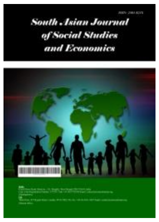

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Welfare Effects of the Production of Indigenous Food Crops in Farming Communities in the Northern Region of Ghana

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Aims: Maintaining diverse diets through diversified farming systems presents opportunities for better nutrition and greater health status for peasant families in rural communities around the globe. This study explores the welfare effects of the adoption of indigenous food crops by farming communities in the Northern Region of Ghana.
Study Design: The study followed a multi-stage sampling procedure and utilized primary data collected.
Methodology: Using a standard treatment effect estimation approach, the study examined the effect of the production of indigenous food crops on household dietary diversity using primary data collected from 405 households in farming communities in Ghana's Northern Region for the 2016/17 crop season.
Results: Descriptive results reveal a mean dietary diversity score of 8.5 for producer households which is significantly different from the score of 6.2 for non-producer households. Also, the results show a high proportion of indigenous crop-producing households in the medium and high dietary diversity scores compared to non-producing households. Empirical results reveal a positive and significant impact of the production of indigenous food crops on household dietary diversity. The study also finds that household head education, non-farm work, livestock ownership, age and number of children have a positive effect on household dietary diversity.

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Conclusion: The study concludes that the production of indigenous food crops promotes the consumption of diverse foods among farm families and recommends that policies aimed at diverse food consumption and improved nutrition security among rural farming communities should consider promoting increased production of indigenous food crops.

Keywords: Welfare effects; dietary diversity; rural communities; farm households; indigenous food crops, nutritional security.

1. INTRODUCTION

Poor nutritional status of the world's poor is often a reflection of deficiencies in protein, energy and micronutrients [1-4]. According to Jones, Shrinivas [5], diets of poor resource households are of low quality because they are often comprised of starchy foods with little or low vegetables, fruits with nutritive value in them. As the most poverty affected parts of Ghana, the Northern Regions have also been flagged as areas recording high incidence of low dietary diversity [6-8]. The World Food Programme, WFP [8] finds that 16% of households in northern Ghana are not only food insecure but are also characterized by poor diet due to lack of diverse food.

Maintaining diverse diet through diversified farming systems presents opportunities for better nutrition and greater health status especially for peasant families around the globe [9]. However, the erosion of agro-biodiversity poses a challenge as crop diversity in agricultural systems today has declined as a consequence of changes in climatic conditions and the adoption of modern food production technologies [10-12]. Adequacy, food availability and affordability are often been widely conceived as the individual's state of being food secure in the literature. However, nutrition security extends to the absorption and utilization of required food nutrients in the right quantities [13]. One proxy indicator of nutrition security status of populations in empirical studies is dietary diversity [5,14-20]. It has been largely asserted that better access to diverse foods is directly linked to higher dietary diversity and thus, much emphasis has been placed on diversifying smallholder farmers' crop production [5,10,21-24].

Most of research recommends diversified food production through indigenous and underutilized or neglected crops as effective strategies to tackle malnutrition among farm families [11,22,25,26]. Indigenous food crops are widely known for important desirable traits ranging including nutritional, agronomic, ecological and economic advantages that make them more suitable to address the challenge of agricultural systems particularly in developing countries [11,25,27]. The common indigenous food crops that are grown in the Northern Region include fonio, Bambara nuts, melon seeds, pigeon-pea, lentils, sesame among others. Empirical evidence exists in respect of a positive relationship between dietary diversity and crop production diversity [5,20,28-32] but whether crop production diversity through indigenous food crops improves farm household diet is yet a novel area in empirical research. This paper, therefore, explores the empirical linkage between the production of indigenous food crops as an approach to crop production diversity and farm households' welfare, using dietary diversity as a proxy of indicator. Specifically, the paper assesses the impact of farm households' indigenous crop production decisions on farm households' dietary diversity in the Northern Region of Ghana. In the rest of the paper are sections on materials and methods results and discussion, conclusions and policy recommendations.

