Impact of Agricultural Commercialization on Household Food Insecurity in Kenya

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Abstract

Agricultural production in Kenya has remained low with relative food insecurity affecting many citizens in most parts of the country because of the increase in population growth over the past two decades. This study, specifically, examined the impact of agricultural commercialization on household food insecurity in Kenya using Panel data from Kenya's 2020 Covid-19 Rapid Response Phone Survey. An endogenous switching regression was utilized to establish the impact of agricultural commercialization on household food security and at the same time account for endogeneity and self-selection problems. The endogenous switching regression (ESR) model also controlled for structural differences between the commercialized and the non-commercialized households in terms of food security outcome functions. Particularly, land size had a significant $(p < 0.01)$ *positive* $(\beta_{AC=1} = 0.3266)$ *impact on the food security of the commercialized households while it had a negative* $\beta_{AC=0} = -0.1805$ *but significant* $(p < 0.01)$ *impact on the food security of the non-commercialized households. Therefore, households with large land sizes are more likely to improve by a greater extent household food security compared to households with small land sizes when they participate more in the market. However, age* $(\beta_{AC=1} = 0.1364, \beta_{AC=0} = 0.0992)$ *,women empowerment* $(\beta_{AC=1} = 0.4356, \beta_{AC=0} = 0.1618)$ *and internet access* $(\beta_{AC=1} = 0.2351, \beta_{AC=0} = 0.1174)$ *recorded a significant* $(p < 0.01)$ *homogenous effect on the food security of the households among the commercialized and non-commercialized group of households. The results further suggest that both the observed and unobserved characteristics influence the decision to commercialize and food security outcome give the decision to commercialize. The results reveal that households participating in agricultural commercialization would experience improved food security through increased dietary diversity. The study recommends that there is a need to support agricultural commercialization to increase household food security. This could be achieved by empowering households through adequate online training and education on agricultural commercialization, improving infrastructures and institutions such as internet connectivity, credit and commercial institutions.*

Keywords: Household Food (in)Security, Agricultural Commercialization, Endogenous Switching Regression, Kenya, Panel Data

INTRODUCTION

Globally, governments are facing a significant problem with food insecurity, which has emerged as one of the most crucial issues on the current international political agenda. According to the World Bank Global Report on Food Crises, 140 million people in Africa are thought to be suffering from severe food insecurity, with at least one in five of them going to bed hungry (World Bank, 2022). In Kenya as well as other emerging nations, food insecurity continues to be a major development concern. Around 2.4 billion people worldwide are overweight, but 820 million people still go hungry (FAO, 2019).

The situation is most concerning in Africa, where since 2015; the frequency of undernourished people has shown a minor but continuous increase in practically all sub-regions (FAO, 2019). Despite the fact that there is enough food for everyone, over a billion people still struggle to get nutritious meals (FAO, 2020). In rural Sub-Saharan Africa (SSA) and South Asia, where a sizable portion of the population is extremely poor (52% of the rural population in SSA and 27% of the rural population in South Asia), significant progress has yet to be made despite significant reductions in poverty and hunger over the past ten years. In 2020, the Food and Agriculture Organization reported that one in four people in SSA was undernourished (FAO 2020).

Food insecurity has been a concern on a worldwide scale for several decades (Smith, 2005), given the number of people who experience starvation and other forms of malnutrition (FAO, 2021; WHO, 2021). Even though food insecurity is a problem that affects people all across the world, it appears to be at its worst in sub-Saharan Africa, which ranks the highest in the percentage of people who are malnourished (World Bank, 2020). According to the most recent estimates, sub-Saharan Africa is in second place, behind Southern Asia, in terms of the number of people in the globe who are undernourished (FAO, 2019). According to Wossen et al. (2017), the issue of food insecurity in Africa is linked to poverty, which decreases individuals' economic access to food that is both safe and nutritious. In addition, when compared with other regions, sub-Saharan Africa is the one that sees the greatest amount of volatility in the cost of staple foods. According to Minot (2010), the current state of hunger in sub-Saharan Africa is expected to worsen over the course of the next two decades if appropriate actions are not taken to address the issue.

Improving food and nutrition security continues to be a crucial part of national and international policy frameworks for eradicating poverty in developing economies (Bizikova et al., 2020; Issahaku et al., 2020). For instance, the United Nations' top priorities are to end extreme poverty by ensuring that everyone has unrestricted access to a sustainable food supply for their health and well-being. This is reflected in its sustainable development targets (UN, 2015). For the underprivileged and destitute in society, food security refers to the availability, accessibility, usefulness, and stability of food (Abdullah et al., 2015; Bahta et al., 2018). The prevalence of hunger in SSA decreased by almost 30% between 1990 and 2015, yet there are still significant disparities between SSA sub-regions and individual nations. According to Beegle et al. (2016), 82% of the poor in SSA still reside in rural regions and depend heavily on agriculture for their livelihoods. A median African rural home earns around three-quarters of its income from agriculture, and approximately 92% of rural households in SSA are engaged in farming to some extent (Davis et al. 2017).

Household dietary diversity was employed in this study to measure food security. HDD measures the number of different food groups consumed over a given reference period (FAO, 2013). HDD reflects the economic ability of the household to access a variety of foods (Swindle and Bilinsky, 2006; Leroy et al., 2015). HDD is strongly associated with other measures of food security (FAO, IFAD and WFP, 2013; Hoddinott, 2012) and it is an efficient measure that has been widely utilized to measure food security (FAO, 2015a; Headey and Ecker, 2013). The food groups selected to establish HDD were categorized into 12 food groups following Swindle and Bilinsky (2006). The identified food items used to compute HDD include; cereals, roots and tubers, vegetables, fruits, meat, eggs, fish and shellfish, legumes, seeds and nuts, milk and milk products, oils and fats, sugar, condiments, and beverages (FAO, 2013).

The majority of the food insecure people in the world are rural smallholder farmers, who inhabit the developing world. Sub-Saharan Africa (SSA) including Kenya, which comprises 23.8 % of the food insecure people, represents one of the food insecure regions (FAO, 2015b). Of this proportion, 80% live in rural areas, working as peasants, landless laborers,

and pastoralists, who suffer from a dearth of the most needed resources such as land (IFAD, 2011). Despite the fact that improved household incomes in low-income agrarian countries may be possible as a result of agricultural commercialization, worries about the availability of food are at the center of the argument over the impacts of agricultural commercialization (Goldstein et al., 2013). The new environment, which is characterized by rising population, urbanization, income, global interconnectedness, policy reforms, technology, food industry restructuring, and climate change, calls for the transformation of agriculture in order to improve agricultural production and, as a result, food security for smallholder households (Barrett, 2008; World Bank, 2008). Transformation of agriculture can be accomplished through the use of commercialization by reorienting production techniques away from a focus on consumption and toward an emphasis on the market (Brush and Turner, 1987; Pingali and Rosegrant, 1995; World Bank, 2008).

