample selection model is based on the following two latent variable models (Eq.8 - Eq.9).

$$y_j^* = x_j'\beta + \varepsilon_j \quad (8)$$
$$y_i^* = x_i'\beta + \varepsilon_i \quad (9)$$

Where:
y_i^* is only observable if $y_j^* > 0$. In this way, the real dependent variable is $y = y_i$ if $y_j^* > 0$, y is a missing value is $y_j^* < 0$.

For each person i we can write the utility difference between adapting and not adapting as a function of observed characteristics, x_i and unobserved characteristics, ε_i. In this case, for a fisher to adapt they first have to perceive the impacts of climate change and the utility of adaptation should exceed a certain threshold, usually set at 0. Adaptation, $y_i = 1$ is observed if and only if $y_i^* > 0$ and $y_i = 0$ (no adaptation) otherwise, expressed as the Eq.10.

$$y_i^* = \begin{cases} y_i = 1 \; if \; y_i^* > 0 \\ y_i = 0 \; if \; y_i^* \leq 0 \end{cases} \quad (10)$$

Multivariate Probit Model

A multivariate probit model was used to determine factors that affect specific choice of adaptation strategies. The model is a multi-response variable model which specified the relationship between choosing adaptation options and a set of independent variables (**Ben-Akiva and Bolduc, 1996; Greene, 2005**). The model's latent variables are expressed as discrete variables through a threshold specification. The structural form of the model is as the Eq. 11.

$$y_{im}^* = \beta_m' x_{im} + \varepsilon_{im}, m = 1, \ldots, M \quad (11)$$
$$y_{im} = 1 \; if \; y_{im}^* > 0 \text{ and 0 otherwise}$$

Where:
y_{im} is a vector of adaptation strategies, β_m' is a vector of parameters and x_{im} is a vector of explanatory variables. $\varepsilon_m, m = 1, \ldots, M$ are error terms distributed as multivariate normal, each with a mean of zero, and variance–covariance matrix, with values of 1 on the leading diagonal and correlations $\rho_{1m} = \rho_{m1}$ as off-diagonal elements.

The structural form of the model allows more than one equation with correlated disturbances. The dependent variable represents adaptation strategies. The model is estimated through maximum likelihood using the Geweke–Hajivassiliou–Keane (GHK) smooth recursive conditioning simulator (**Geweke, 1996; Chib and Greenberg, 1998; Cappellari and Jenkins, 2003**).

Data Sources

Primary data was collected through a cross section survey of small scale/artisanal fishers in Mangochi district, Malawi. Mangochi is a district located in the southern region of Malawi. Mangochi district has a coverage of 6, 273km^2. It is located at the southern end part of Lake Malawi and 8 km south of Lake Malombe which is also in the district. It has an average annual temperature of 29.9 ^{o}C, and an average daily temperature of 24.1 ^{o}C and an average annual precipitation of 846 mm.

RESULTS AND DISCUSSION

Descriptive Statistics

Table 1 presents summary statistics of key variables. The average number of years spent schooling was six. This implies that most of the respondents did not finish primary school. It was expected that the probability of adaptation would be higher among highly educated fishers. The addition labour force associated with being married was expected to increase the probability of a fisher adapting to the impacts of climate change. Fishing experience and age were expected to increase the probability of adaptation as more experienced fishers may easily notice changes in climatic patterns than their counterparts.

Table 1 Summary Statistics of Key Variables

Variable	Observations	Mean	Std. Dev.
Fishing location (1=lake Malawi)	220	0.86	0.34
Sex of respondent (1=male)	220	0.98	0.12
Age of respondent (years)	220	42	10
Education level (years)	220	6.0	4.1
Marital status (1=married)	220	0.095	0.21
Access to land (1=yes)	220	0.78	0.41
Fishing experience (years)	220	12	7.4
Household size (number)	220	6.0	2.2
Total income (MK)	220	178,306.8	139,886.2
Fishing income (MK)	220	123,113.6	105,719.8
Catch rate (Kg per day)	220	128.0	100
Social Capital (1=Yes)	220	0.47	0.5
Access to credit (1=Yes)	220	0.38	0.03
Contacts with extension agent (1=Yes)	220	0.25	13.9

Table 2 Perceived trends of some climate variables

Climate Variable	Perceptions	Count	Percent
Temperature	Increasing	191	87
	Decreasing	5	2.1
	No change	24	10.9
	Total	220	100
Rainfall	Increasing	18	8.4
	Decreasing	200	90.9
	No change	2	0.7
	Total	220	100
Wind Speed	Increasing	213	97
	Decreasing	0	0
	No change	7	3
	Total	220	100
Wind direction	Predictable	0	0
	Unpredictable	220	100
	Total	220	100

The effect of having access to land for farming was expected to vary. Income was expected to be positively associated with adaptation since it requires financial resources. It was expected that fishers with access to credit could use that opportunity as a means of enhancing their adaptive capacity, this was also expected to be true for both social capital and access to extension services.

Adaptation Strategies

Fishermen who perceived climate change (92%) were asked to mention how they perceived it. As Table 2 shows, over 90% percent of the respondents mentioned noticing changes in temperatures, rainfall, and wind patterns.

Naturally, not everyone who perceives climate as changing takes measures to reduce vulnerability and enhance resilience to its impacts. This was also true for this study as of 92% of the respondents who perceived climate as changing, only 66% had had taken measures to lessen the negative impacts of climate change on their fishing livelihoods. The 34% who failed to adapt accounted it to shortage of income, labour, and negligence.

Literature revealed a number of adaptation strategies employed by fishers elsewhere. Respondents of this study however employed the following four non-mutually exclusive adaptation strategies: first, increasing fishing effort. We considered nominal fishing effort as it is readily observable and easily measurable. It describes the resources allocated to fishing such as number of vessel days, gear (net size), time (days or hours), and labour (number of crew) (**McCluskey and Lewison, 2008**). This strategy was employed by 54% of the respondents. Second, migratory fishing. We consider internal migration which involves moving of a fisher from one beach to another within the same locality in response to declining catch rate (**Kennedy and Raj 2014**). This strategy was employed by 52% of the respondents. Third, investing in improved gear. This involves investing in vessel stability to withstand the harsh conditions associated with climate change. This strategy was employed by 37% of the respondents. Fourth, livelihood diversification. Livelihood diversification is achieved when households engage in more than one income generating activity to spread risk and decrease vulnerability (**Saha and Bahal, 2015**). It was employed by 19% of the respondents.

Respondents of this study employed more than one strategy at any point in time. Of the fishers (41%) who increased their fishing effort and engaged in migratory fishing simultaneously, 32% also diversified their livelihood portfolio, and 14% also invested in improved gear. We went a step further to assess correlations between the four strategies. We found a complementary relationship between increasing fishing effort and migratory fishing, significant at $p < 0.01$; livelihood diversification and migratory fishing, significant at $p < 0.01$; livelihood diversification and investing in improved gear, significant at $p < 0.05$.

Factors Affecting Adaptation to Climate Change

In Table 3 we present estimates of the binary probit model on factors affecting fishers' adaptation to climate change. The data were tested for multicollinearity using Variance Inflation Factors (VIF) through the 'collin' of the Stata package and there was no evidence of worrisome collinearity. Robust standard errors were used to take care of any heteroskedasticity in the model. The IMR was not significant meaning that there was no proof of selection biasness in the data which appropriated the use of the standard binary probit model. Discussion of the results is based on marginal effects which provide a meaningful way of quantifying changes in the dependent variable due to changes in independent variables. For dummy variables, the marginal effects represent discrete change of dummy from 0 to 1. Interpretation of the marginal effects assumes a ceteris paribus condition for the other independent variables.

The model was robust and overall significant ($Prob > \chi^2 = 0.0000$). The results in Table 3 show that the probability of adaptation was higher for male fishers than for their female counterparts. A marginal effect of 0.1960 implies that being a male fisher significantly ($p < 0.1$) increases the probability of adapting to the impacts of climate change by 19.6 percentage points. This result was expected as women's access to resources that would enable them to adapt to climate change in the same way as men may not be the same as men's.

Education had a significant ($p < 0.01$) relationship with adaptation. A marginal effect of 0.0164 suggests that a unit increase in a fisher's education increases their probability of adapting to the impacts of climate change by 1.64 percentage points. Being educated is associated with openness to change and an easy understanding of complex concepts such as climate change as such it enhances the ability of a fisher to make informed decisions based on available information.

With a marginal effect of 0.10, having access to land had a negative significant ($p < 0.05$) effect on fishers' adaptation decisions. Having access to land decreased the probability of a fisher adapting to the impacts of climate change by 10 percentage points. This could be because farming is an alternative source of income such that those with more land are more likely to invest in farming than adapt their fishing practices to the impacts of climate

change, more especially when fishing is not the main income source.

Fishing experience was positive and significant ($p < 0.01$). A marginal effect of 0.016 suggests that a unit increase in fishing experience increased the probability of the fisher adapting to the effects of climate change by 1.6 percentage points. Highly experienced fishers can easily notice changes in climatic conditions. They become acquainted with weather forecasting which enables them to easily adjust themselves to actual and anticipated changes. This result agrees with **Maddison (2007)** and **Hassan and Nhemachena *et al.* (2008)** on their climate change adaptation studies in crop production for farmers in southern Africa.

Household size was positive and significant ($p < 0.05$). An increase in household size by one member corresponded to an increase in the probability of a fisher adapting to the impacts of climate change by 2 percentage points. The possible reason could be that larger household sizes are associated with a higher labour endowment. This is more likely to enable them to carry out various labour demanding adaptation activities more than their counterparts (**Bryan *et al.*, 2009**). However, **Hassan and Nhamachena (2008)** reported that household size has mixed impacts in spite of their finding that it increased adaptive capacity of farmers. They explained that some households with larger sizes tend to divert their members to source income from other activities and hence reducing labour allocated to the main source of income and hence making adaption less likely.

A 10 percent increase in fishing income was significantly ($p < 0.01$) associated with an increase in the probability of a fisher adapting to the impacts of climate change by 1.66 percentage points. This might be because adaptation requires financial resources hence an increase in income obtained from fishing acts as an incentive for further investments in the same.

Membership to a social group was used as a proxy for social capital. This refers to formal or informal social networks in which members of a household are engaged to secure their livelihood. Social capital significantly ($p < 0.01$) increased the probability of a fisher adapting to the impacts of climate change by 13 percentage points. This could be because such groups act as a platform for exchange of information and other resources which could then enhance adaptation.

A unit increase in the number of extension visits by an extension worker significantly ($p < 0.01$) corresponded to an increase in the probability of a fisher adapting to impacts of climate change by 0.9 percentage points. Fishers with more extension visits are better informed about the consequences of climate change and possible actions that could be taken (**Deressa *et al.*, 2008; Hassan and Nhemachena, 2008; Khanal *et al.*, 2018**).

Factors Affecting Choice of Adaptation Strategies

We estimated a multivariate probit model to examine factors influencing choice of adaptation strategies. The results are presented in Table 4.

The model was robust and overall, significant ($Prob > \chi^2 = 0.0000$). The model had a log likelihood ratio of -361.047 with 30 draws per observation. Robust standard errors were used to account for any heteroscedasticity in the data. The hypothesis that the correlations between the error terms in the adaptation strategies equations were equal to zero was rejected ($Prob > \chi^2 = 0.000$) implying that there was endogeneity within the data and multivariate probit was the right model to use. This endogeneity was corrected using the Geweke–Hajivassiliou–Keane (GHK) smooth recursive conditioning simulator, a simulation method for evaluating multivariate normal distribution functions (**Capellari and Jenkins, 2003**).

Table 3 Binary Probit Model Estimates

Variable	Marginal effects	Robust Std. Err.	z-statistic
Fishing location (1=lake Malawi)	-0.003	0.056	-0.05
Sex of respondent (1=male)	0.196	0.109	1.79*
Marital status (1=married)	-0.024	0.082	-0.29
Age of respondent (years)	-0.002	0.002	-0.75
Education level (years)	0.016	0.005	3.06***
Access to land (1=yes)	-0.101	0.047	-2.15**
Fishing experience (years)	0.017	0.004	3.78***
Household size (number)	0.021	0.011	1.96**
Log of total income (MK)	-0.088	0.056	-1.58
Log of fishing income(MK)	0.166	0.059	2.8***
Catch rate (Kg)	0.000	0.000	-1.63
Social Capital (1=yes)	0.132	0.041	3.22***
Access to credit (1=yes)	-0.013	0.039	-0.34
Contacts with extension agents (contacts/Year)	0.009	0.002	5.09***
Number of obs	220		
Pseudo R^2	0.5989		
LR χ^2 (15)	86.30		
Prob > χ^2	0.0000		
Pearson χ^2 (192)	423.66		
Prob > χ^2	0.0000		

Note: * = Significant *p*-value<0.1, ** = Significant *p*-value<0.05, *** = Significant *p*-value<0.01, 1 Malawi Kwacha = 750USD.

Table 4: Multivariate Probit Model Estimates

Variables	Increasing fishing effort dy/dx (Std. Err.)	Migration of fishing efforts dy/dx (Std. Err.)	Investing in improved gear dy/dx (Std. Err.)	Livelihood diversification dy/dx (Std. Err.)
Fishing location (1=lake Malawi)	-0.146 (0.091)	-0.042 (0. 089)	0.160 (0.099)	-
Sex of respondent (1=male)	0.142 (0.222)	-0.045 (0.172)	-0.052 (0.246)	-
Marital status (1=yes)	-0.051 (0.133)	-0.110 (0.104)	0.153 (0.160)	-0.078 (0.067)
Age of respondent (years)	-0.002 (0.003)	-0.006 (0.003)**	-0.001 (0.003)	0.000 (0.002)
Education level (years)	0.021 (0.008)***	0.020 (0.007)***	0.010 (0.007)***	0.020 (0.006)***
Access to land (1=yes)	-0.185 (0.066)***	-0.099 (0.067)	-0.049 (0.068)	0.167 (0.058)***
Fishing experience (years)	0.022 (0.005)***	0.029 (0.004)***	0.021 (0.004)***	0.007 (0.003)*
Household size (number)	0.039 (0.012)***	0.009 (0.012)	0.000 (0.016)	0.009 (0.009)
Log of total income (MK)	-0.121 (0.094)	-0.242 (0.073)***	0.092 (0.074)	-0.003 (0.056)
Log of fishing income (MK)	0.200 (0.087)**	0.243 (0.072)***	0.066 (0.081)	-0.016 (0.062)
Catch rate (Kg)	-0.0001 (0.0004)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Social capital (1=yes)	0.196 (0.061)***	0.124 (0.058)**	0.077 (0.061)	0.111 (0.050)**
Access to credit (1=yes)	0.028 (0.067)	0.041 (0.060)	-0.000 (0.062)	-0.051 (0.052)
Access to extension services (Contacts/year)	0.006 (0.002)***	0.010 (0.002)***	0.005 (0.002)**	0.011 (0.002)***
Number of obs	220			
Wald χ^2 (60)	265.23			
Prob > χ^2	0.0000			
Log likelihood	-361.047			

* = Significant *p*-value<0.1, ** = Significant *p*-value<0.05, *** = Significant *p*-value<0.01, 1 Malawi Kwacha = 750USD.

Factors that affect increasing fishing effort

We found positive and significant correlations between increasing fishing effort strategy, and education level of the fisher, fishing experience, household size, fishing income, social capital and access to extension. On the other hand, we found negative correlations between fishing effort and land access.

A unit increase1 in the number of years spent in school corresponded to an increase in the probability of a fisher increasing his or her fishing effort as a response to the effects of climate change by 2.1 percentage points, significantly at $p < 0.01$.

Having access to land, significantly ($p < 0.01$) decreased the probability of a fisher to increase his or her fishing efforts in response to climate change by 18.5 percentage points. This could be because farming and fishing both compete for the same human and financial resources within a fisher's decision unit. For this reason, those who have access to land and engage in farming could increase their effort in such activities than in fishing.

A unit increase in fishing experience increased the probability of fishers adapting to impacts of climate change by increasing their fishing effort by 2.2 percentage points.

A unit increase in household size significantly ($p < 0.01$) increased the probability of that household unit increasing its fishing effort as a climate change adaptation measure by 3.9 percentage points. This could be because more household members translate into a higher labour endowment, enough to accommodate the labour demanding nature of this adaptation option.

The relationship between log of fishing income and fishing effort suggests that a 10 percent increase in fishing income increases the probability of a fisher adapting to impacts of climate change by increasing fishing effort by 2 percentage points, significant at $p < 0.05$. Increasing fishing effort is subject to increasing costs hence increased income helps fishers to meet transaction costs which are associated with increasing fishing effort (**Anderson, 1988; McClusky and Lewison, 2008; Khanal, 2018**).

Having social capital, significantly ($p < 0.01$) increased the probability of increasing fishing effort in response to climate change by 19.6 percentage points. This is consistent with our priori expectation since social capital lubricates transaction costs, facilitates learning and the associated peer influence could translate into cheap labour for a fisher to hire crew men, even net mending or boat construction. Social capital could also facilitate non-cash transactions between members.

Increasing access to extension by one unit significantly ($p < 0.01$) contributed to fishers increasing their fishing effort in response to climate change by 0.6 percentage points. We suspect that the messages which extension agents provide to fishers help them make comparative decisions among competing adaptation alternatives according to their different situations.

Factors that affect migratory fishing

We found positive and significant relationships between migratory fishing and education level, fishing experience, fishing income, social capital and access to extension. We found significant and negative relationships between migratory fishing, age, and total income.

A unit increase in the age of a fisher decreased the likelihood of that fisher engaging in seasonal migration by 0.6 percentage points, significant at $p < 0.05$. It could be explained by the fact that migratory fishing might be too demanding for older fishers. This also agrees with **Kennedy and Raj (2014**).

A unit increase in education corresponded to an

increase in the probability of a fisher engaging in migratory fishing in response to climate change by 2 percentage points, significant at $p < 0.01$.

A unit increase in fishing experience significantly ($p < 0.01$) increased the probability of a fisher engaging in migratory fishing in response to impacts of climate change by 2.9 percentage points. More experienced fishers are more likely to know when and where efforts are productive with respect to specific climatic conditions.

A 10 percent increase in total income decreased the probability of a fisher engaging in migratory fishing in response to impacts of climate change by 2.42 percentage points, significant at $p < 0.1$. As **Jul-Larsen *et al.* (2003)** explained, wealthier fishers combine a number of sources of income, this could reduce their time on fishing if it is declining and hence reduce chances of seasonal migration. However, a 10 percent increase in fishing income suggested a significant ($p < 0.01$) increase in the probability of a fisher engaging in migratory fishing in response to the impacts of climate change by 2.43 percentage points. This is consistent with findings by **Kennedy and Raj (2014)** who reported that an increase in fishing income increased the probability of migration for fishers. **Allison *et al.* (2007)** also reported that rich fishers whose main source of income was fishing, migrated to Lake Malawi and Malombe from Lake Chilwa during the Lakes dry out periods in the past.

Having social capital, significantly ($p < 0.01$) contributed to a fisher engaging in migratory fishing in response to impacts of climate change by 12.4 percentage points and a unit increase in contacts with an extension agent significantly ($p < 0.01$) increased the probability of a fisher engaging in migratory fishing by 1 percentage point.

Factors that affect investment in improved fishing gear

We found positive and significant relationships between investing in improved gear and education level, fishing experience, and access to extension. The relationship between education level and investments in improved fishing gear was positive and significant ($p < 0.01$). A unit increase in the education of a fisher increased the probability of that fisher adapting to the impacts of climate change by investing in improved fishing gear by 1 percentage point.

A unit increase in fishing experience significantly ($p < 0.01$) increased the probability of a fisher investing in improved fishing gear in response to climate change by 2.1 percentage points.

Access to extension was significant at $p < 0.05$. A unit increase in extension service increased the probability of a fisher investing in improved fishing gear in response to climate change by 0.5 percentage points.

Factors that affect livelihood diversification

We found positive and significant relationships between livelihood diversification and education level, fishing experience, access to land, social capital, and access to extension.

A unit increase in a fisher's education level significantly ($p < 0.01$) increased the probability of a fisher diversifying their livelihood sources in response to impacts of climate change by 2 percentage points. Higher education generally builds human capital and contribute to improved skills in an individual. Uneducated fishers are unable to weave skills that could help them tap into other resources. These are obstructed from accessing alternative livelihood niches especially in the non-fishing sector (**Kassie *et al.*, 2017**).

Having access to land for farming, significantly ($p < 0.01$) increased the probability of a fisher diversifying their livelihood sources, by 16.7 percentage points. In response to impacts of climate change, fishers with land might diversify their source of income by engaging more in commercial farming (**Saha and Bahal, 2015; Kassie *et al.*, 2017; Edet and Etim, 2018**).

The relationship between fishing experience and livelihood diversification was positive and significant ($p < 0.1$). A unit increase in fishing experience increased the probability of a fisher diversifying their livelihood portfolio by 0.7 percentage points. This implies that fishers with more fishing experience were more likely to engage in livelihood diversification than their counterparts. It can be explained by the notion that having more experience relates to acquisition of skills which can be applied in other income generating activities like boat repairing.

Having social capital, significantly ($p < 0.05$) increased the probability of a fisher diversifying their livelihood sources, by 11.1 percentage points. As **Kassie *et al.* (2017)** also reported, individuals who come together in promotion of mutual interests could help each other perceive and capitalise on livelihood alternatives.

Access to extension, significant at $p < 0.01$, also contributed to livelihood diversification among fishers. A unit increase in visits by an extension agent increased the probability of a fisher diversifying their livelihood sources in response to impacts of climate change by 1.1 percentage points. It could be because extension agents act as a source of information on how livelihood diversification spreads risk and how it is a pathway to poverty reduction.

CONCLUSIONS

The study revealed that most fishers are aware of climate change but not all take action to lessen its adverse impacts on their fishing practices. The study revealed the following four private adaptation strategies that fishers employ: increasing fishing effort; migratory fishing; investing in improved gear; and livelihood diversification. Adaptation and choice of adaptation strategies were affected by factors such as sex, education level, fishing experience, household size, fishing income, social capital and access to extension service are positively associated with adaptation while access to land is negatively associated with fishers' adaptation to the effects of climate change.

The study recommends improving the adaptive capacity of fishers by increasing awareness of climate change among fishermen. This can be achieved by strengthening both formal and informal extension services; and by strengthening the education system in riparian communities and equipping them with vocational

skills which they could weave to tap into other resources for income which would consequently relive pressure off the aquatic ecosystem and hence prevent overfishing.

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REFERENCES

ALLISON, E. H., ANDREW, N. L., & Oliver, J. (2007). Enhancing the Resilience of Inland Fisheries and Aquaculture Systems to Climate Change. *Journal of SAT Agricultural Research, 4(1)*, p. 1-35. https://hdl.handle.net/20.500.12348/1593

ARNDT, C., SCHLOSSER, A., STRZEPEK, K., & THURLOW, J. (2014). Climate Change and Economic Growth Prospects for Malawi: An Uncertainty Approach. *Journal of African Economies*, 23(2), p. ii83-ii107. DOI: 10.1093/jae/eju013

BEN-AKIVA, M.E., & BOCCARA, B. (1995). Discrete choice models with latent choice. *International Journal of Research in Marketing 19, p. 9*-24. DOI: 10.1016/0167-8116(95)00002-J

BRYAN, E., DERESSA, T. T., GBETIBOUO, G. A., & RINGLER, C. (2009). Adaptation to Climate Change in Ethiopia and South Africa: Options and Constraints. *Environmental Science and Policy*, 12(4), p. 413-426. DOI: 10.1016/j.envsci.2008.11.002

CAPELLARI, L., & JENKINS, S. P. (2003). Multivariate Probit Regression Using Simulated Maximum Likelihood. *The Stata Journal*, 3(3), p. 278-294. DOI: https://doi.org/10.1177/1536867X0300300305

CINNER, J. E., DAW, T., and McCLANAHAN, T. R. (2009). Socioeconomic Factors that Affect Artisanal Fishers' Readiness to Exit a Declining Fishery. *Conservation Biology*, 1, p. 30-124. DOI: https://doi.org/10.1111/j.1523-1739.2008.01041.x

CHEUNG,W.W. L., LAM, V.W. Y., SARMIENTO, J. L., KEARNEY, K.,WATSON, R., & PAULY, D. (2009). Projecting global marine biodiversity impacts under climate change scenarios. *Fish and Fisheries* **10,** 235–251. DOI: https://doi.org/10.1111/j.1467-2979.2008.00315.x

CHIB, S., & GREENBERG, E. (1998). Analysis of Multivariate Probit Models. *Biometrika*, 85(2): 347-367. DOI: 10.1371/journal.pone.0031460

DAW, T. M., CINNER, J. E., MCCLANAHAN, T. R., BROWN, K., STEAD, S. M., GRAHAM, N. A., & MAINA, J. (2012). To Fish or ot to Fish: Factors at Multiple Scales Affecting Artisanal Fishers' Readiness to Exit a Declining Fishery. *PLoS ONE*, 7(2), p. 1-10. DOI: https://doi.org/10.1371/journal.pone.0172075

DERESSA, T., HASSAN, R., ALEMU, T., YESUF, M., & RINGLER, C. (2008). *Analyzing the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia*. Discussion Paper, IFPRI.

EDET, G. E., & ETIM, N. A. A. (2018). Factors Influencing Rural Livelihood Diversification: Implications for Poverty Reduction. *International Journal of Agriculture, Forestry and Fisheries*, 6(2), p. 23-28.

GALAPPATHTHIA, E.K., FORD, J.D., & BENNETT, E.M. (2018). A framework for assessing community adaptation to climate change in a fisheries context. *Environmental Science and Policy*, 92, p. 17-26. DOI: doi.org/10.1016/j.envsci.2018.11.005

GEWEKE, J. (1996). Monte Carlo Simulation and Numerical Integration. In *Handbook of Computational Economics*, 1, p. 731-800. DOI: https://doi.org/10.1016/S1574-0021(96)01017-9

HASSAN, R., & NHEMACHENA, C. (2008). Determinants of African Farmers' Strategies for Adapting to Climate Change: Multinomial Choice Analysis. *African Journal of Agricultural and Resource Economics*, 2(1), p. 83-104. DOI: 10.22004/ag.econ.56969

JUL-LARSEN, E., KOLDING, J., NIELSEN, J. R., & VAN ZWIETEN, P. A. (2003). *Management, Co-Management or No Management? Major Dilemmas in Sourthern African Freshwater Fisheries*. Rome: FAO fisheries Technical paper 426/1.

KASSIE, G. W., KIM, S., & FELLIZAR, F. P. (2017). Determinant Factors of Livelihood Diversification: Evidence from Pretoria. *Cogent Social Sciences*, 3 (1), p. 1-16. DOI: 10.1080/23311886.2017.1369490

KEEFER, M. L., CLABOUGH, T. S., JEPSON, M. A., BOWERMAN, T., & CAUDILL, C. C. (2018). Temperature and depth profiles of Chinook salmon and the energetic costs of their long-distance homing migrations. *Journal of Thermal Biology* 79, p. 155-165. DOI: 10.1016/j.jtherbio.2018.12.011

KENNEDY, D. J., & RAJ, S. P. (2014). Determinants of Fishermen Migration: Study on a Traditional Marine Fishing Village in Kanyakumari District. *International Journal of Research in Management, Social Sciences and Technology*, 8(8), p. 1-8.