2. MATERIALS AND METHODS

2.1 Analytical Framework

Farm households' decision to produce indigenous food crops is modelled as a random utility function following Greene [33]. That a household participates in the production of indigenous food crops if the expected utility derived from participation exceeds that from non-participation. Thus, $\mathrm{U}_1 > \mathrm{U}_0$, where 1 denotes a household's decision to produce and 0 otherwise. U_1 and U_0 are modelled as $\mathrm{U}_1 = \times'\beta_1 + \varepsilon_1$ and $\mathrm{U}_0 = \times'\beta_0 + \varepsilon_0$ respectively. However, because U_1 and U_0 are latent, the probability of the observed decision to produce or not produce is modelled as a binary response variable, Z_i^*, with, $Z_i^* \in \{0,1\}$ where $i = 1, \dots, n$ farm households. Given P as the probability that $Z_i^* = 1$, given $\times$, then,

$$P(Z_i^* = 1| \times) = Prob(U_1 > U_0) = Prob(\times' \beta_1 + \varepsilon_1 - \times' \beta_0 - \varepsilon_0 > 0| \times).$$

$$= Prob[\times' (\beta_1 - \beta_0) + (\varepsilon_1 - \varepsilon_0) > 0].$$

$$= Prob(\times' \beta + \varepsilon > 0).$$

This implies that two sets of respondents; indigenous crop producers and non-producers emerge, leading to a dichotomous treatment variable. The probit model or a logit model allows for estimating dichotomous dependent variables in such situations. This makes it possible to estimate the probability that an observation with a particular characteristic falls into one specific category. The binary choice model is therefore estimated as a probit model and specified as follows:

$$Z_i^* = \delta K_i + U_i \tag{1}$$

where Z_i^* is a latent variable indicating a households' indigenous food crops production status; K_i is a vector of household and farm characteristics that are said to affect households' decision concerning indigenous food crops production; δ is a vector of parameters to be estimated and U_i is a random error term. From Equation 1, a household produces indigenous food crops if $Z_i^* > 0$. The observable dichotomous variable Z_i which indicates whether or not a household is a producer of indigenous food crops can then be defined as follows:

$$Z_i = \begin{cases} 1 \text{ iff } \delta K_i + U_i > 0 \\ 0 \text{ iff } \delta K_i + U_i \le 0 \end{cases} \tag{2}$$

where $S_i = 1$ signifies that the household is a producer of indigenous food crops and $S_i = 0$ otherwise.

If households' welfare (household dietary diversity) is defined to be a linear function of indigenous food crops production together with other observable factors, the linear regression equation can then be stated as

$$D_i = \beta X_i + \theta Z_i + V_i \tag{3}$$

where D_i is household dietary diversity score, X_i is a vector of farmer, household and farm characteristics, β is a vector of parameters to be estimated, U_i is a random error term, θ is a vector of parameters and Z_i, and U_i as defined earlier.

To estimate the impact of indigenous food crop production on household dietary diversity using Ordinary Least Squares (OLS) approach on Equation 3 could produce biased and inconsistent estimates. This could be as the result of the potential endogeneity of households' indigenous food crop production decision indicated by Equation 1 [34]. Households' decision to produce or not to produce indigenous food crops could be voluntary and might be based on self-selection. The presence of self-selection therefore implies that the impact of indigenous food crop production be isolated from that of the observed and unobserved factors which determine household dietary diversity and households' indigenous food crop production status. It is argued that unobserved factors such as personal skills (U_i) influencing households' decisions to produce indigenous food crops may correlate with unobserved factors (V_i) that influence household dietary diversity, the outcome variable, and this may lead to biased and inconsistent coefficient estimates. The error terms, U_i and V_i are therefore said to bivariate normal with mean zero and covariance matrix $\begin{bmatrix} \sigma & \rho \\ \rho & 1 \end{bmatrix}$.