While Igberaese and Okojie (2010) investigated the causes of food insecurity in Nigeria, they concluded that it can be traced back to a number of different factors. These factors include excessive exports of food at the expense of Nigeria's domestic requirements, excessive party waste, and a lack of storage facilities that leads to post-harvest losses. They suggested that the revenue be redistributed, that money be invested in storage facilities, that the internal order be strengthened, that there be a high limitation placed on the export of food, and that there be a need to spur additional food production. Also. Babatunde (2009) conducted research in Nigeria to investigate the relationship between income and calorie consumption. He found that domestic food production had a positive and significant influence on calorie consumption at 1%. He suggested that measures should be taken to improve Nigeria's food production, income, and nutrition in order to lessen the country's level of food insecurity. According to Falcon and Naylor (2005), agriculture is an essential component of continuous economic growth, which is required to ensure that all individuals, particularly the poor, do not have to worry about their ability to obtain adequate nutrition. They say that a significant source of growth in most low-income nations has been agricultural development, with the exception of a number of countries that have an abundance of natural resources such as oil. These countries are the exception to the rule.

This study aimed at establishing the impact of agricultural commercialization in Kenya. This objective contributes to the theoretical and empirical literature on the relationship between agricultural commercialization, other covariates, and smallholder household food security in Kenya with a keen application of the non-separable farm household model and employing measures of food security; modified HDDS. This paper also adds knowledge to the literature on the effect of crop commercialization and livestock commercialization on household food security in Kenya. This work was carried out with the intention of contributing to the existing body of research by exploring panel data, this work also contributes to the existing body of research by discussing and resolving potential endogeneity issues that are relevant to estimating the causal relationship between agricultural commercialization and food security in Kenya. While the majority of the previous research is based on cross-sectional data (Ogutu et al., 2017; Radchenko and Corral, 2017; Von Braun and Kennedy, 1994; Wood et al., 2013), the current study exploits the panel component of our dataset, which enables one to estimate a fixed effects model that controls for potential time-invariant confounders. Results are derived from an Endogenous Switching Regression model that determines the impact of agricultural commercialization on food security in Kenya.

RESEARCH METHODOLOGY

This study relied heavily on the panel data from the household and individual survey questionnaire from the Kenya Covid-19 Rapid Response Phone Survey conducted by The World Bank in collaboration with the Kenya National Bureau of Statistics and Berkeley University. The aim of the exercise was to track the socioeconomic impacts of the Covid-19

pandemic and to provide timely and reliable data to inform the targeted response. The Kenya Covid-19 Rapid Response Phone Survey dataset contains information from the Covid-19 RRP Survey which is part of a five-bimonthly panel survey that targets Kenyan Nationals. The samples covered urban and rural areas and were designed to be representative of the population of Kenya using cell phones. The survey includes information on household background, travel patterns and interactions, service access, employment, food security, income loss, transfers, health, and COVID-19 knowledge for the sampled households.

Analytical Framework

Since agricultural commercialization is potentially endogenous, the problem of endogeneity results. Thus, the application of endogenous switching regression model (ESRM) is very appropriate since it accounts for both endogeneity and sample selection problems. The model also permits the interaction between agricultural commercialization choice, and the covariates in the food security model. The ESRM express such interlinkage between agricultural commercialization, and covariates of food security by determining two separate functions along with the selection equation; the first function for the commercialized households and the second function for the non-commercialized households.

The efficient technique to determine endogenous switching regression (ESR) model is employing the full information maximum likelihood (FIML) estimation (Lokshin and Sajaia, 2004). Lokshin and Sajaia (2004) have demonstrated other methods of estimating ESR such as the two stage least squares (2SLS) and the maximum likelihood estimation which can be used by fitting one regression equation at a time. These techniques are less efficient compared to the full information maximum likelihood (FIML) which depends heavily on joint normality of the error terms that makes the model estimator more efficient. They require very hard and complicated modifications in determining consistent standard errors. They also reveal impecunious accomplishment in scenarios of high multicollinearity between the covariates and the selection model (Maddala, 1983).

Thus, the first step of the two-step endogenous switching regression model (ESRM) entailed modelling household's binary choice to commercialize employing the probit model that is structurally expressed below;

$$C_{it} = \alpha_{it} X_{it} + \eta_{it} \quad (3.1)$$

Where; C_{it}= is a binary indicator for agricultural commercialization for household i in period t such that; 1=commercialized, 0=otherwise; α_{it}= is the vector of parameters to be estimated of household, farm, institutional and region-specific characteristics of household *i* in time *t;* X_{it} =are the vector of explanatory variables; η_{it} = is the error term.

The second step was the estimation of the two probit regressions explaining the two outcome variables of each group of households in the two regimes (commercialized and non-commercialized).

Therefore, the household food security and equations on the commercialization choice are expressed in an endogenous switching regression model as presented below;

Regime 1:

$$y_{1it} = \beta_1 X_{1it} + \varepsilon_{1it}: \quad if\ C_{it} = 1 \quad (3.2.a)$$

Regime 2:

$$y_{0it} = \beta_0 X_{0it} + \varepsilon_{0it}: \quad if\ C_{it} = 0 \quad (3.2.b)$$

Where: y_{1it} = The outcome indicator for commercialized household i at time t; y_{0it} = The outcome indicator for non-commercialized household i at time t; X_{1it} = The observed vectors of explanatory variables determining outcome variable for commercialized household i at time t; X_{0it} = The observed vectors of explanatory variables determining outcome variable for non-commercialized household i at time t ; β_1 and β_0 = are

the vectors of parameters to be determined; ε_{1it} and ε_{0it} = These are the error terms ($\varepsilon \sim N(0, \sigma^2_{\varepsilon_{it}})$

The existent anticipated food security probability outcomes for commercialized and non-commercialized households was determined as shown in equation (3.6a) and (3.6b) respectively. On the flip side, for the commercialized and non-commercialized households, the counterfactual predicted food security probability outcomes were computed as described in (equations 3.7a) and (3.7b) respectively.