KHANAL, U., WILSON, C., HOANG, V. N., & LEE, B. (2018). Farmers' Adaptation to Climate Change, Its Determinants and Impacts on Rice Yield in Nepal. *Ecological Economics* 144, p. 139-147. DOI: 10.1016/j.ecolecon.2017.08.006

MADDISON, D. (2007). The Perception of and Adaptation to Climate Change in Africa. *Policy Research Working Paper No. 4308*. Washington DC: World Bank. DOI: https://doi.org/10.1596/1813-9450-4308

McCLUSKEY, S. M., & LEWISON, R. L. (2008). Quantifying Fishing Effort: a Synthesis of Current Methods and their Applications. *Fish and Fisheries*, 9, p. 188-200. DOI: 10.1111/j.1467-2979.2008.00283.x

MULWA, C., MARENYA, P., RAHUT, D.B., & KASSIE, M. (2017). Response to climate risks among smallholder farmers in Malawi: A multivariate probit assessment of the role of information, household demographics, and farm characteristics. *Climate Risk Management 16*, p. 208-221. DOI: 10.1016/j.crm.2017.01.002

OGUTU-OHWAYO, R., NATUGONZA, V., MUSINGUZI, L., OLOKOTUM, M., & NAIGAGA. (2016). Implications of climate variability and change for African lake ecosystems, fisheries productivity, and livelihoods. *Journal of Great Lakes Research* 42(3), p. 498-510. DOI: 10.1016/j.jglr.2016.03.004

PANGAPANGA, I. P., JUMBE, C., KANYADA, S., &

THANGALIMODZI, L. (2012). Unravelling Strategic Choices towards Droughts and Floods Adaptation in Southern Malawi. *International Journal of Disaster Risk Reduction*, 2, p. 57-66. DOI: 10.1016/j.ijdrr.2012.08.002

PRADHAN, N. C., & LEUNG, P. (2004). Modeling Entry, Stay, and Exit Decisions of the Longline Fishers in Hawaii. *Marine Policy*, 28, p. 311-324. DOI: 10.1016/j.marpol.2003.09.005

SAHA, B., & BAHAL, R. (2015). Factors Leading to Success in Diversified Occupation: A Livelihood Analysis in India. *The Journal of Agricultural Education and Extension*, 21(3), p. 249-266. DOI: 10.1080/1389224X.2014.927372

THOAI T. Q, RANOLA R. F, CAMACO L. D., & SILMETON E, 2017. Determinants of farmers' adaptation to climate change in agricultural production in the central region of Vietnam. *Land Use Polic*y 70, p. 224-231. DOI: 10.1016/j.landusepol.2017.10.023

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REGULAR ARTICLE

MODELLING RICE FARMERS' SUBSCRIPTION TO AGRICULTURAL EXTENSION METHODS IN GHANA

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ABSTRACT

Agricultural extension programmes are the main pathways to transfer improved innovations or information from extension agents to farmers in rural and peri-urban areas. Agricultural extension methods have been perceived by many to have significant influence on the adoption of improved production techniques by farmers. This study modelled the factors influencing farmers' subscription to various agricultural extension methods using data from 543 rice farm households in northern Ghana. A generalised Poisson regression (GPR) model was estimated to account for errors in the dispersion of the data. The results reveal farmer-to-farmer extension method, the use of demonstration farms, and household extension method as the most significant mechanisms to communicate information to farmers in the study area. Farm size, membership of farmer association, number of years spent as an irrigation farmer, research and location (upper east region) were found to be significant in influencing farmers' subscription to various agricultural extension methods, and should be considered by extension agents who extend knowledge on improved production techniques to farmers. Governments and actors in the agricultural space must recognise the importance of farmer-to-farmer extension method, as well as the use of field demonstrations to train farmers on improved practices. Radio, as a mass media mechanism should be used to support the other conventional extension methods, to deploy information on improved production techniques to rice farmers.

Keywords: Extension methods; Generalised Poisson; Farmers
JEL: R52, R58, H41

INTRODUCTION

High poverty and food insecurity are threat to global security, especially in sub-Sahara Africa. To fight poverty and food security, enhancing farmers' capacity for higher agricultural productivity through effective agricultural technology transfer mechanism is significant. Technological change and research, coupled with adoption of agricultural enhancing production practices are important steps in building farmers capacity to increase production and income in a sustainable way **(Azumah *et al.*, 2018).** The significance of rice to fight poverty and food insecurity cannot be downplayed in Africa as it is considered to be one of the food security crops to achieve the African Green Revolution **(Tsusaka & Otsuka, 2013).** In Ghana, the domestic demand for rice exceeds total production necessitating government to import over 40 percent of the commodity to meet the domestic demand **(MoFA, 2016).**

To revamp and enhance the performance of the rice industry, farmers' subscription to agricultural extension methods which will enhance technology adoption is relevant. Agricultural extension methods are the main pathways of transferring agricultural innovations or information from extension agents to farmers in rural and peri urban areas. Agriculture extension simply refers to the application of scientific research and improved/new knowledge to agriculture practices via farmers' education (**FAO, 2011**). It is a research and development tool for transferring research-based findings to farmers with the aim of farmers adapting leading to adoption of improved technologies to enhance productivity. Thus, agriculture extension is the act of communicating with farmers and stakeholders involved in agricultural value chains through extension agents. Agricultural extension methods are communication channels or medium through which extension agents pass research base-solutions to farmers. Research, education and extension are key in the agricultural system **(Deneke and Gulti, 2016; Lemma and Tesfaye, 2016)** as they are responsible for transferring information to farmers. Hence, extension methods play a vital role in the agricultural technology transfer model of agricultural extension **(Azumah *et al.*, 2018).**

The performance and capability of researchers and extension agents in ensuring rural food security depends on the continuous flow of agricultural knowledge and information to farmers. In the field of agricultural development, delivering quality information to farmers is one of the primary ingredients to enhance agricultural productivity (**Pandey, 2017).** Extension methods are necessary for better exchange of information between

extension agents and farmers to foster adoption of technologies. Successful adoption and efficient use of improved agricultural innovations depend on the effective communication and the utility of the innovation as well as, the enablement of the skills efficacy of the end user **(Gathecha *et al.*, 2012)**. Extension methods are agricultural technology transfer approaches (ATTA) and techniques used by an extension agent, which include field demonstration led by farmers, and farmer-to-farmer extension to enhance farmers' capacity to adopt improved innovations.

In this study, the extension methods are categorized into four: household extension method, farmer-to-farmer method, school methods (lectures/discussions and field demonstration) and mass media methods (radio, television, video show, mobile phone, drama, posters and newspapers). All these extension methods have their merits and demerits depending on the situations. Meaning that one method cannot be described as superior to the other **(Azumah *et al.*, 2018).** The choice of a particular method is influenced by several factors which include the tenure system, education, farmers' belonginess to association and resource availability **(Anandajayasekeram *et al.*, 2008)**.

Despite the role of agricultural extension methods in technology adoption, there is no empirical studies on modelling farmers' subscription to agricultural extension methods. For instance, **Folorunsho (2019)** employed descriptive statistics to examine rice farmers most preferred extension teaching methods for capacity building in Nigeria using a three-stage sampling technique. The study concluded that the most common extension teaching method was management training plots. The study further recommended that extension organisations should put premium on managing training plots to promote technology adoption. In Kenya, a study was conducted to appraise the access and use of extension approaches in promoting uptake of improved sorghum technologies using descriptive statistics and Pearson correlation of moment **(Chimoita *et al.*, 2017)**. The researchers concluded that extension methods such as mobile phones technology and radio services perform better in promoting uptake of improved sorghum varieties and gender, age and household position of the farmer contribute to promoting uptake of improved sorghum technologies.

Lugman *et al.* (2019) used 150 farmers to investigate the determinants of the application of Information and Communication Technologies (ICTs) among farmers in the Punjab province of Pakistan. By using descriptive statistics, the researchers concluded that there is a significant association of the extent of ICTs use for agricultural information with age, landholding and educational level of farmers. The recommendation made was that government and development agencies should initiate different agricultural technology transfer programmes in liaison with national and multi-national private telecommunication firms to enhance availability of ICTs to farmers.

Other researchers who employed descriptive statistics to explore agricultural extension methods and the effectiveness of agricultural technology transfer approaches are **Lamontagne-Godwin *et al.* (2017); Azumah *et al.* (2018); and Gathecha *et al*. (2012)**. This study builds on the previous works by applying a quantitative approach in modelling the determinants of farmers' subscription to agricultural extension methods. Northern Ghana has a unique situation given the high poverty levels and lower productivity relative to other parts of the country. Therefore, knowing the factors that influence the subscription of farmers to particular extension methods may guide development practitioners and government in the dissemination of improved agricultural technologies.

In the context of this study, farmers' subscription implies the usage of an extension method to acquire information on improved production techniques – which could be paid for or accessed free of charge depending on the medium.

DATA AND METHODS

Sampling and data type

The study was conducted using rice farmers from the Upper East, Savannah, and Northern regions of Ghana. A three-stage sampling approach was employed to select the rice farmers. In the first stage, the three regions in Northern Ghana were purposively selected based on their rice production potentials. In the second stage, ten (10) districts were randomly selected from the three regions using simple random sampling approach. Within each district, 5 communities were randomly selected. Based on **Slovin's (1960)** sample size determination formula, a total of 543 rice farmers were sampled from ten (10) administrative districts using systematic sampling technique in the three regions of Northern Ghana: Upper East Region (Kasena-Nankana, Bolgatanga, Bongo, Bulsa-North), Northern Region (Karaga, Savelugu, Gusheigu Tolon and Kumbungu), and Savanna Region (Central Gonja). Sampled farmers were visited at their homes to explain the purpose of the study, and to seek for their consent to administer questionnaires to them at their convenience after the pre-test of the questionnaire.

Analytical framework

Several models could be used to estimate count data. The commonest of them is the Poisson regression (PR) model which is appropriate when a researcher' aim is to investigate factors influencing the intensity of adoption without accounting for excess zeros. PR model is supported by some assumptions **(Sharma *et al.*, 2011)**. The first assumption is that if a farmer derives an optimum utility from the last technology adopted (in this case, subscription to extension methods), then there is no limit to the number of methods to subscribe to. For instance, subscribing to many extension methods is seen to be better where the marginal value of subscription is at least, equal to the marginal cost.

The second assumption is that a farmer's decision to subscribe to anyone of the extension methods does not rule out the subscription to the other available methods. The subscription to a given method may not be independent of another as the effects of certain methods might be complementary **(Isgin *et al.*, 2008)**. **Co**mplementary

subscription decision gives room to measure the intensity of subscription to extension methods using PR model. In this study, count modelling is applied to investigate the drivers of intensity of subscription to extension methods by rice farmers in northern Ghana. In all, 11 agricultural extension methods were identified and considered (Table 3). Given y_i which represents the extension methods, is an integer count variable and assumes a Poisson normal distribution, the standardize PR model can be expressed as Eq. 1 **(Greene, 2008; Winkelmann, 2008).**

$$Pr\ o\ b(\pi_i = y_i|x_i) = \frac{\pi^{-\lambda_i}\lambda^{y_i}}{y_i!}, \lambda_i \in K^+, y_i = 0,1,2, \dots n \quad (1)$$

Where: $\lambda_i = E(y_i|x_i) = Var(y_i|x_i)$ and the mean is mostly well-defined as$y_i = exp(x_i\beta)$ where x_i is a vector of socioeconomic characteristics of farmer i, and β is a vector of unknown parameters to be estimated. The marginal effect in the PR model is specified as Eq. 2.

$$\frac{\partial E(y_i|x_i)}{\partial x_i} = \lambda_i\beta \quad (2)$$

This marginal effect is mostly translated as the unit change in the intensity of subscription variable resulting from a change in the explanatory variable in the count data model **(Cameron and Trivedi, 1998).**

Standardize PR model has been widely used for empirical studies, but some scholars have criticised the PR model because of the assumption of equality between the variance of the count-dependent variable and its conditional mean, known as the equi-dispersion condition **(Winkelmann, 2008)**. According to **Nkegbe and Shankar (2014)**, the count-dependent variable can be witnessed to display over-dispersion, suggesting the variance is greater than the conditional mean, due largely to the multitude of zero observations of the dependent variable in a data set. In some instances, too, there could be the reverse (under-dispersion). There is the need therefore, to use appropriate model to account for this problem. In this study, the count dependent variable (subscription intensity) is shown to have variance less than the mean resulting in under-dispersion (Table 4). The Generalized Poisson Regression (GPR) model has been suggested as it is a flexible count data approach in handling count data of any nature to cover dispersion errors **(Famoye *et al.*, 2004)**.

If the generalized Poisson distribution function is normalize given a random variable Y then its probability mass distribution function can be express mathematically as Eq. 3.

$$f(y_i, \pi_i, \delta) = \frac{\pi_i(\pi_i + \delta y_i)^{\lambda_i^{-1}}\lambda^{-\pi_i - \delta y_i}}{y_i!}, y_i = 1,2 \dots \dots n \quad (3)$$

Where $\pi_i > 0\ and\ max(-1, \pi_i) < \delta, 1.$ y_i denotes the various practices adopted by farmers. The variance and mean of the random variable y_i can be computed as Eq. 4.

$$u_i = E(y_i) = \frac{\pi_i}{1-\delta}, var(y_i) = \frac{\pi_i}{(1-\delta)^3} = \frac{1}{(1-\delta)^2}E(y_i) = \alpha E(y_i) \quad (4)$$

Table 1: Description and measurement of variables as well as its expectation

Variable	Description	Measurement	A prior expectation extension methods
Dependent variables			
Extension methods (total)	Extent of subscription to extension methods	Number of extension methods a farmer subscribes to.	N/A
Independent variables			
Sex	Gender of respondent	Dummy: 1 = male, 0 = female	+/-
Experience	Years in rice farming	Years	+/-
Education	Farmers years of education	Years	+
Off-farm business	Farmers' engagement in off-farm activities	Dummy: 1 = yes, 0 = no	+/-
Farm size	Rice farm size	Acres	+/-
Credit	Access to credit/loan	Dummy: 1 = yes, 0 = no	+
Irrigation	Farmers years in irrigation	Years	+
Extension	Extension visits of MoFA extension officers	Number of visits per annum	+/-
Land tenure	Land ownership for farming	Dummy: 1 = own 0 = otherwise	+
Road network	Access to good roads	Dummy: 1 = yes, 0 = otherwise	+
Farmer association	Farmer belong to any famer association	Dummy: 1= yes 0= otherwise	+
Research	Farmer had direct contact with research scientist	Dummy: 1= yes, 0= otherwise	+
Region	Location of respondent	Dummy: 1= Upper East 0= otherwise	+/-

The $\alpha = \frac{1}{(1-\delta)^2}$ represents the dispersion factor in the GPR model. So, if we have $\delta = 0$ then there is evidence of equi-dispersion and standardized PR model is preferred. Conversely, if it is found that $\delta > 0$ then over-dispersion is presence. Conversely, if $\delta < 0$ it indicates under-dispersion which support the use of GPR model as in this study. The log likelihood estimation of the GPR model is given by the Eq. 5.

$$L = \sum_{i=1}^{n} L(\pi_i, \delta; y_i) = \sum_{i=1}^{n} InL(\pi_i, \delta; y_i) = \sum_{i=1}^{n}\{In\pi_i + (y_i - 1)In(\pi_i + \delta y_i) - (\pi_i + \delta y_i) - Iny_i!\} \quad (5)$$

Description of the variables used in the Poisson regression models, the measurement and likely directions (a priori expectations) of each variable are been presented in Table 1.

RESULTS AND DISCUSSION

Profile of sampled farmers

Descriptive statistics of sampled rice farmers give a picture and behaviour of the variables used in the model. Table 2 illustrates the profile of rice farmer considered for the study. About 83 percent of the respondents were male rice farmers. The mean years in formal education was approximately 4 years among the respondents with about 12 years in rice cultivation experience. About 27 percent of the respondents were into off-farm businesses to supplement their rice production. The average farm plot size in the study area was 2.42 acres.

Table 2: Summary statistics of variables

Variable (continuous)	Mean	Std. Dev.	Min	Max
Education	4.05	5.13	0	27
Experience	11.72	7.66	1	40
Farm size (acres)	2.42	3.62	0.25	60
Extension visits	3.4	5.34	0	35
Irrigation (years)	5.29	6.36	0	30
Variable (dummy)	*Freq.*	*Percent*		
Sex	451	83		
Off farm business	147	27		
Farmers association	348	64		
Land tenure	478	88		
Road network	223	41		
Research	424	78		
Region (location)	174	32		
Credit	65	12		
Obs.	543	100		

Source: computed from field data, 2017/2018

Majority (64%) of the respondents belonged to farmers associations (Table 2). This builds farmers' capacity to access loans to purchase inputs in order to increase production as well as minimize cost in terms of labour. The results revealed that averagely, a farmer received at least 3 times extension visit from extension officers per year. In terms of land tenure system, about 88 percent of the farmers used their own land for rice cultivation. Meaning that about 12 percent of the rice farmers had leased their land for rice cultivation. The study also shows that about 41 percent of the respondents had access to good road network linking to market centres. In addition, about 78 percent of the rice farmers had direct contact with research scientists. In terms of location, about 32 percent of the farmers were from Upper East region of Ghana. About 12 percent of the rice farmers had access to production credit/loan and the average years a farmer spent in irrigation in the study area is 5 years.

Level of Subscription to Agricultural Extension Methods by Farmers

This section focusses on farmers' subscription to agricultural extension methods as identified by **Azumah *et al.* (2018)** by using frequencies, and Kendall's coefficient of concordance to test the agreement among the ranked methods. These extension methods include household, lectures/discussions, demonstration plots, radio television (TV), video, mobile phone, drama, posters, newspapers and farmer-to-farmer extension methods (Table 3). These are grouped into four extension methods as discussed in section 1. For household extension method, about 42.2 percent of the farmers subscribed to this method. In terms of school extension method, about 32.0 percent of the rice farmers subscribed to lecture/discussions method while about 72.7 percent subscribed to technology plot demonstrations (i.e. field training). Similarly, for the mass media extension method, 71.8 percent, 28.4 percent, 35.4 percent, 63.0 percent, 19.7 percent, 21.6 percent and 18.6 percent of the rice farmers subscribed to radio, TV, video, mobile phone, drama, posters and newspaper respectively. About 64.3 percent of the rice farmers subscribed to farmer-to-farmer extension method. Despite the less subscription to mobile phones by farmers, it is still considered as a powerful extension tool that farmers use to explore information for agricultural marketing, micro-credit disbursement and crop management practices (Butt, et al., 2017). It has reported in literature that farmers have minimal practical exposure in accessing agricultural information from mass media mechanisms **(Shankaraiah and Swamy, 2012)**. Generally, the first five extension methods the farmers subscribed to were plot demonstration, radio, farmer-to-farmer, mobile phone and household extension methods.

Kendall's coefficient of concordance (*W*) was used to assess the level of agreement in responses among rice farmers (Table 3). The test statistic (*W)* was significant at 1 percent and estimated to be 0.45, giving more evidence to reject the null hypothesis that there was no agreement in the responses among the farmers. In the order of relevance, farmer-to-farmer extension method was ranked first by the farmers as the most effective extension method among the identified methods (Table 3). This finding corroborates with **Nakano *et al.* (2018)**. According to **Kiptot and Franzel (2015),** farmer-to-farmer extension plays a complementary role to formal extension services by facilitating the spread of improved agricultural production techniques and improving farmers' capacities. However, the effectiveness and sustainability of the farmer-to-farmer extension method depend largely on volunteer farmer trainers' technical abilities to overcome process-related challenges that hinder them from achieving the desired technology transfer outcomes.

Practical field demonstration led by farmers was ranked second with the mean value of 3.04. Household extension method was ranked third ranked fifth with the mean value of 3.95. This means that field demonstration led by farmers is more effective compare to lectures/discussions. According to **Pangborn *et al.* (2011),** demonstration farm with clearly defined extension messages is necessary to enhance farmer adoption of improved agricultural technologies.

Among the mass media extension methods, radio had the highest subscription and ranked fourth with a mean value of 4.32; mobile phone ranked sixth with a mean value of 6.43; video ranked seventh with a mean value of 6.88; TV ranked eighth with a mean value of 7.03; drama ranked ninth with a mean value of 7.68; posters ranked tenth with a mean value of 8.59 and newspapers ranked eleventh with a mean value of 9.1. Even though radio ranked fourth, it is still considered as one of the most powerful extension methods to disseminate agricultural technologies to majority of farmer in the rural area of Ghana because of issues of cost and coverage of wider audience. Radio has been found by **Aremu *et al*. (2015)** to be a faster method in disseminating agricultural technologies, inputs and output process to the masses of the rural folks. Radio is a powerful instrument to circulate information to farmers as it aides in the announcement of meetings, and disseminating improved skills, production techniques, and enhanced methods of agricultural production that will eventually improve crop productivity and household income, hence farmers welfare.

Extent Subscription to Extension Method by Farmers

Farmers could subscribe to different extension methods to have access to information and new skills. Table 4 presents the distribution of subscription intensity by farmers to the various extension methods identified. From the results, the mean subscription was found to be about 4.7 – meaning a farmer subscribed averagely to about 5 extension methods at a time. About 26 percent and 19.52 percent of the farmers subscribed to four (4) and three (3) extension methods respectively, while 16.02 percent subscribed to five (5) extension methods to receive information on improved production techniques. Only 1.47 percent of the farmers did not subscribe to any extension method, with no farmers subscribing to all eleven (11) identified extension methods. The rest are as presented by Table 4.

Subscripting to many extension methods by farmers should expose them to new and improved innovations which should intend, increase their capacity to adopt innovations to enhance agricultural productivity. However, there are several factors influencing farmers' subscription to many extension methods which the next section discusses.

Determinants of Extent of Subscription to Extension Methods – Standard Poisson versus Generalised Poisson Models

The estimates of factors influencing farmers' intensity of subscription to extension methods are presented in Table 5 by comparing the estimates of standard and generalized Poisson models. Diagnosis test was conducted to examine which model was more robust with efficient estimates. The model diagnosis tests are shown in Table 5.

To begin with, the coefficient of the delta was found to be negative and significant at 1 percent, indicating the presence of under-dispersion and supporting the use of the Generalised Poisson Regression (GPR) model. Similarly, both the deviance goodness of fit (296.673; Prob>chi^2 (517) =1.000) and Pearson goodness of fit (273.064; Prob>chi^2 (517) =1.000) were found to be insignificant, indicating that the standard Poisson Regression (PR) model is not appropriate for the analysis but rather the GPR model. Further test using AIC and BIC revealed that GPR performs better than standard PR model as AIC and BIC of the GPR recorded lower values compared to the PR model. We therefore proceed on the account of the diagnosis tests to discuss the results of the GPR.

Table 3: Farmers' subscription to extension methods

Extension method		Subscription Freq.	%	Mean value	Rank
Household		224	41.2	3.95	3rd
School approach	Lectures/discussions	174	32.0	6.19	5th
	Demonstration plots	395	72.7	3.04	2nd
Mass media	Radio	390	71.8	4.32	4th
	Television (TV)	154	28.4	7.03	8th
	Video	192	35.4	6.88	7th
	Mobile phone	342	63.0	6.43	6th
	Drama	107	19.7	7.68	9th
	Posters	117	21.6	8.59	10th
	News paper	101	18.6	9.1	11th
Farmer to farmer		349	64.3	2.8	1st
Kendall's W[a]	0.45***				
Chi-Square	1258.622				
Df	10				
N	543				

Notes: The ranking was done from 1 to 11, 1 being the most subscribed to, and 11 being the least. The mean was measured on a 5-point Likert scale. 5 being most effective and 1 being least effective. [a]Kendall's coefficient of concordance. ***1% Level of significance.

Source: Adapted from **Azumah *et al.* (2018)**.

Table 4: Distribution of extent of subscription to extension methods

Number of ext. method used	Freq.	%
0	8	1.47
1	7	1.29
2	39	7.18
3	106	19.52
4	143	26.34
5	87	16.02
6	43	7.92
7	23	4.24
8	69	12.71
9	16	2.95
10	2	0.37
11	0	0.00
Total	543	100
Mean value		4.69
Standard deviation		2.03

Source: Analysis of field data, 2019

Variables which were found to have significant effect on the intensity of farmers' subscription to extension methods include off-farm business, farm size, membership of farmer association, extension visits, land tenure, road network, contact with researchers, regional location, and years of involvement in irrigation practice.

Farm size was positive and statistically significant at 1 percent level, corroborating with our a priori expectation as shown by Table 1. The implication is that farmers with relatively larger farm plots were more likely to subscribe to many extension methods than farmers with smaller farm size, corroborating with **Lugman *et al.* (2019)**.

Similarly, membership of farmer association was found to have positive and significant effect on intensity of subscription to extension methods. This indicates that there was a higher probability for farmers who belonged to farmer associations to subscribe to several extension methods to receive information on production methods. Farmer association is supposed to expose farmers to many extension agents, research scientist and non-governmental organisations, giving the opportunity to farmers to subscribe to many extension methods.

Consistent with our a priori expectation in Table 1, land tenure system had positive effect on farmer intensity to subscribe to extension methods and was also significant at 1 percent level. This interprets to mean that if a farmer owned land the land on which he/she farmed, there was a greater likelihood of that farmer subscribing to several extension methods compared to those who cultivated on leased land. Direct contact of a farmer to a research scientist was also found to have a positive and significant effect on intensity to subscribe to extension methods.

Table 5: Estimates of determinants of extent of subscription to extension methods - count data model

Variable	Standard Poisson			Generalized Poisson Regression		
	Coefficient	Std. Err.	P>z	Coefficient	Std. Err.	P>z
Sex	-0.016	0.057	0.777	-0.022	0.042	0.606
Education	0.001	0.005	0.770	0.004	0.003	0.208
Experience	-0.005	0.003	0.148	-0.002	0.002	0.345
Off-farm business	-0.080	0.052	0.123	-0.067***	0.037	0.067
Farm size	0.014***	0.005	0.009	0.014***	0.004	0.001
Farmers association	0.137***	0.050	0.006	0.131***	0.036	0.000
Extension visits	-0.021***	0.005	0.000	-0.018***	0.003	0.000
Land tenure	0.188***	0.068	0.006	0.157***	0.049	0.001
Road network	-0.193***	0.051	0.000	-0.216***	0.037	0.000
Research	0.170***	0.056	0.002	0.140***	0.040	0.001
Region	0.225***	0.059	0.000	0.190***	0.042	0.000
Credit	-0.085	0.073	0.246	-0.053	0.053	0.314
Irrigation (years)	0.009**	0.004	0.018	0.008***	0.003	0.006
Constant	1.215***	0.103	0.000	1.248***	0.073	0.000
Model diagnosis tests						
Atanh delta				-0.358***	0.041	
Delta				-0.344***	0.036	
Deviance goodness-of-fit	296.673: Prob > chi2(517) = 1.0000					
Pearson goodness-of-fit	273.064; Prob > chi2(517) = 1.0000					
Likelihood-ratio test of delta=0:				$chi^2(1)$ = 89.67; Prob>=chi^2 = 0.0000		
LR $chi^2(13)$	184.330			268.87		
Prob > chi^2	0.0000			0.0000		
Log likelihood	-1025.954			-981.119		
Pseudo R^2	0.082			0.121		
AIC	2079.908			1992.237		
BIC	2139.755			2056.359		
Dispersion				-0.344		

Source: STATA 14 estimation, 2019

Meaning if a farmer had direct contact with research scientist, the probability of that farmer to subscribe to several extension methods increased. Also, the location variable had positive and significant (5% level) effect on subscription intensity to extension methods. The implication is that farmers in the Upper East were more likely to subscribe to many extension methods than farmers in the other regions in the study area.