To address the possibility of misleading attribution due to sample selection bias that could arise from the voluntary nature of households' decisions regarding indigenous food crops production, the treatment effect model is applied and estimated using a maximum likelihood technique on Equation 3 following William, George [35]. The maximum likelihood function for a household participating in indigenous crop production for which $D_i = 1$ is $ln\Phi\left(\frac{-K_i\theta+(D_i-X_i\beta-\delta)^{\rho}/_{\sigma}}{\sqrt{1-\rho^2}}\right) - \frac{1}{2}\left(\frac{D_i-X_i\beta-\delta}{\sigma}\right)^2 - ln(\sqrt{2\pi\sigma})$. For a non-producing household where $D_i = 0$, the maximum likelihood function is specified as $ln\Phi\left(\frac{-K_i\theta(D_i-X_i\beta)^{\rho}/_{\sigma}}{\sqrt{1-\rho^2}}\right) - \frac{1}{2}\left(\frac{D_i-X_i\beta}{\sigma}\right)^2 - ln(\sqrt{2\pi\sigma})$, where $\Phi(\bullet)$ is the distribution function of the standard normal distribution. In the maximum likelihood estimation σ and ρ are not directly estimated but $ln\rho$ and $atanh\rho$ are where, $atanh\rho = \frac{1}{2} ln\left(\frac{1+\rho}{1-\rho}\right)$.

The main assumption underlying the treatment effect model is that the error terms in the selection and outcome equations (Equations 1 and 3 respectively) are correlated and the level of correlation is ρ, which indicates that unobserved factors that increase or decrease the outcome (dietary diversity) occur with unobserved factors that increase/decrease the probability of a household's indigenous crop production [20]. A significant Wald test of a significant of correlation between U_i and V_i indicates the appropriateness of the use of the treatment effect model for the analysis of the impact of indigenous crop production on nutrition outcome in farm households.

2.2 Description of Variables

In explaining the determinants of household dietary diversity, the independent variable of interest was households' indigenous crop production, measured as a dummy variable taking the value "1" if the household produced indigenous crops and "0", otherwise. It was hypothesized that participation in indigenous food crop production by farm households affects household dietary quality using the household dietary diversity score as a proxy. Household socio-economic and demographic factors as well as farm characteristics and institutional factors were included as control variables in the analysis.

Dietary Diversity Score (DDS) was calculated by first classifying all food items into food groups according to guidelines proposed by Swindale and Bilinsky [36]. The food groups included cereals, roots and tubers, vegetables, fruits, meat, eggs, fish and seafood, pulses and nuts, milk and milk products, oils and fats, sugar/honey, and condiments. To account for indigenous crops, some of the food groups (cereal, pulses and vegetable and oil seeds groups) were sub divided into two groups (indigenous and non-indigenous) to obtain an expanded DDS following earlier applications such as in Mazunda, Kankwamba [29] and Verduzco-Gallo, Ecker [16]. Each household was then awarded a score of 1 if any food item from the group was eaten by any member in the household within the previous 24 hours. As a result, DDS was computed from 14 food groups for each sampled household.

2.3 Study Area, Sampling and Data

The study was conducted in the Northern Region (Fig. 1) which covers one-third of the land mass of Ghana with a total population of 2,479,461 occupying about 70,384 km^2 of land [37,38]. This makes the region the least densely populated in the country with about 35 persons per square kilometre and this illustrates a high agricultural potential of the region in terms of possibility of expansion in farm lands. The Northern Region is bounded by two of Ghana's neighbouring nations in the sub region in the east and west, and four other regions in the country. It shares borders to the east with the People's Republic of Togo, to the south with the Brong-Ahafo and Volta Regions, to the west with La Cote d'voire; and to the north with both the Upper West and Upper East Regions.