Actual scenarios (observed from data sample):

$$Commercialized: E(y_{1it} \backslash C_{it} = 1;\ X_{1it}) = \beta_1 X_{1it} + y_{1\varepsilon}\lambda_{1it} \quad (3.6a)$$

$$Non-commercialized: E((\mathbf{y_{0it}} \backslash C_{it} = 0;\ X_{0it}) = \beta_0 X_{0it} + y_{0\varepsilon}\lambda_{0it} \quad (3.6b)$$

Conditional Counterfactual scenarios:

$$Commercialized\ if\ not\ commercialized: E(y_{1it} \backslash C_{it} = 0;\ X_{0it}) = \beta_1 X_{0it} + y_{1\varepsilon}\lambda_{0it} \quad (3.7a)$$

$$Non-commercialized\ if\ commercialized: E(y_{0it} \backslash C_{it} = 1;\ X_{0it}) = \beta_0 X_{1\,it} + y_{0\varepsilon}\lambda_{1it} \quad (3.7b)$$

The endogenous Switching Regression Model (ESRM) was used to compare the expected household food insecurity status of the households that commercialized (equation 3.6a) to the households that did not commercialize (equation 3.6b). The ESR model also helped to examine the expected household food security status in the counterfactual hypothetical cases where the households that commercialized did not commercialize (equation 3.7a) and where the non-commercialized households did commercialize (equation 3.7b). The above four scenarios of the actual cases and their counterfactuals are presented shown in Table 1 below.

Table 1: Conditional expectations, treatments effects and heterogeneity effects

Household Type	Household food security probability outcomes		
	Commercialized Characteristics	Non-commercialized Characteristics	Treatment Effects
Commercialized	(3.6a) $E(Y_{1it}/C_{1it})$	(3.7a) $E(Y_{0it}/C_{1it})$	(3.6a)- (3.7a)
Non-commercialized	(3.7b) $E(Y_{1it}/C_{0it})$	(3.6b) $E(Y_{0it}/C_{0it})$	(3.7b)- (3.6b)
Heterogeneity Effects	$LE_0 = (3.6a) - (3.7b)$	$LE_1 = (3.7a) - (3.6a)$	$(3.7a) - (3.6b)$

Source: Author's Compilation (2021)

RESULTS AND DISCUSSIONS

This section presents the descriptive statistics, interpretation and discussion of inferential results as provided in the tables shown.

Agricultural commercialization plays a key role in improving food security, especially among households. In this study, the proportion of commercialized households who consumed 0-3 HDDS was less than commercialized households who consumed 4-12 HDDS by about 0.3% while the average agricultural commercialization for both groups was 22.69%. The difference in the proportion was significant at a 10 % level. This implies that commercialization in agriculture improves household food variety and hence enhances food security (Seng, 2016). Both crop and livestock commercialization are paramount in

facilitating the households' range of food items in the market (Fischer and Qaim, 2012). Through commercialization, the ratio of market sales to total production increases, which leads to increased income. The increased income can be used for food purchases and other household items. Savings can also be made for future use. Thus, in the long run, enhances the food security of the household.

Descriptive Statistics

Table 2: Descriptive Statistics and Test of Equality of Means for HDDS (0-3) and HDDS (4-12)

Variable	HDDS (0-3) (N=4854)		HDDS (4-12) (N=7699		Total Sample (N=12344)		P-Value
	Mean	Std. Err	Mean	Std. Err	Mean	Std. Err	
AC	0.2010	0.0045	0.2308	0.0035	0.2202	0.0028	*
WEAI	0.6382	0.0056	0.6571	0.0045	0.6497	0.0035	***
Household size	4.2275	0.0151	4.2749	0.0121	4.2563	0.0095	**
Age	43.5632	.1667	43.4575	0.1348	43.4991	0.2146	
Gender	0.3618	0.0056	0.3429	0.0045	0.3503	0.0035	***
Land size	2.1386	0.0140	2.1846	0.0116	2.1665	0.0089	**
Education	9.9500	0.0223	9.9708	0.0175	9.9627	0.0137	
Remittances	0.2515	0.0078	0.2345	0.0061	0.2414	00048	*
Group Membership	0.1771	0.0045	0.1874	0.0037	0.1834	0.0058	*
Credit Access	0.5315	0.0058	0.5528	0.0047	0.5401	0.0038	**
Internet Access	0.0653	0.0029	0.0753	0.0025	0.0714	0.0019	***
Food Expenditure	1367.676	17.1737	1391.098	13.4793	1381.872	10.6070	
Western	0.5224	0.0059	0.5173	0.0047	0.5193	0.0037	
TDWAVE4	0.2294	0.0029	0.2180	0.0047	0.2225	0.0037	
Mobile Phone Ownership	2.5085	0.0720	2.4579	0.0435	2.4172	0.0435	

****, **, * shows significant difference at 0.01, 0.05 and 0.1 significance levels respectively*

Source: Author's compilation (2021)

Women empowerment in agriculture is an important factor in boosting food security among households (Alkire et al., 2013). While the average women empowerment scores for both households who consumed 0-3 HDDS and 4-12 HDDS was about 65%, the average women empowerment score among the households who consumed 4-12 HDDS was more than the average women empowerment score of households who consumed 0-3 HDDS by 0.2%. The mean difference test result showed that the average women empowerment score for households that consumed 0-3 HDDS was significantly different from the average women empowerment score of households that consumed 4-12 HDDS at a 1% level. Thus, empowering women in both livestock and crop production helps to improve households' food security. Empowering women through enhancing access to financial resources, productive resources, involvement in the allocation of household income, and participating in leadership roles will aid them to achieve a food-secure household (Sraboni, et al., 2014: Seymour, 2017).

The mean household size for the households who were food secure in terms of consuming 4-12 HDDS was significantly different from the average household size of households that consumed fewer food items of 0-3 HDDS. For both groups, the average household size was about 4 members. The mean difference was significant at a 5% level. The mean household

size for households that consumed more food items was higher compared to the mean household size of households that consumed fewer food items. This could mean that the more the household size the more it provides labor to improve the production of food items for household food security. Labour is a key input in any production process (Sanusi, Badejo and Yusuf, 2006).