Again, we found that number of years of practicing irrigation was positive and significantly related to intensity to subscribe to extension methods at 1 percent level. This can be interpreted to mean that farmers who spent more years in irrigation are more likely to subscribe to many extension methods than their counterpart rain fed farmers. Agricultural extension visits had significant and negative effect on intensity farmers to subscription to extension methods. This implies that farmers with less extension visits had a higher probability to subscribe to many extension methods.

Off-farm business had negative coefficient and significant at 1 percent. This indicates that the probability of a farmer's intensity to subscribe extension methods is likely to reduce if the farmer engaged in off-farm businesses. Off-farm business or employment has the tendency to reduce farmers' capacity to subscribe to extension methods due to lack of time and space to engage fully in agricultural activities, reducing the need for extension mechanisms.

Access to good road network had negative and highly significant effect, hence, reduced likelihood of extent of subscription by farmers to various extension methods.

CONCLUSIONS

Agricultural technology transfer mechanisms have been perceived by farmers in northern Ghana to influence the adoption of improved production techniques. This study was conducted to ascertain the factors that influence the intensity of subscription of farmers to various agricultural extension methods using count data modelling. Farmer-to-farmer extension method, the use of demonstration farms, and household extension methods are the most significant mechanisms to communicate information to farmers in northern Ghana. Farm size, membership of farmer association, number of years spent as an irrigation farmer, research and location (region) are significant in influencing farmers' subscription to agricultural extension methods and should be considered by extension agents who extend knowledge on improved production techniques to farmers. There is the need for government and non-governmental organisations who operate in the agricultural space, to recognise the importance of the farmer-to-farmer extension method as well as the use of field demonstrations to train farmers on improved practices. Radio, as a mass media mechanism should be used to complement the advantages of the conventional methods, to deploy information on improved agricultural technologies to farmers.

REFERENCES

ANANDAJAYASEKERAM, P., PUSKUR, R., SINDU W., & HOEKSTRA, D. (2008). Concepts and practices in agricultural extension in developing countries: A source book. *IFPRI (International Food Policy Research Institute), Washington, DC, USA, and ILRI* (International Livestock Research Institute), Nairobi, Kenya. https://cgspace.cgiar.org/bitstream/handle/10568/99/Source_book.pdf

AREMU P.A., KOLO I. N., GANA A.K., & ADELERE F. A. (2015). The crucial role of extension workers in agricultural Technologies transfer and adoption. *Global Advanced Research Journal of Food Science and Technology*, 4(2), 014-018. http://garj.org/garjfst/index.htm

AZUMAH, S. B., DONKOH, S. A., & AWUNI, J. A. (2018). The perceived effectiveness of agricultural technology transfer methods: Evidence from rice farmers in Northern Ghana. *Cogent Food & Agriculture*, *4*(1), 1-11. DOI: http://doi.org/10.1080/23311932.2018.1503798

BUTT, T. M., QIJIE, G., HASSAN, M. Z., LUGMAN, M., KHAN, M., TIAN, X., & MEHMOOD, K. (2017). An exploration of information communication technology (ICTS) in agricultural development: The experiences of rural Punjab-Pakistan. *Transylvanian Review*, *16*(XXV), 4087-4096. transylvanianreviewjournal.org

CAMERON, A. C., & TRIVEDI, P. K. (1998). *Regression Analysis of Count Data*. Cambridge: Cambridge University Press. DOI: https://doi.org/10.1002/sim.768.

CHIMOITA, L. E., ONYANGO, C. M., KIMENJU, J. W., & GWEYI-ONYANGO, J. P. (2017). Agricultural Extension Approaches Influencing Uptake of Improved Sorghum Technologies in Embu County, Kenya. *Universal Journal of Agricultural Research, 5*(1), 39 – 45. DOI: https://doi.org/10.13189/ujar.2017.050106

DENEKE, T. T., & GULTI, D. (2016). Agricultural Research and Extension Linkages in the Amhara Region, Ethiopia. In Technological and Institutional Innovations for Marginalized Smallholders in Agricultural Development. *Springer, Cham*, 113-124.

FAMOYE, F., WULU, J. T., & SINGH, K. P. (2004). On the generalized Poisson regression model with an application to accident data. *Journal of Data Science, 2*(2004), 287-295.

FAO. FOOD AND AGRICULTURAL ORGANISATION (2011). Communication for development. Paper presented at FAO Expert Consultation. www.fao.org/oek/communication-for-development/en

FOLORUNSHO, A. I. (2019). Rice Farmers Preferred Extension Teaching Methods for Capacity Building in Kwara State, Nigeria. *Journal of Agricultural Extension, 23*(2), 13-21. DOI: https://doi.org/10.4314/jae.v23i2.2

GATHECHA, C. W., BOWEN, M., SILIM, S., & KOCHOMAY, S. (2012). The Diffusion of Agricultural Innovations: The Effectiveness of Communication Channels used in the Improved Pigeon pea Varieties in Makueni County, Kenya. *International Conference on Agriculture, Chemical and Environmental Sciences (ICACES'2012)*. Dubai, UAE.

GREENE, W. H. (2008). *Econometric Analysis l.* (6. ed.,

Ed.) New Jersey, Prentice Hall, USA.

ISGIN, T., BILGIC, A., FORSTER, D. L., & BATTE, M. T. (2008). Using count data models to determine the factors affecting farmers' quantity decisions of precision farming technology adoption. Computers and Electronics in Agriculture, *62*(2), 231–242. DOI: https://doi.org/10.1016/j.compag.2008.01.004.

KIPTOT, E., & FRANZEL, S. (2015). Farmer-to-farmer extension: opportunities for enhancing performance of volunteer farmer trainers in Kenya. *Development in Practice*, *25*(4), 503-517. DOI: https://doi.org/10.1080/09614524.2015.1029438.

LAMONTAGNE-GODWIN, J., WILLIAMS, F., BANDARA, W. P., & APPIAH-KUBI, Z. (2017). (2017). Quality of extension advice: A gendered case study from Ghana and Sri Lanka. . *The Journal of Agricultural Education and Extension*, *23*(1), 7–22. DOI: https://doi.org/10.1080/1389224X.2016.12.

LEMMA, M., & TESFAYE, B. (2016). From research-extension linkages to innovation platforms: Formative history and evolution of multi stakeholder platforms in Ethiopia. Journal of Agricultural Economics. *Extension and Rural Development*, *4*(7), 496-504. https://www.researchgate.net..

LUGMAN, M., YASEEN, M., ASHRAF, S., MEHMOOD, M. U., & KARIM, M. (2019). Factors Influencing Use of Information and Communication Technologies among Farmers in Rural Punjab, Pakistan. *Journal of Agricultural Extension*, *23*(2), 101-112. Retrieved from www.journal.aesonnigeria.org.

MoFA. MINISTRY OF FOOD AND AGRICULTURE (2016). Agriculture in Ghana. Facts and figures 2015. www.mofa.gov.gh.

NAKANO, Y., TSUSAKA, T. W., AIDA, T., & PEDE, V. O. (2018). Is farmer-to-farmer extension effective? The impact of training on technology adoption and rice farming productivity in Tanzania. *World Development*, *105*, 336-351. DOI: https://doi.org/10.1016/j.worlddev.2017.12.013

NKEGBE, P. K., & SHANKAR, B. (2014). Adoption intensity of soil and water conservation practices by smallholders: evidence from Northern Ghana. *Bio-based and Applied Economics*, *3*(2), 159-174. DOI: https://doi.org/10.13128/BAE-13246.

PANDEY, N. (2017). Role of information and communication technology in agriculture development: a study of Nabarangpur district. *Scholedge International Journal of Business Policy & Governance*, *4*(4), 24-35. DOI: https://doi.org/10.19085/journal.sijbpg040401.

PANGBORN, M. C., WOODFORD, K. B., & NUTHALL, P. L. (2011). Demonstration farms and technology transfer: the case of the Lincoln University dairy farm. *International Journal of Agricultural Management*, *1*(1), 29-33. DOI: https://doi.org/10.22004/ag.econ.149905:

SHANKARAIAH, N., & SWAMY, B. K. (2012). Mobile communication as a viable tool for Agriculture and Rural Development. *Proceedings of Mobiles for Development held on 2012*. Bangalore: Department of Agricultural Extension, University of Agricultural Sciences. https://www.researchgate.net/profile/Jakob_Svensson2/publication/305108801.

SHARMA, A., BAILEY, A., & FRASER, I. (2011). Technology adoption and pest control strategies among UK cereal farmers: Evidence from parametric and nonparametric count data models. Journal of Agricultural Economics, 62(1), DOI: https://doi.org/10.1111/j.1477-9552.2010.00272.x

SLOVIN, E. (1960). Slovin's formula for sampling technique. https://www.statisticshowto.datasciencecentral.com/how-to-use-slovins-formula/.

TSUSAKA, T. W., & OTSUKA, K. (2013). The changes in the effects of temperature and rainfall on cereal crop yields in Sub-Saharan Africa: A country level panel data study, 1989 to 2004. . *Environmental Economics*, *4*(2), 70–80. http://oar.icrisat.org/7344/.

WINKELMANN, R. (2008). *Econometric Analysis of Count Data*. (5. ed., Ed.) Berlin Heidelberg: Springer-Verlag. https://www.springer.com/gp/book/9783540776482.

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REGULAR ARTICLE

DETERMINANTS OF MULTIDIMENSIONAL POVERTY TRANSITIONS AMONG RURAL HOUSEHOLDS IN NIGERIA

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ABSTRACT

Despite the progress in poverty reduction globally, millions of people are either near or living in severe multidimensional poverty in Nigeria. This study examined multidimensional poverty transitions in rural Nigeria, employing the Alkire and Foster measure of multidimensional poverty, Markov model of poverty transitions and the multinomial logistic regression model for analysis. Results showed that multidimensional poverty among rural households in Nigeria was mainly chronic (46.5%) while education and assets dimensions contributed most to the incidence and severity of multidimensional poverty among the households respectively. Educational and marital status, household size and number of assets owned influenced transient poverty while tertiary education, household size and number of assets owned influenced chronic poverty. The enactment and implementation of relevant laws and policies against the marginalization of the poor and vulnerable with respect to ownership of assets and intensification of efforts and incentives, aimed at encouraging human capital development, is key in the fight against poverty in rural Nigeria.

Keywords: Multidimensional Poverty, Transitions, Rural households, Nigeria
JEL: I32, D01

INTRODUCTION

In its multidimensional nature, poverty is the source of all human and social ills capable of constraining the creative ability of man, making him think of just mere existence (**Chukwuma, 2013**). The poor experience a sense of voicelessness, powerlessness, exposure to ill treatment, gross inability to influence key decisions affecting their lives as well as inadequate social networking within the institutions of state and society (**World Bank, 2001**). Some of these broader aspects of poverty are captured in the concept of multidimensional poverty which concentrates on deprivations in the living standard of a population in terms of functioning failures of different quality of life attributes such as per capita real GDP, life expectancy at birth and educational attainment (**Chakravarty, 2006**). In 104 developing countries, 1.2 billion people had an income of $1.25 or less a day but the multidimensional poverty headcount for 91 developing countries was an estimated 1.5 billion people—as measured by the Multidimensional Poverty Index (MPI). This is owing to the fact that the MPI measures not only the proportion of people deprived but also the intensity of deprivation for each poor household. Based on these intensity thresholds, people are then classified as near multidimensionally poor, multidimensionally poor or in severe poverty, respectively (**UNDP, 2014**). According to the Multiple Indicator Cluster Survey (MICS) carried out in 2011, 18.2% and 31.4% of Nigerians live near multidimensional poverty and in severe poverty respectively. However, in 2014, 19.3% of Nigerians remained vulnerable to poverty while 25.3% lived in severe poverty (**OPHDI, 2014**). While there is an obvious decline in the number of people living in severe multidimensional poverty, there is an apparent increase in the number of people living near or vulnerable to multidimensional poverty suggesting that households do not remain in a steady state but move in and out of poverty. This introduces dynamics to multidimensional poverty assessment.

Dynamics research presents a dramatically more comprehensive understanding of poverty than static studies **(Valletta, 2006; Dahl *et al.* 2008**). While static studies do not track household poverty spells over time **(Gottschalk *et al.* 1994**), dynamics or longitudinal research traces the same individuals or households over time and so is able to record stories of change. It also helps explain the fluidity of movement in and out of poverty and the complexity of policy solutions required for an inclusive social protection mechanism. This is especially needed in rural communities where multidimensional poverty is most prominent. According to **OPHDI (2014**), about 85% of the worlds multidimensionally poor live in rural areas. The percentage of rural households living in multidimensional poverty is even more in Africa. For instance, in Somalia, it affects 60% of the population in urban households and over 95% of the population in rural households while in Burkina Faso, 43% and 94%, in Niger 56% and 96% and in Ethiopia 54% and 96% of urban and rural households respectively (NBS, 2005). In Nigeria, the severity of poverty has also been found to be more pronounced in the rural areas **(IFAD, 2012).**

Successive governments have adopted various poverty alleviation strategies such as National Fadama Development Project I, II and III, Community Social Development Projects, Seven Point Agenda and Vision 20-2020. Sadly, their level of social impact leaves much to be desired as they have failed to achieve the objectives for which they were established **(Ovwasa, 2000; Adesopo, 2008; Omotola, 2008)**. The failure of these measures has been ascribed to political and policy instability, lack of mechanisms for the sustainability of the programs and lack of effective targeting mechanisms for the poor **(Obadan, 2001; Garba, 2006**).

Targeting mechanisms become effective in poverty alleviation efforts if poverty is treated as being multidimensional and if they emanate from a dynamic analysis of poverty **(Maggio, 2004, Thorbecke, 2005; Kay, 2006; Justino *et al.*, 2008)**. This understanding among researchers interested in the well-being of households (urban and rural) over time has resulted in a number of empirical studies on multidimensional poverty both home and abroad **(Sen, 1999; Gass and Adetunmbi, 2000; Oyeyomi, 2003; Alkire and Foster, 2007; Adeoti, 2014).**While these studies have examined the trend, determinants, incidence and spatial dimension of multidimensional poverty, there have been very few studies on the dynamics of multidimensional poverty most especially in sub-Saharan Africa where 29% of the multidimensionally poor reside **(OPHDI, 2014**). In fact, to the best of our knowledge, there has been no study on multidimensional poverty transitions of rural households in Nigeria. Apart from contributing to scarce literature on multidimensional poverty transitions in Nigeria, this study will also allow for the identification of the dimensions in which multiple deprivations have been reduced the most over time. This would lead to better understanding of what policies worked and what practical applications need to be modified. Identifying those who remain multidimensionally poor and those who are likely to become multidimensionally poor will go a long way in assisting concerned stakeholders in formulating strategies not only to reduce the present menace of multidimensional poverty in Nigeria but also prevent possible increase in the number of the multidimensionally poor.

DATA AND METHODS

The scope of the study is rural Nigeria representing 49.7% of the country's population. The country has 36 states plus the Federal Capital Territory (FCT) - Abuja. The climate of the country generally falls within the humid tropics and the country is located close to the equator. High humidity is experienced from February to November in the South and from June to September in the North. Low humidity coincides with the dry season. Annual rainfall decreases Northward; rainfall ranges from about 2000 millimeters in the coastal zone to 500-700 millimeters in the North (**Library of Congress, 2008**). The presence of multiple vegetation zones, abundant rain, surface water and underground water resources and moderate climatic extremes, allow for production of diverse food and cash crops by over 60% of the population making the agricultural sector to be the chief employer of the country's total labour force, providing livelihood for about 90 percent of the rural population **(IFAD, 2012**).

The secondary data used in this study is the General Household Survey-Panel collected by the National Bureau of Statistics in conjunction with the Federal Ministry of Agriculture and Rural Development (FMA&RD), the National Food Reserve Agency (NFRA), the Bill and Melinda Gates Foundation (BMGF) and the World Bank (WB). Both urban and rural enumeration areas (EAs) were canvassed. However, this study utilized the rural EAs only. The first wave of the GHS-Panel was carried out in two visits to the panel households (post-planting visit in August-October 2010 and post-harvest visit in February-April 2011). The second wave of the GHS-Panel was also carried out in two visits (post-planting visit in September – November 2012 and post-harvest visit in February-April 2013). Information was obtained from the same set of households in wave one to track households that moved between wave one and wave two and households that moved during wave two, that is between the post planting visit and the post-harvest visit. There was some attrition of households between the post-planting and post-harvest visits and consequently between the two waves. This was due to the inability to relocate the households who were not at home or moved away. Thus the number of people varied between the two waves.

Households were selected for the GHS panel using the two-stage probability sampling procedure. In the first stage, Primary Sampling Units (PSUs) also known as Enumeration Areas (EAs) were chosen. These were selected based on probability proportionate to size (PPS) of the total EAs in each state and Federal Capital Territory (FCT), Abuja and the total households listed in those EAs. A total of 500 EAs were selected using this method. The second stage involved the selection of households employing the systematic selection of ten (10) households per EA. In all, 500 clusters/EAs were canvassed and 5,000 households were interviewed (3,370 rural households and 1,630 urban households). However, only 2,746 rural households with complete and relevant data in wave 1 and 2 constituted the sample size for this study.

Alkire and Foster (2011) multidimensional poverty measures, Markov model of poverty transitions and multinomial logistic regression were applied to examine the multidimensional poverty status of households in rural Nigeria and the relative contributions of dimensions. Five dimensions to multidimensional poverty were chosen based on literature **(Alkire and Foster, 2011, Alkire and Santos, 2010**); some enduring consensus, particularly surrounding human rights, the Millennium Development Goals (MDGs), psychological accounts of basic needs, universal values and data availability. The dimensions are; Housing, Sanitation, Education, Health and Assets. For simplicity, the dimensions were equally weighted. That is, each dimension carried a weight of 1/5 and as such the weights of the dimensions sum up to 1. The equal weighting between the dimensions follows the HDI convention, upon which a critical literature has developed **(e.g, Chowdhury and Squire, 2006).**

Table 1 Dimensions, indicators, deprivation cut-offs and weights of MPI

Dimension (Weight)	Indicator (Weight)	Deprivation cut-off
Housing (1/5)	Floor Material (1/25)	Households live in a house with mud floor
	Wall Material (1/25)	Households live in a house with mud wall
	Roof Material (1/25)	Households with inadequate roofing material (grass)
	Cooking Fuel (1/25)	Households using firewood and coal as main source of cooking fuel
	Lighting Fuel (1/25)	Households without electricity and other improved sources as main lighting material.
Sanitation (1/5)	Toilet type (1/10)	Households using unimproved toilet facilities such as uncovered pit latrine, bucket toilet and hang toilet (United Nations, 2003).
	Source of Drinking Water (1/10)	Households using water from an unimproved source like open wells, open springs and surface water (United Nations, 2003).
Education (1/5)	Ever attended school (1/10)	Household head never attended school
	Household head having at least primary education (1/10)	Household head does not have at least 6 years of formal education (United Nations, 2003).
Health (1/5)	Suffer any form of illness (1/10)	Household head suffers from any form of illness
	Activities stopped due to illness (1/10)	Household head stopped activities as a result of such illness.
Assets (1/5)	Asset Ownership (1/10)	Household own only one of the following assets: bicycle, radio, house, television, telephone
	Land Ownership (1/10)	Household does not own agricultural land

Sources: Normative choice by authors with reference to the data available, **UNDP (2010) and Alkire and Santos (2014).**

The change in poverty over two time periods (waves) composed of four different seasons in this study can be due to the effect of changes in the incidence of poverty or intensity of poverty or the interaction between the two **(Alkire *et al.*, 2011**). Following **Adeoti (2014**), this change was assessed by considering either the absolute change across the two time periods or the percentage change in poverty. The absolute change is the difference in the level of any focal indicator across two time periods while the percentage change in poverty expresses the change relative to the initial poverty level.

Movement of households into and out of multidimensional poverty during the two waves was examined using the spells approach of poverty decomposition and the Markov model employed by **Barrientos and Mase (2012), Adepoju (2012), Finn and Leibbrandt (2013**). A household that is multidimensionally poor in only one period (wave) is said to be experiencing transient multidimensional poverty while a household that is poor in both periods is considered to be chronically poor.

The multinomial logit (MNL) model following **Cunguara (2008)** was used to analyse the factors influencing the shifts in multidimensional poverty status between the two waves (wave 1 and 2).

The MNL model is explicitly expressed as Eq. 1-4.

$$Y_1 = \propto_1 + \beta_{11}X_1 + \beta_{21}X_2 \ldots\ldots\ldots\ldots\ldots\ldots \beta_n X_n + \epsilon_i \quad (1)$$

$$Y_2 = \propto_2 + \beta_{12}X_1 + \beta_{22}X_2 \ldots\ldots\ldots\ldots\ldots\ldots \beta_n X_n + \epsilon_i \quad (2)$$

$$Y_3 = \propto_3 + \beta_{13}X_1 + \beta_{23}X_2 \ldots\ldots\ldots\ldots\ldots\ldots \beta_n X_n + \epsilon_i \quad (3)$$

$$Y_0 = \propto_0 + \beta_{10}X_1 + \beta_{20}X_2 \ldots\ldots\ldots\ldots\ldots\ldots \beta_n X_n + \epsilon_i \quad (4)$$

Where:

Y_1 those who were multidimensionally poor in both periods (i.e. chronically poor).

Y_2 those who were multidimensionally poor in the first period, but not in the second period (i.e. transitory poor).

Y_3 those who were non-poor in the first period, but multidimensionally poor in the second period (i.e. transitory poor).

Y_0 those who were non-poor in both periods (i.e. always non-poor).

X_1 ... X_n represents vector of the explanatory variables.

β_1 ... β_n represents the parameter coefficients.

ϵ_i represents the independently distributed error terms.

$\propto_{0 \ldots} \propto_3$ shows the intercept or constant terms.

Specifically, the independent variables used in the model are as follows;

X_1 Sex (male = 1, 0 if otherwise) ; X_2 Age (in years); X_3 Marital Status (Never Married = 1, 0 if otherwise); X_4 Marital Status (Separated/Divorced = 1, 0 if otherwise); X_5 Marital Status (Widowed = 1, 0 if otherwise); X_6 Household Size (number); X_7 Access to Credit (yes = 1, 0 if otherwise); X_8 Household Head has secondary education (yes = 1, 0 if otherwise); X_9 Household Head has tertiary education (yes = 1, 0 if otherwise); X_{10}Monthly Expenditure (Naira); X_{11} House Ownership (Owned = 1, 0 if otherwise); X_{12}Distance to Health Centre (Minutes); X_{13}Membership in Cooperative (yes = 1, 0 if otherwise); X_{14} Access to Remittances (yes = 1, 0 if otherwise);

μ Error term.

RESULTS AND DISCUSSION

The mean age of respondents was 49.7 years while almost all the respondents have one form of formal education or the other but with majority having primary education (Table 2). This could be attributed to the fact that most rural dwellers seem not to consider secondary and post-secondary education as being vital for rural-life sustenance. Also, more than four-fifths of the sampled household heads were married having a mean household size of approximately 6 members per household with the

majority residing in the North Western zone of Nigeria. The average monthly expenditure of the respondents stood at ₦29,451.00.

Table 2 Selected socio-economic characteristics of respondents

Variables	Frequency	Percentage
Age (in years)		
≤ 30	288	10.5
31 – 60	1841	67.0
61 – 90	606	22.1
> 90	11	0.4
Mean	49.7	
SD	15.1	
Marital Status		
Never Married	66	2.40
Married	2244	81.8
Separated/Divorced	76	2.70
Widowed	360	13.1
Household Size		
1 – 5	1260	45.9
6 – 10	1221	44.5
11 – 15	247	9.0
> 15	18	0.6
Mean	6.1	
SD	3.1	
Educational Status		
No Formal Education	208	7.6
Primary	2280	83.0
Secondary	19	0.7
Tertiary	239	8.7
Geopolitical Zone		
North Central	521	19.0
North East	434	15.8
North West	621	22.6
South East	512	18.7
South South	468	17.0
South West	190	6.9
Monthly Expenditure		
≤ 40000	2219	80.8
40001 – 80000	468	17.0
80001 – 120000	48	1.7
> 120000	11	0.5
Mean	₦29,451	
SD	₦18,655	

Source: Own computation based on **GHS (2011 & 2013)** panel data

Table 3 presents the estimated multidimensional poverty indices (headcount of poverty, adjusted head count of poverty, adjusted poverty gap and the adjusted poverty severity measure) based on different cut-offs *(k).* As shown in Table 1, the multidimensional poverty estimates were derived using five dimensions; sanitation, housing, health, education and assets with equal weights assigned to all. For each dimension, thresholds were set which is the first cut-off to identify if the household is deprived in that dimension. A second cut-off, *k* was set which states the number of dimensions in which a household can be deprived to be considered multidimensionally poor. It can be observed from Table 3 that in both waves, the headcount (H) and the adjusted headcount ratio (M_0) decreased with increase in *k*. This is in accordance with *a priori* expectation that the number of multidimensionally poor households reduces as the number of dimensions used increases and is consistent with the findings of **Batana (2008)** and **Adeoti (2014).**

With the number of deprivations experienced by the households at *k* equals 1, the poverty head count ratio stood at 92% in wave 1 and about 95% in wave 2 indicating that only a few of the panel households were not deprived in at least one dimension. At *k = 3*, the mid-point of the considered dimensions, all indices of poverty increased from wave 1 to wave 2. While the poverty head count increased from 34.6% to 43.1%, the intensity of poverty increased from 73.4% to 74.2%. These changes in the percentage the poor (H) and the share of deprivations in which the poor are deprived (A) accounted for the increase in the multidimensional poverty index (M_0) from 0.254 to 0.320. However, an increase in *k* decreased M_0. This implies that as the percentage of households estimated poor is reducing, the intensity of poverty among the poor is increasing.

The adjusted poverty gap (M_1) values at different cut-offs *(k)* indicates how far the poor are from the poverty line and what it will take to move the poor out of poverty. However, for a multidimensional poverty measure, the poverty line is not clearly defined. Hence, this measure is subjective. However, a high adjusted poverty gap implies the farther away the poor are from the poverty line. The adjusted poverty severity (M_2) for households in rural Nigeria is also subjective but points out that the larger the value of M_2, the harder it is to eliminate poverty.

The changes in MPI, head count ratio and intensity of poverty at *k = 3* as presented in Table 4 for poverty headcount (H) than intensity (A). This implies that efforts at alleviating poverty in rural Nigeria should focus more on reducing the number of the multidimensionally poor than in reducing the deprivation share of each of the multidimensionally poor. This agrees with the findings of **Alkire *et al.* (2011**) that changes in MPI in Nigeria, Lesotho and Kenya are achieved by reduction in H and hardly by a reduction in A.