In terms of climatic conditions, the region is much drier than the southern parts of the country due to its proximity to the Sahel and the Sahara and as a result, the area is drought prone. The vegetation consists predominantly of grassland with clusters of drought-resistant trees such as baobabs or acacias, shea, among others with a long period of dryness. The Region is characterized by smallholder farming systems, low agricultural productivity, poor and inadequate social and economic infrastructure and a general poor access to critical agricultural inputs. The population is predominantly indigenous with major crops being maize, rice, groundnuts, cassava, yam and soybean [39]. On a lesser scale, farmers also cultivate some indigenous food crops such as Bambara nuts, pigeon pea, sesame, fonio, cowpea, melon ('egusi'), lentils and hibiscus/rosette ('bra') which are nutritious and supplement household diet to meet required nutrients.

The study employed a multi-stage procedure for sample selection. Three districts including Chereponi, Karaga and West Mamprusi (Fig. 1) were purposively selected in the first stage because they were identified as areas where indigenous crops were being promoted. Using a simple random sampling approach, between five and six farming communities were selected in the second stage. The third and final stage involved a random selection of between 25 and 30 households from each community giving a total of 405 households to which questionnaire were administered. The study utilized primary data collected using a structured and pretested questionnaire. Data related to the socio-economic and demographic characteristics as well as agricultural production and food consumption profiles of sampled households.