Among the households that consumed more food items, their average age (43.46) was slightly lower compared to the mean age (43.56) of the households that consumed fewer food items. The average age of households for the two groups was approximately 43.0 years. The mean age difference between the two groups was insignificant. However, age plays a significant role in a household's food security level. Age is taken to be equivalent to experience such that farmers with advanced age have more experience in farming and are thus likely to be more food secure compared to young farmers. With age comes an understanding, knowledge and skills risk management, proper planning of household food stability, food access, and utilization (Fekadu and Mequanent, 2010).

Gender plays a very role in the advancement and planning of household food security. The type of household gender affects the decision-making on matters to do with productive resources such as land, labor, capital, use of income, and access and utilization of credit facilities (Malapit and Quisumbing, 2015; Seebens, 2011). The findings show that households that consumed less than 4 HDDS had 36.18% females as compared to the households that consumed more than 3 HDDS with about 34% females. The proportional difference between the two groups was significant at a 1% level. Thus, the majority of households where more females were food insecure compared to households that were food secure. Theoretically, women play a very significant role in enhancing food security. Thus, the current study elucidates that there is a need to empower women for improved food security since they account for over 40% of the agricultural labor force, significantly participate in agricultural activities, and contribute to more than 50% of the world's food production (FAO, 2011).

While the average land size for both households who consumed 0-3 HDDS and 4-12 HDDS were about 2.167 acres, the average land size (2.1846) for households who had more HDDS was higher compared to the average land size (2.1386) of households who consumed fewer HDDS. The mean difference in land size for both groups was significant at a 5% level. This implies that more land size creates more space for food production and hence ensures food security among households unlike when the land space is very small. With more land, comes diversification, commercialization, and intensification of farm enterprises. Such practices caution the farmers from production failures, climate shocks, and other vagaries of nature. It also leverages households' food security through food variety choices when they participate in the local market.

The time spent in education by the respondents on average was about 9.96 years which means most households finished primary education. Households that had more HDDS spent more years in education as compared to households that consumed fewer food items. However, the mean difference in years spent in education was insignificant. Thus, education improves HDDS through increased knowledge, increased income through formal employment, and understanding and application of good farming practices for improved food security (Abdullah et al., 2019). Education is a very paramount requisite in building human literacy. Throughout decades and centuries, a lot of transformations in the education sector have been implemented to build and improve human capital through instilling knowledge, skills, and understanding of different subject matters and disciplines (Agyeman et al., 2014; Asfaw et al., 2015). The average proportion of households who received remittances was about 24%. The proportion of households that received remittances and consumed more food items was less than the proportion of households that consumed fewer

food items. The mean proportional difference between the two groups was significant at the 10% level. This means that remittances possibly could lead to overdependence rather than boosting farming activities for increased food production, especially among households who consumed fewer food items. It could also mean that those who receive remittances could be settling debts or paying fees for children's education. On the other hand, remittances increase capital for agricultural production. It helps reduce household expenses including farming expenses (Moniruzzaman, 2020).

The proportion of households that ate fewer food items and were members of a group was about 17.71% while the proportion of households that ate more food items and were members of a group was about 18.74%. The overall proportion of group membership for the two groups was about 18.34% while the mean proportional difference was significant at a 10% level. This means that households that were members of a group received benefits including farming advice, proper saving habits, market information, and even informal credit facilities to boost their farming activities and improve collective bargaining hence improving food security (Kabunga et al., 2012). Groups that promote women's participation should be encouraged and supported fully to explore women's potential in market participation, farming management opportunities, and the adoption of innovative technologies (Padmanabhan, 2008; Gotschi et al., 2009).

The overall proportion of households, that accessed credit facilities, was approximately 54% with households that consumed more food items and had access to credit being more proportionally, compared to households that consumed fewer food items and had access to credit facilities. The proportional difference was significant at the 5% level. This means that credit facilities enhance food security through increased capital and input purchases for food production. It also accelerates farm diversification which reduces risk to households because of the failure of one enterprise (Kassie et al., 2015). Access to credit enhances the purchase of new farm machinery, and improved technologies for investment in agriculture which then promotes commercialization hence increased production that guarantees improved household food security.

There was a significant (1%) proportional difference in households who accessed the internet between those that consumed fewer food items and those that consumed more food items comparatively. Despite the overall small proportion of households who accessed the internet of about 7.14%, the households who accessed credit (7.53%) and ate fewer food items were proportionally less compared to households that ate more food items and had access to credit (6.53%) by about 1%. Accessing the internet means accessing information related to improving the food variety of households (Ma et al., 2020). Households that access the internet are able to learn new farming practices and can get skills on improving household diet using locally available resources; they can also get market information on the available food items and their prices which allows them to make informed choices on the best food variety mix for the household food security (Xue et al., 2021). Internet access also improves household preferences and increases the consumption of food and non-food items through online shopping (Yuan et al., 2021). Internet access among households reduces the cost of market access, it cuts transportation costs (Hou et al., 2018).

The average food expenditure among households was approximately Ksh. 1381.872. The households who consumed more food items spent more as compared to the households who consumed fewer food items by about Ksh. 23.422. The mean difference between the food expenditure for those who consumed fewer HDDS and more HDDS was statistically insignificant. This means that food expenditure increases as households purchase more food items for household consumption (Babatunde et al., 2010:2020). Thus, households that spent a higher proportion of their income on food are more likely to be food secure (Kumar et al., 2015). The proportions of households that reside in the Western region and consume fewer

HDDS are about 52.24% while those who consume more HDDS are about 51.73%. The proportional difference between households that consume fewer HDDS and those who consume more HDDS is statistically insignificant. Different regions have different agroecological zones, characteristics, and farming patterns (Habtemariam et al., 2021). The Time dummy variable recorded an insignificant proportional difference between households that consumed fewer food items and those that consumed more food items. With time, households adapt to changing climatic and economic conditions to ensure they are food secure (Asfaw et al., 2015). In this study, the number of mobile phones owned by a household was used as an instrument variable in the regression analysis. Descriptively, households had two phones on average but the mean difference between the number of phones owned by the households that consumed more food items and those that consumed fewer HDDS was statistically insignificant.

EMPIRICAL RESULTS

Table 2 presents the estimates of the endogenous switching regression model estimated by Full information maximum likelihood. The first column reports the estimation by OLS of HDDS function with no switching and with a dummy variable equal to 1 if the household commercialized and 0 if the household did not commercialize. The second, third, and fourth columns present the estimated coefficients of the selection equation (1), on commercializing or not commercializing and of the HDDS functions (2a), and (2b) for households that commercialize and did not commercialize respectively. Mobile ownership was used as the selection variable since it passed the falsification test.