Table 3 Household multidimensional poverty indices

K	Wave 1					Wave 2				
	M_0	H_o	A	M_1	M_2	M_0	H_o	A	M_1	M_2
1	0.419	0.920	0.455	0.39	0.383	0.482	0.946	0.510	0.45	0.442
2	0.354	0.596	0.594	0.33	0.321	0.438	0.727	0.602	0.41	0.400
3	0.254	0.346	0.734	0.23	0.230	0.320	0.431	0.742	0.29	0.286
4	0.147	0.168	0.875	0.13	0.131	0.193	0.221	0.873	0.17	0.170
5	0.065	0.065	1.000	0.06	0.058	0.084	0.084	1.000	0.07	0.075

Source: Authors' computation based on **GHS (2011 & 2013)** panel data

Table 4 Changes in MPI, Headcount Ratio (H) and Intensity of Poverty (A) at $k = 3$

	M_0		H		A	
Waves	Wave 1	Wave 2	Wave 1	Wave 2	Wave 1	Wave 2
	0.254	0.32	0.346	0.431	0.734	0.742
Annual Absolute Change		0.011		0.014		0.001
Annual Percent Change		4.33		4.1		0.18

Source: Authors' Computation based on **GHS (2011 & 2013)** panel data

Table 5 Relative Contributions of Dimensions to MPI

K	Housing contribution (%)	Sanitation contribution (%)	Education contribution (%)	Health contribution (%)	Assets contribution (%)
Wave 1					
1	13.68	12.06	20.77	35.58	17.91
2	15.18	13.42	23.55	27.13	20.72
3	15.91	13.72	24.48	23.13	22.76
4	19.39	16.70	22.50	19.97	21.44
5	20.00	20.00	20.00	20.00	20.00
Wave 2					
1	13.26	11.85	18.42	30.62	25.85
2	14.11	12.53	19.40	27.66	26.29
3	17.02	14.22	21.27	23.18	24.32
4	20.62	16.05	21.06	20.32	21.96
5	20.00	20.00	20.00	20.00	20.00

Source: Own computation based on **GHS (2011 & 2013)** panel data

The relative contributions of dimensions to multidimensional poverty during wave 1 and 2 at different cut-offs, *k* is shown in Table 5. The result reveals that the highest contribution is from health dimension with 35.58% and 30.62% at $k = 1$ in waves 1 and 2 respectively. Thus, investments in improved health of rural dwellers in Nigeria is key in ensuring significant reduction in multidimensional poverty. While education contributed most to poverty in wave 1, followed by health and assets at k = 3, assets contributed most to poverty in wave 2 followed by health and education. This indicates that multidimensional poverty of rural households in Nigeria can be mainly attributed to lack of access to basic education, low level of assets and poor health condition of household heads.

According to Table 6, multidimensional poverty indices increased for all zones between waves 1 and 2 except for the intensity of poverty that decreased from 0.696 to 0.662 for the South South zone. In all, the North East zone recorded the highest poverty rate followed by the North Central zone. Like all the other zones, North East and North Central zones recorded an increase in multidimensional poverty index from wave 1 to wave 2. Notably, the intensity of poverty in those two zones was equal and the highest of all the geopolitical zones. This could be linked to large family sizes, insurgents' activities and the relatively high illiteracy level prevalent in the Northern region of Nigeria. In fact, results from the 2017 Nigeria MPI show a high incidence of poverty across the North with the intensity of deprivation in the region of above 40% for most states (**MPPN, 2017**). With respect to annual percentage change, rural households in South East experienced the highest percentage increase in poverty followed by the North-Central zone while the South-South had the lowest percentage increase in poverty.

The multidimensional poverty transition matrix in Table 7 indicates that 46.5% of poor households in wave 1 remained poor in wave 2 while 14.8% of poor households who were poor in wave 1 exited poverty in wave 2. On the other hand, the percentage of households that moved into poverty in the second wave was 8.2%. However, 30.5% of households were non-poor in both waves.

Arising from the findings in Table 7, figures in Table 8 indicate that chronic and transient multidimensional poverty rates were 46.5% and 23.0% respectively. This indicates that rather than most households moving into and out of poverty between periods, a majority of rural households remained multidimensionally poor between periods. Implying that poverty is predominantly chronic than transient in Nigeria.

Table 9 shows the multidimensional poverty profile of households in rural Nigeria by selected socio-economic characteristics. With respect to sex of household head, female headed households had a higher multidimensional poverty index (M_0) of 0.267. This might not be unconnected with the traditional marginalisation of women in rural communities leading to their owning fewer assets than their male counterpart or at best, relatively low value assets. Also, women's ability to accumulate assets is often governed by norms that historically have favoured men limiting the extent of women's control over assets **(Kumar and Agnes, 2014).** The result also revealed that household heads between 61 and 90 years of age had the highest M_0 of 0.285 while household heads between 31 and 60 years of age had the lowest M_0 of 0.116. This is expected as household heads between 31 and 60 years of age were still economically active and could multi-task to generate more income to cater for family needs.

Table 6 Changes in MPI, headcount ratio and intensity of poverty at $k = 3$ by geopolitical zones

Geopolitical zones	Waves	M_0	H	A
North Central	1	0.392	0.499	0.785
	2	0.502	0.631	0.796
Annual Absolute Change		0.018	0.022	0.002
Annual Percentage Change		4.7	4.4	0.23
North West	1	0.202	0.284	0.711
	2	0.253	0.347	0.729
Annual Absolute Change		0.009	0.011	0.003
Annual Percentage Change		4.1	3.7	0.42
North East	1	0.466	0.594	0.785
	2	0.527	0.658	0.8
Annual Absolute Change		0.01	0.011	0.003
Annual Percentage Change		2.2	1.8	0.3
South East	1	0.169	0.25	0.676
	2	0.262	0.367	0.714
Annual Absolute Change		0.016	0.02	0.006
Annual Percentage Change		9.2	7.8	0.9
South South	1	0.222	0.319	0.696
	2	0.239	0.361	0.662
Annual Absolute Change		0.003	0.007	0.006
Annual Percentage Change		1.3	2.2	-0.8
South West	1	0.161	0.237	0.679
	2	0.193	0.281	0.687
Annual Absolute Change		0.005	0.007	0.001
Annual Percentage Change		3.3	3.1	0.02

Source: Own computation based on **GHS (2011 & 2013)** panel data

Table 7 Poor/Non-Poor Transition Matrix

		Wave 2		
		Poor	Non-Poor	Total
Wave 1	Poor	1278 (46.5)*	406 (14.8)	1684 (61.3)
	Non-Poor	224 (8.2)	838 (30.5)	1062 (38.7)
	Total	1502 (54.7)	1244 (45.3)	2746 (100.0)

Note: Top number is cell frequency and number in parenthesis is cell percentage
Source: Own computation based on **GHS (2011 & 2013)** panel data

Similarly, households having between 11 and 15 members had the lowest multidimensional poverty index. Since family labour is usually employed in most rural communities for agricultural production, rural households with large number of members who are of working age would have more opportunity to improve their livelihood through increased production and consequently higher income **(Bruck and Workneh Kebede, 2013).** Households could also generate income by supplying labour to other non-farming activities to augment household resources. The educational status profile of the households revealed that household heads with primary education had the highest M_0 of 0.725 followed by those with no formal education (0.492). This can be ascribed to the relatively high percentage of representative households (83.0%) having primary education in this study and the limited opportunities available for household heads having no post primary education to be gainfully employed by any firm or establishment in this technological driven 21st century. Also, with respect to marital status, household heads that were married had the highest M_0 of 0.387 while those who were never married had the least MPI of 0.170. This could be as a result of the added responsibilities associated with being married which could greatly reduce resources available to increase assets, acquire more education and access better health care relative to those who are still single.

Confirming the findings above, the adjusted poverty gap (M_1) values and those of adjusted poverty severity (M_2), also shown in Table 9 revealed that the households with the highest multidimensional poverty indices (M_0), which include- female-headed households, married household heads, household heads aged 61-90 years with 6 to 10 members, households having primary education and households residing in the North East zone, were also the farthest from the poverty line and as such, hardest to lift out of poverty.

Table 10 presents the results of the multinomial logit analysis of factors influencing chronic and transient multidimensional poverty in the study area. Similar sets of explanatory variables were used in each case and the relative risk ratios (RRR) associated with the different explanatory variables are presented. With a log likelihood

of -1938.7218 and a Chi-square statistics of 2741.70 significant at 1% (0.000), the model is well fitted.

Results showed that household size, tertiary education, number of household assets acquired, house ownership and distance to health care were the significant factors affecting the likelihood of households being chronically poor. The positive coefficient of distance to health care indicates that distance to health care centre is strongly associated with chronic poverty in rural Nigeria. In other words, health care centers situated far from the residence of rural households contribute to their being chronically poor. This might be owing to the fact that additional resources which otherwise could have been used for some productive purposes by rural dwellers are expended on transportation to receive medical care. Also, when health care centers are not easily accessible, rural households might become discouraged altogether from taking the needed step or resort to unorthodox options which might worsen their situation, leaving them in an impoverished state that limits their productivity and capacity to create wealth.

The negative but significant coefficient of household size implies that as household members increase, the probability that households will experience chronic poverty decreases. Precisely, an additional member to the household reduces the likelihood of chronic poverty by 0.951. This could be attributed to additional labour that would be supplied by the new member(s) of the household, leading to increased returns that could be used to meet other pressing deprivations. Similarly, tertiary education of household head variable had a negative coefficient, supporting the view that increased years of education decrease the probability that a household will be chronically poor. The corresponding relative risk ratio shows that having secondary education decreased the odds of being chronically poor by 0.026. This implies that a household head with tertiary education has a higher likelihood of exiting poverty relative to the head with no formal education. This is because educated household heads are better poised to cope with risk and uncertainty.

With respect to the number of assets acquired which was negatively significant, an increase in the number of assets acquired by households reduced their duration of poverty. Put differently, a unit increase in the number of assets owned by households decreased the likelihood of households remaining multidimensionally poor by 0.953. When assets are put into productive use, households become better off through increased income. That an increase in the number of assets reduces the chances of households remaining multidimensionally poor explains why house ownership also had a negative effect. That is, owning a house reduced the odds that households will remain chronically poor by 0.582.

Results shown in Table 10 also indicate that household heads having tertiary education and number of household assets owned were the statistically significant factors explaining households' exit from poverty. The positive coefficient associated with tertiary education of household head suggests that development of human capital is a key determinant of rural households' exiting poverty. Formal education affords people with opportunities, through gainful employment or skills and knowledge acquisition that could ultimately lift households out of poverty. With respect to assets, the negative and significant coefficient of 0.028 indicated that additional asset acquisition reduced the odds that households will exit poverty. Purchase of additional household assets is a drain on meagre households' resources available to meet basic needs that might contribute appreciably to their exit from poverty. An exception to this is if additional household assets purchased are put to productive use.

Movement into multidimensional poverty is a function of household size, tertiary education of household head, number of household assets, distance to health centre and marital status (never married and divorced). While marital status (never married and divorced), household size and distance to health centre positively influenced the odds of entering poverty, tertiary education of household head and number of household assets had negative effects on the probability that households will become poor. The positive coefficient of household heads who were never married, that is, single household heads implies that being single increased the likelihood that a non-poor household will be poor. This might not be unconnected with the fact that single household heads, unlike married household heads, will not be able to enjoy the benefits of pulling of resources together, which to a large extent serve as a bulwark from slipping to poverty **(Hokayem and Heggeness, 2013)**. The positive coefficient of being separated or divorced followed the same pattern as that of never married household heads. Also, positively significant in explaining movement of households into poverty was household size. That is, as the number of household members increased, the probability that households will fall into poverty increased. Specifically, an additional member to the household increased the likelihood of slipping into poverty by 1.071. Increase in household size could be a negative force with respect to household welfare since it could exert additional pressure on limited household resources. This is especially so if there are more dependants in the household relative to adults.

Distance to health care also increased the probability that households will fall into poverty by 1.056 as shown by the positive sign which is significant at 1%.

Table 8 Multidimensional Poverty Decomposition (Spells Approach)

Multidimensional poverty status	Number of households	Percentage
Always Multidimensionally Poor (Chronic)	1278	46.5
Sometimes Multidimensionally Poor (Transient)	630	23.0
Never Multidimensionally Poor	838	30.5
Total	2746	100.0

Source: Own computation based on **GHS (2011 & 2013)** panel data

Table 9 Multidimensional poverty profile of households by selected characteristics

Socioeconomic characteristics	Multidimensional poverty index (M_0)	Adjusted poverty gap (M_1)	Adjusted poverty severity (M_2)
Sex of Household Head			
Male	0.181	0.160	0.155
Female	0.267	0.250	0.243
Age			
< 30	0.235	0.220	0.217
31-60	0.116	0.100	0.095
61-90	0.285	0.260	0.261
91-120	0.181	0.160	0.154
Household Size			
1-5	0.224	0.200	0.218
6-10	0.291	0.270	0.265
11-15	0.240	0.220	0.218
>15	0.234	0.070	0.220
Educational Status			
No Formal Education	0.492	0.477	0.469
Primary Education	0.725	0.687	0.668
Secondary Education	0.235	0.219	0.212
Tertiary Education	0.116	0.108	0.104
Marital Status			
Never Married	0.170	0.154	0.146
Married	0.387	0.363	0.351
Separated/Divorced	0.276	0.258	0.249
Widowed	0.264	0.248	0.240
Geopolitical Zones			
North Central	0.392	0.356	0.338
North West	0.202	0.190	0.183
North East	0.466	0.436	0.422
South East	0.169	0.164	0.162
South South	0.222	0.209	0.202
South West	0.161	0.152	0.147

Source: Own computation based on **GHS (2011 & 2013)** panel data

Table 10 Determinants of chronic and transient multidimensional poverty

	Chronic Poverty			Exiting Poverty			Moving into Poverty		
Variable	RRR	Coeff	Z-value	RRR	Coeff	Z-value	RRR	Coeff	Z-value
Sex	1.063	0.061	0.13	1.741	0.554	1.11	0.502	-0.632	-1.46
Age	0.999	-0.001	-0.09	1.000	0.000	0.00	0.989	-0.011	-1.60
Never Married	0.830	-0.186	-0.31	0.907	-0.097	-0.16	2.225	0.800	1.74*
Sep./Divorced	1.149	0.139	0.25	0.706	-0.348	-0.58	2.705	0.995	1.99**
Widowed	1.371	0.135	0.64	0.736	-0.307	-0.59	1.954	0.670	1.38
Hh Size	0.951	-0.050	-1.69*	0.962	-0.039	-1.27	1.071	0.076	2.47**
Credit Access	1.264	0.234	1.10	1.150	-0.140	0.63	1.309	0.269	1.30
Secondary	-0.006	-14.637	-0.03	0.416	0.878	0.32	1.088	0.084	0.07
Tertiary	0.026	-3.660	-7.70***	0.117	2.143	5.03***	0.340	-1.624	-4.07***
Asset count	0.953	-0.048	-4.64***	0.972	-0.02	-3.22***	0.955	-0.046	-3.71***
Mthly Expend.	1.000	-0.374	-0.09	1.000	-0.06	1.36	1.000	-0.004	-0.94
House Own.	0.582	-0.541	-2.36**	0.860	-0.15	-0.65	0.697	-0.362	-1.60
Dist. Health	1.071	0.069	6.95***	1.015	0.01	1.13	1.056	0.055	6.33***
Coop. Memb.	0.751	-0.286	-0.84	0.895	-0.111	-0.31	0.868	-0.142	-0.41
Remittances	1.106	0.101	0.20	2.102	0.743	1.53	1.031	0.030	0.06
Constant	0.003	31.246	16.37	0.538	22.406	11.78	34.5	9.895	5.30

Note: ***, **, * Significant at 1%, 5% and 10% respectively
Source: Authors Computation from GHS panel data, 2011
Observations = 2746; LR chi^2 (22) = 2741.70; Prob > chi^2 = 0.000
Log likelihood = -1938.7218; Pseudo R^2 = 0.4142
Dependent variable: Multidimensional poverty status (0=non-poor, 1=chronic poor, 2=poor-non-poor,3=non poor-poor),with base category poverty status=0.

The implication of this is that the farther the health care centres from the residence of households, the higher the likelihood of slipping into poverty. The negative coefficient of tertiary education of household heads and the RRR value of 0.340 suggests that having tertiary education decreased the odds that a non-poor household will become poor. In other words, for those with tertiary education, there is a high likelihood that they were meeting their present needs and planning for possible future needs. In addition, for those who were yet to be gainfully employed, there is a high probability of being engaged in a profitable venture owing to the knowledge and skills already acquired which can be provided at a cost. Further, ownership of assets had a negative impact on the odds of moving into poverty. That is, an increase in assets decreased the probability of a non-poor household becoming poor. Specifically, an additional asset acquired reduced the chances of movement into poverty by 0.955. This can be attributed to the fact that assets assist households in responding effectively by providing options for smoothing consumption in the event of economic shocks.

CONCLUSIONS

The study revealed a high incidence of multidimensional poverty in rural Nigeria and suggested that efforts at alleviating poverty in rural Nigeria should focus more on reducing the number of the multidimensionally poor than in reducing the deprivation share. Lack of access to basic education, low level of assets and poor health condition of household heads mainly contributed to multidimensional poverty in rural Nigeria. Generally, multidimensionally poor households were mainly resident in the North East zone of Nigeria, large sized, female-headed, with married and aged household heads. Multidimensional poverty in rural Nigeria is largely chronic with movement of households into and out of multidimensional poverty basically influenced by human capital (tertiary education) and number of assets owned. However, while efforts should be geared towards addressing the key factors influencing chronic multidimensional poverty, factors influencing transitions into and out of poverty among rural households should not be ignored for effective social protection. Also, efforts towards promotion of basic education for all, creation of scholarship schemes specifically targeted at encouraging rural households to pursue higher education and the enactment and implementation of relevant laws against gender discrimination and marginalization of rural women in ownership of assets are imperative policy requirements in the alleviation of multidimensional poverty in rural Nigeria.

REFERENCES

ADEOTI, A.I. (2014). Trend and determinants of multidimensional poverty in rural Nigeria. *Journal of Development and Agricultural Economics*, *6*(5), 220-231. doi:10.5897/JDAE2013.0535

ADEPOJU, A. O. (2012). Poverty transitions in rural south west Nigeria. *Global Journal of Science Frontier Research Agriculture & Biology*, *12*(2), 19-30. Retrieved from: https://globaljournals.org/item/192-poverty-transitions-in-rural-south-west-nigeria

ADESOPO, A. (2008). The poverty question and the national anti-poverty programmes in Nigeria. In K. Ajayi (Ed.), *public administration and public policy analysis in Nigeria* (pp. 213 -227). Abuja, Nigeria: Panaf Publishing Inc.

ALKIRE, S., & FOSTER, J. (2007). *Counting and multidimensional poverty measurement* (Oxford Poverty and Human Development Initiative, Working Paper No. 7). Retrieved from: https://ophi.org.uk/working-paper-number-07/

ALKIRE, S., & FOSTER, J. (2011). Counting and multidimensional poverty measurement. *Journal of Public Economics*, *95*(7-8), 476-487. doi: https://doi.org/10.1016/j.jpubeco.2010.11.006

ALKIRE, S., & SANTOS, M. E. (2010). *Acute multidimensional poverty: A new index for developing countries* (Oxford poverty and human development initiative working Paper No. 38). Retrieved from: http://dx.doi.org/10.2139/ssrn.1815243

ALKIRE, S., & SANTOS, M. E. (2014). Measuring acute poverty in the developing world: robustness and scope of the multidimensional poverty index. *World Development Journal*, *59*(c), 251–274. doi: https://doi.org/10.1016/j.worlddev.2014.01.026

BARRIENTOS, A., & MASE, J. (2012). Poverty transitions among older households in Brazil and South Africa. *European Journal of Development Research*, *24*(4), 570-588. doi: https://doi.org/10.1057/ejdr.2012.13

BATANA, Y. (2008). *Multidimensional measurement of poverty in sub-Saharan Africa*. (Oxford Poverty and Human Development Initiative, Working Paper 13). Retrieved from: https://ophi.org.uk/working-paper-number-13/

BRÜCK, T., & WORKNEH KEBEDE, S. (2013). Dynamics and divers of consumption and multidimensional poverty Evidence from rural Ethiopia. (The Institute for the Study of Labor (IZA) Discussion Paper No. 7364). Retrieved from http://ftp.iza.org/dp7364.pdf.

CHAKRAVARTY, S. R. (2006). An axiomatic approach to multidimensional poverty measurement via fuzzy sets. In A. Lemmi and G. Betti (Eds.). *Fuzzy set approach to multidimensional poverty measurement*. (pp.49-72). Springer-Verlag, New York: Springer, Boston,MA.

CHOWDHURY, S., & SQUIRE, L. (2006). Setting weights for aggregate indices: An application to the commitment to development index and human development index. *Journal of Development Studies*, *42*(5), 761–771. doi: https://doi.org/10.1080/00220380600741904

CHUKWUMA, D. C. (2013). *Poverty trap in Nigeria: a multidimensional perspective*. (Unpublished thesis). Nnamdi Azikiwe University, Awka, Nigeria.

CUNGUARA, B. A. (2008). *Pathways out of poverty in rural Mozambique*. (Unpublished masters thesis). Michigan State University.

DAHL, E., FLOTTEN, T., & LORENTZEN, T. (2008). Poverty dynamics and social exclusion: An analysis of Norwegian panel data. *Journal of Social Policy*, *37*(2),

231-249. doi: https://doi.org/10.1017/S0047279407001729

FINN, A., & LEIBBRANDT, M. (2013). The dynamics of poverty in the first three waves of NIDS. (Southern Africa labour and development research unit working paper No.119). Retrieved from: https://ideas.repec.org/p/ldr/wpaper/119.html

GARBA, A. (2006). *Alleviating poverty in northern Nigeria*. A paper presented at the annual convention of Zumunta Association, Minneapolis, MN, USA, July 28-29.

GASS, G., & ADETUNMBI, D. (2000). *Summary report of DFID's civil society consultation process in Nigeria, 13 December 1999 – 2 February 2000*. Retrieved from dfid database

GOTTSCHALK, P., MCLANAHAN, S., & SANDEFUR, G. D. (1994). The dynamics and intergenerational transmission of poverty and welfare participation. In Danziger, S. H., Sandefur, G. D., & D.H Weinberg (Eds.), *Confronting Poverty: Prescriptions for Change* (pp. 85-108). New York, NY: Russell Sage Foundation

HOKAYEM, C., & HEGGENESS, M. L. (2013). *Factors influencing transitions into and out of near poverty: 2004-2012*. (SEHSD Working Paper, 2014-05). Retrieved from: https://www.census.gov/library/working-papers/2013/demo/SEHSD-WP2013-02.html

IFAD. International Fund for Agricultural Development. (2012). *Enabling poor people to overcome poverty*. Retrieved from www.ifad.org

JUSTINO, P., LITCHFIELD, J., & PHAM, H. T. (2008). Poverty dynamics during trade reform: evidence from rural Vietnam. *Review of Income and Wealth, 54*(2), 166-192. doi: https://doi.org/10.1111/j.1475-4991.2008.00269.x

KAY, C. (2006). Rural poverty and development strategies in Latin America. *Journal of Agrarian Change, 6*(4), 455-508. doi: https://doi.org/10.1111/j.1471-0366.2006.00132.x

KUMAR, N., & AGNES, Q. (2014). *Gender, shocks and resilience, building resilience for food and nutrition security*. 2020 Conference brief 11. May 17-19 2014, Addis Ababa, Ethiopia. Washington, D.C. Retrieved from http://www.ifpri.org/publication/gender-shocks-and-resilience

LIBRARY OF CONGRESS. (2008). *Country profile: Nigeria*. Retrieved from http://lcweb2.loc.gov/frd/cs/profiles/Nigeria.

MAGGIO, G. (2004). *Multidimensional analysis of poverty dynamics in Great Britain*. (ISER Working Papers 2004-10). Retrieved from: https://www.iser.essex.ac.uk>...PDF multidimensional

MPPN. Multidimensional Poverty Peer Network. (2017). *National Multidimensional Index for Nigeria.* Retrieved from. https://mppn.org/nigeria-national-mpi.

NBS. National Bureau Of Statistics. (2005). *Poverty profile for Nigeria*. Retrieved from nbs Nigeria database

OBADAN, M. I. (2001). Poverty reduction in Nigeria: The way forward. *CBN Economic and Financial Review, 39* (4), 159 -188.

OMOTOLA, J. S. (2008). Combating poverty for sustainable human development in Nigeria: The continuing struggle. *Journal of Poverty, 12*(4), 496 – 517. doi: https://doi.org/10.1080/10875540802352621

OPHDI. Oxford Poverty and Human Development Initiative. (2014). *Country Briefing January: Nigeria* Retrieved from ophdi database.

OVWASA, L.O. (2000). Constraints on poverty alleviation in Nigeria. *Political Science Review, 1* (1), 56 – 80.

OYEMOMI, E.O. (2003). *An assessment of poverty reduction strategies in Nigeria 1983 – 2003* (Unpublished Ph. D dissertation). St Clements University, The Turks and Caicos.

SEN, A. K. (1999). *Development as Freedom* (1). United States of America: Oxford University Press.

THORBECKE, E. (2005). *Multi-dimensional poverty: conceptual and measurement issues*. A paper prepared for the many dimensions of poverty international conference, UNDP International Poverty Centre, Brasilia. Retrieved from https://thorbecke.economics.cornell.edu>...PDF

UNDP. United Nations Development Programme. (2002). *World Energy Assessment*. Retrieved from UNDP database.

UNDP. United Nations Development Programme. (2010). *Human Development Report 2010: The real wealth of nations: Pathways to human development.* Retrieved from UNDP database.

UNDP. United Nations Development Programme. (2014). *Human development report 2014: Sustaining human progress: Reducing vulnerability and building resilience.* Retrieved from UNDP database.

UNITED NATIONS. (2003). *Indicators for Monitoring the Millennium Development Goals*, New York: United Nations.

VALLETTA, R. G. (2006). The ins and outs of poverty in advanced economies: Government policy and poverty dynamics in Canada, Germany, Great Britain, and United States. *Review of Income and Wealth, 52(2)*, 261-284. doi: https://doi.org/10.1111/j.1475-4991.2006.00187.x

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REGULAR ARTICLE

FACTORS AFFECTING THE PROFITABILITY OF POULTRY EGG PRODUCTION IN SOUTHWEST NIGERIA: AN APPLICATION OF QUANTILE REGRESSION

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ABSTRACT

This study investigated the key factors affecting the profitability of poultry egg production in Southwest, Nigeria. A multi-stage sampling procedure was employed to select 360 egg farmers using a structured questionnaire. Data collected were analysed using descriptive and inferential statistics. Descriptive statistics showed that the mean age of egg farmers was 45 years. Majority (68.3%) of the farmers were male households. Over half (57.8%) of the farmers had tertiary school education and majority (85.0%) of them were married. The distribution of flock size showed that majority of the farmers was medium-scale poultry farmers. The result revealed that egg production is profitable. Results of the quantile regression revealed that farmer's age, farm size, price per crate of egg, cost of drugs as well as farm location had positive significant impacts on farm income at various quantiles. However, education, experience and household size, costs of labour, feed and day-old-chicks were identified to have negative but significant impact on farm income across the quantiles.

Keywords: Quantile regression, Poultry Egg, Farm income
JEL: C14, C21, Q12

INTRODUCTION

Agriculture is a major non-oil sector, contributing significantly to the Nigerian economy. In 2018, this sector contributed about 26.2% to the overall gross domestic product (GDP) in real terms. Livestock industry is one of the subsectors in agriculture, employing over 25 million of Nigeria's population directly and indirectly specifically in poultry industry (**NBS, 2018)**. Livestock contributed 6% to 8% of national GDP **(ASL, 2018)**. It is a good weapon to fight poverty and unemployment. **Okunmadewa, (1999)** asserted that livestock are instruments that can turn around the socioeconomic life of the rural people especially in the developing countries. It is possible to rear them in small, medium and large scale. Nigerian livestock consists of poultry, cattle, pig, sheep and goat. **NASS (2011)** revealed that livestock population in Nigeria consists of 19.5 million cattle, 41.3 million sheep, 72.5 million goats, 7.1 million pigs, 145 million poultry, 11.6 million ducks, 28,000 camels, 1.2 million turkey, and 974,499 donkeys in 2011. Poultry distribution accounted for almost half of the total livestock reared in Nigeria.