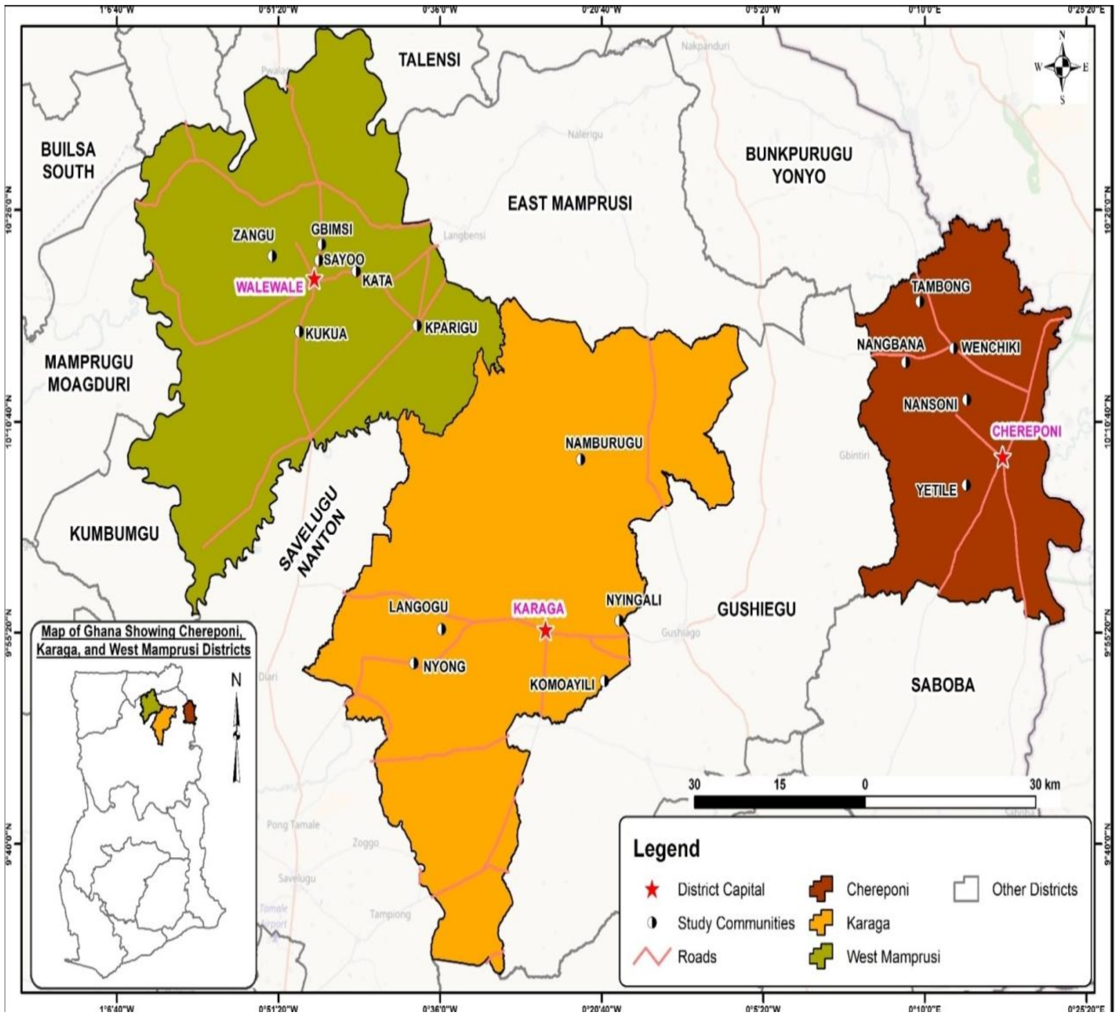

Fig. 1. Northern regional map showing study districts and communities
Source: Extracted from google map of Ghana

3. RESULTS AND DISCUSSION

The mean household dietary diversity score for all households is 7.8 which is lower than the score of 8.5 for indigenous crop producing households. Non-producing households has a dietary diversity score of 6.2 and this is significantly lower than that of the producer group at 1% level. Keeping of small ruminants and poultry in the Northern Region is one strategy that farm households normally use either for income or direct consumption. It was found that on the average a little more than half (51.9%) of households kept at least one type of livestock and this was higher at almost 54% for producer households as compared to 47.8% of non-producer farm households.

Analysis of the patterns of dietary diversity categorized as low (0- 5), medium (6-9) and high (10-14) dietary diversity groups following Ajani [40] reveals that on the average, 32%, 40% and 28% of households have low, medium and high dietary diversity respectively. Sarkar [41] reported a similar finding in a study of households' dietary diversity among rural households in West Bengal in India. When categorized into producers and non-producers of indigenous crops, a higher proportion of producer households dominate in both the medium and high diet diversity groups (Fig. 2).

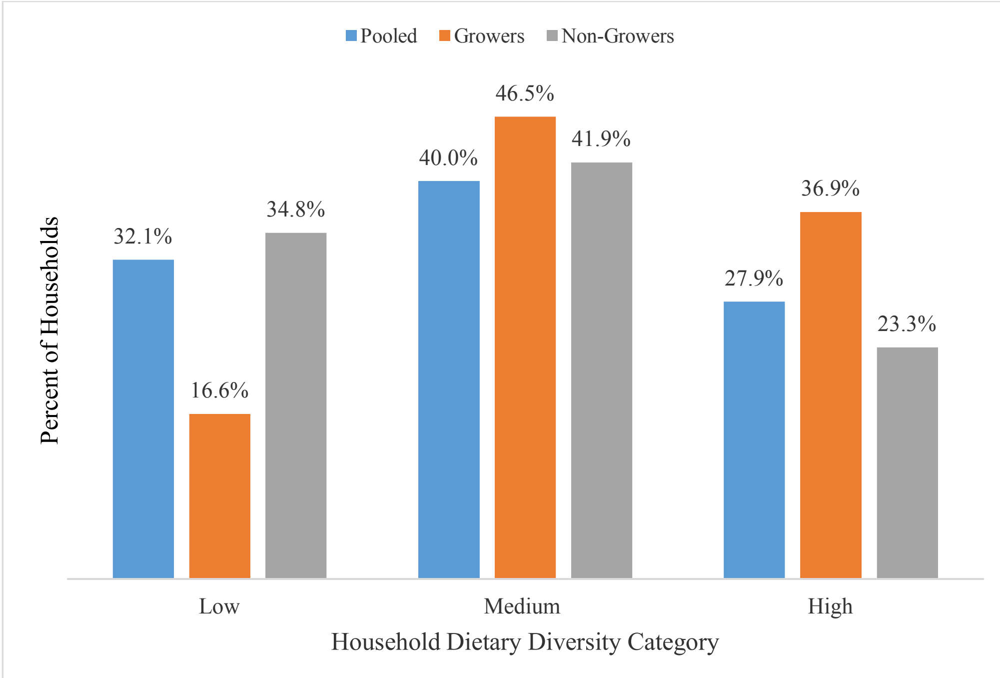

Fig. 2. Percentage of households and dietary diversity patterns
Source: Field Survey Data, May/June 2016