Agricultural Commercialization and Household Food Security Outcome

This section discusses the food security implications of agricultural commercialization by households. The simplest approach to examine the effects of agricultural commercialization on household HDDS is by estimating a simple OLS model of HDDS that includes a dummy variable equal to 1 if the household commercialized and 0 if the household did not commercialize as presented in table 2 (column 1). Using this simple approach can make the researcher conclude that there is no difference in HDDS consumed by the household that did not commercialize since the coefficient of the dummy variable agricultural commercialization is positive but statistically insignificant. This technique, however, assumes that agricultural commercialization is exogenously determined while it is a potentially endogenous variable. The estimation via OLS would yield biased and inconsistent estimates. Moreover, OLS estimates do not explicitly account for potential structural differences between the HDDS function of households that participated in agricultural commercialization and the HDDS function of households that did not commercialize.

The estimated parameters of the endogenous switching regression model are presented in Table 2. In the third and fourth columns of Table 3.2, the determinants of household food security outcomes are presented. The results indicate that there is a systematic difference between commercialized and non-commercialized households.

The coefficient of women empowerment in agriculture was significantly $(p < 0.01)$ positive $(\beta_{AC=1} = 0.4356, \beta_{AC=0} = 0.1618)$ for both commercialized and noncommercialized households. For the commercialized and noncommercialized households, women empowerment increased their food security by 43.56% and 16.18% respectively. The women empowerment coefficient had more impact on HDDS of the households that commercialized by 27.38% compared to the noncommercialized households. This implied that the more the women are empowered in both livestock and crop production, the more the households becoming more food secure. Women can be fully empowered in five key areas as outlined by Alkire et al. (2013), and these are; participation

in decision making on productive resources including owning of assets, involving in use and utilization of farm income, access and proper utilization of financial resources and active participation in groups through leadership responsibility. Women involvement in food production has been proven as a key factor in ensuring household food security (Seng. 2016; Kassie et al., 2014).

The coefficient of household size negatively $\beta_{AC=0} = 0.0378$ and significantly $(p < 0.05)$ influenced household dietary diversity for the noncommercialized households. An increase in one member in the household of the noncommercialized reduced the HDDS by 3.678%. This implied that household's food security declines with increase in household size, such that larger households have higher consumption, which requires more food hence creating more food security issues. This finding is in line with Seng (2016) who found that household size negatively and significantly influenced household dietary diversity of both market participants and non-participants, though the effects were greater among the non-participating households. The findings are also in tandem with Asfaw et al. (2012) who found that family size had a negative and significant effect on the adopters and non-adopters of improved pigeon pea varieties, where the effect was more felt among the non-adopters. In addition, Shiferaw et al. (2014) found that family size had a negative and significant effect on the probability of household food security and the per capita food consumption expenditure of the adopters and non-adopters of wheat technology among smallholder farmers in Ethiopia.

The age of the household had a significant $(p < 0.01)$ and positive $(\beta_{AC=1} = 0.1364,\ \beta_{AC=0} = 0.0992)$ effect on household dietary diversity of both regimes. Increasing the age of the household head increases the food security of the household by 13.64% and 9.92% of both the commercialized and non-commercialized households respectively. The effect is felt more in commercialized households as compared to non-commercialized households. This suggests that the older households head might be associated with higher labour force participation in other income-generating activities which in turn exposes the household to food security (Dube and Okzan, 2022). The findings agree with Asfaw et al. (2012) who found that age of the household head positively and significantly influenced consumption expenditure among the adopters of pigeon pea varieties, though the effect was insignificant on the non-adopters despite the effect being positive. In addition, Seng (2016) found that household head's age had positive and significant on the household food security of the market participants only, while the effect of age was negative and insignificant on the household food security of the non-market participants. On the contrary, Shiferaw et al. (2014) found that age of the household head had an insignificant differential effect on the probability of household food security and the per capita food consumption expenditure of both adopters and non-adopters of wheat technology among smallholder farmers in Ethiopia. The results also agree with Wossen et al. (2017) who found age to have a positive and significant effect on households' welfare and asset ownership of members and non-members of a cooperative society and households with and without access to extension services respectively.

The coefficient of gender had a significant $(p < 0.01)$ and negative$(\beta_{AC=1} = 0.1655)$ effect on the household dietary diversity of the commercialized households compared to the non-commercialized households. Thus, being a female increases household food security as compared to being a male in the commercialized households. This is supported by the higher women empowerment effect on household food security of the commercialized households. Women in the households play a very critical role in ensuring the household is food secure. They mainly engage in gardening and main farming activities, especially women with children. However, Asfaw et al. (2012) found gender of the household head to negatively and significantly influence consumption expenditure among the adopters of pigeon pea varieties only while Dube and Ozkan (2022) found no significant effect of gender on

household dietary diversity and consumption expenditure among the livestock market participants and non-participants. Also, Di Falco et al. (2011) found a significant effect of gender on food productivity among the adopters and non-adopters of climate change while Shiferaw et al. (2014) found that gender had a significant positive effect on the per capita consumption expenditure of the household of adopters of wheat technology, though the effect of gender on per capita food consumption expenditure of non-adopters of wheat technology among smallholder in Ethiopia was insignificant. Consequently, the gender of the household had an insignificant effect on the probability of household food security of both the adopters and non-adopters of wheat technology among smallholders in Ethiopia (Shiferaw et al., 2014). Wossen et al. (2017) found gender of the household to have a positive but insignificant effect on the household welfare of both members and non-members of a cooperative society, and on the other hand, gender had a negative and significant effect on the asset ownership of households who did not have access to extension services.

The coefficient of land size had a significant $(p < 0.05)$ and differential $(\beta_{AC=1} = 0.3266, \beta_{AC=0} = -0.1805)$ effect on the two regimes. Land size improved the HDDS among the commercialized households while it reduced the HDDS among the non-commercialized households. This reveals that more landholdings positively influence household food security. Households with large lands are less likely to be food insecure since they can minimize their production risks and increase productivity (Dube and Ozkan, 2022). Furthermore, commercialized households place more emphasis on generating a large market surplus which is normally associated with large land sizes. On the other hand, negative effect of that land size on household food security could mean that the non-commercialized households use their available land in less productive ways compared to the commercialized households (Seng, 2016) and at the same time produce only for self-sufficiency which is always associated with small landholdings. The results agree with Dube and Ozkan (2022) who found land size to positively and significantly influence the food security of the market participants, though the effect was insignificant on the non-market participants. According to Wossen et al. (2017), land size had an insignificant differential effect on the household welfare of both members and non-members of cooperative society, while on the other hand land size had an insignificant positive effect on the asset ownership of households with and without access to extension services.