The contribution of poultry farming to livestock production and gross domestic product was 58.2% (**Amos, 2006)**. There are many gainful opportunities in the poultry industry. Poultry provides a diversity of business interests which include egg and meat production, hatchery and inputs providers and this in turn provides additional income to the family (**Oluyemi and Roberts, 1979; Laseinde, 1982)**.

The supply of poultry eggs and meat in Nigeria over the years has been on the increase in spite of challenges but the proportion of its increases still falls short of desire. Major factors responsible for low production in poultry industry as revealed in **Alabi and Isah (2002)** are low capital base, lack of equity, infection with diseases and parasites, high cost of feed and use of poor quality of day-old chicks. The high costs of maize and soybeans have gone beyond the means of most poultry farmers **(Sahel, 2015)**. The quality of soybean and corn produced in Nigeria is low and inadequate to meet the needs of local feed millers. Fueling the input crisis, the high cost of imported feed has forced majority of the farmers to improvise and reformulate poultry feeds with low quality materials such as peanut cake, cotton seed and palm kernel meal **(World Poultry, 2013)**. Therefore, high cost of inputs (e. g feeds) is a major challenge in poultry industry because feeds purchase, for example consumed as much as 70% of the cost of production which has even led to a large reduction in the number of commercial poultry farmers especially the small-scale ones who could not withstand production of eggs at high cost **Adebiyi, 2000; Ashagidigbi, Sulaimon and Adesiyan, 2011).**

The high cost of inputs would definitely affect the level of income among poultry egg farmers. Nigerian

government in the past and even recently has come up with many programs that geared towards abating the problem of high cost of inputs in poultry industry. Some of these programs include Micro-Credit Scheme for Livestock Production, Community-Based Agricultural and Rural Development Project **(ADF, 2003**) and National Egg Production (NEGPRO). NEGPRO is the Federal Government of Nigeria initiative designed to create more job opportunities, remove hunger and alleviate poverty. The program is aimed at giving accredited farmers an enabling environment to access a 25 billion set aside by the Central Bank of Nigeria through Bank of Industry (BOI). The scheme also aimed at increasing the output of egg production to 50 million table egg daily by 2018. Similar effort in this direction is the African Chicken Genetic Gain in Nigeria (ACGG-NG) launched in 2015 as collaborative research agreement between the International Livestock Research Institute (ILRI) and Obafemi Awolowo University (OAU) with a major objective of conducting baseline survey on the status of smallholder chicken (SHC) farmers across the agro-ecological zone in the country and to determine genetically improved chicken preferred by smallholder chicken producers. These programs are not heard of again because they are politically motivated and ill-funded.

The present study is therefore undertaken to investigate the factors affecting farm income among poultry egg farmers in Southwest, Nigeria. Specifically, the study computed the cost and returns associated with poultry egg farming and identified factors influencing farm income among egg farmers in the study area. Several studies have been carried out on economic analysis of poultry egg farming before now but majority of them focused on efficiency of resource-use in poultry egg farming with little or no attention on factors determining the distribution of income among egg farmers in the study area. For examples, **Ojo (2003)** employed stochastic frontier production function to determine technical efficiency of poultry egg production in Nigeria. **Amos (2006)** carried out the analysis of backyard poultry production in Ondo State, Nigeria, using multiple regressions. Result from the study showed that the cost of feeding and veterinary cost were major factors affecting production poultry in the study area. In a similar study by **Emokaro and Emokpae (2014)** stochastic frontier production function was also used to investigate the technical efficiency and production elasticity of broilers in Edo State, Nigeria. Results of their study showed that 82.9% of broiler farmers had technical efficiency ranging between 0.81 and above. The estimated gamma coefficient was 0.74, indicating that a technical inefficiency exists in broiler production in the study area. Result further revealed that broiler farmers in the study area operated within the stage 1 of the production function based on the production elasticity of 1.2 estimated in the study.

Majority of past literature has concentrated on average income accruing to egg farmers. The assumption of homogeneity in the income earned among poultry egg farmer using mean may be grossly inadequate. However, policy measures taken according to these results are not likely to be equally effective for all farmers who are into egg production**.** It is, therefore, imperative to consider the heterogeneity among the population of egg farmers. The results from this study will provide useful information for policy makers.

DATA AND METHODS

Study Area

The study was carried out in Southwest, Nigeria. Southwest is one of the six geo-political zones in Nigeria which comprises of six States that include Lagos, Ogun, Ondo, Ekiti, Osun and Oyo. The total population as at 2006 census was 28,767,752 **(NPC, 2006)**. The region enjoys tropical climate with two distinct seasons, the rainy season (April-October) and the dry season (November-March). The study area lies between longitude $2^0 31´$ and $6^0 00´$ E and latitude $6^0 21´$ and $8^0 37´$N with a total land area of 77,818km^2 **(Agboola, 1979)**. Southwest is bounded in the east by Edo and Delta States, in the North by Kwara and Kogi States, in the West by the Republic of Benin and in the South by the Gulf of Guinea. The wet season is associated with the Southwest monsoon wind from the Atlantic Ocean while the dry season is associated with the northeast trade wind from the Sahara Desert.

Agriculture is one of the major occupations of the people in the study area. Livestock farming is a popular business among the people. They rear animals like goat, sheep, pig and poultry keeping. Poultry management is common in both the rural, peri-urban and urban areas of Southwest, Nigeria. The area is blessed with rivers which gives them diverse opportunities like transportation, fishing and lumbering.

A multi-stage sampling procedure was used to select the respondents. Data were collected from 360 egg farmers in the study area through a structured questionnaire and interview schedule. In the first stage, three out of six States in Southwest that are highly prominent in egg production were purposively selected. The selected States include Lagos, Oyo and Ogun (**NBS, 2006)**. In the second stage, two Local Government Areas (LGAs) from each of the State that are highly prominent in layers production were also purposively selected using the list of members of Poultry Association of Nigeria (PAN) as a guide. The Local Government Areas (LGAs) selected were Shagamu and Odeda in Ogun State, Alimosho and Ojo in Lagos State and Afijio and Oyo West in Oyo State.

In the third stage, sixty (60) egg farmers were randomly selected from each of the LGAs of the States sampled, giving one hundred and twenty (120) poultry egg farmers per State. Finally, a pool of three hundred and sixty (360) egg farmers were randomly sampled from the three States and analysed in this study.

Net Income Estimation

Profitability in egg production was computed using net income estimation method to ascertain profit accruing to the poultry egg producers in the study area. This can be specified as the Eq. 1-3.

$$NI_i = TR_i - TC_i \quad (1)$$

$$TR_i = P_i * Q_i \quad (2)$$

$$TC_i = TFC_i + TVC_i \quad (3)$$

Therefore,

$$NI_i = P_i * Q_i - (TFC_i + TVC_i) \quad (4)$$

Where:

NI_i Nnet income accrued to ith farmer on sale of egg (₦);
TR_i Total revenue realised from the sale of eggs by ith farmer (₦);
TVC_i Total variable cost incurred on production of eggs by ith farmer (₦);
Q_i Total quantity of eggs produced by ith farmer (crate)
P_i Current price per unit of output (₦);
TFC_i Total fixed cost incurred by ith farmer (₦)

Quantile Regression Model

Given the Ordinary Least Square model as Eq. 5.

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_n X_n + \varepsilon_i \quad (5)$$

With ε_i independently and identically distributed with mean zero and constant variance. Given a random variable with a probability

$F(y) = P(Y \leq y)$

As opined by Koenker and Bassett (1982), the τth quantile of Y is given as

$Q_y(\tau) = \{\inf(y = F(y) \geq \tau\}$ where $\tau \in [0,1]$. Hence, the conditional quantile $Q_{(\tau/x)}$ is the inverse of the conditional function of the response variables.

Therefore, the quantile function Equation 5 can be written as Eq. 6.

$$Y_i = \beta_0(\tau) + \beta_1(\tau)X_1 + \beta_2(\tau)X_2 + \cdots . + \beta_n(\tau)X_n + \varepsilon_i \quad (6)$$

The conditional quantile function is given by Eq. 7.

$$Q_{(\tau/\varepsilon)} = \beta_0(\tau) + \beta_1(\tau)X_1 + \beta_2(\tau)X_2 + \cdots . + \beta_n(\tau)X_n + u_i \quad (7)$$

$\varphi_t = Q_{(\tau)}\varepsilon_t$ is identically distributed with mean zero and variance one. This can simply be written as Eq. 8.

$$Q_{yi}(\tau/\varepsilon) = X^T{}_i \beta_i(\tau) \quad (8)$$

Where:

$$X = (1, X_0 \ldots\ldots\ldots\ldots X_n)^T \quad (9)$$

The conditional cumulative probabilities of (Y_i), is given by Eq.10.

$$Pr(Y_i \leq q(Xi)/Xi = x = \tau \quad (10)$$

We solve the minimization problem

$$E\ (|Y_i - q(Xi)\tau|X_i = x) \quad \min_{f \in L(u)} E(|Y_i - f(Xi)|\tau|X_i = x) \quad (11)$$

The τth quantile regression estimator $\widehat{\beta_i}$ that minimizes over β_τ the objective function is given as the Eq. 12.

$$Q(\beta_\tau) = \sum_{y_i > X_i\beta\tau}^{n}(\tau)|Y_i - X_i^T| + \sum_{y_i < X_i\beta\tau}^{n}(1-\tau)|Y_i - X_i^T\beta\tau \quad (12)$$

Where: $\tau|e_i|$ and $(1-\tau)|e_i|$ are called the asymmetric penalties for under prediction and over prediction and $0 < \tau < 1$ (**Nyantakyi, Peiris and Gunaratne, 2015**).

To evaluate the effects of socio-demographic variables and poultry specific attributes on farm income of the poultry egg farmers, quantile regression was used in this study based on several advantages of the model over Ordinary Least Square method (OLS) which include ability to capture outlier when distribution of data skews to one side and some are far away from the mean, Again, quantile regression can help to address the problem of heterogeneity in data. It looks beyond locating the central location of data. Looking exclusively on changes in the mean may underestimate, overestimate, or even fail to distinguish real non-zero changes in heterogeneous distributions (**Cade, Terrell and Schroeder, 1999**). The explicit functional form can be stated as Eq. 13.

$$Q\tau(Y/X) = x) = X^T\ (\tau) 0 < \tau < 1 \quad (13)$$

Where:

Y Average total income earned per annum by ith farmer from egg production;
X_1-X_n Socio-demographic characteristics of farmers and poultry specific attributes in egg production;
Bτ marginal change in the τth quantile due to marginal change in X.

The dependent variable and independent variables used in this study are presented in Table 1.

Table 1: Description and Measurement of Variables used in Quantile Regressions Model

Variable	Name	Measurement	*A priori* expectations
Y_i	Average Net income	Naira	
X_1	Age	Years since birth	-
X_2	Education	Years of schooling	+
X_3	Household size	Number of persons in household	-
X_4	Experience	Years in egg production	+
X_5	Farm size	Area in m^2	+
X_6	Price of egg	₦/crate of egg	+
X_7	Cost of Labour	₦/hour worked	-
X_8	Cost of Feed	₦/kilogramme	-
X_9	Cost of day-old-chicks	₦/Bird	-
X_{10}	Cost of Drugs	₦/Dose used	-
D_{2i}	Ogun State	If Poultry farmer is in Ogun = 1, 0 otherwise	±
D_{3i}	Oyo State	If Poultry farmer is in Oyo =1, 0 otherwise	±

RESULTS AND DISCUSSION

Socioeconomic Characteristics of Poultry Egg Farmers

The socio-economic characteristics of egg farmers in the study area are presented in Table 2. The mean age of the egg farmers was 45 years, implying that the farmers were still economically active. The farmers will be able to cope with the stress and rigour associated with poultry farm operations. This finding is in line with the findings of **Ojo (2003)** who found an average of 45 years for egg farmers in Oyo State, Nigeria. Majority (68.3%) of the farmers were male households with female households accounting for 31.7%. The mean poultry farming experience was 12 years, suggesting that farmers would be able to take reasonable decisions based on their years of experience in poultry management. This finding is in line with the study conducted by **Adeyonu *et al.*, (2016)** who reported 13 years of mean experience of poultry egg farmers in Oyo State. The mean household size was 5 persons per household. The mean household size estimated in this study agreed with the findings by **Emokaro and Emokpae (2014)** who reported that majority of poultry egg farmers in Edo State, had a family size range between 1and 6 persons.

Table 2: Socioeconomic Characteristics of Poultry Egg Farmers

Variable	Frequency	Percentage (%)
Age in years		
≤30	52	14.4
31-45	150	41.7
46-60	118	32.8
>60	40	11.1
Mean	44.53±11.8	
Gender		
Male	246	68.3
Female	114	31.7
Poultry experience		
≤10	42	11.7
11-20	228	63.3
21-30	82	22.8
>30	08	2.2
Mean	11.99	
Household size		
≤5	274	76.1
6-10	84	23.3
>10	02	0.6
Mean	5.0	
Education		
No formal school education	14	3.9
Primary school education	22	6.1
Secondary school education	116	32.4
Tertiary school education	208	57.8
Marital status		
Single	54	15.0
Married	306	85.0
Total	360	100.0

Source: Field survey, 2018

Over half of the sampled farmers (57.8%) had tertiary school education. About 3.9% of the farmers were not educated. Thus, 96.1% of the poultry egg farmers had formal school education. This result here agreed with the findings of **Adeyonu *et al.* (2016)** that over 50% of poultry farmers in Oyo State had tertiary school education. The study further unveiled it that majority (85.0%) were married while about 15.0% were yet to marry. Majority (70.0%) of the farmers had access to extension services in the surveyed area, indicating that the farmers would be highly informed and aware of poultry egg related innovations

Flock Size

Table 3 presented the distribution of poultry egg farmers by flock size. The mean flock size was 2003.19. This structure according to the classification of **Omotosho and Oladele (1988); Ojo (2003) and Adene and Oguntade (2006)** showed majority of poultry egg farms in the surveyed area fall within the range of medium-scale farming.

Table 3: Distribution of Respondents by Flock Size

Flock Size	Frequency	Percentage (%)	Mean
≤1000	62	17.2	
1001-2000	107	29.7	
2001-3000	139	38.6	2003.19
> 3000	52	14.4	
Total	360	100	

Source: Field survey, 2018

Cost and Returns Structure in Poultry Egg Production per 2003 birds

The profitability analysis of poultry egg production using net income estimation is presented and discussed as follows. Table 4 presents the cost and returns in poultry egg farming in the study area. The depreciation on TFC incurred on fixed items was ₦239,691.32 representing 12.0% of the TC. The average value of the TVC was ₦1,750,502.9 per annum, and this value accounted for about 88.0% of the TC. Evaluation of the TVC reveals that the cost of labour, day-old-chicks, medications and feeds accounted for a pool of 84.6% of the TC of egg production. The table reveals that the four major inputs in egg production are feeds, labour, DOC and medications. These variables inputs gulp more than half (85.0%) of the TC of production in egg faming.

It was also observed that about 53.3% of the TC went for feeds making it the highest cost incurred on variable items in the production of egg. This result agrees in part with findings from a number of studies on economic analysis of poultry egg farmers. For example, the findings in separate studies carried out by **Adepoju (2008); Afolami; Aladejebi and Okojie (2013)** on poultry egg farming in Nigeria showed that feed had the largest cost share of the TC of production. On the other hand, the result on proportion of expenditure that went for feeds was lower than the one reported in the aforementioned literature. This also implies that some of the poultry egg farmers are likely to be new entrants in the industry. As new entrants, they are yet to spread or reduce the average fixed costs of their farms.

Table 4: Cost and Returns Structure in Poultry Egg Production per 2003 Birds

Item	Mean value (₦/year)	Percentage (%)
Variable cost Items		
Labor	338,197.00	16.99
Day-old-chicks	199,129.80	10.01
Medications	85,278.00	4.28
Feeds	1,061,393.50	53.33
Transport	8,833.10	0.44
Electricity	3,633.30	0.18
Fuel	5,674.10	0.29
Water	2,671.20	0.13
Saw-dust	1,319.90	0.07
Repairs and Maintenance	5,757.04	0.29
Veterinary Charges	35,338.30	1.78
Disinfectants	3,277.60	0.16
Total Variable Cost (TVC)	1,750,502.90	87.95
Fixed Cost Items		
Depreciated cost of vehicles	54,330.20	2.73
Depreciated cost of buildings	76,012.30	3.82
Depreciated cost of cages	5,924.50	0.30
Depreciated cost of shovels	92.30	0.01
Depreciated cost of empty crates	558.60	0.03
Depreciated cost of land	100,489.90	5.05
Depreciated cost of feeders	1,086.80	0.05
Depreciated cost of drinkers	1,196.70	0.06
Total Fixed Cost (TFC)	239,691.32	12.05
Total Cost (TC) = TFC+TVC	2,990,194.22	100.0
Revenue from egg sold	3,633,093.25	74.92
Revenue from spent layers sold	1,216,215.31	25.08
Total Revenue (TR)	4,849,308.56	100.0
Net Income NI=TR-TC	2,859,114.35	
Returns on Investment (ROI) = NI/TC	1.44	
Net profit Ratio = NI/TR	0.59	

Source: Field Survey, 2018

The result also reveals that costs of the following variable items; transport, electricity, fuel, water, saw-dust, disinfectants, repairs and maintenance and veterinary charges accounted for 3.3% altogether.

For the revenue aspect, the mean value of the total sales on eggs and spent layer was ₦4,849,308 as the value of eggs alone contributed 74.9% to the total revenue while value of spent layers accounted for about 25.1% of the total revenue. This result implies that egg is the major revenue contributor in poultry egg production. The result of profitability of egg business showed that it was profitable in the study area, given a net income of ₦2,859,114.35. The profitability ratios computed in this study revealed that the returns on investment (ROI) was 1.44 which implied that for every ₦1 invested in poultry egg farming, a profit worth of ₦0.44 will be accrued to the farmer. Similarly, a net income ratio of 0.59 was computed, implying that 59 kobo will be realised as gain on every ₦1 expended on poultry egg farming. The profitability ratios reported here are all higher than any of the agricultural interest rate of 10% for the Bank of Agriculture (BOA) and Bank of Industry (BOI). The result here supports the findings of **Afolami *et al*. (2013), Evbuomwan (2005)** that egg production is a profitable venture.

Factors Influencing Farm Income among Egg Farmers

Table 5 shows the coefficients and t-values of quantile regression and Ordinary Least Square (OLS) results. The first three columns displayed the results of various quantile regression models considered and OLS regression model occupied the fourth column for comparison. To judge the predictability of various models in this study, economic theory and econometric criteria were employed which include the F-statistics, plausibility of variables signs, number of significant variables and adjusted R-squared of individual model. The F-statistics was statistically significant at the 1% level, which implies that all the explanatory variables in the model jointly exerted a significant impact on farm income realised from egg.

Looking at the various quantile models, the pseudo R^2 at 25^{th}, 50^{th} and 75^{th} quantiles, were 54%, 59% and 62%, respectively. For example, at 25th percentile, about 54% of the variation in the net income of egg farmers was explained by all the independent variables in the model. Similarly, 59% of variation in the dependent variable was also explained by all the explanatory variables in the model at median quantile. At 75^{th} quantile, the proportion of variation of income explained by the entire independent variables was 62%.

Table 5: Parameter Estimates of the Quantile Regression V OLS

Quantile	τ = 0.25		τ = 0.5		τ = 0.75		OLS	
Variable	Coeff	t-ratio	Coeff	t-ratio	Coeff.	t-ratio	Coeff.	t-ratio
Constant	-9.8775	-0.82	-95.8487**	-2.63	-201.6141***	-3.91	-258.775**	-2.38
Age	0.7888***	164.68	1.2007***	79.78	1.4080***	53.13	1.9187***	43.33
Experience	-0.1907***	-19.85	-0.4383***	-17.53	-0.5666***	-13.73	-0.6320***	-8.52
Household size	-0.4329***	-8.51	-0.1143	-0.91	0.1582	0.87	-0.5487	-1.45
Education	-0.0921**	-2.78	0.0340	0.55	0.0644	0.96	0.0296	0.16
Farm size	0.0201***	5.25	0.0369***	5.98	0.0607***	10.33	0.0830***	4.58
Price of Egg	0.0201***	3.30	0.0760***	4.45	0.1178***	5.00	0.1713***	3.36
Cost of labour	-0.0144***	-3.43	-0.0572***	-5.6	-0.0681***	-4.71	-0.1369***	-4.41
Cost of feed	-0.0016	-0.45	0.0074	0.71	0.0100	0.63	0.0260	0.82
Cost of DOC	-0.0398	-0.79	0.1970	1.29	0.6520***	3.01	0.7182	1.59
Cost of Drugs	0.3453**	2.06	1.9487***	4.14	4.0574***	6.18	4.9863***	3.57
Ogun State	0.5146*	1.91	0.6828	1.2	0.8741	1.36	0.5048	0.3
Oyo State	0.1983	0.73	1.0002*	1.77	1.2711*	1.88	3.3201*	1.98
Pseudo R^2	0.54		0.59		0.62			
F-statistics	0.000		0.000		0.000		0.000	
No. of Obs.	360		360		360		360	

Source: Field Survey, 2018

Note: ***, **, * significant at 1%, 5% and 10% respectively.

The coefficient of determination (R^2) estimated using OLS was 0.879 which implies that 88% of the variation in farm income was explained by the independent variable included in the model.

The result differs from *a priori* expectation as the slope coefficient of age of the respondents was positive, though significant across all the models at the 1% level. This finding implies that a year increase in the age of respondents, leads to an increase in farm income across different quantiles by 0.7%, 1.2% and 1.4%, respectively. It is also observed that as farmer grows older, s/he may have better access to resources and more skills are acquired which may eventually improve s/he income.

Education provides opportunities to have better information, acquires new skill and thus stimulates the mind of the farmers to accept new farming techniques. The coefficient of years of schooling was negatively signed but statistically significant across all quantiles at the 1% level. The absolute values of this variable increase from lower to upper quantile. However, education of the farmers was hypothesized to be positive, but failed to carry the expected sign. This could be probably meant that farmers can acquire the needed skills in poultry egg farming through extension services, seminar and workshop. This result agrees with the finding of **Valerien *et al.* (2011)** that find negative relationship between education and household income in rice-producing areas of Philippines using quantile regression.

Household size had a negative and significant impact on the income of poultry egg farmers as expected at lower and median percentiles. A large family size may mean that more egg will be consumed by house members. The result posits that an additional member to a household, holding other variables constant, leads to income reduction by 0.4% and 0.1% at 25^{th} and 50^{th} quantile, respectively. This study concurs with the finding of **Okon (2014)** that a large family household has negative effect on income. Household size variable was positively related to net income at the upper quantile. This means large scale poultry egg farming requires more hands which can be substituted through family labour or the effect of large family has no significant impact on their income.

As shown in the table, the coefficient of farming experience had a negative significant impact on farm income of egg farmer. This was not however consistent with the *a priori* expectation of the study. The estimated coefficients, on the average, were -0.1907, -0.4383 and -0.5666 respectively, at various chosen quantiles. This result shows that farmers with years of experience are likely to be facing land tenure challenges especially in the urban area where the rate of urbanization is increasing on daily basis compared with the rural areas.

Farm income is a relative term which can be expressed as a function of farm size, all things being equal. Result also showed that farm size had positive relationship with farm income at 1% probability level, thereby suggesting that a unit increase in farm size, holding other variables constant, farm income will increase across all chosen quantiles by 0.02%, 0.04% and 0.06%, respectively. This result differs from the findings of **Valerien *et al.* (2011)** that farm size was inversely proportional to the household income.

The slope coefficient of price of egg estimated was theoretically consistent with the hypothesis and significant at the 1% level of probability. The positive association between farm income and the price of egg is an indication that if there is a unit increase in the price of egg, the influence on farm net income will be as high as 0.02%, 0.07% and 0.11%, respectively across all the quantiles compared to the result obtained from OLS. However, the coefficient of cost of labour, as expected, was inversely proportional to farm income in egg production, thus implying that a 1% increase in labour wage per hour, all things being equal, farm income will reduce by 0.01%, 0.05% and 0.06%, respectively across the quantiles. It is observed that the absolute value of labour variable obtained in the study increases as quantile increases. It was observed that the estimate obtained through OLS method appeared to be larger than that of quantile in this study indicating the coefficient produced by OLS is not

asymptotically efficient. The result from the present study agreed with the study conducted by **Oladunni and Fatuase (2014)** that cost of labour is inversely proportional to the total revenue derived from backyard poultry farming in Akoko North West LGA of Ondo State, Nigeria.

The result displays in the table showed that cost of feed was negatively related to the income as expected across all quantiles, but this was not statistically significant at 25th and 50th quantiles respectively. At 75th quantile, the cost of DOC was statistically significant at the 1% level. This, however, means that a 1% increases in the cost of DOC per bird, assuming other variables in the model are controlled, will induce an increase in the price per crate of egg, hence, this will also translate to an increase in income by ₦0.65.

The slope coefficient of cost of medication was positively signed and statistically significant at the 1% level all through, implying that a unit increase in the cost of medication will trigger off an increase of ₦0.34, ₦1.94 and ₦4.05, respectively, in the price of medication. This finding is contrary to the findings of **Amos (2006)** who found negative relationship between the gross income realised from the production of backyard and cost of vaccination.

The result further showed that dummy variable for farm location was included as a predictor to capture the effect of differences in geographical area on farm income. The location included were Lagos, Ogun and Oyo States, respectively. Lagos State was chosen as the base category. At 25th quantile, the coefficient for Ogun State dummy was 0.5146. The dummy variable had a positive and significant relationship with the income of poultry egg farmer at the 10% probability level. The probability of setting up a poultry farm in Ogun State, holding other variables constant, farm income will increase by 0.5% compared to Lagos State. However, the same variable had no significant impact at median and higher percentiles (e. g 75th quantile) in Ogun State. The effect of owning a poultry farm in Oyo State was found to be positively related to the income of poultry egg farmer at the probability level of 10% for median and 75th quantile. The coefficient for Oyo dummy at 50th and 75th were 1.0002 and 1.2711, respectively, indicating if a poultry farm is established in Oyo State compared to Lagos State, farmer's income will commensurately increase by 1.0% and 1.2%, respectively.

CONCLUSIONS

This study carried out on the factors affecting the profitability of farm income among poultry egg farmers in Ondo State, Nigeria showed that poultry egg farmers are still young to cope with the stress associated with poultry egg business. The result concluded that majority of the respondents are male households. This could be due to the fact that male-headed households are always considered to possess more resources and risk-takers compared to women. It was also concluded that majority are married in the study area with a high probability of family labour supply. The mean experience of the farmers was 12 years, and more than half of the respondents were educated. The net income computed from field survey data showed that poultry layer business is profitable in the study area while quantile regression result showed that age of the respondent, farm size, price of egg, cost of drugs and farm location had positive significant impacts on farm income at one quantiles or the other. However, education of respondents, farmer's experience, household size, costs of labour, feed and day-old-chicks were identified as factors that had negative but significant influence on poultry farm income across the quantiles. Based on the findings of this study, the following recommendations are given as:

(i) Governments at all levels should encourage youths to embrace poultry business in order to reduce poverty and unemployment in the country;
(ii) Government should formulate policy that will stimulate competitiveness in poultry industry;
(iii) Also, policy that will increase farmers' profit and reduce input prices should be put in place by the policy maker;
(iv) Efficient extension services should be put in place to provide timely delivery of poultry egg information to the farmers; and
(v) Access to credit facility in the country should be improved upon since capital is one of the major obstacles confronting poultry egg farmers.