3.1 Maximum Likelihood Estimation Results of the Treatment Effect Model

This section discusses the effects of farm households' participation in indigenous crop production on household dietary diversity. The discussion is limited to the analysis of the results obtained from the outcome equation specified earlier in Equation 3 since an earlier related study Andani [42] has discussed the determinants of households' participation decisions which constitutes the selection equation in this study. Some validity tests were conducted to determine the appropriateness of the use of the treatment effect model. The main assumption underlying the treatment effect model is that the error terms in the outcome and selection equations are correlated and the level of correlation is rho (ρ). The test results show that the estimated value of rho is significant for the model, implying that endogeneity bias created by the selection bias associated with households' indigenous food crops production have been taken care of by the joint estimation of the treatment effect model [20]. The negative value of ρ implies that unobservable factors that raise dietary diversity of farm households tend to occur with unobservable factors that lower households' participation in indigenous food crops production and vice versa. This means that the correlation between the unobservable factors of household dietary diversity and the unobserved factors influencing indigenous food crops production participation is -0.

Subsequently, a test of the null hypothesis that ρ is non zero is conducted to compare the joint likelihood of a separate probit model for the selection equation and a regression model on the observed data against the likelihood of the treatment effect model. Results of a Wald test of independent equations under the hypothesis that: $H_0: \rho = 0; \& H_a: \rho \neq 0$ are reported in Table 1.

From Table 1, there is enough evidence against the null hypothesis that the value of rho is zero at 1% significance level. Also, results obtained from the Wald test on the goodness of fit of the model failed to accept the null hypothesis that all the independent variables included in the model are jointly equal to zero. The model is statistically significant with a Wald chi-square ratio of 418.77 at 1% significant level (Prob > chi^2 = 0.000). Based on this, it was concluded that at least one independent variable in the model was not equal to zero and hence the model was appropriate for the present estimation.

Table 1. Wald test of independent equations and goodness of fit

Type of Test	Independent equations	Goodness of fit
Rho	-0.5601***	
Chi^2 (1)	8.66	418.77
Prob > chi^2	0.0033	0.000
Log-likelihood		-986.86
Conclusion	$\rho \neq 0$ at 1% level of significance	

****, ** and * indicate 1% level of significance.*
Source: Field Survey Data, May/June 2016

Table 2. Determinants of household dietary diversity-maximum likelihood estimates

Variables	Coefficient	Robust SE	z	P>|z|
Household head has formal education	1.273***	0.255	4.99	0.000
Male household head	-0.181	0.275	-0.66	0.512
Household head age	0.0190*	0.0100	1.90	0.058
Household size	-0.0684	0.0454	-1.50	0.132
Number of household members<15 years	0.176**	0.0721	2.44	0.015
Control of crop proceeds	-0.246	0.313	-0.79	0.432
Production objective	0.384	0.277	1.38	0.166
Participation in non-farm work	0.348*	0.207	1.68	0.093
Household has livestock	2.350***	0.229	10.24	0.000
Mean market distance (km)	-0.0213	0.0139	-1.53	0.126
Indigenous crop producer	3.196***	0.799	4.00	0.000
Constant	2.557***	0.719	3.56	0.000
athrho	-0.633**	0.318	-1.99	0.046
Insigma	0.657***	0.0669	9.81	0.000
Other Statistics				
rho	-0.5601	0.2181		
sigma	1.9283	0.12908		
lambda	-1.0802	0.4821		
Number of observations	405			