The coefficient of education had a significant $(p < 0.01)$ and positive $(\beta_{AC=1} = 0.0252)$ effect on the household dietary diversity among the commercialized households while the effect was insignificant among the non-commercialized households. Thus, more years spent in school increases the households' knowledge, skills, and capacity to engage in commercialization for improved household food security. The study is in line with Seng (2016) who found that education of the household had a positive and significant effect on household food security among the market participants only while the effect was insignificant for the non-market participants despite the fact that the coefficient is positive. However, Di Falco et al. (2011) observes that education had a negative and significant effect on household food security among the adopters of climate change strategies while it was negative but insignificant for the non-adopters of climate change strategies. The results further imply that the effects of education are great amongst commercialized households, since more educated commercialized households may be more productive in agricultural production than non-commercialized households (Seng, 2016). The study results further agree with Abdulai and Huffman (2014) whose results indicate that education had a positive and significant effect on the rice yields and net returns of both adopters and non-adopters of conservation technology. On the contrary, Dube and Ozkan (2022) found education level to have no significant effect on household dietary diversity and per capita consumption expenditure of both market participants and non-participants using the endogenous switching regression for continuous outcomes, while on the other hand, they found that

education had a negative and significant effect on the household self-reported food insecurity of both the market participants and non-participants using the endogenous probit regression model (Dube and Ozkan, 2022). The findings are further supported by Wossen et al. (2017) who found that education had positive and significant effect on asset ownership of households who both with and without extension excess while education had a significant and positive effect on the household welfare of households who were non-cooperative members.

Remittances had a positive $(\beta_{AC=0} = 0.0374)$ and significant $(p < 0.05)$ effect only on the HDDS of the non-commercialized households, though remittances had a positive but insignificant effect on the HDDS of the commercialized households. Households receiving remittances are more likely to increase their HDDS by about 3.74%. Remittances increase household income and hence increase their purchasing power and affordability of basic food items. Households who receive remittances are more likely to be food secure, which portrays the important role of remittances in ultimately reducing poverty among households. The study results agree with Seng (2016) who found that remittances had a significant and positive effect on the household food security of the market participants and non-participants. The results are supported by Dube and Ozkan (2022) who found that remittances had a significant positive effect on the household dietary diversity and per capita food consumption expenditure of both market participants and non-participants while employing the endogenous switching regression for continuous outcomes. They also found that remittances had a positive and significant effect on the negative change in diet and reduced food intake of the market participants while it had a negative and significant effect on self-reported food insecurity of the market participants using the endogenous switching probit regression model (Dube and Ozkan, 2022). As Mora-Rivera and van Gameren (2020) discovered, when a member of a household migrates to another nation, it can have a favorable impact on the food security of those who remain in the original country. In addition, there are fewer mouths to feed; on the other hand, the family members who are left behind may have a better chance of gaining access to additional information and expertise, which may assist to reduce the level of food insecurity they are experiencing.

The coefficient of group membership had a positive $(\beta_{AC=0} = 0.1786)$ and significant $(p < 0.01)$ effect on the household dietary diversity of the non-commercialized households, though the effect on the HDDS of the commercialized households was insignificant and negative. Thus, a non-commercialized household being in a group is more likely to be food secure. Groups that encourage saving practices, provide market information, and avail materials on garden farming, create more negotiation power and improve household food security. The findings agree with Abdulai and Huffman (2014) who found that being in a farmer group had a positive and significant effect on the household net returns among the adopters and non-adopters of conservation technology strategies. On the contrary, using endogenous switching regression (ESR) and endogenous switching probit regression model (ESP), Dube and Ozkan (2022) found that being a member of a cooperative had an insignificant but differential effect on the household dietary and per capita food consumption expenditure and self-reported food insecurity, negative change in diet and reduced food intake on both the market participants and non-participants respectively.

Access to credit had a positive $(\beta_{AC=1} = 0.0805)$ and significant $(p < 0.01)$ effect on the household dietary diversity among the commercialized households while it had an insignificant positive effect on the household dietary diversity of households that did not participate in commercialization. Thus, households accessing credit facilities are more likely to increase their food security by 8.05%. Access to credit enhances the household's purchasing power to acquire more resources to increase their surplus for the market which in turn opens opportunities to improve household food security. The study results agree with Abdulai and Huffman (2014) who found that credit access had a positive and very

significant effect on the household net returns and rice yields of both adopters and non-adopters of conservation technology. On the contrary, Di Falco et al. (2011) found credit access to have a negative and significant effect on the food productivity of households that did not adapt to climate change strategies while it had no significant effect on the food productivity of households that adapted climate change strategies. The results are opposite Dube and Ozkan (2022) who found that credit aces had a negative significant effect on per capita food consumption expenditure and self-reported food insecurity among the non-market participants and the market participants respectively. Notably, Wossen et al. (2017) found a positive and insignificant effect of access to credit on household welfare and asset ownership of both the members and non-members of a cooperative society and households with and without extension access respectively.

Internet access had a significant $(p < 0.01)$ positive $(\beta_{AC=1} = 0.2351, \beta_{AC=0} = 0.1174)$ effect on household dietary diversity among the commercialized and non-commercialized households and the effect on household food security of commercialized households is more by 11.77%. Access to the internet implies having access to food and diets related information. Households accessing the internet are more likely to have better diets and hence improved household food security. The results agree with Twumasi et al. (2021) who found that internet access and usage have a positive impact on smallholders' food and nutrition security especially among households with off-farm work and large-size landholdings and through the incentives it places on household income and other metrics that contribute to an increase in household welfare and food security. Also, Mishra et al. (2009) suggested that the majority of farm households rely entirely on e-commerce, which thrives on the Internet, for higher shares of groceries and other nondurable commodities due to the longer physical distances to the metropolitan markets. Both Liu et al. (2019) and Ma et al. (2020) discovered that access to the internet and usage of the internet had a favorable and substantial effect on the dietary diversity of households. Therefore, having access to and using the internet can assist boost the nutritional diversity of households. In addition, people who use the internet receive a number of benefits including information to help them find work away from the farm and a platform for advertising and selling agricultural or other products that improve the welfare of their households, making it more likely that those households will improve the nutritional variety and safety of their food. If more homes had access to the internet, it would also mean that there would be fewer instances of food insecurity.