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REFERENCES

ADEBIYI, M. A. (2000). Economic Analysis of Egg production in Ondo State, B. Tech Project, Department of Agricultural Economics and Extension, FUT, Akure. Unpublished.

ADENE, D. F., & OGUNTADE, A. E. (2006): The Structure and Importance of the Commercial and Village-Based Poultry Systems in Nigeria/ FAO,

ADEPOJU, A. A. (2008). Technical Efficiency of Egg Production in Osun State. *International Journal of Agricultural Economics and Rural Development IJAERD, Pp 7-14*

ADEYONU, A. G., OYAWOYE, E. O., OTUNAIYA, A. O., & AKINLADE, R. J. (2016). Determinants of poultry Farmers' Willingness to Participate in National Agricultural Insurance Scheme in Oyo State, Nigeria. Applied Tropical Agriculture, A publication of the School of Agriculture and Agricultural Technology, The Federal University of Technology, Akure, Nigeria. Volume 21, No 3, pp 55-62,

ADF. AFRICAN DEVELOPMENT FUND (2003). Community-based Agricultural and Rural Development Project Appraisal Report. *Agricultural and Rural Development Department, Central and West Regions, Federal Republic of Nigeria.* 1-9

AFOLAMI, C. A., ALADEJEBI, O. J. & OKOJIE, L. O. (2013). Analysis of Profitability and Constraints in Poultry Egg Farming Under Battery Cage and Deep Litter

Systems in Ogun State, Nigeria: A Comparative Study. *IJAFS* 4 (1&2). pp 581-595.

AGBOOLA, S. A. (1979). An Agricultural Atlas of Nigeria, Oxford University Press, Nigeria. Pp248.

ALABI, R. A., & ISAH, A. O. (2002). Poultry Production Constraints. The Case of Esan West Local Government Area of Edo State, Nigeria: *African Journal of Livestock Extension* 1(1), (2002) 58-61. https://www.ajol.info/index.php/ajlex/article/view/115

AMOS, T. T. (2006). Analysis of Backyard Poultry Production in Ondo State, Nigeria. *International Journal of Poultry Science* 5(8), 247-250. DOI: 10.3923/ijps.2006.247.250

ASHAGIDIGBI, W.M., SULAIMON, S.A., & ADESIYAN, A. (2011). Technical efficiency of egg production in Osun State. *International Journal of Agricultural Economics and Rural Development*, *4* (6):120-131. DOI: 10.3923/aj.2011.124.130

ASL. AFRICA SUSTAINABLE LIVESTOCK (2018). Livestock production systems spotlight Nigeria. FAO, Rome, Italy.

CADE, B. S., TERRELL, J. W., & SCHROEDER, R. L. (1999). Estimation Effects of Limiting Factors with Regression Quantiles. *Ecology* 80: (1999) 311-23. DOI: 10.1890/0012-965(1999)080[0311:EEOLFW]2.0.CO;2

DE JANVRY, A., SADOULET, E., & ZHU, N. (2005). The Role of Non-Farm Income in Reducing Poverty and Inequality in China. CUDARE Working Paper 1001, University of California, Berkeley. https://escholarship.org/uc/item/7ts2z766

EMOKARO, C. O., & EMOKPAE P. O. (2014). Technical Efficiency and Production Elasticity of Broiler Producers in Edo State, Nigeria, Applied Tropical Agriculture, Vol. 19, No 1, Pp 59-69. www.futa.edu.ng/journal/home/paperd/383/10/11

EVBUOMWAN, G. O. (2005). Empirical Analysis of Cost and Returns to Commercial Table Egg Production in Lagos State. Farm Management Association of Nigeria Conference, Asaba, Nigeria, Research and Statistics Department, Central Bank of Nigeria, Pp. 27-37

KOENKER, R. W., & BASSETT, G. W. (1982). Robust Tests for Heteroscedasticity based on Regression Quantiles, *Econometrica*, Vol. 50, pp. 43–61. DOI: 10.2307/1912528

LASEINDE, E. A. O. (1982). Technical Guide to Poultry Production Division of Agricultural Colleges, *Newsletter*, Vol. 1: 4, (14-18), Ahmadu Bello University, Zaria, Nigeria.

NASS. NATIONAL AGRICULTURAL SAMPLE SURVEY (2011). National bureau of statistics/ federal ministry of agriculture and rural development collaborative survey on national sample survey 2010/2011 http://www.premiumtimesng.com

NYANTAKYI, K. A., PEIRIS, B. L., & GUNARATNE, L. H. P. (2015). Analysis of the Interrelationships between the Prices of Sri Lankan Rubber, Tea and Coconut Production Using Multivariate Time Series. *Advances in Economics and Business* 3.2 (2015) 50 - 56. DOI: 10.13189/aeb.2015.030203.

NBS. National Bureau of Statistics. (2018). National Bureau of Statistics Report 2018

NPC. National Population Commission (2006). Analysis of Nigeria 2006 Census Result, NPC, Abuja, Nigeria.

OJO, S. O. (2003). Productivity and Technical Efficiency of Poultry Egg Production in Nigeria. *International Journal of Poultry Science*, 2(6); 459-46. DOI: 10.3923/ijps.2003.459.464

OKON, U. E. (2014). Assessment of Income Generating Activities among Urban Farm Households in South-South, Nigeria, University of Nigeria Nsukka, Virtual Library PhD Thesis (Unpublished).

OKORJI, E. C. (1988). Women and Rural Development Strategies for Sustaining Women Contribution in Rural Households of Anambra State, Nigeria. *Working paper, No 166. Women in International Development*, Michigan state University, pp 16.

OKUNMADEWA, F. (1999). Livestock Industry as Tool for Poverty Alleviation. *Tropical Journal of Animal Science*, 2(2): pp 21-30

OLADUNNI, M. E., & FATUASE, A. I. (2014). Economic analysis of backyard poultry Farming in Akoko North West Local Government Area of Ondo State, Nigeria. *Global Institute for research and Education* ISSN: 2319-5584, Vol. 3(1), 141-147. https://www.longdom.org/articles/economic-analysis-of-backyard-poultry-farming-in-akoko-north-west-localgovernment-area-of-ondo-state-nigeria.pdf

OLUYEMI, J. A. & ROBERTS, F. A. (1979). *Poultry Production in the Warm Wet Climate*. Macmillan Press Ltd London, 197 p.

OMOTOSHO, O. A., & OLADELE, A. A. (1988). Management Problems in Large Scale Poultry Business in Nigeria. *Farm Management Nigerian Journal, Vol*.3: pp, 27-35

SAHEL. Sahel Capital (Mauritius) Limited (2015). *An Assessment of the Nigerian Poultry Sector*. Vol. 11, Pp. 1-3. http://sahelcp.com/wp-content/uploads/2016/12/Sahel-Newsletter-Volume-11.pdf

VALERIEN, O. P., JOYCE, S. L., THELMA, R. P., & JUSTIN, D. M. (2011). Determinants of Household Income: A Quantiles Regression Approach for Four Rice-Producing Area in the Philippines. *Asian Journal of Agriculture and Development, Vol*. 9, No. 2, pp. 65-76. DOI: 10.22004/ag.econ.199102

WORLD POULTRY (2013). Feed Prices Stunt Poultry Industry in Nigeria. *Poultry World*, Mar 5, 2013.

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REGULAR ARTICLE

FARM DIVERSIFICATION IN THE CENTRAL HIGHLANDS OF ETHIOPIA: PATTERNS, DETERMINANTS AND ITS EFFECT ON HOUSEHOLD INCOME

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ABSTRACT

Crop-livestock production is the major farming system in the highlands of Ethiopia. This study aimed to describe crop-livestock diversification pattern, examine determinants of diversification patterns, and evaluate effects of diversification on household income. Principal component analysis (PCA), seemingly unrelated regression (SUR) and ordinary least square (OLS) regression models were employed. Five major crop-livestock diversification patterns: sheep and goat, staple crops, chicken, vegetables, and animal feed-based farming were identified. The SUR model revealed that sex, education, income, extension contact, land size, market and road distance, irrigated land, and household size were significant factors that influence crop-livestock diversification patterns. It is also found that sheep and goat, vegetable, and chicken-based farming were significant production patterns that had positive effects on household income. We suggest that adoptive and adaptive agricultural practices such as small-scale irrigation, chicken rearing and sheep-based production patterns are the most potential farming systems in the highlands of Ethiopia.

Keywords: Agriculture, competition; diversification pattern; mixed farming
JEL: C12, C38, D13, Q12

INTRODUCTION

Agriculture is the most common livelihood strategy and basis for Ethiopian economy (**Dinku, 2018**). The agriculture sector contributes for 39% of national GDP (**UNDP, 2018**), and 83% of the population is engaged in agriculture (**ILO, 2014**). The majority (90%) of the rural population rely mainly on crop-livestock systems and natural resources for their livelihoods, and nearly 60% of the land coverage is under non-pastoral production systems (**Lebeda *et al*., 2010; Dinku, 2018**). Mixed crop-livestock production is a regular activity in the highlands of the country (**Asante *et al*., 2017**). Heterogeneous farming systems have economic, social, and ecological advantages and the sources of food, household income, foreign exchange earnings, and response for employment opportunities and raw materials for industries (**Nigussie and Alemayehu, 2013; Martin *et al*., 2016**). Moreover, most households use crops and livestock for risk reduction and coping strategies (**Berhe**, **2011; Kassie, Kim and Fellizar, 2017**). In uncertain environment and unstable marketing situations, diversified farms are less risky than monocultures (**Shahbaz *et al*., 2017**).

Many literatures argue for a range of farm activities as a means to minimize income insecurity and insurance against crop failures (**Alemayehu, Dorosh and Sinafikeh, 2011; Lin, 2011; Liniger *et al*., 2011; Herrero *et al*., 2012**). Mixed crop-livestock systems provide bio-diversity and ecosystem services (**Nkonya *et al*., 2011; IFAD, 2013**). The systems reduce vulnerability to food insecurity. On top of this, mixed farming provides recreational, cultural and spiritual significance (**IFAD, 2010; Liniger *et al*,. 2011; Moraine *et al*., 2014).** Agricultural intensification is also considered as another alternative strategy for smallholders (**Shideed and El Mourid, 2005; Manyong, Okikeb and Williams, 2006**; **Iiyama *et al*., 2007a**). Population pressure is the key driver for agricultural intensification and production dynamics in the farming systems (**Boserup, 1965, 1981; McIntire, Bourzat and Pingali, 1992**). However, intensification has been criticized for environmental pollution, soil deterioration, land degradation, and nutrient depletion (**IFAD 2013**). Many researchers have tried to mediate the contrasted debates between diversification and intensification in agriculture (for instance, **Daniel, 2010; Todaro and Smith, 2012**). The latter is more appropriated for large-scale, location specific and capital-intensive enterprises.

Even though the government of Ethiopia has made efforts to improve the livelihoods of the rural poor, persistent challenges have been continued on agriculture for centuries. Food insecurity and high population density have always been adversely affecting the landscape situations of the highlands (**Lin, 2011; Kuria *et al*., 2014**). Population pressure, land fragmentation, soil erosion, and poverty are the main confronts in the highlands agro-climates (**IFAD, 2013; Abate, 2014; Haregeweyn *et al*., 2015**). At country level, one-third of the rural households could not produce adequate food for the rising population and exhibited large rates of malnutrition (**Harerro *et al*., 2012**). The population living below poverty line and under nourishment is 29.6 and 35.0%, respectively (**FAO, 2014**). The ever-increasing human population and severe land fragmentation made the food situations worsened

(**Sisay, Degsew and Mekuria, 2018**). Despite apparent yield improvements have been reported, evidences on agricultural technologies particularly crop varieties and animal breeds are not overwhelming (**Mekuria and Mekonnen, 2017**).

Mekuria *et al.* (2018) have also found that competition among crop-livestock activities for land resources is increasing. Therefore, it is crucial to identify patterns for crop-livestock production and determine associated factors to alleviate such competitions. One of the strategies, often adopted to tackle livelihood confronts, is producing integrated diversified crop-livestock activities. Crop-livestock diversity in turn helps to improve dietary diversity (**Sibhatu, Krishina and Qaim, 2015**). Diversified agriculture has a potential to produce adequate food, provide sufficient incomes, and maintain agro-ecosystem services (**Rudel *et al.*, 2016**). Despite mixed farming contributes in managing production risks, previous studies on agricultural diversification are minimal as mainly focused on livelihoods and crop diversification (**Mesfin, Fufa and Haji, 2011; Rehima et al., 2013; Sibhatu, Krishina and Qaim, 2015**). Moreover, there is no study conducted in Ethiopia that addressed crop-livestock diversification patterns and determinants of diversification. Therefore, the objectives of the paper were (i) to examine crop-livestock diversification patterns, (ii) analyze determinants of diversification patterns and, (iii) evaluate effects of diversification on household income in the farming systems.

DATA AND METHODS

Description of the study area

The study watershed was located in *Gudo Beret Kebele*, *Basona Worana* district, North *Shewa* Zone, *Amhara* region, Ethiopia. The geographical coordinates are situated between 9° 76′ to 9° 81′ of northern latitudes and 39° 65′ to 39° 73′ eastern longitudes. The study watershed covered about 2425 ha of land. The altitude in the watershed ranges between 2828 and 3700 meter above sea level. The mean daytime temperature was between 2.4 °C and 19.2 °C. The climate of the watershed was wet and moist highland with a bimodal rainfall pattern. The mean annual rainfall in the watershed was 1651 mm. According to ***Kebele* census (2016)**, the total population size of the study watershed was 2070 and 447 households.

The research watershed was characterized by mixed farming systems. The dominant livelihood sources include mainly subsistence crop cultivation, livestock husbandry, and plantation of eucalyptus woodlots. There was no natural forest in the watershed but eucalyptus trees around homesteads, hillsides, and gully buffers covered about 15.2% of the total study area (**Tadesse and Tafere, 2017**). Barley, wheat, faba bean, field pea, and vegetables are the major crops grown in the watershed, while the major livestock types include cattle, sheep, and equines. In often times, livestock husbandry has been practiced in combination with crop production and eucalyptus plantation. The sources of animal feed include crop residue, industrial byproducts, and open grazing in communal and individual plots. Despite livestock were allowed to graze under the eucalyptus woodlots, the high density of woodlots inhibited pasture growth for animals.

Sampling techniques and data collection

A three-stage sampling procedure was employed. At first stage, the study district was selected purposively. Similarly, the study watershed was selected purposively for the reason that intensive mixed farming systems have been practiced. The watershed was also a part of the USAID; feed the future funded Africa RISING project in the highlands of the country. In this watershed, 211 household-heads were randomly selected. The study was based on cross-sectional data collected in the watershed between May and June of 2016. Questions in the interview schedule were prepared to capture the details of farm households. Training on methods of data collection was conducted for enumerators. Finally, the data were collected at household level that include demographic, socioeconomic, institutional, and biophysical variables such as crop varieties, livestock breeds, incomes, and others.

Methods of data analysis

Descriptive statistics such as percentage, frequency, standard deviation, mean, and specifically a multivariate analytical technique PCA was employed to determine crop-livestock diversification patterns. Econometric methods such as SUR and Linear regression models were also used to examine determinants of diversification and effects of diversification on household income.

Model specification

PCA analysis: A multivariate statistical technique, PCA was employed to identify the dominant crop-livestock diversification patterns (**Lesschen and Verburg, 2005; Iiyama, Maitima and Kariuki, 2007b; Kebede *et al.*, 2016**). PCA is used to derive new sets of reduced and uncorrelated variables-diversification patterns (**Abdi and Williams, 2010; Keho, 2012**). PCA was derived from correlation matrix once different units of crop-livestock activities were standardized using z-score (**Gujarati 2003:173; Manyong, Okikeb and Williams, 2006**). Two criteria were employed to retain major components. High percentage of the total variation in the original variables is the first criterion (**Iiyama, Maitima and Kariuki, 2007b**) and as a rule of thumb Eigen values greater than 1.0 is the second criterion (**Manyong, Okikeb and Williams, 2006; Abdi and Williams, 2010**). The formula was adapted in **Keho (2012).**

$$Y_n = \alpha_{n1}(X_1) + \alpha_{n2}(X_2) + \cdots + \alpha_{np}(X_p) \qquad (1)$$

Where:

Y_n, the subject score on principal component indicates patterns and to what extent households engage in the production system; α_{n1} is the weight for variable X_1 in creating the component Y_n; $X_1, X_2, \ldots X_p$ are variables or activities; α_{np} is regression coefficient for observed variable *P*; and X_p is subject score on observed variable *p*.

Model for determinants of diversification

Determinants for the major components of mixed farming systems were modelled using SUR assuming that error terms between components are expected to be correlated. SUR model is an efficient estimator of coefficients compared with OLS regression when the error terms between equations are correlated. The former provides a more robust parameter of estimates of coefficients, standard errors, and covariance compared to OLS regression (**Liew, 2017**). SUR model estimates more than two equations simultaneously. The parameters of each equation take information provided by the other equation into account (**Cadavez and Henningsen, 2012**).

$$Y_i = X_i\beta_i + \varepsilon_i \quad i = 1,2,\dots,M \qquad (2)$$

Where:

Y_i is (T*1) vector with elements y_{ti}, X_i is (T*K_i) matrix whose columns represent T observation or an explanatory variable in the i^{th} equation, β_i is (K_i*1) vector with elements β_{ij}, M is parameters of equations and $\varepsilon_i = [\varepsilon_1', \varepsilon_2', \varepsilon_3', \dots \varepsilon_M']$ is vector of disturbances.

The independent variables were selected based on previous empirical studies and the data gathered from household survey. The hypothesized variables were expected to influence diversification patterns differently; either positively or negatively (Table 1).

Model for the effect of diversification on household income

The impacts of crop-livestock diversification patterns on household income were modelled using OLS regression. The formula was adapted in **Greene (2002)** and computed as Eq. 3.

$$Y_i = X\beta + \varepsilon_i \qquad (3)$$

Where:

Y is t he proportion of annual income obtained in the i^{th} farmer, X is a vector of diversification patterns determining the amount of household income β is a vector of parameters to be estimated and ε_i is the error term.

RESULTS

Socio-economic attributes of households

In the study area, 29% of households were women-headed. The average household members were 4.5. Man equivalent and active labour force were accounted for 3.9 and 2.9 per household, respectively. The mean age of household heads was 44 years with a minimum and maximum of 23 and 82 years old. The age for the majority (90.5%) of household heads were between 23 and 65 years indicating that almost all household heads are in the range of active age. In terms of educational status, about 21% of household heads were illiterate while 43% household heads could read and write. The result also showed that, the mean land holding size was 1.3 hectare with a minimum of 0.1 and a maximum 4 hectares. Households have used inorganic and organic fertilizers for crop production. The majority of households (85%) used on average 100 kg compost while 58% of households applied on average 62 kg of inorganic fertilizer per household. Some households (30%) used on average 52 kg of improved seed (Table 2), mainly barley and wheat varieties.

Extension service is an advice that informs and influences rural households' decision while extension contact is the frequency of interaction of development agents with farmers for advisory services (**Anderson and Feder, 2003**) and technical supports. Extension service has immense roles for technology transfer. Nearly 23% of households had no contact with development agents throughout a year, while 39% and 28% of households had one and two contacts in monthly basis. Limited number of households (10%) could access three to five contacts per month. The local market, asphalt road, health clinic, elementary schools, electric power, potable water, and churches are key institutions and infrastructures found in the watershed.

Table 1: Independent variables in relation to crop-livestock diversification patterns

Acronyms	Variable explanations and measurements	Hypothesis
Dependent variables (Y_i)		
CLDP	Crop-Livestock Diversification Patterns	
Independent variables (X_i)		
SEX	Sex of household head (1=male; 0=otherwise)	+ (male)
AGE	Age of household head measured in years	+
EDUC	Educational level of household head in class years	-
LABOR	Household labor measured in man-equivalent	+
HHSIZE	Household size measured in number	-
LAND	Land holding size in ha	+
INCOME	Annual household income in $USD*	+
IRRIGAT	Irrigated land size in ha	+
CREDIT	Access to credit (1= access to credit; 0= otherwise)	+
EXTEN	Extension contact in number of days per year	+
DMKT	Distance between household's residence and the nearest local market measured in walking minutes	-
DROAD	Distance between household's residence and the nearest asphalt road measured in walking minutes	-

Note: *Official exchange rate1.00 US dollar =21.5 Ethiopian Birr (June, 2016)

The nearest local market is *Gudo Beret* located at the center of the watershed. The main asphalt road crosses the small town of *Gudo-Beret* from southwest to northeast direction. Accesses to tarmac road and the expansion of market opportunities have increased demands for market-oriented commodities such as eucalyptus poles, crop yields, and livestock products.

Table 2: Socio-economic attributes of sample households

Variable description	Mean	Std. Dev.	Min	Max
Age of household head	44.0	12.4	23.0	82.0
Land holding size	1.3	0.6	0.1	4.0
Household labour	2.9	1.3	1.0	7.0
Household size	4.5	1.8	1.0	10.0
Annual income	4.8	5.2	0.0	38.5
Extension contacts	1.3	1.1	0.0	5.0
Market distance	27.5	25.8	0.0	90.0
Road distance	18.4	20.1	1.0	90.0
Irrigated land size	0.1	0.1	0.0	0.3

Source: Survey data (2016)

Crop-livestock diversification patterns

Cereal crops were the most abundant varieties followed by pulses, and less land size was allocated for oil crops, oats, vegetables and potatoes. Almost every (99%) household has grown crops and 94% of households rear livestock. Of the total cultivated area, wheat and barley were accounted for 48%. Households also produced faba bean, field pea, lentil, vegetables, Irish potato, oats and linseed on small plots of land. Figure 1 shows the types and proportions of crop varieties and livestock breeds. According to **Magurran (2004),** diversities in crop species and animal breeds demonstrate the abundance while the extent to which one or more species or breeds dominate the watershed evenness. The percentage was calculated in terms of hectare for cultivated crops and TLU for number of livestock.

Cattle, equines, sheep, goat, and chicken were the major livestock types reared in the study watershed. Three-quarters (75%) of the cattle population were indigenous breeds while 25% were improved breeds. The highest cattle population was oxen while sheep and chicken were the highest livestock population in number. Sheep production was the most common practice mainly for the source of household incomes through selling. The majority (61%) of livestock population was livestock followed by sheep and goat (20%), equine (18%) and chicken (1%) in terms of TLU. In total, thirteen variables were included in PCA, in which five principal components with Eigen values greater than one were retained. Consequently, five major types of farming patterns were identified. The five principal components explained almost 71% of the total variability. These crop-livestock diversification patterns are presented in Table 3.

The first principal component explained 24.22% of the total variance and it is correlated substantially with sheep and goat, equines, and indigenous cattle production. This component represented a diversification pattern for animal production. Similarly, principal components II, III, IV, and V explained 20.13, 9.47, 8.56, and 8.50% of the total variance, respectively.

Determinants of crop-livestock diversification patterns

After determining diversification patterns, the next task of this study was identifying factors that cause crop-livestock diversification. To carry out it, the diversification patterns were regressed against socio-economic, demographic, and institutional variables that are expected to affect diversification pattern using seemingly unrelated regression procedure. This method was selected because the error terms between equations were assumed to be correlated. The estimated SUR model was tested for independence between the residual terms of diversification patterns using Breusch-Pagan test. The chi^2 value of the test is 28.83 and rejected at 1% significant level. The test result confirmed that the SUR model is appropriate to estimate the simultaneous equations of the diversification patterns.

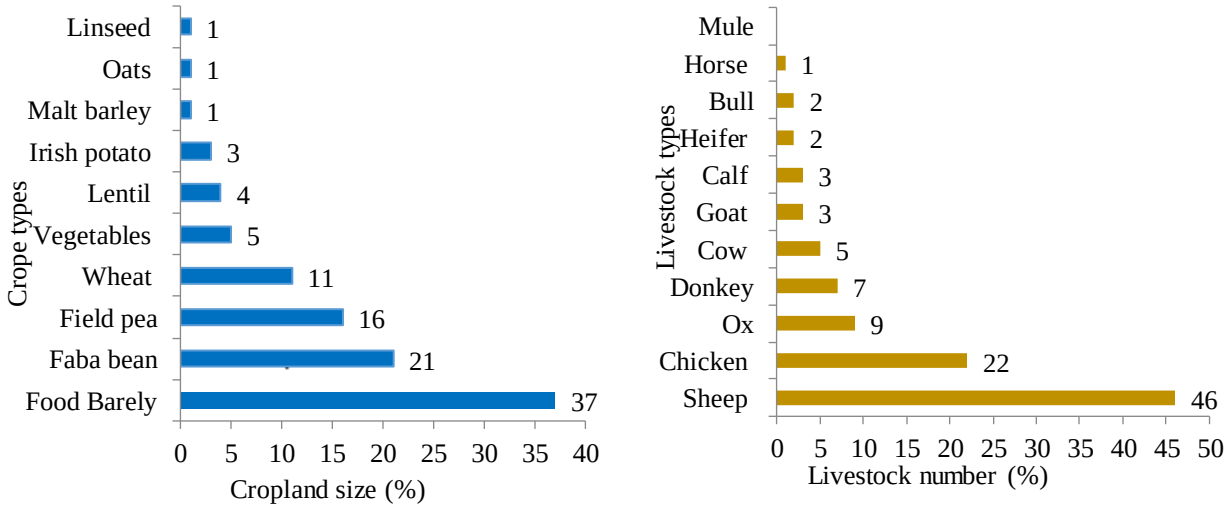

Figure 1: Crop and livestock diversity

Table 3: The major crop-livestock diversification patterns (PCA result)

Major crop-livestock activities	Major components				
	CLD I	CLD II	CLD III	CLD IV	CLD V
	Sheep and goats	Staple crops	Chicken	Vegetables	Animal feed
Improved cattle (%)	0.56	-0.29	0.31	0.09	-0.17
Indigenous cattle (%)	0.72	0.39	-0.14	-0.02	0.17
Equines (%)	0.76	0.23	0.03	-0.08	0.05
Sheep and goat (%)	0.78	0.10	0.15	0.07	0.09
Chicken (%)	0.14	0.15	0.79	-0.18	-0.15
All animals (TLU)	0.97	0.18	0.10	0.02	0.06
Cereal (%)	0.28	0.66	0.01	0.23	-0.03
Pulse (%)	0.12	0.79	-0.03	-0.04	0.06
Oil crops (%)	-0.03	0.58	0.21	-0.35	0.00
Vegetables (%)	-0.01	0.13	-0.02	0.86	-0.05
Oats (%)	0.12	0.08	-0.05	-0.09	0.88
Total crop land (ha)	0.22	0.92	0.00	0.24	0.07
Bee colonies (No)	0.10	-0.09	0.64	0.28	0.48
Eigen values	3.15	2.62	1.23	1.11	1.11
% variance	24.22	20.13	9.47	8.56	8.50
Com. explained variance	24.22	44.35	53.82	62.38	70.88

Note: Coefficients are factors loadings; extraction methods are principal component analysis. A rotation method is varimax with Kaiser Normalization.