****, ** and * indicate respectively 1, 5 and 10% level of significance.*
Source: Field Survey Data, 2016

3.2 Determinants of Farm Household Dietary Diversity in the Northern Region

To estimate the welfare effect of the production of indigenous food crops of farm households, the determinants of household dietary diversity are reported in Table 2. The results show that the adoption of indigenous crop production has a positive and significant effect on household dietary diversity as indicated by the highly significant positive coefficient of the variable on households' participation status. The results imply that dietary diversity of producer households was about 3.2 times over and above the dietary diversity of non-producer households. According to the Stata Treatment-Effects Reference Manual [43], this represents the average treatment effect of the production of indigenous crops on household dietary diversity. From the descriptive statistics discussed earlier, the mean dietary diversity for producers was estimated at 8.5 for producers and 6.2 for non-producers which were significantly different at the 1% level. This finding of indigenous crop production and household dietary diversity finds support in the literature. For example, related studies such as Jones, Shrinivas [5] and Mazunda, Kankwamba [29] reported a positive effect of farm production diversity and crop diversification on household dietary diversity in their respective research works. In the case of Malapit, Kadiyala [44] whose study investigated the mitigating effects of crop production diversity on maternal health and child nutrition via the empowerment of women in

Nepal, the authors found a strong positive effect of diversified crop production on children's dietary diversity. A recent study on the welfare effects of the adoption of indigenous vegetable production and commercialization in Kenya by Krause, Faße [45] revealed a positive and significant effect on household food security.

Other significant variables in the model are education and age of household head, number of young household members, households' participation in non-farm work and ownership of livestock. The effect of education of household head on dietary diversity is positive and significant at 1% level and this finds support in previous empirical studies [31,46-48]. The result suggests that households headed by educated people consume more diversified diets and this meets a-priori expectation since education broadens a person's understanding of the importance of eating nutritionally balanced diets. Household head's age is also positively associated with household dietary diversity though at the 10% significant level. This finding could be attributed to the fact that because the aged may be more advantaged in terms of their awareness and knowledge about the nutritional, social and economic importance of indigenous crops, households with older heads may tend to produce and consume the crops thereby increasing the sources of food for their families. Earlier studies that have also found positive association between the age of household head and dietary diversity include Babatunde, Opeyemi [49] in Nigeria with some others such as Mazunda, Kankwamba [29] in Malawi finding a contrary results as their study found an inverse relationship between age of household head and household dietary diversity.

The regression results also indicate that household dietary diversity tends to increase with an increase in the number of young household members. This might be particularly so in households that can appreciate the importance of diversified diets for the physical growth and cognitive development of children. The coefficient is positive and significant at 5% and increases household dietary diversity by 17%. Similar finding was reported by Das [50] in India which suggested that the diet of household increases in diversity with increased number of young household members.

Household ownership of small ruminants had a positive and significant effect on household dietary diversity. The keeping of livestock particularly poultry and small ruminants in the area is a common practice for home consumption and or for income to meet both household food and non-food expenditure needs. Livestock could therefore impact household food consumption patterns directly or indirectly through sales income which might be used to procure other food items that the family does not produce. Similar findings have been reported in the literature [5,29,41,46].

Households' participation in non-farm work, probably during the off-farming season, is also an important determinant of household dietary diversity, albeit weakly at 10% significance level. Similar to the effect of livestock ownership on dietary diversity, off-farm work increases the livelihood sources of the household which may translate into their increased ability to procure food from more diversified sources and ultimately leading to diversified diets for household members. The result is consistent with Sibhatu, Krishna [4] who reported a significant and positive effect of income earned from non-farm work on household dietary diversity in a number of countries including Indonesia, Kenya, Ethiopia and Malawi. It however contradicts that of Babatunde, Opeyemi [49] who found income from non-farm activities to have a negative effect on household dietary diversity in a study that assessed the impact of irrigation on household dietary diversity in Nigeria.

4. CONCLUSION

From the econometric analysis, indigenous crop production has positive and significant effects on household dietary diversity. The results show that household diets were about 3 times more diversified if they engaged in the production of indigenous crops relative to the diets of households that did not. It is recommended that policies aimed at diverse food consumption and improved nutrition security among rural farming communities should consider promoting increased production and consumption of indigenous food crops and more farm households should be encouraged to include indigenous food crops in their cropping.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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