Food expenditure had a negative $(p < 0.01)$ and significant $(\beta_{AC=0} = -0.1436)$ effect on household dietary diversity among the non-commercialized households, though the effect was positive but insignificant among the commercialized households, such that households that do not participate in agricultural commercialization are more likely to be food insecure by 14.36% compared to households that really participate in agricultural commercialization. Thus, the decline in food security as a result of food expenditure implies that either income is reduced through a decline in cash transfers (Burgh et al., 2015) or a decline in remittances. An increase in food expenditure could also mean an increase in more mouths to feed and hence straining the available limited resources this decline in household food security (Seng, 2016). Tiwari et al. (2016) found that an increase in food spending ought to also result in a bigger calorie consumption on a per capita basis, which is not the case in this study.

Western, as a region dummy variable, had a negative $(\beta_{AC=0} = -0.1723)$ and significant $(p < 0.05)$ effect on the household dietary diversity among the non-commercialized households while the effect was negative but insignificant on the commercialized households. Thus, being in the Western region reduces household food security. The findings are supported by Asfaw et al. (2012) who found that location had a negative and significant effect on household consumption expenditure among the non-adopters of the pigeon pea variety. Different locations have different agroecological zones which then affect

productivity in different ways. On the contrary, Abdulai and Huffman (2014) who found that location-specific effects may significantly explain the differences in farm outcomes. In particular, they found that location had a positive and significant effect on the rice yields and net returns of both the adopters and non-adopters of conservation technology in northern Ghana. Thus, tailoring policies, programs, and interventions best adapted to specific agroecological zones will go a long way in improving the food security of the households and reducing poverty which ultimately improves household well-being.

Table 3: Parameters Estimates of Agricultural Commercialization and Food Security Outcomes Equations

	(1)	(2)	(3)	(4)
			Endogenous Switching Regression	
	OLS		AC=1	AC =0
Dependent Variable	HDDS	AC =1/0	HDDS	HDDS
AC	0.4790(0.3680)			
WEAI	0.6152***(0.1795)	0.7386***(0.0493)	0.4356***(0.0718)	0.1618***(0.0531)
Household size	-0.1020***(0.0379)	-0.0841***(0.1133)	-0.0191 (0.6056)	-0.0378**(0.0165)
Age	0.0163 (0.0109)	0.0157**(0.0077)	0.1364***(0.0134)	0.0992*** (0.0324)
Gender	-0.1555 (0.1008)	0.0956(0.2405)	0.0261(0.0661)	0.1655***(0.3200)
Land size	0.0131 (0.0759)	0.2229**(0.0173)	0.3266*** (0.1082)	-0.1805*** (0.0536)
Education	-0.0027(0.0148)	0.0241***(0.0060)	0.0252***(0.0080)	-0.0282(0.0379)
Remittances	0.7120***(0.2384)	0.0683(0.3405)	0.0410(0.0446)	0.0374**(0.0162)
Group membership	-0.1902(0.5450)	0.0335(0.0541)	-0.0103(0.0236)	0.1786***(0.0617)
Credit Access	0.1259*(0.0747)	0.0737**(0.0352)	0.0805***(0.0336)	0.1480(0.1689)
Internet access	0.2043(0.0992)	0.4120***(0.0148)	0.2351***(0.0168)	0.1174***(0.0190)
Food Expenditure	-0.297***(0.0380)	-0.0962***(0.0150)	0.0438(0.2171)	-0.1436***(0.0195)
Western	-0.0886***(0.0441)	0.2498(0.2098)	-0.1522(0.1364)	-0.1723**(0.08560
TDWAVE4	0.0502(0.0380)	0.0040*(0.0021)	0.1054***(0.0374)	0.0660(0.3311)
Mobile phone Ownership		-0.0515**(0.0239)		
Constant	6.9923***(1.2147)	1.7816***(0.1756)	4.4510***(0.2452)	3.7384(2.3931)
AIC	82391.86	97657.73	97657.73	97657.73
BIC	82485.05	97991.68	97991.68	97991.68
Wald Chi2 (14)	F-Stat.=2.70***	37.52***	37.52***	37.52***
σ_i			2.5071***(0.0380)	2.6170***(0.0227)
ρ_i			-0.5120***(0.0113)	-0.3992***(0.08561)
Observations	12344			

LR Test of Independence of Equations: Chi2(1) =97.06***; AC denotes Agricultural Commercialization

σ_i denotes the square root of the variance of the error terms, ε_{1it} and , ε_{0it} in the outcome equations (3.2a) and (3.2b) respectively; ρ_i denotes the correlation coefficient between the error term η_{it}, of the selection equation (3.1) and the error term, ε_{1it} and , ε_{0it} in the outcome equations (3.2a) and (3.2b) respectively; ***p<0.01, **p<0.05, and *p<0.10

Source: Authors Computation (2021)

The time dummy variable, wave four, of the household survey had a positive $(\beta_{AC=1} = 0.1054)$ and significant $(p < 0.01)$ effect on the household dietary diversity among the commercialized households, however, the effect was positive but insignificant on the non-commercialized households. Thus, with time, commercialized households tend to have improved food security compared to non-commercialized households. The findings are contrary to Dsouza et al. (2020) who used the time tummy variable to control for variations

over time and found that the time dummy variable had a negative and significant effect on the share of food expenditure due to off-farm work and labor allocations, which means that households in India were more food secure.

The likelihood ratio test and correlation coefficients of the covariance term between the error terms in decision and outcome equations, in the ESR estimation, have economic interpretations (Fuglie and Bosch, 1995) as shown in Table 3. The likelihood ratio test for joint independence of agricultural commercialization decision and the food security outcome equations were jointly dependent (Lokshin and Sajaia, 2004) and thus providing evidence of endogeneity that needs to be controlled in the model specifications of the food security outcome equations. The results from the endogenous switching regression estimated by full information maximum likelihood show that the estimated coefficient of correlation between agricultural commercialization equation and the food security outcome equations were negative and significantly different from zero. The correlation coefficients are statistically significant indicating the presence of self-selectivity.