Table 4: Results of SUR model (N=211)

Independent Variables	Dependent Variables				
	Sheep and goat	Staple crops	Chicken	Vegetables	Animal feed
AGE	0.005 (0.005)	-0.007 (0.005)	0.005 (0.006)	-0.009 (0.006)	-0.008 (0.006)
EDUC	0.015 (0.048)	-0.217*** (0.050)	0.098 (0.063)	0.087 (0.062)	0.017 (0.062)
SEX	0.350*** (0.122)	-0.054 (0.128)	-0.421*** (0.160)	0.151 (0.157)	0.133 (0.158)
LAND	0.173* (0.104)	1.079*** (0.110)	-0.168* (0.136)	0.454*** (0.134)	-0.056 (0.135)
FLAB	-0.022 (0.060)	0.013 (0.064)	-0.128 (0.079)	0.054 (0.078)	0.030 (0.078)
INCOME	0.047* (0.025)	-0.012 (0.026)	0.051 (0.032)	0.038 (0.032)	-0.011 (0.032)
CREDIT	-0.057 (0.108)	-0.136 (0.114)	-0.103 (0.142)	0.263 (0.140)*	-0.045 (0.140)
EXTEN	0.070 (0.052)	0.077 (0.055)	0.135** (0.068)	0.026 (0.067)	-0.002* (0.067)
DMKT	0.007* (0.004)	0.001 (0.004)	0.005 (0.005)	-0.011** (0.005)	0.004 (0.005)
DROAD	0.011** (0.005)	-0.006 (0.005)	-0.002 (0.006)	0.010 * (0.006)	0.008 (0.006)
IRRIGAT	-0.073 (0.758)	2.155*** (0.797)	0.643 (0.993)	-0.470 (0.977)	-1.308 (0.981)
HHSIZE	0.156*** (0.048)	-0.080 (0.051)	0.093 (0.063)	-0.071 (0.062)	0.012 (0.063)
Cons	-2.185*** (0.340)	-0.172 (0.358)	-0.611 (0.445)	-0.277 (0.405)	0.027 (0.440)
R^2	0.464	0.406	0.080	0.109	0.100
Chi^2	182.42***	144.38***	18.43**	25.91***	23.67***

Note: The parenthesis are standard errors; *, **, and *** are significance at 10, 5, and 1%.

The results of SUR model showed that different factors could influence crop-livestock diversification patterns. The hypothesized and tested independent variables were included in the model as shown in Table 4. The major determinants that influenced crop livestock diversification patterns were educational level of household heads, sex of household head, total land size, frequency of extension contact, distance to the nearest market place, distance to the nearest asphalt road, household size and land used for irrigation. The mixed farming systems had five diversification patterns in the study area. However, there was no a common factor that influenced all diversification patterns at the same time; due to the fact that diversification patterns have different attributes that were not influenced by common factors. Indeed, land size could affect the four diversification patterns at different significant levels with positive and negative coefficients. It implies crop and livestock-based diversification patterns had different socio-economic and bio-physical attributes.

EDUC: Educational level negatively affected the staple crop-based diversification patterns at 1% significant level. As a household head level of education increases by one year of schooling, the household decreases staple-based crop diversification by 21.7%. Similarly, some other studies also found that education has negative effects on livestock husbandry, vegetable production, and crop-livestock diversification (**Mesfin, Fufa and Haji, 2011; Matsane and Oyekale 2014; Ojo *et al.*, 2014; Kassie, Kim and Fellizar, 2017**). There are possible explanations for negative relationships between education and farm diversification. As a farm household acquires skills and knowledge, either she /he may prefer specialized farm activities or search for non-farm employment opportunities. On the contrary, some previous studies revealed that a farmer with better level of education is more likely to adopt crop and livestock diversification

compared to an illiterate farmer (**Manyong, Okikeb and Williamsc, 2006; Iiyama, Maitima and Kariuki, 2007b**). Thus, education can have mixed effects on farm activities depending on other factors.

SEX: Gender difference has mixed effects on farm diversification. Male-headed households affected sheep/goat-based production positively at 1% significant level. As a household head being male, the production pattern for sheep and goat increases by 35%. On the contrary, a household head being male had negative correlation with chicken-based diversification and it was significant at 1%. As a household leads by male, chicken-based production declines by 42.1%. In the traditional farming systems, shepherd is for males while reproductive roles including poultry and child care is for females. Findings of other studies also revealed that male-headed households found to have positive correlation with cereal, vegetable and oat production while it is negative with livestock and chicken production (**Ochieng, Owuor and Bebe, 2012**; **Xaba and Masuku, 2013; Asante *et al.*, 2017**).

LAND: Land is the most important variable on which different farm activities were carried out. Land size had positive effects on sheep/goat, staple and vegetable based production at 10%, 1% and 1% significant levels, respectively. As land size increases by 1.0 ha, the sheep/goat, staple, and vegetable-based production patterns increases by 17.3, 107.9, and 45.4%, respectively. A farmer with more lands, can access pasture for livestock, eucalyptus trees, and vegetable crops. **Rehima *et al.* (2013)** and **Asante *et al.* (2017)** have found that land size has negative effects on farm diversification while **Ojo *et al.* (2014**) and **Matsane and Oyekale (2014)** found that land size is positive on oats, vegetables, and sheep and goat-based diversifications.

EXTEN: Agricultural extension service has positive effects on chicken-based diversification at 5% significant level. As extension contact frequency increases by one day per month, chicken-based diversification pattern increases by 13.5%. Extension contact is one of the major sources of information for agricultural practices and improved technologies such as animal breed, and other agricultural inputs. Extension is found to have positive correlation with crop diversification and chicken production in many studies (**Ochieng, Owuor and Bebe, 2012; Rehima *et al.*, 2013; Ojo *et al.*, 2014**). There are cases where extension contacts could adversely affect the crop-livestock systems (**Manyong, Okikeb and Williams, 2006; Mesfin, Fufa and Haji, 2011**).

DMKT: The relationship between market distance and vegetable-based diversification market was negative at 5% significant level. As walking distance increases by one minute, vegetable-based diversification declines by 1.0%. The possible reason may be households who reside near to the local market diversify their farm activities mainly vegetables for home consumption and market demands. **Asante *et al.* (2017**) reported that market distance has mixed effects on crop-livestock diversification. They found that market distance is negative towards the probability of adoption on crop production and the extent of decision on livestock production. Many studies reported that distance to the local market have negative correlations with crop diversification, vegetable production and chicken rearing (**Mesfin, Fufa and Haji, 2011; Ochieng, Owuor and Bebe, 2012**). In the study of **Rehima *et al.* (2013),** market distance is positive with crop diversification. Similarly, in this study market distance has positive correlation with sheep and goat-based production at 10% significant level. As market distance increases by one minute, sheep and goat-based production increases slightly by 0.7%.

IRRIGAT: Irrigation land impacted the staple crop-based diversification pattern positively at 1% significant level. As irrigation land increases by 1 ha, the staple crop-based diversification pattern increases by 215.5%. Hoffman and **Livezey (1987)** also reported similar findings. In the study of **Rehima *et al.* (2013**), irrigation is positively correlated with oats production and negatively associated with crop diversification.

DROAD: Road distance has positive correlation with both sheep and goat and vegetable based-diversification at 5% and 10% significant level, respectively. As road distance increases by one minute, the sheep and goat and vegetable-based diversification increases by 1%. Sheep and goat-based farming is positive for market and road distance. It implies households who reside far from the center of the *Kebele* and the main asphalt road have better access to grazing fields for small ruminants.

HHSIZE: Household size has positive and significant correlation with sheep and goat-based diversification at 1% significant level. As household size increases by one member, the diversification for sheep and goat increases by 15.6%. It implies that this pattern is labor intensive activity in the farming systems.

Effects of crop-livestock diversification on household income

In the study area, the three major sources of income include 68% farm, 25.3% non-farm, and 6.7% off-farm activities. This section is devoted to evaluate the effect of identified patterns on annual household income in the study area. Demographic, economic, social, institutional and bio-physical variables are potential factors that can affect the total household income. Nevertheless, from the previous studies, the missing link is crop-livestock diversification patterns and its impact on household income that obtained from various income sources. From the total farm incomes, sale of crop yields, animals and their products and agro-forestry products accounted for 55.4, 26.4, and 18.2%, respectively. Payment for retirement, remittance, masonry, carpentry, petty trading, and related activities were the major source of non-farm income. In *Gudo Beret* watershed, the main source of off-farm income was labour wage. The annual average total income was 4837 birr per household, which is equivalent to 225 dollars. However, there is a large variation among households on farm income levels as they pursue different crop-livestock diversification patterns.

To determine the effect of crop-livestock diversification on household income, the major components or crop-livestock diversification patterns are considered as explanatory variables. The total annual income level of households then regressed against the

major components using OLS regression procedures. The result is presented in Table 5.

Table 5: Effects of crop-livestock diversification patterns on household income

Diversification patterns	Coefficients	Std. Err.	t-value
Sheep and goat	59.86***	22.72	2.63
Staple crops	5.74	24.27	0.24
Chicken	38.31**	15.95	2.40
Vegetables	45.84*	23.61	1.94
Animal feed	2.65	19.89	0.13
Constant	224.99 ***	15.66	14.36
R-square			0.12
F-value			3.43***

Note: ***, **, * significant at 1%, 5%, and 10%

The results in Table 5 revealed that sheep and goat, chicken, and vegetable-based diversification were positively correlated with household income and significant at 1%, 5% and 10%, respectively. As diversification for sheep and goat, chicken, and vegetable-based farming increases by each of one standardized unit, household income increases by 59.86, 38.31, and 45.84 dollars, respectively. It implies that small body size animals (chicken, sheep, and goat) and vegetables such as onion, tomato, and potatoes grown with supplementary irrigation were the major sources of farm income for rural households. Intensive production of small ruminants in the private, communal and open access grazing lands bring high economic returns that served mainly for home consumption and cash incomes.

DISCUSSION

The focus of this study is to identify crop-livestock diversification pattern, determinants of diversification and its effect on household income. Sheep and goat, staple crops, vegetables, chicken, and animal feed (Oats)-based diversifications are identified patterns. Most of crop-livestock activities are integrated within and among different patterns in the farming systems. Diversified farming has incentives not only to enhance household income but also lessons competition among crop-livestock activities. Patterns of production for sheep and goat, vegetables, and chicken are positively associated with household incomes.

The most significant and predominant diversification pattern is sheep and goat, which is associated with equine, cattle and cereal production. In this pattern, the highest factor loading is for sheep and goat production. The average holding size of sheep is seven per household whereas goat is very limited in size between zero and one animal per household. In our study, like many previous studies did, for instance, **Iiyama *et al.* (2007a),** sheep and goat are under one category. In the study area, the proportion of households that own sheep and goat is 82% and 18%, respectively. It implies that sheep is the most potential livestock breed in this highland agro-climate. **Edea *et al.* (2012)** also pointed out that sheep is the most diversified breeds and the main source of livelihood in many parts of Ethiopia. It is also a source of meat, skin, manure and coarse wool or long hairy fleece (**Mengesha and Tsega, 2012).** In this study, it is found the most influential source of household annual income.

Chicken-based diversification pattern is the third component in the mixed crop-livestock systems. Chicken production is the leading activity after sheep rearing. The average holding size of chicken is 4.5 per household. Beekeeping, improved cattle, and oil crops are integrated with this pattern. In contrast, indigenous cattle, equine, chicken, pulse crops, vegetables, and oats are correlated negatively with the pattern. Chicken production is one of the identified opportunities for smallholder where small landholding size is prevalent. The study area has suitable agro-climate for chicken production.

Some activities (beekeeping and cereal crops) are integrated with vegetable-based diversification pattern whereas activities such as pulses, oil crops and the majority of livestock species are competed with this pattern. Depending on availability of land and agro-climate suitability, vegetables can be grown either as sole crop or intercropped with other vegetables or cereals through rain-fed or supplementary irrigation systems. Ethiopia is potentially profitable and comparative advantage in production of vegetables because its favourable climate, cheap labour, market proximity to Europe, and rivers for irrigation (**Ashebre, 2015**).

CONCLUSIONS

Mixed crop-livestock production is one of the major livelihood strategies in rural highlands of Ethiopia. Diversified farming is the major source of food, cash income, and agro-ecological services. Nevertheless, crop production has competed with the livestock sub-systems for land resources. Hence, households have prioritized major farming patterns in the crop-livestock systems to minimize competitions among farm activities and reduce pressures on land resources. Male-headed households are potential producers of sheep-based diversification pattern, while chicken-based diversification pattern or small-scale poultry production is appropriated for landless and rural women.

Households that have access to adequate farmlands are found to adopt crop production in general, and, grain and vegetable-based farming systems in particular. In the same way, access to irrigation lands enabled to adopt irrigation-based farming, whereas households led by educated farmers had adverse effects on crop-based farming systems because they shift their decision mainly from crop production to off-farm and non-farm activities. Overall, diversified farms are the source of income for the majority of households, which can improve the livelihoods of farm households. Among the identified farming typologies, sheep and vegetable-based farming were the major source of income followed by chicken-based farming systems. Women friendly agricultural technologies and agro-climate adaptive practices such as small-scale vegetable production, chicken rearing and sheep-based farming patterns should be encouraged to improve the livelihood of smallholder farmers in the study area.

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REFERENCES

ABATE, A. (2014). Assessing the Consequence of Land Use Change on Agricultural Productivity in Nadda Asendabo Watershed Gilgel Gibe Sub-Catchment of Ethiopia. *Int. J. Environ. Sci*, 3(2), p. 72-77.

ABDI, H., & WILLIAMS, L. J. (2010). Principal Component Analysis. Wiley Interdisciplinary Reviews: *Computation Stat*, 2(4), p. 433-459. DOI: https://doi.org/10.1002/wics.101

ALEMAYEHU, S., DOROSH, P., & SINAFIKEH, A. (2011). *Crop Production in Ethiopia: Regional Patterns and Trends:* International Food Policy Research Institute (IFPRI). ESSP II Working Paper No. 0016.

ANDERSON, J. R., & FEDER, G. (2003). *Rural extension services. Agriculture and Rural Development Department*, Working paper 2976. World Bank, Washington, DC. http://econ.worldbank.org.

ASANTE, B. O., VILLANO, R. A., PATRICK, I. W., & BATTESE, G. E. (2017). Determinants of Farm Diversification in Integrated Crop-Livestock Farming Systems in Ghana. *Renewable Agri. Food Sys*, 1-19. DOI: https://doi.org/10.1017/S1742170516000545

ASHEBRE, K.M. (2015). Opportunities and Potential in Ethiopia for Production of Fruits and Vegetables: A Graduate Senior Seminar Paper. *African Journal of Basic & Applied Sciences* 7 (6), p. 328-336. DOI: 10.5829/idosi.ajbas.2015.7.6.1153

BERHE, A.A. (2011). Coping with Drought for Food Security in Tigray, Ethiopia. MSc Thesis. Wageningen, the Netherlands.

BOSERUP, E. (1965). The Conditions of Agricultural Growth: The Economics of Agrarian Change under Population Pressure. London, Allen and Unwin.

BOSERUP, E. (1981). Population and Technological Change: A Study of Long-term Change: Chicago, University of Chicago Press.

CADAVEZ, V., & HENNINGSEN, A. (2012). The Use of Seemingly Unrelated Regression (SUR) to Predict the Carcass Composition of Lambs. *Meat Science*, 92, p. 548-53. DOI: https://doi.org/10.1016/j.meatsci.2012.05.025

DANIEL, D. (2010). Sustainable Land Management Technologies and Approaches in Ethiopia, Addis Ababa, Ethiopia, MoARD.

DINKU, A.M. (2018). Determinants of livelihood diversification strategies in Borena pastoralist communities of Oromia regional state, Ethiopia. *Agriculture and Food Security*, 7:41. DOI: https://doi.org/10.1186/s40066-018-0192-2 .

EDEA, Z., HAILE, A., TIBBO, M., SHARMA, A. K., SOLKNER, J., & WURZINGER, M. (2012). Sheep production systems and breeding practices of smallholders in western and south-western Ethiopia: Implications for designing community-based breeding strategies. *Livestock Research for Rural Development*, Vol. 24, (117). http://www.lrrd.org/lrrd24/7/edea24117.htm.

FAO, (2014). *Analysis of Price Incentives for Wheat in Ethiopia*. Technical Notes Series, MAFAP, by Wakeyo M B, Lanos B, Rome.

GREENE, W. H. (2002). *Econometric Analysis*. 5thed. New Jersey. Prentice-hall Inc.

GUJARATI, D. N. (2003). *Basic Econometrics*. New York: McGraw Hill Book Co.

HAREGEWEYN, N., TSUNEKAWA, A., NYSSEN, J., POESEN, J., TSUBO, M., MESHESHA, D. T., SCHÜTT, B., ADGO. E., & TEGEGNE, F. (2015). Soil Erosion and Conservation in Ethiopia: A Review. *Prog. Phys. Geog*, 39(6): 750-774. DOI: https://doi.org/10.1177/0309133315598725

HERRERO, M., THORNTON, P. K., NOTENBAERT, A., MSANGI, S., WOOD, S., & KRUSKA, R. (2012). Drivers of Change in Crop–Livestock Systems and their Potential Impacts on Agro-Ecosystems Services and Human Wellbeing to 2030. *A Study Commissioned by the CGIAR System wide Livestock Programme*. Addis Ababa, Ethiopia: ILRI.

HOFFMAN, L. A., & LIVEZEY, J. (1987). The U.S. OATS Industry, Commodity Economics Division, Economic Research Service, U.S. Department of Agriculture. Washington, DC. *Agricultural Economic Report No. 573*.

IFAD. INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT. (2010). Integrated Crop-livestock Farming Systems. Livestock Thematic papers. Tools for Project Design. Pp. 8.

IFAD. INTERNATIONAL FUND FOR AGRICULTURAL DEVELOPMENT. (2013). Smallholders, Food Security and the Environment. pp. 54.

IIYAMA, M., KAITIBIE, S., KARIUKI, P., & MORIMOTO, Y. (2007). The Status of Crop-Livestock Systems and Evolution toward Integration. *Ann. Arid Zone*, 46 (3 -4), p.1-23. DOI: https://hdl.handle.net/10568/2459.

IIYAMA, M., MAITIMA, J., & KARIUKI, P. (2007). Crop-Livestock Diversification Patterns in Relation to Income and Manure Use: A Case Study from a Rift Valley Community, Kenya. *Afr. J. Agr. Res*, 2(3), p. 058-066.

ILO. INTERNATIONAL LABOR ORGANIZATION. (2014). Decent Work Country Program 2014-15, Ethiopia.

KASSIE, G. W., KIM, S., & FELLIZAR, F. P. (2017). Determinant Factors of Livelihood Diversification: Evidence from Ethiopia. *Cogent Social Sci*, 3: 1369490. DOI: 10.1080/23311886.2017.1369490

KEBEDE, T., HAJI, J., BELAINEH LEGESSE, B. & MAMMO, G. (2016). Econometric Analysis of Rural Households' Resilience to Food Insecurity in West Shoa, Ethiopia. *J. Food Secur*, 4(3), p. 58-67. DOI: 10.12691/jfs-4-3-2.

Keho, Y. (2012). The Basics of Linear Principal Components Analysis. In Principal Component Analysis. DOI: 10.5772/38577.

KURIA, A., LAMOND, G., PAGELLA, T., GEBREKIRSTOS, A., HADGU, K., & SINCLAIR, F. (2014). Local knowledge of farmers on opportunities and constraints to sustainable intensification of crop-livestock- trees mixed systems in LemoWoreda, Southern Nations Nationalities and People Region (SNNPR), Ethiopian highlands. A field study report.

https://cgspace.cgiar.org/bitstream/handle/10568/41669/Lemo_ARmay.pdf?sequence=1&isAllowed=y

LEBEDA, P., CHAMBERS, Z., DESTRÉE, A., DOLEŽAL, J., LUKÁŠ, I., MARČÍK, F. MARITZ, CH. & MILEROVÁ–PRÁŠKOVÁ, D. (2010). Ethiopia's Food Insecurity: Europe's Role within The Broader Context of Food Flows, Climate Change and Land Grabs. Glopolis, Prague.

LESSCHEN, J. P., & VERBURG, P. H. (2005). Statistical methods for analysing the spatial dimension of changes in land use and farming systems. LUCC Report Series 7 Land-Use and Land-Cover Change (LUCC) Project. IV International Human Dimensions Programme on Global Environmental Change (IHDP) V. International Geosphere-Biosphere Programme (IGBP)

LIEW, H. (2017). Health and well-being of middle age Indonesians: An application of seemingly unrelated regression (SUR) models. *Health Policy and Technology*, 6, p. 322-327. DOI: https://doi.org/10.1016/j.hlpt.2017.07.002

LIN, B. B. (2011). Resilience in Agriculture through Crop Diversification: Adaptive Management for Environmental Change. *Bioscience*, 61(3), p. 183-193. DOI: https://doi.org/10.1525/bio.2011.61.3.4

LINIGER, H., MEKDASCHI, S. R., HAUERT, C., & GURTNER, M. (2011). Guidelines and Best Practices for Sub-Saharan Africa: Field Application, FAO.

MAGURRAN, A. E. (2004). *Measuring Biological Diversity*. Blackwell Science Ltd.

MANYONG, V. M., OKIKEB, I., & WILLIAMS, T. O. (2006). Effective Dimensionality and Factors Affecting Crop-Livestock Integration in West African Savan NRC: A Combination of Principal Component Analysis and Tobit Approaches. *Agricultural Economics*, 35, p. 145-155. DOI: https://doi.org/10.1111/j.1574-0862.2006.00148.x

MARTIN, G., MORAINE, M., RYSCHAWY, J., MAGNE, M-A., ASAI, M., SARTHOU, J. P., DURU, M., & THEROND, O. (2016). Crop–livestock integration beyond the farm level: A review. Agronomy for Sustainable Development, Springer Verlag/EDP Sciences/INRA, 36 (3), pp. 53. DOI: 10.1007/s13593-016-0390-x

MATSANE, S. H., & OYEKALE, A. S. (2014). Factors Affecting Marketing of Vegetables among Small-scale Farmers in Mahikeng Local Municipality, North West Province, South Africa. *Mediterranean Journal of Social Sciences*, 5(20), p. 390-397. DOI: DOI: 10.5901/mjss.2014.v5n20p390

MCINTIRE, J., BOURZAT, D., & PINGALI, P. (1992). *Crop-Livestock Interaction in Sub-Saharan Africa*. Washington DC. World Bank.

MEKURIA, W., MEKONNEN, K., THORNE, P., MELKAMU BEZABIH, M., TAMENE, L. & ABERA, W. (2018). Competition for land resources: Driving forces and consequences in crop-livestock production systems of the Ethiopian highlands. *Ecological process*, 7(30), p. 1-15. https://doi.org/10.1186/s13717-018-0143-7

MEKURIA, W., NEGATU, W., & MEKONNEN, K. (2017). Adoption of Improved Dairy Cows and Implications for Household Food Security: Evidence in Central Highland of Ethiopia. *Global Journal of Science Frontier Research: D Agriculture and Veterinary*, 17(3), p. 29-37.

MENGESHA, M., & TSEGA, W. (2012). Indigenous Sheep Production in Ethiopia: A Review. *Iranian Journal of Applied Animal Science*, 2(4), p. 311-318. http://ijas.iaurasht.ac.ir/article_514280.html

MESFIN, W., FUFA, B., & HAJI, J. (2011). Pattern, trend and determinants of crop diversification: Empirical evidence from smallholders in Eastern Ethiopia. *J. of Econ. and Sustainable Devt.* 2(8), p. 78-89.

MORAINE, M., DURU, M., NICHOLAS, P., LETERME, P., & THEROND, O. (2014). Farming System Design for Innovative Crop-livestock Integration in Europe. *Animal*, 8(8), p. 1204-1217. DOI: https://doi.org/10.1017/S1751731114001189

NIGUSSIE, Z., & ALEMAYEHU, G. (2013). Levels of Household Food Insecurity in Rural Areas of Guraghe Zone, Southern Ethiopia. *J. Agr. Res*, 2 (1), p. 008-014.

NKONYA, E., GERBER, N., BAUMGARTNER, P., von BRAUN, J., De PINTO, A., GRAW, V., KATO, E., KLOOS, J., & WALTER, T. (2011). The Economics of Desertification, Land Degradation, and Drought: Toward an Integrated Assessment. ZEF Discussion Paper on Development Policy No. 150, Centre for Development Research, Bonn. Pp. 184. DOI: http://dx.doi.org/10.2139/ssrn.1890668

OCHIENG, J., OWUOR, G., & BEBE, B. O. (2012). Determinants of Adoption of Management Interventions in Indigenous Chicken Production in Kenya. *AfJARE*, 7(1), p. 39-50. DOI: 10.22004/ag.econ.156977

OJO, M. A., OJO, A. O., ODINE, A. I., & OGAJI, A. (2014). Determinants of Crop Diversification among Small-scale Food Crop Farmers in North Central Nigeria. *PAT Dec*, 10(2), p. 1-11.

REHIMA, M., BELAY, K., DAWIT, A., & RASHID, S. (2013). Factors Affecting Farmers' Crop Diversification: Evidence from SNNPR, Ethiopia. *Int. J. Agri. Sci*, 3(6), p. 558-565.

RUDEL, T. K., KWON, O., PAUL, B. K., BOVAL, M., RAO, I. M., BURBANO, D., MCGRODDY, M.; LERNER, A.M., WHITE, D., CUCHILLO, M., LUNA, M., & PETERS, M. (2016). Do Smallholder, Mixed Crop-Livestock Livelihoods Encourage Sustainable Agricultural Practices? A Meta-Analysis. *Land*, 5 (6): 6; DOI: https://doi.org/10.3390/land5010006

SHAHBAZ, P., BOZ, I., UL HAQ, SH. & KHALID, U. B. (2017). Mixed Farming and Its Impact on Farm Income: A study in District Faisalabad, Punjab Pakistan. IJRDO- *Journal of Agriculture and Research*, 3(8), p. 16-25.

SHIDEED, K. H., & EL MOURID, M. (eds.) (2005). Adoption and Impact Assessment of Improved Technologies in Crop and Livestock Production Systems in the WANA Region. The Development of Integrated Crop/Livestock Production in Low Rainfall Areas of Mashreq and Maghreb Regions. ICARDA, Aleppo, Syria. Pp. 160.

SIBHATU, K. T., KRISHINA, V. V., & QAIM, M. (2015). Production Diversity and Dietary Diversity in Smallholder Farm Households. Proceedings of the National Academy of Sciences (PNRC), 112(34), p.

10657–10662. DOI: www.pnas.org/cgi/doi/10.1073/pnas.1510982112

SISAY, Y., DEGSEW, M., & MEKURIA, W. (2018).The Status of Household Food Insecurity: The Case of West Belesa, North Gondar, Amhara Region, Ethiopia. *International Journal of Scientific Research and Management (IJSRM)*, 6(6), p. 158-166. DOI: https://doi.org/10.18535/ijsrm/v6i6.ah02

TADESSE, S. A., & TAFERE, S. M. (2017). Local people's knowledge on the adverse impacts and their attitudes towards growing *Eucalyptus* woodlot in Gudo Beret Kebele, Basona Worena district, Ethiopia. *Ecol Process* 6, 37 p. 3-13. DOI: https://doi.org/10.1186/s13717-017-0105-5

TODARO, M. P., & SMITH, S. C. (2012). Population Growth and Economic Development: Causes, Consequences, and Controversies. Economic development. Eleventh edition. Boston: Pearson Addison Wesley.

UNDP. United Nations Development Program. (2018). Ethiopia: National Human Development Report 2018. Industrialization with a Human Face. Addis Ababa, Ethiopia.

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REGULAR ARTICLE

UNDERSTANDING THE LINKAGE BETWEEN SOCIAL CAPITAL AND MAIZE AVAILABILITY EQUIVALENT AMONG SMALLHOLDER MAIZE-LEGUME FARMERS IN KENYA

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ABSTRACT

Feeding everyone in sub-Saharan African countries remains a challenge because of the high population growth rate, climate change effects and declining soil fertility, particularly affecting maize and legumes availability. In Kenya, maize and legumes are important staple crops and a recipe in most household dinner tables. However, smallholder farmers are still faced with low maize and legumes security. Understanding the factors that influence a given household to produce above or below the household annual requirements, is crucial and largely ignored in the literature. Therefore, this study was carried out to understand the factors influencing maize availability equivalent among smallholder maize-legume farmers in selected counties in Kenya. Panel data were collected from 613 randomly sampled households from five counties. A maize availability equivalent was then calculated and grouped into three categories, which included those households that produced maize equivalent below the average (deficient), along average (sufficient) and those above average (surplus). An ordered logistic regression model was then fitted to estimate the effect of social capital, socioeconomic and institutional factors on maize availability equivalent. The econometric results showed that only the network density as a measure of social capital positively and significantly influenced maize availability equivalent in the household. Other factors like gender, education, age, income of the household head and average plot distance to nearest market were significant too. Policy recommendations must address gendered production, development of farmer education, participation on social institutions, creation of greater and stronger network density, as well as informing the correct age that will improve the maize equivalent in the households.

Keywords: Maize availability equivalent; ordered logistic model; social capital
JEL: C01, C13, C31, Q12

INTRODUCTION

The smallholder maize-legume farmers contribute a bigger percentage of aggregate cereal production in Kenya. Maize and legume form a major component of many dinner tables. Their availability, accessibility, and stability are vital in many households since their absence implies food insecurity **(Yeyo *et al.*, 2014)**. Maize and legumes are major staple crops in Kenya. This is because of the favourable ecological conditions. In the recent past, there have been growing concerns about the many households going hungry in the country. This can be attributed to many factors among them declining soil fertility, climate change effects and rapid population rise. Maize availability equivalent can be achieved through own production, by buying or through donations in kind. Accessibility is achieved through the household purchasing power while utilization is dependent on household decision to purchase, prepare and consume **(Andersen and Watson, 2011)**. The amount of available cereal in the household for use is dependent on factors such as access to essential production resources, household characteristics and land cultivated **(Matshe, 2009; Abdu-Raheem and Worth, 2011; Yahaya *et al.*, 2018).**

Matshe (2009) noted that food security is predominantly determined by external factors to the household and household characteristics. Related latter are factors such as resource access which include soil quality, household labour per hectare cultivated, the income of the household, income diversification, land area cultivated and health status of household members. External factors are prices of farm inputs and outputs, availability and quality of health services and the existence of formal and informal networks **(Abudul-Raheem and Worth, 2011).** Different studies have used different methods to measure food security. For instance, a study by **Gowele (2011)** on gender differences and food security status, found out that geographical location of a household, education levels, assets owned by a household, production methods employed, market accessibility, income and reliance on social support and grants explains significantly food security in terms of accessing food.

Social capital also plays a role in increased production **(Kuku *et al.*, 2013).** This can be in the form of eased adoption or the ability to obtain help from friends and

relatives when in need. Who the household knows and can contact to get help from in times of need, is important in acquiring food **(Lin, 1999; Uphoff and Wijayaratna, 2000)**. This is because no single household lives in a single autonomous unit but there exists interdependence. The mutual co-existence between the households calls for care for each other. The group institutions where households are members increases the network of friends for each household and learning from each other. In the process, they can interact and even be aware of the places where they can get information about fair prices of the cereals to buy. Who the household trusts enhance transactions and willingness to share information. One can be able to take a loan and buy food if from where the loan is offered, or food given on credit trust the member of the household.

Social capital has been promoted by literature to improve household food security and production in general. Moreover, the existing agricultural economics literature has focused primarily on the role of social capital and other socio-economic factors on the adoption of different crop and livestock technologies whilst their direct linkage to maize availability equivalent has been largely ignored. This paper aimed to address these gaps in the literature. The objective of our study was to understand the influence of social capital, socio-economic and other institutional factors on ensuring maize availability equivalent among smallholder maize-legume farmers in selected counties in Kenya. Understanding the linkage between social capital and maize availability equivalent will remain a starting point for developing national maize and food security strategies for improving rural livelihoods. Several studies have applied several econometric models such as conditional fixed effects logit, ordinary least squares regression, tobit, multinomial logistic models, among others in estimating the effect of social capital, socio-economic and other institutional factors on food and nutritional security **(Uphoff and Wijayaratna, 2000; Loison and Bignebat, 2017)**. In this paper, an ordered logistic regression model was used to estimate this relationship.

DATA AND METHODS

Study Area

Adoption Pathways data was used in this study. The counties covered included Siaya and Bungoma in the Western region and Embu, Meru and Tharaka Nithi counties in the Eastern region. Adoption Pathways data was used in this study. The counties covered included Siaya and Bungoma in the Western region and Embu, Meru and Tharaka Nithi counties in the Eastern region. The conditions in these five counties provide a suitable climatic condition that is suitable for maize and legume production, and this remains the reason why they were chosen as study areas. Despite ample rainfall and maize-legume production potential of these counties, they still record high levels of their population living below the poverty line as well as experiencing food insecurity problems.

Sampling and Data Collection

A multi-stage sampling technique was used to choose lower levels of sampling clusters; divisions, locations, sub-locations, and villages. In 2013, a total of 535 households were sampled out of the possible 613 in the baseline survey in 2011. This represented an attrition rate of 13%. In 2015, 495 households were surveyed, suggesting an attrition rate of 19%. The attrition rate was attributed to among other factors; households 'migration like rural-urban migration, deceased respondents or respondent not available for interview. However, 60 observations were excluded from the analysis because of missing data as well as some being outliers. Table 1 shows the sample size across the panel with the respective attrition rates. A structured questionnaire was designed and administered to the smallholder farmers to obtain data.

Econometric Model Specification

The household food requirements depend on the household size expressed as adult equivalent, using the adult equivalent table by the World Health Organization (WHO). The household food requirement was then estimated and compared with the amount of maize available in the household. The total amount of maize per household was calculated from own production, donations, what they bought and maize equivalent from the beans they had. This was then ordered as deficient for those having less maize than what the household requires, average for those who had just what they needed in the household, and lastly surplus for those who had more maize than what they required.

The maize availability indicator was specified as a measure of the cereal, converted in maize availability equivalent. From intuition and theory, the amount of food (maize availability equivalent) consumed by an individual depends on factors such as age, sex, occupation subject to availability of food **(McCrory *et al.*, 2000)**. Using the adult equivalent indicator, the average household cereal requirement was estimated. The WHO and FAO recommend dairy amount of maize cereal of about 400 grams per person per day, which approximates 140 to 146 kilograms per person per year (2100 kilocalories per person per day) **(FAO 1996)**.

Table 1: Sampling and sample size

County	Baseline 2011	AP Midline	Attrition (%)	End line (2015)	Attrition (%)
Bungoma	150	137	9	120	20
Embu	111	93	16	85	23
Tharaka-Nithi	101	81	20	81	20
Meru	102	81	21	67	34
Siaya	149	143	4	142	5
Total	613	535	13	495	19

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$$z_{i1} = f(Hh_i)x365 \quad (1)$$

where z_{i1} represents the amount of maize equivalent that a household needs in one year for consumption purposes, and Hh_i is the size of the ith household expressed as an adult equivalent. This was for calculating the amount of maize that a household requires.

An ordered logistic model was used to find out the factors associated with the likelihood of a household having adequate available maize cereal all the time, sometimes and not having adequate available cereal all the time. The threshold for adequacy was calculated from the average of individual cereal requirements categorized as follows **(Owino *et al.*, 2014)**.

1 - Deficient. This category includes those households having inadequate amount of cereal all the times of the year

2 - Sufficient/Average. This category includes those households having an adequate amount of cereal that only meet their demand all time of the year, without deficit or surplus.

3 - Surplus. This category includes those households having excess amount of cereal that would meet their demand all the time of the year, and still remains with a surplus.

If y is an ordered response, taking values 1,2,3 and y^* is the latent value of y. Following **Wooldridge (2002),** the ordered logistic model for Y (conditional on explanatory variables X_i) can be derived from a latent variable model as follows then (Eq. 2);

$$y_{it}^* = x_{it}\beta_i + \varepsilon_{it} \quad (2)$$

The j cut off point will be given as $\alpha_1 < \alpha_2 < \alpha_3$ such that;

$$y_{it} = \begin{cases} 1\ if, y_{it}^* \le \alpha_1 \\ 2\ if,\ \alpha_1 \le y_{it}^* \le \alpha_2 \\ 3\ if, y_{it}^* \ge \alpha_2 \end{cases} \quad (3)$$

The vector of independent parameter estimates is provided in the coefficient vector β (**Greene, 2008; Wooldridge, 2002),** consisting of social capita, socio-economic and other institutional factors (Tables 1 and 2). The ordered logit model adjusts better to a probability curve by using a normal distribution function to estimate the probability of falling in a certain ranking or ordered category **(Greene, 2008).** This model was also used because the dependent variable was ordinal variable (Deficient, Average/sufficient, and Surplus) given a number of independent variables. It also results in robust and efficient estimates. The regression coefficients of the ordered logistic models can be interpreted using the marginal change in the explanatory variable (social capital, socio-economic and other institutional variables) on the expected value of the dependent variable (**Greene, 2008; Wooldridge, 2002**). A positive correlation between variables is interpreted as a complementary relationship, whereas a negative correlation between variables is interpreted as being a substitute.

RESULTS AND DISCUSSION

Descriptive Statistics of the dependent and independent variables

Food scarcity is a major problem faced by farmers from time to time. The economic measurement of the scarcity is a challenge because of the differences in calories among food groups. This study measured the household food scarcity using maize availability equivalent. That is, the food consumption needed in a year was estimated per the adult equivalents for each household. Maize is the staple food in Kenya hence the most valuable food commodity which is produced and consumed by many smallholder farmers. From past studies, the maize required for consumption by each adult equivalent in a household is 400 grams per day. The total food production by each household was converted to maize availability equivalent. Therefore, the difference between maize needed for consumption and what is produced by the household represents maize availability equivalent to scarcity or surplus. Table 2 shows the percentage of households with respective levels of maize availability equivalent.

Table 2: Maize equivalent balance by year used as dependent variable

	2011	2013	2015
Deficit	34.06	33.47	30.63
Sufficient	14.74	19.43	15.14
Surplus	51.20	47.10	54.23

Source: Authors' classification done using Adoption Pathways Project Data, 2011, 2013 and 2015

About half the households had a maize equivalent surplus in the year 2011. Further, about 14.74% were at risk of food scarcity being with almost just enough food for the family. However, about 34.06% of the households in 2011 had high maize equivalent deficits. The results also revealed that in 2013, there was low food production in the country with the percentage of households experiencing maize equivalent surplus reduced to about 47.10%. The low production levels of maize in 2013 could be explained by extended electioneering period which had potentials of clashes. This led to about 33.47% and 19.43% of the respondents be at risk of falling into deficit and sufficient class, respectively. Maize availability equivalent production improved in 2015 with about 54.23% of the households being maize secure with a maize equivalent surplus. This showed that in 2015, there were efforts to increase household food production. This was shown by only 30.63% of the respondents having a deficit in their households and about 15% having exactly what they needed in their household.

Descriptive statistics on the variables used in our analysis are presented in Table 3. The results showed that on average, the age of the household head was 53 years old, with a family size of 6 members. The household size also varied from as low as one member to 19 members Majority of the respondents had primary education followed by secondary (37%) and tertiary (8%) education. Only 7% of the sampled respondent were illiterate. It is worth noting that some households did not attend school at all. The average farm size owned per household was 1.2 hectares with a range maximum acreage of 4.0 hectares. A minimum value of farm size owned of 0.0 hectare implies that some of the households only had rented in plots for cultivation. It is worth noting that some households do not own land, but use rented in plot. Most of the households were headed by male (63.9%). The average walking distance to the nearest market centre was found to be 38 walking minutes. Credit was important in accessing commercial inputs such as hybrid seeds and fertilizer. Out of the sampled population, 56.2% demanded and received credit to buy inputs such as seeds and fertilizer. The remaining 43.8% who did not want credit for inputs either were not cash-constrained or were using local or recycled seeds, manure as a substitute or planted without fertilizer or manure. Over 63% of the respondents received extension or agricultural information or training. The average number of people (relatives, non-relatives, and friends including people in leadership position) that a household can rely on for help in times of need was 36 people.

Table 3: Independent Variables Description and Measurement

Variable	Description	Measurement	Obs	Mean/ Percent	Std. dev	Min	Max
Agehh	Age of the household head (years)	Continuous	1583	53.0	15.3	18.0	90.0
Educhh_level	Education level of the head	Categorical	1583	None	117	7.3	
				Primary	756	47.8	
				Secondary	587	37.1	
				Tertiary	123	7.8	
Hhsiz	Household size (members)	Continuous	1583	6.0	2.3	1.0	19.0
Farmsiz	Farm size owned by household (hectares)	Continuous	1583	1.2	1.8	0.0	4.0
Network_density	The number of people (relatives, non-relatives, and friends including people in leadership position) that a household can rely on for help in times of need	Continuous	1583	36.0	12.0	0.0	103.0
Prtcpn_score	The score of participation in groups where a household is a member	Continuous	1583	0.6	0.3	0.0	2.4
Cognscore	The score of cognitive-based on who the household trust	Continuous	1583	7.8	2.9	1.0	14.0
avrg_plot_dist	Average plot distance to nearest market centre (Walking minutes)	Continuous	1583	38.0	13.0	5.0	180.0
Mbrshp_score	The score of membership in groups	Continuous	1583	1.5	0.8	0.0	6.0
lTOTAL_sav	The logarithm of the amount of savings a household made		1583	7.5	2.8	0.0	13.8
lTOTAL_incom	The logarithm of the total amount of money income a household got		1583	8.4	4.6	0.0	14.4
nd_crdt_seed	If the household demanded and received credit to buy inputs seeds/fertilizer	Dummy	1583	No	694	43.8	
				Yes	889	56.2	
Genderhh	Gender of household head	Binary	1583	Male	960	60.6	
				Female	623	39.4	
got_ext	Household received extension or information or training	Dummy	1583	No	571	36.1	
				Yes	1012	63.9	

Econometric results of factors influencing maize availability equivalent among smallholder maize-legume farmers

The maize availability equivalent was ordered into three categories that are, households with deficits, those that are at the average (sufficient) and those with surpluses. An ordered logistic regression (xtologit in Stata 14) was used to determine socioeconomic, institutional and social network factors affecting household maize availability equivalent. A dynamic model was used to incorporate the time element of food production in households. Before the interpretation of the study results, the model was subjected to various tests to prove its fitness and robustness. The test revealed that the ordered logit model had a good fit to the data (p = 0.000). The model results also fail to reject the null hypothesis that the model without explanatory variables is as good as the model with the explanatory variables. Since the ordered logit model fitted the data well and did not violate the parallel line assumption, and multicollinearity test, its application in this study was justified. The results of the dynamic ordered logistic regression were presented in Table 4

Table 3: An ordered logistic regression results of factors influencing maize availability equivalent

Variable	Coefficient	Std. Err.	P>z
network_density	0.021	0.020*	0.075
prtcpn_score	-0.037	0.176	0.738
Cognscore	-0.009	0.123	0.847
mbrshp_score	0.026	0.087	0.768
Age	0.011	0.003***	0.021
Genderhh	-0.254	0.179*	0.096
Hhsiz	-0.004	0.023	0.869
Educhh_level	0.028	0.053*	0.095
Farmsiz	0.037	0.142	0.324
lTOTAL_sav	0.010	0.106	0.498
slTOTAL_incom	0.055	0.035**	0.037
got_ext	-0.075	0.228	0.683
nd_crdt_seed	-0.031	0.025	0.777
y2013	-0.042	0.334	0.709
y2015	0.097	0.148	0.458
avrg_plot_dist	0.003	0.011*	0.081
/cut1	-0.972	0.295**	0.015
/cut2	-0.192	0.388	0.633

Note: ***, **, and * are significant at 1%, 5% and 10% levels respectively; Number of observations = 1583, Wald Chi-square (17) = 96.48; Prob > Chi-square = 0.000; Pseudo R^2 = 0.260; Log pseudo likelihood = −301.9

The results of the ordered logit model indicated that number of people a household rely in time of need (network_density), age of the household head (Agehh), gender of the household head (Genderhh), education level of household head (Educhh_level), income received by the household (lTOTAL_Income) and average distance of the household plot from the nearest market centre (avrg_plot_dist) have a statistically significant influence on maize availability equivalent as shown in Table 4. Network density as one of the measures of social capital was found to be a positive and significant predictors of maize availability equivalent at 10% level. An increase in the number of people (relatives, non-relatives, and friends including people in leadership position) that a household can rely on for help in times of need raises the probability of being food secure or in surplus class. Households with greater network density tend to be food secure compare to those with smaller network density. This is attributable to the fact that the greater network density represents many helping hands that can come to aid in the form food production or food donation. Household also benefits from access to agricultural information that also come along with greater network density.

The results also revealed that the higher the age of the household head, the more maize availability equivalent to the household, and it was statistically significant (p<0.021). This implies that older household heads can secure food for their families compared to the young ones. This is attributable to the fact that the new families are faced with many challenges in terms of farming such as inadequacy of farming land and financial resources hence they find it difficult to stock enough. The older households have accrued experiences in farming and are well prepared for food shortages. Therefore, it is expected that the old families are more likely to have food surpluses as compared to the upcoming families. These results were consistent with the findings of **Abdullah (2017)** who alluded that older members of the society are aware of production techniques and patterns of production to harvest more output, hence have a surplus. The old too could have developed links with other members of their families and friends who can give food donations in times of need. However, this was contrary to the findings of **Zakari *et al.*, 2014)** who found out that the age of the household head negatively influenced food security in Southern Niger. According to **Zakari *et al.* (2014)**, young people are energetic and have gathered knowledge of the production techniques, which places them above the older people.

The gender of the household head was also revealed to be negatively and statistically significant in influencing the level of maize availability equivalent in the household at a 10% level. That is, male-headed households are less food secure than female-headed households. This may be because most subsistence farming in Kenya is done by women. Moreover, women tend to save and plan their production and finances more efficiently than men. Further, women plan their farming activities more effectively such that the available land is maximally and efficiently used. On the other hand, males tend not to be rational in subsistence farming decision making since they are guided by financial motives while women are guided by the need to satisfy their families. That is, women make farming decisions based on the immediate and future needs of the family food requirements **(Ogunlela and Mukhtar, 2009)**. The results were contrary to the findings of **Zakari *et al.* (2014)** who found out that male-headed households in Niger were more food secure than female-headed households.

Maize availability equivalent was also positively and significantly influenced by the level of education of household head at a 10% level. This suggests that the higher level of education increases the likelihood of having food surplus. In other words, an increase in formal education of household head raises maize availability

equivalent. Household's level of education is a very important aspect while making objective judgements regarding agricultural production. Educated farmers are well informed and are able to search, consolidate and interpret agricultural knowledge as well as extension information related to practicability and gains associated with adoption of agricultural innovations thereby increasing their production levels to food surplus. The results are inconsistent with the findings by **Abdullah *et al.* (2017)** who found that education positively influenced household food security.

The income received by the household positively and significantly influences the amount of maize availability equivalent of a household at a 5% level. That is, when the aggregate income of the household increases, the amount of maize availability equivalent available in the household increases too. This implies that families with higher income have more financial resources to invest in subsistence farming hence producing more food. This increases their probability of operating on a surplus all the time. The findings are consistent with the research results of **(Babatunde *et al.*, 2007; Mannaf and Uddin, 2012; Zakari *et al.*, 2014).**

The amount of maize availability equivalent available in the household was also significantly and positively influenced by the average distance of the household plot from the nearest market centre at 10% level. The longer the average distance from the farming plot to nearest market, the more likely for the household to be food secure or have food surplus. This is because longer distance to the nearest market centre discourages commercialization or marketing of produce due to high transportation costs being incurred. Therefore, farmers living far away from market centre opt not to sell and stock more produce due to high transaction cost compared to those living near market centres. Farmers staying near output market tend to sell most of their produce due to lower transaction cost thereby rendering them food deficient at sometimes of the year. **Ebata *et al.*, (2015)** also found that the longer the distance and travelling time to the nearest marketing centre, the lesser the farm gate prices as well as farm margins thus discourages produce marketing. This will encourage households to stock produce for household consumption rather than selling.

CONCLUSION

Understanding the factors affecting household maize availability equivalent is crucial for formulating sustainable smallholder agricultural policies. This is relevant given the high level of crop failure and maize deficiency among smallholder households. This study, therefore, employed econometric models to explore the determinants of maize availability equivalent among smallholder maize-legume farmers in selected counties in Kenya. The study concludes that almost a third of the respondents across the panel was experiencing maize deficiency. On average, 17% had just enough and only about half of the respondents had a surplus. There was a slight rise in the household having a surplus in 2015 compared to 2011 and 2013. The year 2013 recorded the lowest surplus available maize across the panel. For small-scale maize legume-system, the results revealed that network density (number of people a household knows and can rely on for help in terms of need) as a measure of social capital positively and significantly influenced maize availability equivalent or food surplus. However, other social capital variables such as score of participation in groups where a household is a member, score of cognitive-based on who the household trust, and the score of membership in groups are not significant factors contributing to households having a surplus or sufficient or deficit in maize equivalent. This implies that membership and participation level of household members in group institutions and, who the household trusts do not significantly influence the amount of maize available in the household. Again, most of the farming households in groups still not understand the role of social capital when it comes to food production, availability and sharing. In turn, the benefits of membership and participation level of household members in group institutions may be reflected in other social activities other than food production, sharing and availability. Importantly, the benefits of household trust may also be reflected on social and institutional benefits such as other information sharing other than food production and storage. Other household characteristics and unobservable influenced the amount of maize available, expressed as maize availability equivalent. However, the age of household head, level of education of household head, income received by the household, and average plot distance to nearest market positively and significantly influence the amount of maize equivalent to the household. Therefore, greater network density, aging, more education, higher levels of income received by households, and longer distances to the nearest markets increases the likely of becoming food secure or having food surpluses. On the other hand, gender of the household head had a negative and significant influence on the amount of maize equivalent to the household. Being in male headed households lowers participation in farming thus resulting to lower food surplus. Policy recommendations must address gendered production and focus on informing the correct age that will improve the maize availability in the household. Institutional and infrastructural arrangements in subsistence production systems must also be tailor-made to take into account the low income and literacy levels among smallholder farmers. Polices should also focus on literacy level development and agricultural training among farmers as a strategy for improving agricultural production. Participation and regulation policies should also be implemented to upscale and strengthen the role of network density as well as food based incentives resulting from social capital and participation in social arrangements since they act as a potential for ensuring food security or surplus.

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REFERENCES

ABDU-RAHEEM, K. A., & WORTH, S. H. (2011). Household Food Security in South Africa: Evaluating Extension'S Paradigms Relative to the Current Food Security and Development Goals. *South Africa Journal of Agriculture and Extension*, *39*(2): 91–103.

ABDULLA, A. M. (2015). Determinants of household food security and coping strategies: The case of Blue Hora district, Borana Zone, Oromiya, Ethiopia. *European Journal of Food Science and Technology*, *3*(3): 30–44.

ANDERSEN, P., &WATSON, D. I. (2011). *Food Policy for Developing Countries: The Role of Government in Global, National, and Local Food Systems*. Cornell University Press. 392 pp.

BABATUNDE, R., OMOTESHO, O. A., & SHOLOTAN, O. S. (2007). Factors influencing the food security status of rural farming households in North Central Nigeria. *Medwell Journals of Agriculture*, *2*(3): 351–357. URL: https://medwelljournals.com/abstract/?doi=aj.2007.351.357

FAO. (1996). *An Introduction to the Basic Concepts of Food Security Information for Action*. *Published by the EC - FAO Food Security Programme*. URL: www.foodsec.org/docs/concepts_guide.pdf

GREENE, W. H. (2008). *Econometric analysis Seventh Edition*. USA: Prentice-Hall International Inc

GOWELE, V. F. (2011). *Gender analysis of the food security status, assets, shocks and coping strategies among EFSP beneficiaries in the KwaZulu Natal Province, South Africa*. Doctoral Dissertation.

KUKU, A. A., OMONONA, B. T, OLUWATAYO, I. B, & OGUNLEYE, O. O. (2013). Social Capital and Welfare among Farming Households in Ekiti State, Nigeria. *Journal of Biology, Agriculture and Healthcare*, 2013, Vol.3, No.5, pp.115-130

LIN, N. (1999). Building a Network Theory of Social Capital. *Connections*, *22*(1): 28–51. URL: http://www.insna.org/PDF/Connections/v22/1999_I-1-4.pdf

LOISON, A., & BIGNEBAT, C. (2017). Patterns and Determinants of Household Income Diversification in Rural Senegal and Kenya. *Journal of Poverty Alleviation and International Development*, *8*: 93–126.

MANNAF, M., and UDDIN, T. (2012). Socioeconomic factors influencing the food security status of maize growing households in selected areas of Bogra district. *Bangladesh J. Agric. Econs*, *2*:177–187. DOI: 10.22004/ag.econ.196772

MATSHE, I. (2009). Boosting smallholder production for food security: Some approaches and evidence from studies in sub-Saharan Africa. *Agrekon*, *48*(4): 483–511.DOI: https://doi.org/10.1080/03031853.2009.9523837

MCCRORY, M., FUSS, P., & SALTZMAN, E. (2000). Dietary determinants of energy intake and weight regulation in healthy adults. *Journal of Nutrition*, *130*(2): 276S–279S. DOI: https://doi.org/10.1093/jn/130.2.276S

OGUNLELA, Y. I., & MUKHTAR, A. A. (2009). Gender Issues in Agriculture and Rural Development in Nigeria: The Role of Women. *Humanity and Social Sciences Journal*, *4*(1): 19–30. DOI: https://doi.org/10.4172/2157-7617.1000277

SAINT VILLE, A. S., HICKEY, G. M., LOCHER, U., & PHILLIP, L. E. (2016). Exploring the role of social capital in influencing knowledge flows and innovation in smallholder farming communities in the Caribbean. *Food Security*, *8*(3): 535–549. DOI: https://doi.org/10.1007/s12571-016-0581-y

UPHOFF, N., & WIJAYARATNA, C. M. (2000). Demonstrated Benefits From Social Capital: The Productivity of Farmer Organizations. *World Development*, *28*(11): 1875–1890. DOI: https://doi.org/10.1016/S0305-750X(00)00063-2

WOOLDRIDGE, J. M. (2002). *Econometric Analysis of Cross Section and Panel Data*. USA: Prentice-Hall International Inc.

YAHAYA, I., POKHAREL, K., ALIDU, A., & YAMOAH, F. (2018). Sustainable agricultural intensification practices and rural food security: The case of Northwestern Ghana. *British Food Journal, Vol. 120* No. 2, pp. 468-482. https://doi.org/10.1108/BFJ-01-2017-0021

YEYO, O. A., KIBOIJANA, L., WESONGA, R., & NABUGOOMU, F. (2014). Logit Models for Household Food Insecurity Classification. *American Journal of Theoretical and Applied Statistics*, *3*(2): 49-59. DOI: https://doi.org/10.11648/j.ajtas.20140302.14

ZAKARI, S., YING, L., & SONG, B. (2014). Factors influencing household food security in West Africa: The Case of Southern Niger. *Journal of Sustainability*, *6*: 1191–1202. DOI: https://doi.org/10.3390/su6031191

ZIERVOGEL, G., NYONG, A., OSMAN, B., CONDE, C., CORTES, S., & DOWNING, T. (2006). Climate variability and change: implications for household food security. *AIACC Working Paper No. 20*, *1*(20), 1–34. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.561.9400&rep=rep1&type=pdf