The results suggest that both the observed and unobserved factors influence the decision to commercialize and food security outcome equation given the decision to commercialize. Thus, failing to account for these factors may lead to biased estimates. The difference in the food security equation coefficient between the commercialized and non-commercialized explains the presence of heterogeneity in the sample. The food security function of the households that commercialized is significantly different from the food security function of households that did not commercialize.

Conditional Expectations, Treatment, and Heterogeneity Effects

The endogenous switching regression model results of the average treatment effects (ATT), which account for the selectivity bias arising from both the observable and non-observable factors, are presented in Table 4. The actual household dietary diversity for the commercialized households was 8.5507 counts while the household dietary diversity would have been 8.2096 counts had the households decided not to commercialize. This implies that household food security would have fallen by 0.3411 counts had the households decided not to participate in agricultural commercialization (Seng, 2016; Hatab et al., 2019).

Table 4: Conditional Expectations, Treatment, and Heterogeneity Effects

Subsamples	Decision stage		Treatment effects
	To commercialize	Not to commercialize	
Households that commercialize	8.5507	8.2096	0.3411***
	(0.0170)	(0.0380)	(0.0035)
Households that did not commercialize	7.3129	7.1300	0.1830***
	(0.0070)	(0.0160)	(0.0015)
Heterogeneity effects	0.2378	0.0796	0.14

Notes: standard errors are in brackets; ***p<0.01, **p<0.05, and *p<0.10

Source: Authors compilation (2021)

On the other hand, the households that did not commercialize in agriculture had a household dietary diversity of 7.1300 and if they had participated in agricultural commercialization, the household dietary diversity would have been 7.3129. Thus, participation in agricultural commercialization would have improved the non-commercialized households by 0.1830 counts. This means that households deciding to commercialize livestock and crop production are a key income source in improving household food security since income increases dietary diversity by expanding the purchasing power and affordability of the households (Seng, 2016; Sanford and Ashley, 2008; Dorward et al., 2005).

Agricultural commercialization in crops and livestock influences dietary diversity (Njuki and Sangina, 2013) through increased consumption expenditure that leverages households to

access food items of all types (Rawlins et al., 2014). The model findings provide that decision to commercialize is the most significant and key driver of household food security (Muricho et al., 2017). The study results concur with Seng (2016) and Dube and Ozkan (2022) who established that by deciding to commercialize, households are more likely to enjoy increased food security through the consumption of higher dietary diversities. The transitional heterogeneity effect is positive, therefore, the effect of significantly larger for households that actually commercialized relatively to those households that did not commercialize. This implies that there are some important sources of heterogeneity that makes commercialized households have better household dietary diversity than non-commercialized households regardless of the issue of agricultural commercialization. These transitional heterogeneity results are supported by Seng (2016) who found that the transitional heterogeneity effect was significantly larger on dietary diversity for households that actually participated in the market compared to the non-participants. However, Seng (2016) also found that the transitional heterogeneity effect was significantly smaller on per capita food consumption expenditure for households that actually participated in the market relative to the non-participants. Thus, the findings suggest that with proper and relevant intervention, commercialization in agriculture can enhance the food security of the household and at the same time improve household welfare (Saxena et al., 2017). There is a need to promote both crop and livestock production for market surplus among households to increase their income which boosts the household purchase of a wide range of food diets (Lubungu, 2013) and at the same time encourage and support household to use of innovative agricultural technologies (Dhraief et al., 2019) to enhance the commercialization schedules for increased market output

The results of the base heterogeneity were significant for household dietary diversity of both commercialized and non-commercialized households. This indicates that disparities in their household diet diversity are not caused by treatment effects but rather by unobserved heterogeneity in the population as a whole. This indicates that even accounting for the disparities that have been discovered between commercialized and non-commercialized families would not be sufficient to eradicate the inequalities in the dietary diversity of households. This unobserved heterogeneity may be the result of some institutional factors, such as the difficulty non-commercialized households encounter in gaining access to extension services provided by society; this difficulty is one of the factors that contribute to the inherent differences that exist between commercialized and non-commercialized households (Arya et al., 2021).

CONCLUSION AND RECOMMENDATIONS

Using the Covid-19 Rapid Response Phone survey panel data, the current study established the impact of household decisions to participate in agricultural commercialization on household dietary diversity using the ESR model. The ESR model accounts for self-selection among households and explains the systematic differences between commercialized and non-commercialized households in terms of household dietary diversity functions. These differences represent sources of variations between the commercialized group and non-commercialized group that the estimation of an OLS model including a dummy variable for commercializing or not commercializing cannot account for (Asferaw et al., 2012). The results also confirm that the decisions regarding household participation in agricultural commercialization and household food security are affected by unobserved factors of farm households. The presence of structural differences between the commercialized and non-commercialized households is explained by land size which had a positive impact on the food security of the commercialized households while it had a negative impact on the food security of the non-commercialized households. Therefore, households with large land sizes are more likely to improve by a greater extent household food security compared to households with small land sizes when they participate more in

the market. Markets that provide timely information ensure stable and increased earnings which guarantee stable and increased household dietary diversity thus improving and ensuring sustainable household food security.

By accounting for the self-selection and systematic differences between commercialized and non-commercialized, the household dietary diversity gains from participating in commercialization are positive, thus, farm households are more likely to improve household security with the household dietary diversity gains from commercializing (Dube and Ozkan, 2022). The role of agricultural commercialization can never be disputed as it has proven to improve household food security through increased incomes resulting from increased market surplus. Participating in the market has also improved household welfare at the same time reducing and eradicating poverty (Seng, 2016). Households with more members have little access to the internet, face challenges accessing credit, have small land sizes, and more food expenditures are more likely to face a lot of barriers in producing for the market and at the same time experience more risks and exposure to low dietary diversity, hence, food insecurity. While those households with land sizes, well-educated, have good access to credit facilities and to the internet are more likely to overcome any production and market risks, can supply more produce to the market, and at the same time experience increased income which improves their food security through increased dietary diversity.

Policy-wise, attention should be placed on education, especially in the agriculture sector, and training programs that help improve farming productivity and market participation among households. This can be further achieved through strengthening public-private partnerships to have a holistic model that captures the specific farmer needs to commercialize and penetrate the market with ease. Credit policies should also be re-considered to increase access and utilization by farmers with little or no collateral.

The study recommends future studies be done on the region-disaggregated impact of livestock and crop commercialization on household food security while employing both the endogenous switching regression model and endogenous switching probit model to compare results.

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